The relationship of microorganisms to sanitation:

Microorganisms can contaminate and affect food, with dangerous consequences to consumers. The**microorganisms** most common to food are **bacteria**and fungi. The fungi, which are less common than**bacteria**, consist of two major **microorganisms**: molds (which are multicellular) and yeasts (which are usually unicellular).

Microorganisms cause food spoilage through degradation of appearance and flavor, and foodborne illness occurs through the ingestion of food containing microorganisms or toxins of public health concern. Control of microbial load from equipment, establishments, and foods is part of a sanitation program.

Microorganisms have a growth pattern similar to the shape of a bell curve and tend to proliferate and die at a logarithmic rate. Extrinsic factors that have the most effect on microbial growth kinetics are temperature, oxygen availability, and relative humidity. Intrinsic factors that affect growth rate most are water activity (A_w) and pH levels, oxidation-reduction potential, nutrient requirements, and presence of inhibitory substances. Chemical changes from microbial degradation occur primarily through enzymes, produced by microorganisms, which degrade proteins, lipids, carbohydrates, and other complex molecules into simpler compounds.

The most common methods of microbial destruction are heat, chemicals, and irradiation, whereas the most common methods for inhibiting microbial growth are refrigeration, dehydration, and fermentation Microbial load and taxonomy are measurements of the effectiveness of a sanitation program by various tests and diagnoses.

ROLE OF MICROBIOLOGY

Microbiology is the study of microorganisms such as bacteria, protozoa, fungi and similar organisms that can't be seen with the naked eye. ... Macrophages play an important **role** in immune system because they are capable of ingesting microbes that enter our body through open wounds

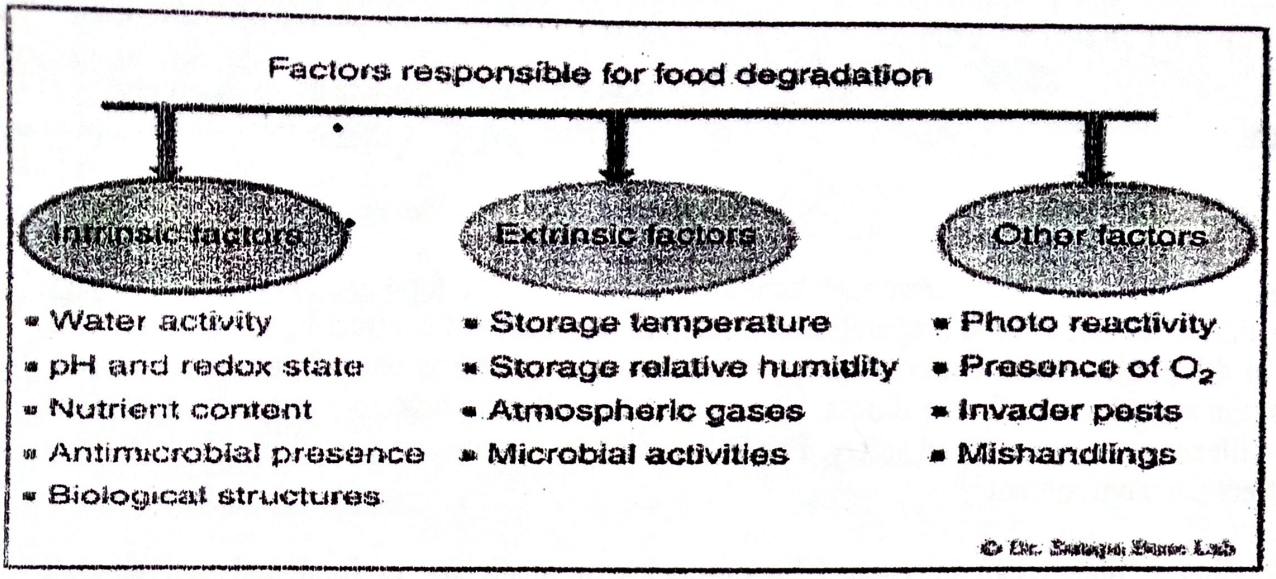
Introduction to Microbiology, History & scope

- **Microbiology:**

- In the broadest sense, **microbiology** is the study of all organisms that are invisible to the naked eye-that is the study of **microorganisms.**
- Its subjects are viruses, bacteria, many algae and fungi, and protozoa.
- The importance of microbiology and microorganisms can not be overemphasized.
- Microorganisms are necessary for the production of bread, cheese, beer, antibiotics, vaccines, vitamins, enzymes, etc.
- Modern **biotechnology** rests upon a microbiological foundation.

- **Microorganisms:**

- Microorganisms are everywhere; almost every natural surface is colonized by microbes, from body to ocean. Some microorganisms can live hot springs, and others in frozen sea ice.
- Most microorganisms are harmless to humans; You swallow millions of microbes every day with no ill effects. In fact, we are dependent on microbes to help us digest our food.
- Microbes also keep the biosphere running by carrying out essential functions such as decomposition of dead animals and plants. They make possible the cycles of carbon, oxygen, nitrogen and sulfur that take place in terrestrial and aquatic systems.
- Microorganisms have also harmed humans and disrupted society over the millennia.



BIOLOGICAL CONTAMINANTS

Bacterial	Viral	Fungal	Parasitic
•Botulism	•Hepatitis A	•Yeast	•Giardiasis
•E-coli Infection	•Norwalk virus	•Mold	•Cyclosporiasis
•Salmonellosis	•Rota virus		•Trichonosis
•Shigellosis			
•Listeriosis			
•Staphylococcal Illness			

Foodborne illness

Foodborne illness (also **foodborne disease** and colloquially referred to as **food poisoning**)[1] is any illness resulting from the spoilage of contaminated food, pathogenic bacteria, viruses, or parasites that contaminate food,[2] as well as toxins such as poisonous mushrooms and various species of beans that have not been boiled for at least 10 minutes.

Symptoms vary depending on the cause, and are described below in this article. A few broad generalizations can be made, e.g.: the incubation period ranges from hours to days, depending on the cause and on quantity of consumption. The incubation period tends to cause sufferers to not associate the symptoms with the item consumed, and so to cause sufferers to attribute the symptoms to gastroenteritis for example.

Symptoms often include vomiting, fever, and aches, and may include diarrhea. Bouts of vomiting can be repeated with an extended delay in between, because even if infected food was eliminated from the stomach in the first bout, microbes, like bacteria, (if applicable) can pass through the stomach into the

intestine and begin to multiply. Some types of microbes stay in the intestine, some produce a toxin that is absorbed into the bloodstream, and some can directly invade deeper body tissues.

Causes

See also: Pathogen

Poorly stored food in a refrigerator

Foodborne illness usually arises from improper handling, preparation, or food storage. Good hygiene practices before, during, and after food preparation can reduce the chances of contracting an illness. There is a consensus in the public health community that regular hand-washing is one of the most effective defenses against the spread of foodborne illness. The action of monitoring food to ensure that it will not cause foodborne illness is known as food safety. Foodborne disease can also be caused by a large variety of toxins that affect the environment.[3]

Furthermore, foodborne illness can be caused by pesticides or medicines in food and natural toxic substances such as poisonous mushrooms or reef fish.

Bacteria

Bacteria are a common cause of foodborne illness. In the United Kingdom during 2000, the individual bacteria involved were the following: *Campylobacter jejuni* 77.3%, *Salmonella* 20.9%, *Escherichia coli* O157:H7 1.4%, and all others less than 0.56%.[4] In the past, bacterial infections were thought to be more prevalent because few places had the capability to test for norovirus and no active surveillance was being done for this particular agent. Toxins from bacterial infections are delayed because the bacteria need time to multiply. As a result, symptoms associated with intoxication are usually not seen until 12–72 hours or more after eating contaminated food. However, in some cases, such as Staphylococcal food poisoning, the onset of illness can be as soon as 30 minutes after ingesting contaminated food.[5]

Salmonella

Most common bacterial foodborne pathogens are:

- *Campylobacter jejuni* which can lead to secondary Guillain–Barré syndrome and periodontitis[6]
- *Clostridium perfringens*, the "cafeteria germ"[7]
- *Salmonella* spp. – its *S. typhimurium* infection is caused by consumption of eggs or poultry that are not adequately cooked or by other interactive human-animal pathogens[8][9][10]
- *Escherichia coli O157:H7* enterohemorrhagic (EHEC) which can cause hemolytic-uremic syndrome

Other common bacterial foodborne pathogens are:

- *Bacillus cereus*
- *Escherichia coli*, other virulence properties, such as enteroinvasive (EIEC), enteropathogenic (EPEC), enterotoxigenic (ETEC), enteroaggregative (EAEC or EAgEC)
- *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*

Less common bacterial agents:

- *Brucella* spp.
- *Corynebacterium ulcerans*
- *Coxiella burnetii* or Q fever
- *Plesiomonas shigelloides*

Enterotoxins
See also: Botulism

In addition to disease caused by direct bacterial infection, some foodborne illnesses are caused by enterotoxins (exotoxins targeting the intestines). Enterotoxins can produce illness even when the microbes that produced them have been killed. Symptom appearance varies with the toxin but may be rapid in onset, as in the case of enterotoxins of *Staphylococcus aureus* in which symptoms appear in one to six hours.[11] This causes intense vomiting including or not including diarrhea (resulting in staphylococcal enteritis), and staphylococcal enterotoxins (most commonly staphylococcal enterotoxin A but also including staphylococcal enterotoxin B) are the most commonly reported enterotoxins although cases of poisoning are likely underestimated.[12] It occurs mainly in cooked and processed foods due to competition with other biota in raw foods, and humans are the main cause of contamination as a substantial percentage of humans are persistent carriers of *S. aureus*.[12] The CDC has estimated about 240,000 cases per year in the United States.[13]

- *Clostridium botulinum*
- *Clostridium perfringens*
- *Bacillus cereus*

The rare but potentially deadly disease botulism occurs when the anaerobic bacterium *Clostridium botulinum* grows in improperly canned low-acid foods and produces botulin, a powerful paralytic toxin.

Pseudoalteromonas tetradonis, certain species of Pseudomonas and Vibrio, and some other bacteria, produce the lethal tetrodotoxin, which is present in the tissues of some living animal species rather than being a product of decomposition.

Emerging foodborne pathogens

Many foodborne illnesses remain poorly understood.

- *Aeromonas hydrophila*, *Aeromonas caviae*, *Aeromonas sobria*

Preventing bacterial food poisoning

Proper storage and refrigeration of food help in the prevention of food poisoning

Prevention is mainly the role of the state, through the definition of strict rules of hygiene and a public services of veterinary surveying of animal products in the food chain, from farming to the transformation industry and delivery (shops and restaurants). This regulation includes:

- traceability: in a final product, it must be possible to know the origin of the ingredients (originating farm, identification of the harvesting or of the animal) and where and when it was processed; the origin of the illness can thus be tracked and solved (and possibly penalized), and the final products can be removed from the sale if a problem is detected;
- enforcement of hygiene procedures such as HACCP and the "cold chain";
- power of control and of law enforcement of veterinarians.

In August 2006, the United States Food and Drug Administration approved Phage therapy which involves spraying meat with viruses that infect bacteria, and thus preventing infection. This has raised concerns, because without mandatory labelling consumers would not be aware that meat and poultry products have been treated with the spray.[14]

At home, prevention mainly consists of good food safety practices. Many forms of bacterial poisoning can be prevented by cooking it sufficiently, and either eating it quickly or refrigerating it effectively.[2] Many toxins, however, are not destroyed by heat treatment.

Techniques that help prevent food borne illness in the kitchen are hand washing, rinsing produce,[15] preventing cross-contamination, proper storage, and maintaining cooking temperatures. In general, freezing or refrigerating prevents virtually all bacteria from growing, and heating food sufficiently kills parasites, viruses, and most bacteria. Bacteria grow most rapidly at the range of temperatures between 40 and 140 °F (4 and 60 °C), called the "danger zone". Storing food below or above the "danger zone" can effectively limit the production of toxins. For storing leftovers, the food must be put in shallow containers for quick cooling and must be refrigerated within two hours. When food is reheated, it must reach an internal temperature of 165 °F (74 °C) or until hot or steaming to kill bacteria.[16]

Mycotoxins and alimentary mycotoxicoses

The term alimentary mycotoxicosis refers to the effect of poisoning by mycotoxins through food consumption. The term mycotoxin is usually reserved for the toxic chemical products produced by fungi that readily colonize crops. Mycotoxins sometimes have important effects on human and animal health. For example, an outbreak which occurred in the UK in 1960 caused the death of 100,000 turkeys which had consumed aflatoxin-contaminated peanut meal. In the USSR in World War II, 5,000 people died due to alimentary toxic aleukia (ALA).[17] The common foodborne Mycotoxins include:

- Aflatoxins – originating from *Aspergillus parasiticus* and *Aspergillus flavus*. They are frequently found in tree nuts, peanuts, maize, sorghum and other oilseeds, including corn and cottonseeds. The pronounced forms of Aflatoxins are those of B1, B2, G1, and G2, amongst which Aflatoxin B1 predominantly targets the liver, which will result in necrosis, cirrhosis, and carcinoma.[18][19] In the US, the acceptable level of total aflatoxins in foods is less than 20 µg/kg, except for Aflatoxin M1 in milk, which should be less than 0.5 µg/kg.[20] The official document can be found at FDA's website.[21][22]
- Altertoxins – are those of alternariol (AOH), alternariol methyl ether (AME), altenuene (ALT), altertoxin-1 (ATX-1), tenuazonic acid (TeA), and radicinin (RAD), originating from *Alternaria* spp. Some of the toxins can be present in sorghum, ragi, wheat and tomatoes.[23][24][25] Some research has shown that the toxins can be easily cross-contaminated between grain commodities, suggesting that manufacturing and storage of grain commodities is a critical practice.[26]

- Citrinin
- Citreoviridin
- Cyclopiazonic acid
- Cytochalasins
- Ergot alkaloids / ergopeptine alkaloids – ergotamine
- Fumonisins – Crop corn can be easily contaminated by the fungi *Fusarium moniliforme*, and its fumonisin B1 will cause leukoencephalomalacia (LEM) in horses, pulmonary edema syndrome (PES) in pigs, liver cancer in rats and esophageal cancer in humans.[27][28] For human and animal health, both the FDA and the EC have regulated the content levels of toxins in food and animal feed.[29][30]
- Fusaric acid
- Fusarochromanone
- Kojic acid
- Lolitrem alkaloids
- Moniliformin
- 3-Nitropropionic acid
- Nivalenol
- Ochratoxins – In Australia, The Limit of Reporting (LOR) level for ochratoxin A (OTA) analyses in 20th Australian Total Diet Survey was 1 μg/kg,[31] whereas the EC restricts the content of OTA to 5 μg/kg in cereal commodities, 3 μg/kg in processed products and 10 μg/kg in dried vine fruits.[32]
- Oosporeine
- Patulin – Currently, this toxin has been advisably regulated on fruit products. The EC and the FDA have limited it to under 50 μg/kg for fruit juice and fruit nectar, while limits of 25 μg/kg for solid-contained fruit products and 10 μg/kg for baby foods were specified by the EC.[32][33]
- Phomopsins
- Sporidesmin A
- Sterigmatocystin
- Tremorgenic mycotoxins – Five of them have been reported to be associated with molds found in fermented meats. These are fumitremorgen B, paxilline, penitrem A, verrucosidin, and verruculogen.[34]
- Trichothecenes – sourced from *Cephalosporium*, *Fusarium*, *Myrothecium*, *Stachybotrys*, and *Trichoderma*. The toxins are usually found in molded maize, wheat, corn, peanuts and rice, or animal feed of hay and straw.[35][36] Four trichothecenes, T-2 toxin, HT-2 toxin, diacetoxyscirpenol (DAS), and deoxynivalenol (DON) have been most commonly encountered by humans and animals. The consequences of oral intake of, or dermal exposure to, the toxins will result in alimentary toxic aleukia, neutropenia, aplastic anemia, thrombocytopenia and/or skin irritation.[37][38][39] In 1993, the FDA issued a document for the content limits of DON in food and animal feed at an advisory level.[40] In 2003, US published a patent that is very promising for farmers to produce a trichothecene-resistant crop.[41]
- Zearalenone
- Zearalenols

Viruses

Viral infections make up perhaps one third of cases of food poisoning in developed countries. In the US, more than 50% of cases are viral and noroviruses are the most common foodborne illness, causing 57% of outbreaks in 2004. Foodborne viral infection are usually of intermediate (1–3 days) incubation period, causing illnesses which are self-limited in otherwise healthy individuals; they are similar to the bacterial forms described above.

- Enterovirus
- Hepatitis A is distinguished from other viral causes by its prolonged (2--6 week) incubation period and its ability to spread beyond the stomach and intestines into the liver. It often results in jaundice, or yellowing of the skin, but rarely leads to chronic liver dysfunction. The virus has been found to cause infection due to the consumption of fresh-cut produce which has fecal contamination.[42][43]
- Hepatitis E
- Norovirus
- Rotavirus

- Rotavirus

Parasites

Most foodborne parasites are zoonoses.

- Platyhelminthes:
  - *Diphyllobothrium* sp.
  - *Nanophyetus* sp.
  - *Taenia saginata*
  - *Taenia solium*
  - *Fasciola hepatica*

  See also: Tapeworm and Flatworm

- Nematode:
  - *Anisakis* sp.
  - *Ascaris lumbricoides*
  - *Eustrongylides* sp.
  - *Trichinella spiralis*
  - *Trichuris trichiura*
- Protozoa:
  - *Acanthamoeba* and other free-living amoebae
  - *Cryptosporidium parvum*
  - *Cyclospora cayetanensis*
  - *Entamoeba histolytica*
  - *Giardia lamblia*

-
  - *Giardia lamblia*
  - *Sarcocystis hominis*
  - *Sarcocystis suihominis*
  - *Toxoplasma gondii*

Natural toxins

Several foods can naturally contain toxins, many of which are not produced by bacteria. Plants in particular may be toxic; animals which are naturally poisonous to eat are rare. In evolutionary terms, animals can escape being eaten by fleeing; plants can use only passive defenses such as poisons and distasteful substances, for example capsaicin in chili peppers and pungent sulfur compounds in garlic and onions. Most animal poisons are not synthesised by the animal, but acquired by eating poisonous plants to which the animal is immune, or by bacterial action.

- Alkaloids
- Ciguatera poisoning
- Grayanotoxin (honey intoxication)
- Mushroom toxins
- Phytohaemagglutinin (red kidney bean poisoning; destroyed by boiling)
- Pyrrolizidine alkaloids
- Shellfish toxin, including paralytic shellfish poisoning, diarrhetic shellfish poisoning, neurotoxic shellfish poisoning, amnesic shellfish poisoning and ciguatera fish poisoning
- Scombrotoxin
- Tetrodotoxin (fugu fish poisoning)

Some plants contain substances which are toxic in large doses, but have therapeutic properties in appropriate dosages.

- Foxglove contains cardiac glycosides.
- Poisonous hemlock (conium) has medicinal uses.

Other pathogenic agents

- Prions, resulting in Creutzfeldt–Jakob disease (CJD) and its variant (vCJD)

"Ptomaine poisoning"

In 1883, the Italian, Professor Salmi, of Bologna, introduced the generic name *ptomaine* (from Greek *ptōma*, "fall, fallen body, corpse") for alkaloids found in decaying animal and vegetable matter, especially (as reflected in their names) putrescine and cadaverine.[44] The 1892 *Merck's Bulletin* stated, "We name such products of bacterial origin ptomaines; and the special alkaloid produced by the comma bacillus is variously named Cadaverine, Putrescine, etc."[45] While *The Lancet* stated, "The chemical ferments produced in the system, the... ptomaines which may exercise so disastrous an influence."[46] It is now known that the "disastrous... influence" is due to the direct action of bacteria and only slightly to the alkaloids. Thus, the use of the phrase "ptomaine poisoning" is now obsolete.

Tainted potato salad sickening hundreds at a Communist political convention in Massillon, Ohio,[47] and aboard a Washington DC cruise boat in separate incidents during a single week in 1932 drew national attention to the dangers of so-called "ptomaine poisoning" in the pages of the American news weekly, *Time*.[48] Another newspaper article from 1944 told of more than 150 persons being hospitalized in Chicago with ptomaine poisoning apparently from rice pudding served by a chain of restaurants.[49]

Mechanism

Incubation period

The delay between the consumption of contaminated food and the appearance of the first symptoms of illness is called the incubation period. This ranges from hours to days (and rarely months or even years, such as in the case of listeriosis or bovine spongiform encephalopathy), depending on the agent, and on how much was consumed. If symptoms occur within one to six hours after eating the food, it suggests that it is caused by a bacterial toxin or a chemical rather than live bacteria.[citation needed]

The long incubation period of many foodborne illnesses tends to cause sufferers to attribute their symptoms to gastroenteritis.

During the incubation period, microbes pass through the stomach into the intestine, attach to the cells lining the intestinal walls, and begin to multiply there. Some types of microbes stay in the intestine, some produce a toxin that is absorbed into the bloodstream, and some can directly invade the deeper body tissues. The symptoms produced depend on the type of microbe.[50]

Infectious dose

The infectious dose is the amount of agent that must be consumed to give rise to symptoms of foodborne illness, and varies according to the agent and the consumer's age and overall health. Pathogens vary in minimum infectious dose; for example, *Shigella sonnei* has a low estimated minimum dose of < 500 colony-forming units (CFU) while *Staphylococcus aureus* has a relatively high estimate.[51]

In the case of *Salmonella* a relatively large inoculum of 1 million to 1 billion organisms is necessary to produce symptoms in healthy human volunteers,[52] as *Salmonellae* are very sensitive to acid. An unusually high stomach pH level (low acidity) greatly reduces the number of bacteria required to cause symptoms by a factor of between 10 and 100.

Epidemiology

Asymptomatic subclinical infection may help spread these diseases, particularly *Staphylococcus aureus*, *Campylobacter*, *Salmonella*, *Shigella*, *V. cholerae*, and *Yersinia*.[51] For example, as of 1984 it was estimated that in the United States, 200,000 people were asymptomatic carriers of *Salmonella*.[51]

Infants

Main article: Infant food safety

Globally, infants are a population that are especially vulnerable to foodborne disease. The World Health Organization has issued recommendations for the preparation, use and storage of prepared formulas. Breastfeeding remains the best preventative measure for protection of foodborne infections in infants.[53]

United States

In the United States, using FoodNet data from 2000–2007, the CDC estimated there were 47.8 million foodborne illnesses per year (16,000 cases for 100,000 inhabitants)[54] with 9.4 million of these caused by 31 known identified pathogens.[55]

- 127,839 were hospitalized (43 per 100,000 inhabitants per year).[56][57][58]
- 3,037 people died (1.0 per 100,000 inhabitants per year).[57][58]

Causes of foodborne illness in US[55]

Cause	Annual	Rate

Causes of death by foodborne illness in US[55]

Cause	Annual	Rate

- European Commission Regulation (EC) No 2073/2005 of November 15, 2005
- European Committee for Standardization (CEN): Standard method for the detection of norovirus and hepatitis A virus in food products (shellfish, fruits and vegetables, surfaces and bottled water)
- CODEX Committee on Food Hygiene (CCFH): Guideline for the application of general principles of food hygiene for the control of viruses in food[78]

Food hazards

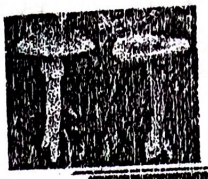
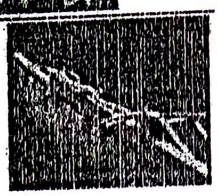
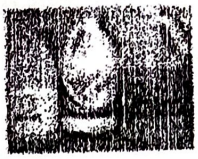
Food hazards may be biological, chemical, physical, allergenic, nutritional and/or biotechnology-related. **Hazards** may be introduced into the **food** supply any time during harvesting, formulation and processing, packaging and labelling, transportation, storage, preparation, and serving.

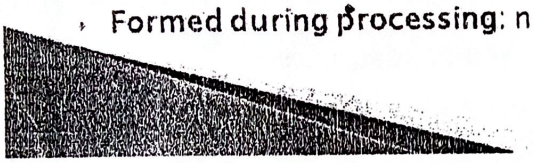
Chemical hazards include water, **food** contact materials, cleaning agents, pest control substances, contaminants (environmental, agricultural and process e.g. acrylamide), pesticides, biocides and **food** additives.Oct

CHEMICAL HAZARDS	PURPOSE	OCCURANCE
Cleaning chemical residues	Used for cleaning and sanitizing food	Water resources
Factory contaminants	Pest control chemicals, lubricants, coatings, paints, refrigerants	Water resources
Agricultural residues	Pesticides, fertilizers, fungicides, antibiotics and growth hormones	Water resources
Food allergens	Cause allergy	Eggs, fish, milk, peanuts, sesame seeds, soy, sulphites, tree nuts and wheat
Naturally occurring harmful chemicals	Mycotoxins, scombrotoxin (histamine)	Mushroom toxins and shellfish toxins
Industrial heavy metals	Lead, zinc, cadmium, arsenic and mercury	Water resources

Chemical hazards –examples

- Naturally occurring in food:
  toxic substances in poisoning mushrooms, arsenic acids in almonds, allergens, alkaloids in potatoes
- Added intentionally:
  pesticide residues in feed, nitrates in meat, preservatives
- Added not intentionally (any unwanted substance): cleaning agents, heavy metals
- Formed during processing: nitrosamines, acrylamides



Chemical Hazards

Identifying Chemical Hazards Presentation

What is a chemical hazard?

The FDA and the USDA have recognized the wide variety of chemicals used in food processing and have decided what chemicals are acceptable additives in food products and which chemical substances are strictly forbidden. These agencies have also determined acceptable levels of other chemical substances. Chemical hazards affect more people than physical hazards, but typically not as many as a biological hazard. Obviously, some chemicals are of greater concern than others.

Chemicals are divided into two primary categories: prohibited substances and unavoidable poisonous or deleterious substances. Each company should make certain that none of the prohibited substances are present in ingredients or supplies. Unavoidable poisonous or deleterious substances have FDA tolerance levels or action levels, in the event that exposure or introduction is unavoidable. Products that fall into these categories include pesticides, herbicides, growth hormones and antibiotics, additives and processing aids, lubricants, paints, cleaners and sanitizers. There are a number of manuals available which contain a laundry list of other items that could contaminate. The FD&C Act regulates all of the above except pesticides. Those products without tolerance levels must not be present in any amount.

Chemical hazards should be addressed in steps in the production process: storage, during use (cleaning agents, sanitizers), prior to receipt (in ingredients and packaging materials), upon receipt of materials, during processing and prior to shipment of product.

Chemicals which should be considered include color additives, direct food additives, indirect food additives, prior-sanctioned substances, pesticide chemicals and substances generally recognized as safe. All chemicals used in and around manufactured product should have specifications developed, as well as a letter of guarantee from the manufacturer.

How can chemical hazards be controlled?

Perhaps foremost in controlling chemical contamination are proper storage and handling practices. Chemicals should be stored separately from food products and packaging materials to avoid contamination. Special care should be taken to thoroughly rinse cleaning products and sanitizers from equipment during clean-up, especially in areas where liquid tends to accumulate. In addition, only USDA approved chemicals should be used during cleaning and sanitizing. Pest control should be performed by professionals and chemical residues in incoming food products should be controlled. Other actions that may be taken include the use of approved chemicals only, keeping of an inventory of all chemicals, colorings and additives, frequent review of current procedures and formulations as well as audits of chemical use, adequate employee training and in-house testing. It is also good policy to keep up with new regulations.

Table 1. Chemical Hazards for Meat and Poultry

Raw Materials	Pesticides, antibiotics, hormones, toxins, fertilizers, fungicides, heavy metals, PCBs.
Processing	Direct food additives-preservatives (nitrite), flavor enhancers, color additives. Indirect food additives-boiler water additives, peeling aids, defoaming agents.
Building and Equipment Maintenance	Lubricants, paints, coatings.
Sanitation	Pesticides, cleaners, sanitizers.
Storage and Shipping	All types of chemicals, cross contamination

ANTIBIOTICS FOOD HAZARDS

Although there is no evidence that **antibiotics** in **foods** harm people directly, most agree that the over-use of **antibiotics** in **food**-producing animals is a problem. It can contribute to the development and spread of drug-resistant bacteria, which is a potential **risk** to public health.

Biological		Chemical	
Parasites	Parasites of public health significance: Trematodes, Nematodes, Cestodes *Clonorchis, Opisthorchis, Paragonimus*	*Agrochemicals*	Disinfectants, pesticides, herbicides, algicides, fungicides anti-oxidants (added in feeds)
		Veterinary drug residues	Antibiotics, growth promoters (hormones), other feed additives from animal manures
Pathogenic bacteria	*Salmonella, Shigella, E. Coli 0157, Vibrio cholerae, Vibrio parahaemolyticus, Vibrio vulnificus, Listeria monocytogenes, Clostridium botulinum*	*Heavy metals*	Metals leached from soil, from industrial wastes, from sewage or animal manures
Biological toxins	Scombrotoxin Ciguatoxin		

Metal toxicity

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Metal toxicity or **metal poisoning** is the toxic effect of certain metals in certain forms and doses on life. Some metals are toxic when they form poisonous soluble compounds. Certain metals have no biological role, i.e. are not essential minerals, or are toxic when in a certain form.[1] In the case of lead, any measurable amount may have negative health effects.[2] Often heavy metals are thought as synonymous, but lighter metals may also be toxic in certain circumstances, such as beryllium and lithium. Not all heavy metals are particularly toxic, and some are essential, such as iron. The definition may also include trace elements when in abnormally high doses may be toxic. An option for treatment of metal poisoning may be chelation therapy, which is a technique which involves the administration of chelation agents to remove metals from the body.

Toxic metals sometimes imitate the action of an essential element in the body, interfering with the metabolic process resulting in illness. Many metals, particularly heavy metals are toxic, but some heavy metals are essential, and some, such as bismuth, have a low toxicity. Most often the definition of toxic metals includes at least cadmium, manganese, lead, mercury and the radioactive metals.[citation needed] Metalloids (arsenic, polonium) may be included in the definition. Radioactive metals have both radiological toxicity and chemical toxicity. Metals in an oxidation state abnormal to the body may also become toxic: chromium(III) is an essential trace element, but chromium(VI) is a carcinogen.

Toxicity is a function of solubility. Insoluble compounds as well as the metallic forms often exhibit negligible toxicity. The toxicity of any metal depends on its ligands. In some cases, organometallic forms, such as methylmercury and tetraethyl lead, can be extremely toxic. In other cases, organometallic derivatives are less toxic such as the cobaltocenium cation.

Decontamination for toxic metals is different from organic toxins: because toxic metals are elements, they cannot be destroyed. Toxic metals may be made insoluble or collected, possibly by the aid of chelating agents, or through bioremediation. Alternatively, they can be diluted into a sufficiently large reservoir, such as the sea, because immediate toxicity is a function of concentration rather than amount.

Toxic metals can bioaccumulate in the body and in the food chain.[citation needed] Therefore, a common characteristic of toxic metals is the chronic nature of their toxicity. This is particularly notable with radioactive heavy metals such as radium, which imitates calcium to the point of being incorporated into human bone, although similar health implications are found in lead or mercury poisoning. The exceptions to this are barium and aluminium, which can be removed efficiently by the kidneys.

Testing for poisoning

People are continually exposed to metals in the environment.[3] Medical tests can detect metals often, but this is to be expected and alone is not evidence that a person is poisoned.[3] Metal screening tests should not be used unless there is reason to believe that a person has had excessive exposure to metals.[3] People should seek medical testing for poisoning only if they are concerned for a particular reason, and physicians should consider a patient's history and physical examination before conducting tests to detect metals.

Treatment for poisoning

Chelation therapy is a medical procedure that involves the administration of chelating agents to remove heavy metals from the body. Chelating agents are molecules that have multiple electron-donating groups, which can form stable coordination complexes with metal ions. Complexation prevents the metal ions from reacting with molecules in the body, and enable them to be dissolved in blood and eliminated in urine. It should only be used in people who have a diagnosis of metal intoxication.[4] That diagnosis should be validated with tests done in appropriate biological samples.[4]

Chelation therapy is administered under very careful medical supervision due to various inherent risks.[5] Even when the therapy is administered properly, the chelation drugs can have significant side effects.[4] Chelation administered inappropriately can cause neurodevelopmental toxicity, increase risk of developing cancer, and cause death;[4] chelation also removes essential metal elements and requires measures to prevent their loss.

Specific types of poisoning

Aluminium phosphide poisoning
Main article: Aluminium phosphide poisoning

Aluminium has no known biological role and its classification into toxic metals is controversial.

Acute aluminium phosphide poisoning (AAlPP) is a large, though under-reported, problem in the Indian subcontinent. Aluminium phosphide (AlP), which is readily available as a fumigant for stored cereal grains, sold under various brand names such as *QuickPhos* and *Celphos*, is highly toxic, especially when consumed from a freshly opened container.[6][7] Death results from profound shock, myocarditis and multi-organ failure.[8] Aluminium phosphide has a fatal dose of between 0.15 and 0.5 grams (0.0053 and 0.0176 oz).[9] It has been reported to be the most common cause of suicidal death in North India.[10] The

very high toxicity of aluminium phosphide is attributed to the phosphine content and is not related to aluminium. Calcium phosphide and zinc phosphide are similar poisons.

Arsenic poisoning
Main article: Arsenic poisoning

Arsenic poisoning is a medical condition caused by elevated levels of arsenic in the body. The dominant basis of arsenic poisoning is from ground water that naturally contains high concentrations of arsenic. A 2007 study found that over 137 million people in more than 70 countries are probably affected by arsenic poisoning from drinking water.[11]

Beryllium poisoning
Main article: Beryllium poisoning

Beryllium poisoning is illness resulting from the toxic effect of beryllium in its elemental form or in various chemical compounds. The toxicity of beryllium depends upon the duration, intensity and frequency of exposure (features of dose), as well as the form of beryllium and the route of exposure (i.e. inhalation, dermal, ingestion). According to the International Agency for Research on Cancer (IARC), beryllium and beryllium compounds are Category 1 carcinogens; they are carcinogenic to both animals and humans.[12]

Cadmium poisoning
Main article: Cadmium poisoning

Cadmium is an extremely toxic metal commonly found in industrial workplaces. Due to its low permissible exposure limit, overexposures may occur even in situations where trace quantities of cadmium are found. Cadmium is used extensively in electroplating, although the nature of the operation does not generally lead to overexposures. Cadmium is also found in some industrial paints and may represent a hazard when sprayed. Operations involving removal of cadmium paints by scraping or blasting may pose a significant hazard. Cadmium is also present in the manufacturing of some types of batteries. Exposures to cadmium are addressed in specific standards for the general industry, shipyard employment, construction industry, and the agricultural industry.[13]

Copper toxicity
Main article: Copper toxicity

Copper toxicity, also called **copperiedus**, refers to the consequences of an excess of copper in the body. Copperiedus can occur from eating acid foods cooked in uncoated copper cookware, or from exposure to excess copper in drinking water, as a side-effect of estrogen birth control pills, or other environmental sources. It can also result from the genetic condition Wilson's disease.

Iron poisoning
Main article: Iron poisoning

Iron poisoning is an iron overload caused by a large excess of iron intake and usually refers to an acute overload rather than a gradual one. The term has been primarily associated with young children who consumed large quantities of iron supplement pills, which resemble sweets and are widely used, including by pregnant women—see overnutrition (approximately 3 grams is lethal for a 2 year old).[14] Targeted packaging restrictions in the US for supplement containers with over 250 mg elemental iron have existed since 1978, and recommendations for unit packaging have reduced the several iron poisoning fatalities

per year to almost nil since 1998.[15][16] No known cases of iron poisoning have been identified that are associated with iron mining.[citation needed]

Lead poisoning
Main article: Lead poisoning

Lead poisoning is a medical condition in humans and other vertebrates caused by increased levels of the heavy metal lead in the body. Lead interferes with a variety of body processes and is toxic to many organs and tissues including the heart, bones, intestines, kidneys, and reproductive and nervous systems. It interferes with the development of the nervous system and is therefore particularly toxic to children, causing potentially permanent learning and behavior disorders. Symptoms include abdominal pain, confusion, headache, anemia, irritability, and in severe cases seizures, coma, and death.[citation needed]

Lithium poisoning

Lithium is used in some medications, specifically to treat bipolar disorder. The level of "sufficient" medication is thought by many physicians to be close to toxic tolerance for kidney function. Therefore, the patient is often monitored for this purpose.[17][18]

Manganese poisoning, or manganism
Main article: Manganism

Manganism or manganese poisoning is a toxic condition resulting from chronic exposure to manganese and first identified in 1837 by James Couper.[19]

Mercury poisoning
Main article: Mercury poisoning

Mercury poisoning is a disease caused by exposure to mercury or its compounds. Mercury (chemical symbol Hg) is a heavy metal occurring in several forms, all of which can produce toxic effects in high enough doses. Its zero oxidation state Hg^0 exists as vapor or as liquid metal, its mercurous state Hg_2^{2+} exists as inorganic salts, and its mercuric state Hg^{2+} may form either inorganic salts or organomercury compounds; the three groups vary in effects. Toxic effects include damage to the brain, kidney, and lungs. Mercury poisoning can result in several diseases, including acrodynia (pink disease), Hunter-Russell syndrome, and Minamata disease.[citation needed]

Symptoms typically include sensory impairment (vision, hearing, speech), disturbed sensation and a lack of coordination. The type and degree of symptoms exhibited depend upon the individual toxin, the dose, and the method and duration of exposure.[citation needed]

Silver poisoning (Argyria)

A 92-year-old Caucasian man (right) with pigmentary changes had used nose drops containing silver for many years. His skin biopsy showed silver deposits in the dermis, confirming the diagnosis of generalized argyria.[citation needed]
Main article: Argyria

Argyria or argyrosis is a condition caused by inappropriate exposure to chemical compounds of the element silver, or to silver dust.[20] The most dramatic symptom of argyria is that the skin turns blue or bluish-grey. It may take the form of *generalized argyria* or *local argyria*. Generalized argyria affects

large areas over much of the visible surface of the body. Local argyria shows in limited regions of the body, such as patches of skin, parts of the mucous membrane or the conjunctiva.[citation needed]

Thallium poisoning
Main article: Thallium poisoning

Thallium and its compounds are often highly toxic.[21] Contact with skin is dangerous, and adequate ventilation should be provided when melting this metal.[22] Many thallium(I) compounds are highly soluble in water and are readily absorbed through the skin.[citation needed] Exposure to them should not exceed 0.1 mg per m^2 of skin in an 8-hour time-weighted average (40-hour work week). Thallium is a suspected human carcinogen.[22]

Tin poisoning
Main article: Tin poisoning

Tin poisoning refers to the toxic effects of tin and its compounds. Cases of poisoning from tin metal, its oxides, and its salts are "almost unknown"; on the other hand certain organotin compounds are almost as toxic as cyanide.[23]

Zinc toxicity
Main article: Zinc toxicity

Even though zinc is an essential requirement for a healthy body, excess zinc can be harmful, and cause **zinc toxicity**. Such toxicity levels have been seen to occur at ingestion of greater than 225 mg of Zinc.[24] Excessive absorption of zinc can suppress copper and iron absorption. The free zinc ion in solution is highly toxic to bacteria, plants, invertebrates, and even vertebrate fish.[25][26][27]

Society and culture

It is difficult to differentiate the effects of low level metal poisoning from the environment with other kinds of environmental harms, including nonmetal pollution.[28] Generally, increased exposure to heavy metals in the environment increases risk of developing cancer.[29]

Without a diagnosis of metal toxicity and outside of evidence-based medicine, but perhaps because of worry about metal toxicity, some people seek chelation therapy to treat autism, cardiovascular disease, Alzheimer's disease, or any sort of neurodegeneration.[4] Chelation therapy does not improve outcomes for those diseases.[4]