The PAM Series ©

Practical Aide Memoirs for the workplace

PAM 5

The Food Safety Miscellany

3nd Edition

Mission 'Establish and maintain a food-safe environment'

Communication Training Improvements

PAM 1 ‘Communication’

PAM 2 ‘Training’

PAM 3 ‘Improvement’

PAM 4 ‘Logistics’

PAM 5 ‘The Food Safety Miscellany’

PAM 6 ‘Projects’

PAM 7 ‘Interaction’

Forward

Practical Aide Memoirs are just that, practical. The **PAMs** are intended as a reference to assist with decision-making, planning and action. The resultant action is intended to improve the workplace performance of individuals and teams, lifting the performance of the company, sustainably. The PAMs are about creating an environment of success; they provide sufficient information to allow the reader to easily digest the content and put it into practice at the workplace.

PAM 1 'Communication' is about laying the foundations. PAM 1 starts with the individual, then places the individual within and around the team. Throughout PAM 1 there is an emphasis on communication skills, an orientation towards objectives and outcomes, and reflective practice.

PAM 2'Training' puts the framework in place. The PAM establishes and maintains the learning environment and sets in place a culture of personal and professional development.

PAM 3 'Improvements' builds on PAMs 1 and 2 and is all about creating an environment of Continuous Improvement. This PAM remains practical due to the principle of being 'applied'; easy to grasp and transferable into the workplace.

PAM 4 'Logistics' provides a practical guide to logistics. The PAM has been put together to act as a springboard to a review of logistics and planning for the optimisation of operations.

PAM 5 'The Food Safety Miscellany' is a tour of topics relevant to the food production environment and is meant to serve as a point of reference. PAM 5 is a handy guide to have at the workplace in support of training and development.

PAM 6 'Projects' is derived from an established, well-known framework and is presented as a series of templates that can be adapted for use at the workplace. The approach offers a structured, flexible, and product-based approach to project management.

PAM 7 'Interaction' takes PAM 1 further and is a focus on advanced communication and coaching; the PAM is based on how information is transferred and processed.

Combined, the PAMs represent a **Systems Approach** to workplace improvements.

David Browne

Contents

Methods of preservation

Design and construction of food premises

General factors affecting design

Facilities required for effective layout:

Food safety design and construction

Pest Control

Definition

Purpose of pest control

The spread of disease

Bird pests

Control of bird pests

Article 4 'Wildlife and Countryside Act 1981'

Cockroaches

Control of cockroaches

Cockroach infestation checklist

Flying insects

Food infection by flying insects

Control of flying insects

Article 5 'Fly Infection'

Rodents

Personal Hygiene

Regulatory requirements

General requirements

Management requirements

Article 6 'Personal hygiene example'

Design of food equipment

Cleaning and disinfection

Background

Definitions

Benefits of cleaning

Consequence of poor cleaning

Guidance on use of cleaning agents

Clean-in-Place (CiP)

Clean -As-You-Go (ClayGo)

- Ultra-violet (UV)

Allergens

- Types of allergens
- Article 7 ‘Key Facts’

Food Preparation

- Thawing raw meat and poultry
- Cook-chill
- Sous vide
- Core temperatures

‘Cold Hold’ and ‘Hot Hold’

- Food Hygiene (England) Regulations 2006
- ‘Chill Hold’ exemptions
- Cooling
- ‘Hot Hold’ defence
- Refrigeration breakdown
- Decomposition

CCP Model

Hazard Analysis and Critical Control Points

- HACCP context
- Significance of HACCP
- Model documents
- Prerequisites
- Seven Principles of HACCP
- The 12 Steps of implementing the HACCP
- Simplified Decision Tree

Threat Assessment and Critical Control Points

- TACCP context
- Aims of TACCP:
- TACCP process
  - Illustration of the TACCP process
- Types of threat
  - Economically motivated adulteration (EMA)
- Article 8 ‘EMA Beef scandal’
  - Malicious contamination

Actions

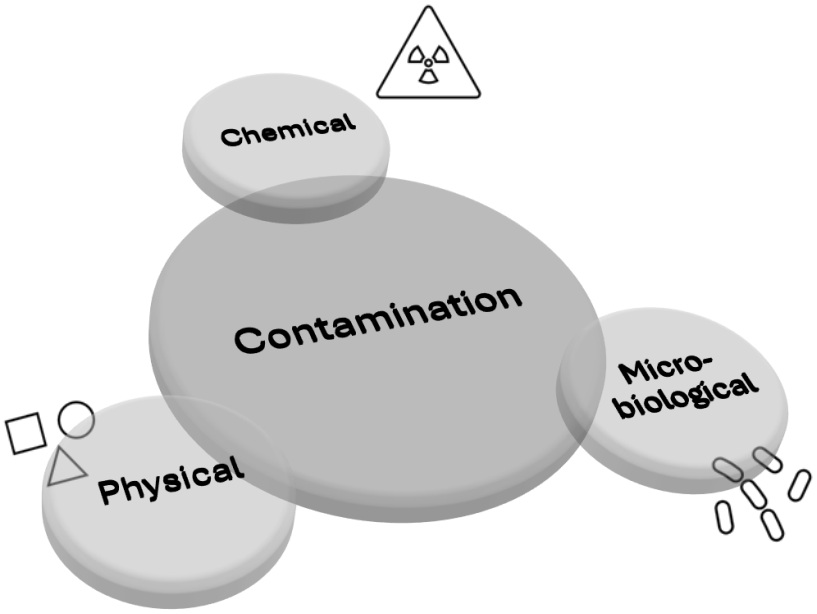
Item	Description	Actions	Stakeholders	Target Date

Notes:

Contamination

Types of Contamination

Chemical	Cleaning chemicals Chemical reactions during the process
Micro-biological	Multiplication (MM) Contamination (MC) Survival (MS)
Physical	Intrinsic- Natural or essential to the nature of something. Extrinsic- Not part of the essential nature of something.



Chemical contamination

Chemical cross-contamination in the food industry is a critical issue that can have severe implications for food safety and public health. It involves the unintended transfer of harmful chemicals from one substance to another, potentially contaminating food products. This can occur at various stages of food production, processing, storage, and transportation. Chemical contaminants can enter the food web from multiple sources, including:

Cleaning materials. Within the food production industry, high standards of cleaning is essential to maintaining food safety. Cleaning chemicals are used that, if not used in accordance with the manufacturer's instructions and Work Instructions, may result in food being contaminated. This could lead to waste and potential harm to the customer.

Environmental contaminants: These include pollutants from industrial activities, agricultural runoff, and contaminated water sources. Examples are heavy metals like lead and mercury, and organic pollutants such as dioxins and polychlorinated biphenyls (PCBs).

Agricultural practices: The use of pesticides, herbicides, and veterinary drugs can lead to residues in food products. These chemicals can persist in the environment and accumulate in the food web.

Food processing and packaging: During food processing, chemicals such as acrylamide can form when starchy foods are cooked at high temperatures. Packaging materials can also leach chemicals into food, especially if they are not food-grade.

Storage and transportation: Improper storage conditions can lead to the growth of moulds that produce mycotoxins, which are harmful to human health. Contaminated containers and equipment used during transportation can also introduce chemicals into food.

Types of chemical contaminants

Chemical contaminants in food can be broadly categorised into several types:

Heavy metals: These include lead, mercury, cadmium, and arsenic. They can accumulate in the body over time and cause various health issues, including neurological and developmental problems.

Pesticides and herbicides: These chemicals are used to protect crops from pests and weeds but can remain as residues in food products. Long-term exposure to these chemicals can lead to chronic health conditions.

Industrial chemicals: Dioxins, PCBs, and other industrial pollutants can enter the food web through contaminated water and soil. These chemicals are known to be carcinogenic and can disrupt endocrine functions.

Food-processing contaminants: Chemicals like acrylamide, formed during high-temperature cooking, and polycyclic aromatic hydrocarbons (PAHs), produced during grilling or smoking of foods, are examples of contaminants that can form during food processing.

Mycotoxins: These are toxic compounds produced by certain types of moulds. They can contaminate crops like grains, nuts, and fruits during storage under humid conditions.

Health impacts of chemical contaminants

The health impacts of chemical contaminants in food can range from acute to chronic effects:

Acute Effects: These occur shortly after exposure and can include symptoms like nausea, vomiting, diarrhoea, and abdominal pain. Acute poisoning can result from high levels of contaminants like pesticides or heavy metals.

Chronic Effects: Long-term exposure to low levels of chemical contaminants can lead to serious health issues such as cancer, liver and kidney damage, reproductive and developmental problems, and endocrine disruption.

Vulnerable Populations: Certain groups, such as infants, pregnant women, and individuals with compromised immune systems, are more susceptible to the adverse effects of chemical contaminants.

Notes:

Preventative measures

Preventing chemical cross-contamination in the food industry requires a multi-faceted approach involving good agricultural practices, stringent regulatory controls, and effective Food Safety management systems:

Good Agricultural Practices (GAP): Implementing GAP can minimise the use of harmful chemicals in farming. This includes using integrated pest management (IPM) techniques, selecting less hazardous pesticides, and ensuring proper application methods.

Regulatory controls: Governments and food safety authorities have established regulations to control the levels of chemical contaminants in food. These regulations set maximum residue limits (MRLs) for pesticides and other chemicals and require regular monitoring and testing of food products.

Food Safety management systems: Implementing systems like Hazard Analysis and Critical Control Points (HACCP) can help identify and control potential sources of chemical contamination throughout the food production process.

Proper storage and handling: Ensuring that food is stored under appropriate conditions to prevent mould growth and using clean, food-grade containers and equipment during transportation can reduce the risk of contamination1.

Consumer Awareness: Educating consumers about the risks of chemical contaminants and how to minimize exposure, such as washing fruits and vegetables thoroughly and choosing organic products, can also play a role in reducing the impact of chemical cross-contamination

Micro-biological contamination

Microbiological survival refers to the ability of microorganisms to endure and thrive in various environments, including extreme conditions.

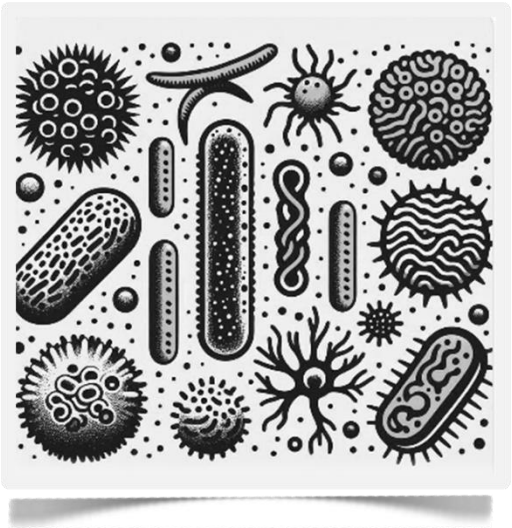
Endospores: Some bacteria, like Bacillus anthracis, can form endospores, which are highly resistant to heat, UV radiation, and disinfectants. This allows them to survive in harsh conditions for extended periods.

Extremophiles: These are microorganisms that can live in extreme environments, such as high radiation or extreme temperatures.

Adaptation mechanisms: Micro-organisms can adapt to various stress factors, such as dehydration, radiation, and chemical exposure.

Environmental factors: The growth and survival of microbes depend on factors like pH, temperature, water activity, and nutrient availability. These intrinsic factors determine how well microorganisms can thrive in a given environment.

Micro-organisms commonly found in food include viruses, bacteria, moulds (fungi) and yeasts.



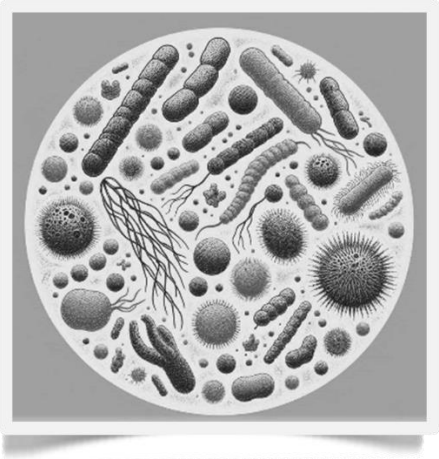
Bacteria

Bacteria are unicellular, prokaryotic organisms that play crucial roles in various ecosystems. They can be found in almost every environment on Earth, from soil and water to extreme environments like hot springs and deep-sea vents. Bacteria are classified based on various characteristics, one of the most important being their oxygen requirements. This classification divides bacteria into two main groups: aerobic and anaerobic.

Bacteria are simple single-celled forms of life which are:

- Microscopic
- Found everywhere
- Mostly harmless
- Some are essential
- Used in food manufacture, for example, yoghurt and cheese.
- Some cause food spoilage
- A few are pathogenic
- Poor hygiene may lead to large numbers in food

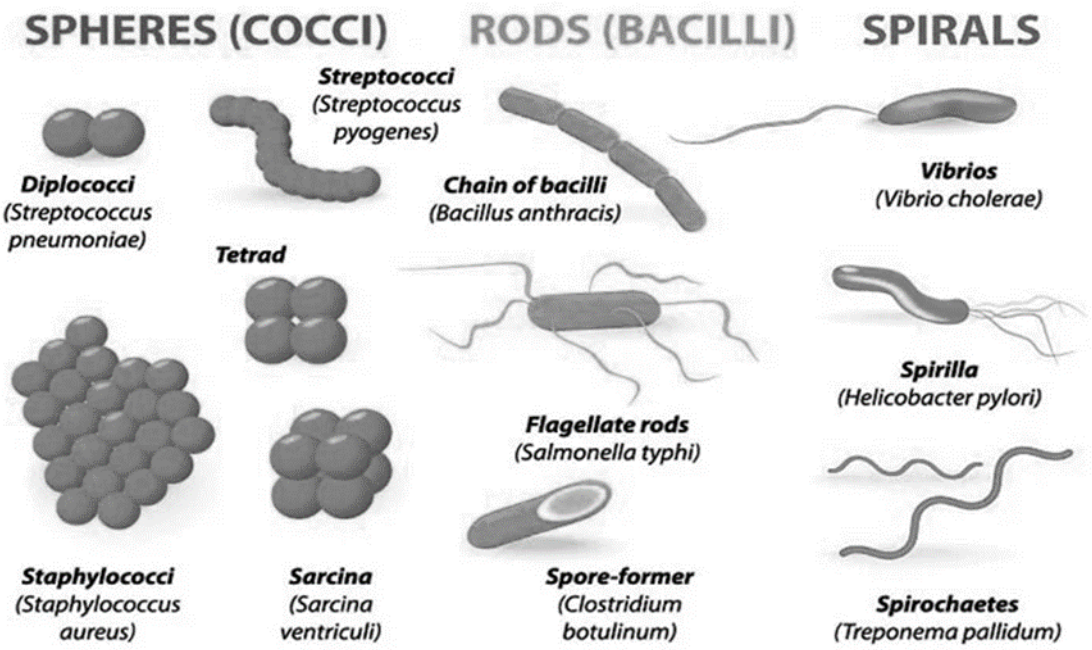
When grown on a suitable nutrient medium bacteria will thrive and form visible populations known as colonies.



Notes:

Classification of bacteria

When observed microscopically it becomes apparent that bacteria vary in size, shape and general appearance as shown in the following diagram.



Typical sizes of bacteria are:

Salmonella: 3 micrometres
Staphylococcus: 0.75 micrometres
(1 micrometre = 1/1000mm)

When observed under extreme magnification (for example, x50,000) the fine details of a bacteria cell can be seen.

Note:

Spore forming: Bacillus, Clostridium

Grain stains: '+' = Blue; '-' = Red

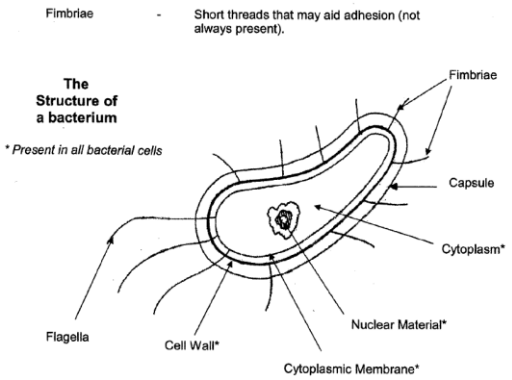
Typical bacteria cell structure

In all bacteria:

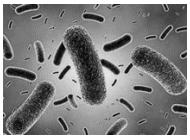
Cell Wall	Gives the cell strength and structure Provides physical protection Determines the shape of the bacterium
Cell Membrane	Semi-permeable Controls the passage of materials in and out of the living cell, for example, food and waste products
Cytoplasm	The contents of the cell where all life activities occur
Nuclear Body (Nucleus, DNA[1])	The genetic material of the cell which determines the cell's characteristics

In some bacteria:

Capsule	Gel-like secretion that gives the cell added protection
Flagellum	A thread-like structure which protrudes from the cell, used for movement
Fimbriae	Short threads that may aid adhesion

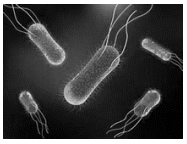


[1] **DNA**. Deoxyribonucleic acid.



Bacilli

Bacilli are typically rod-shaped and can form chains. They are known for their ability to produce endospores, which are highly resistant to extreme conditions such as heat, radiation, and disinfectants. While they are generally Gram-positive, some Bacillus species can appear Gram-negative as they age. Bacilli can be either obligate aerobes, requiring oxygen for growth, or facultative anaerobes, capable of surviving without oxygen. While most Bacillus species are not harmful to humans, some, like Bacillus anthracis (which causes anthrax) and Bacillus cereus (which can cause food poisoning), are pathogenic.



Campylobacter, Enterohaemorrhagic Escherichia coli and Salmonella

These are among the most common foodborne pathogens that affect millions of people annually – sometimes with severe and fatal outcomes. Symptoms are fever, headache, nausea, vomiting, abdominal pain and diarrhoea. Examples of foods involved in outbreaks of salmonellosis are eggs, poultry and other products of animal origin. Foodborne cases with Campylobacter are mainly caused by raw milk, raw or undercooked poultry and drinking water. Enterohaemorrhagic Escherichia coli is associated with unpasteurised milk, undercooked meat and fresh fruits and vegetables.

Cocci

Cocci are typically round or oval-shaped. They can exist as single cells (monococci), in pairs (diplococci), in chains (streptococci), in clusters (staphylococci), in groups of four (tetrads), or in cubical arrangements of eight (sarcinae). Gram-positive cocci, such as **Staphylococcus** aureus and Streptococcus pyogenes, have thick peptidoglycan layers in their cell walls and retain the violet stain during Gram staining. Gram-negative cocci, like **Neisseria** gonorrhoeae, have thinner peptidoglycan layers and do not retain the violet stain. Many cocci are pathogenic and can cause a variety of diseases. For example, **Streptococcus** pneumoniae can cause pneumonia, while Staphylococcus aureus can lead to skin infections and food poisoning.

Cytoplasm

A gel-like substance within the cell membrane that contains all the cell's organelles[2], excluding the nucleus. It is composed mainly of water, salts, and proteins. The cytoplasm plays several crucial roles in the cell: **Support and shape**: It helps maintain the cell's shape and consistency. **Medium for chemical reactions**: Many metabolic reactions occur in the cytoplasm. **Transport**: It facilitates the movement of materials around the cell. **Storage**: It stores nutrients and other essential substances.

[2] **Organelles**. Specialised structures within cells that perform specific functions.

Endotoxins

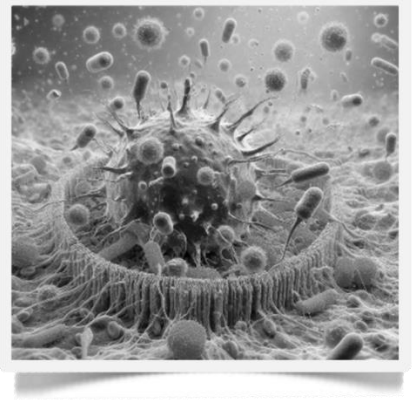
Endotoxins are toxic substances associated with the outer membrane of Gram-negative bacteria. Endotoxins are released when the bacterial cell wall disintegrates or during bacterial cell division. Unlike exotoxins, which are actively secreted by bacteria, endotoxins are part of the bacterial cell wall and are released upon cell death. Endotoxins can trigger a strong immune response in humans and animals. They are potent activators of the immune system and can cause fever, inflammation, and septic shock in severe cases.

Enterotoxins

Enterotoxins are a type of exotoxin produced by certain bacteria that specifically target the intestines. They are typically heat-labile, meaning they lose their toxicity when exposed to high temperatures. Ingestion of enterotoxins can cause symptoms such as nausea, vomiting, abdominal cramps, and diarrhoea. Enterotoxins are produced by several bacteria, including **Staphylococcus aureus**, **Escherichia coli**, and **Bacillus cereus**. Enterotoxins are a major cause of foodborne illnesses. They are particularly concerning in settings where food safety is compromised, such as in cases of improper food handling or storage.

Exotoxins

Exotoxins are **potent toxins secreted by certain bacteria**. Exotoxins are typically proteins, making them heat-labile and capable of being denatured by heat. They often consist of two parts: the A (active) part, which disrupts cellular function, and the B (binding) part, which helps the toxin attach to the host cell. Exotoxins can cause damage by destroying host cells or disrupting normal cellular metabolism. **Cytotoxins** damage host cells directly. **Neurotoxins** affect nerve function, such as botulinum toxin produced by Clostridium botulinum. **Enterotoxins** affect the cells lining the gastrointestinal tract, causing symptoms like diarrhoea. They are responsible for diseases such as diphtheria (caused by Corynebacterium diphtheriae), tetanus (caused by Clostridium tetani), and botulism (caused by Clostridium botulinum). The immune system can produce antibodies against exotoxins, but due to their potency, exotoxins can cause significant damage before the immune response is fully activated.



Notes:

Facultative

These are organisms, typically bacteria, that **can grow in the presence or absence of oxygen**. They prefer to use oxygen for aerobic respiration because it generates more energy, but they can switch to anaerobic respiration or fermentation when oxygen is not available. Examples include Escherichia coli and Staphylococcus aureus.

Flagella

Flagella are long, whip-like structures that protrude from the cell body of certain microorganisms, providing them with motility[3]. Understanding flagella is crucial for studying microbial motility and behaviour.

Listeria

A genus of bacteria that can cause a serious infection known as **listeriosis**. The most common species responsible for this infection is **Listeria monocytogenes**. Although disease occurrence is relatively low, listeria's severe and sometimes fatal health consequences, particularly among infants, children and the elderly, count them among the most serious foodborne infections. Listeria is found in unpasteurised dairy products and various ready-to-eat foods and can grow at refrigeration temperatures.

Mesophilic

An organism that thrives in moderate temperatures, typically between 20°c and 45°c. The optimal growth temperature for mesophiles is around 37°C (99°F), which is close to the human body temperature. Mesophiles are commonly found in environments like soil, water, and the human body. They play significant roles in various processes, including the fermentation of foods like cheese and yogurt, and are also involved in brewing and winemaking. Many human pathogens, such as **Escherichia coli** and **Staphylococcus aureus**, are mesophiles.

Pathogen

Any organism or agent that can **cause disease in a host**. Pathogens can be classified into several types, including bacteria, fungi, parasites, prions[4] and viruses.

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[3]**Motility**. The ability of an organism to move independently using metabolic energy.

[4] **Prions**. Infectious proteins that can cause neurodegenerative diseases- Conditions that involve the progressive degeneration and death of nerve cells in the brain and spinal cord.

Psychrophilic

Microorganisms that thrive in **extremely cold environments**, typically with optimal growth temperatures around 15°c. They can grow at temperatures as low as -20°C and up to 20°c.

Spirochaetes

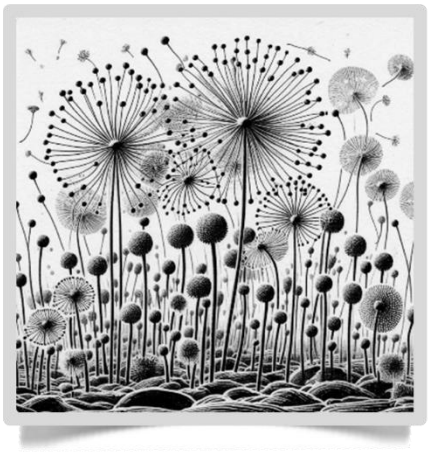
A group of bacteria characterised by their **spiral-shaped**, helical cells. Spirochaetes move using endoflagella; this structure allows them to move in a twisting motion.

Spores

Reproductive cells capable of developing into a new individual without the need for fusion with another cell.

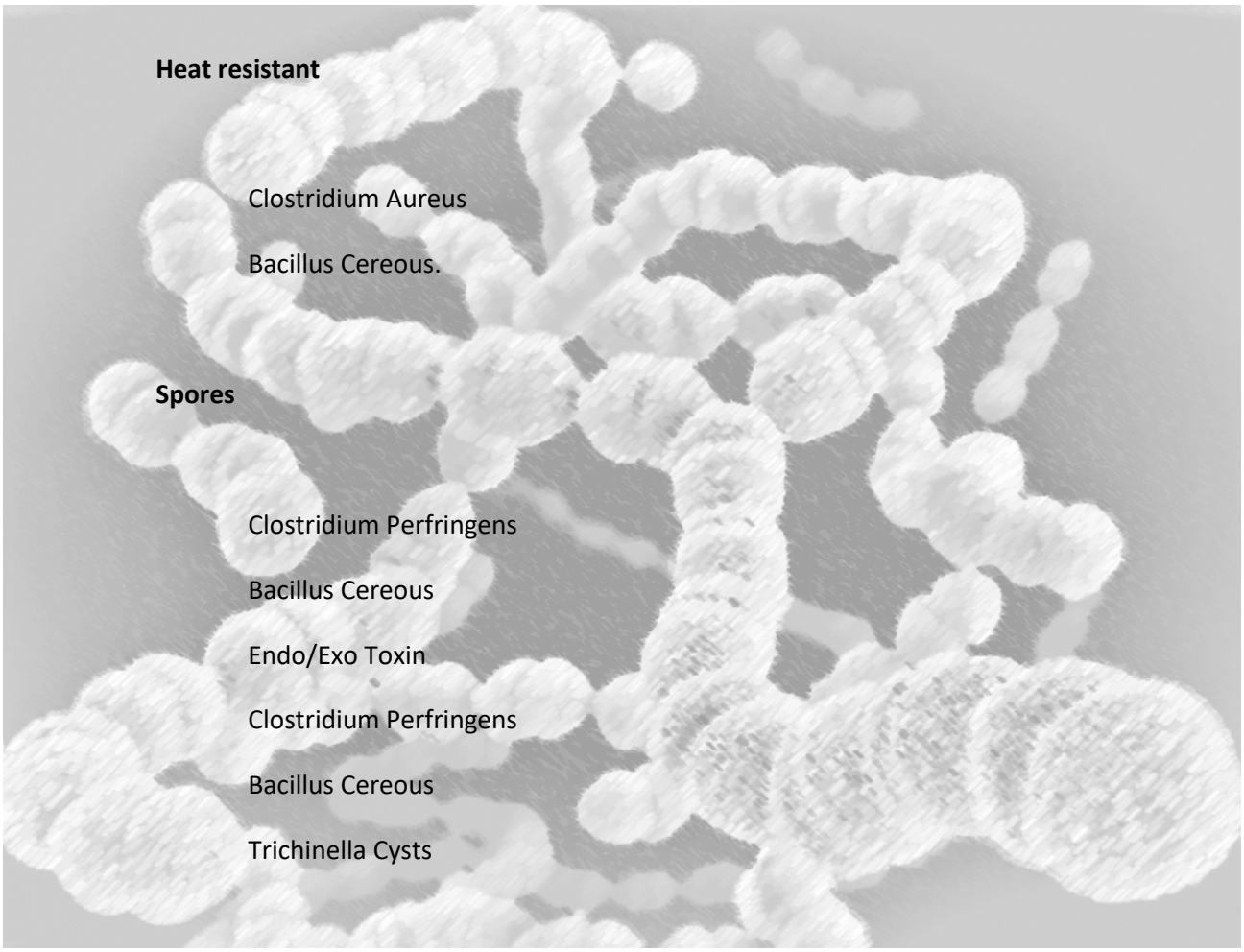
Thermophilic

Thermophilic organisms, or thermophiles, **thrive at relatively high temperatures**, typically between 41°c and 122°c.



Notes:

Pathogens



(See sections ‘Food-borne illnesses’ and ‘Food-borne diseases’)

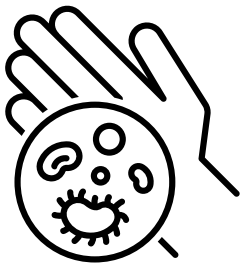
Toxins

Of most concern for health is naturally occurring toxins and environmental pollutants.

Naturally occurring toxins include Mycotoxins, marine biotoxins, cyanogenic glycosides and toxins occurring in poisonous mushrooms. Staple foods like corn or cereals can contain high levels of Mycotoxins, such as Aflatoxin and Ochratoxin, produced by mould on grain. A long-term exposure can affect the immune system and normal development, or cause cancer.

Persistent Organic Pollutants (POPs) are compounds that accumulate in the environment and human body. Known examples are dioxins and polychlorinated biphenyls (PCBs), which are unwanted by-products of industrial processes and waste incineration. They are found worldwide in the environment and accumulate in animal food webs. Dioxins are highly toxic and can cause reproductive and developmental problems, damage the immune system, interfere with hormones and cause cancer.

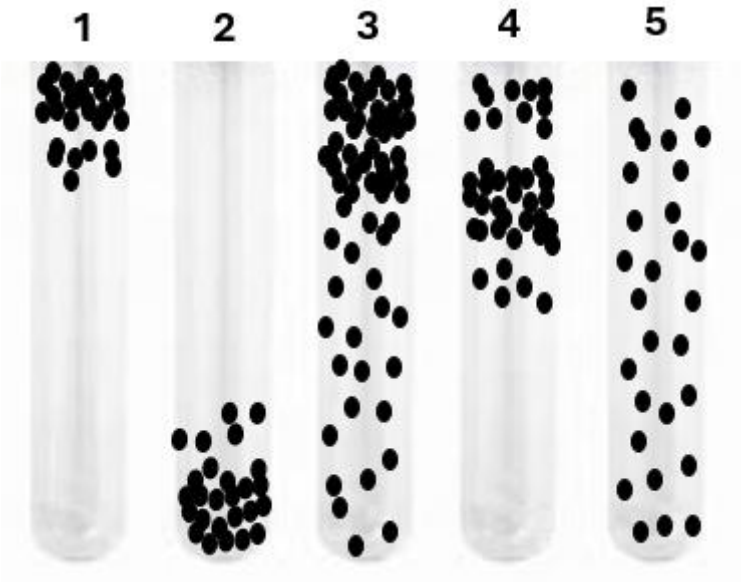
Heavy metals such as lead, cadmium and mercury cause neurological and kidney damage. Contamination by heavy metal in food occurs mainly through pollution of air, water and soil.



Antimicrobials

Antimicrobials, such as antibiotics, are essential to treat infections caused by bacteria. However, their overuse and misuse in veterinary and human medicine has been linked to the emergence and spread of resistant bacteria, rendering the treatment of infectious diseases ineffective in animals and humans. Resistant bacteria enter the food web through the animals (e.g. *Salmonella* through chickens). Antimicrobial resistance is one of the main threats to modern medicine.

Oxygen and bacteria growth



To show the relationship between oxygen and bacteria growth, **Aerobic and Anaerobic bacteria** can be identified by growing them in test tubes of Thioglycolate broth:

1. **Obligate Aerobes** need oxygen because they cannot ferment or respire anaerobically. They gather at the top of the tube where the oxygen concentration is highest.

2. **Obligate Anaerobes** are poisoned by oxygen, so they gather at the bottom of the tube where the oxygen concentration is lowest.

3. **Facultative Anaerobes** can grow with or without oxygen because they can metabolise energy aerobically or anaerobically. They gather mostly at the top because aerobic respiration generates more ATP than either fermentation or anaerobic respiration.

4. **Micro-aerobes** need oxygen because they cannot ferment or respire aerobically. However, they are poisoned by high levels of oxygen. They gather in the upper part of the tube but not the very top.

Aerotolerant Organisms do not require oxygen as they metabolise energy anaerobically. Unlike obligate anaerobes however, they are not poisoned by oxygen. They can be found evenly spread throughout the test tube.

Aerobic Bacteria

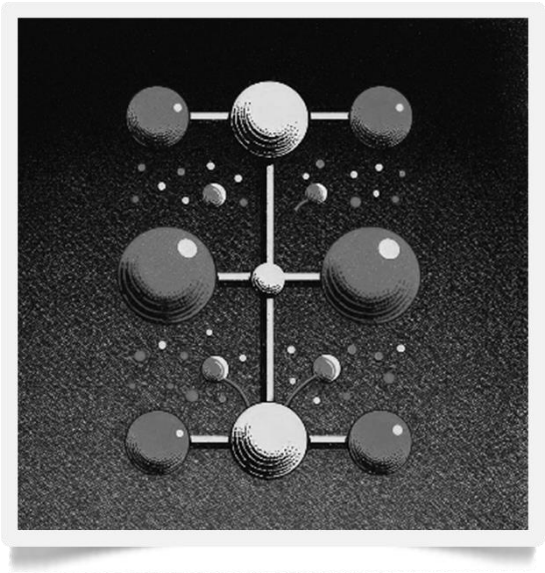
Aerobic bacteria are those that require oxygen for their survival and growth. They use oxygen in their metabolic processes to produce energy. Here are some key points about aerobic bacteria:

Oxygen Requirement: Aerobic bacteria need oxygen to survive. They use oxygen as the final electron acceptor in their respiratory chain, a process known as aerobic respiration.

Energy Production: These bacteria produce energy through the process of cellular respiration, which involves the oxidation of organic compounds. The general equation for aerobic respiration is: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + Energy (ATP). In words: Glucose ($C_6H_{12}O_6$) combines with oxygen (O_2) to produce carbon dioxide (CO_2), water (H_2O), and energy in the form of ATP. This is the process by which cells break down glucose in the presence of oxygen to release energy for cellular activities.

Enzymes: Aerobic bacteria produce enzymes such as catalase, peroxidase, and superoxide dismutase, which help them detoxify harmful byproducts of oxygen metabolism.

Examples: Some common examples of aerobic bacteria include Mycobacterium tuberculosis (causes tuberculosis), Pseudomonas aeruginosa (found in soil and water), and Nocardia.



Anaerobic bacteria

Types of anaerobic bacteria:

Obligate Anaerobes: These bacteria **cannot survive in the presence of oxygen**. Examples include Clostridium tetani (causes tetanus) and Bacteroides fragilis (found in the human gut).

Facultative Anaerobes: These bacteria **can grow with or without oxygen**, but generally prefer oxygenated environments. Examples include Escherichia coli (commonly found in the intestines) and Staphylococcus aureus.

Aerotolerant Anaerobes: These bacteria **do not use oxygen but can tolerate its presence**. An example is Lactobacillus.

Notes:

Importance of Aerobic and Anaerobic bacteria

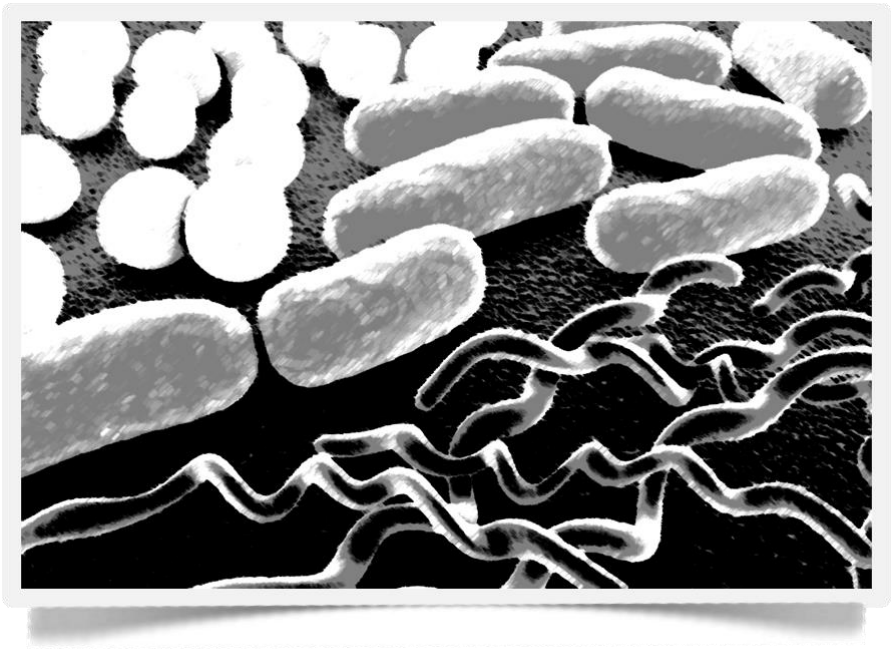
Both types of bacteria play essential roles in various ecosystems and human health:

Decomposition: Aerobic bacteria are crucial in decomposing organic matter, recycling nutrients back into the ecosystem.

Nitrogen Fixation: Some aerobic bacteria, like Azotobacter, fix atmospheric nitrogen into a form usable by plants.

Human Health: Anaerobic bacteria in the human gut help in digestion and maintaining gut health. However, some anaerobic bacteria can cause diseases like tetanus and botulism.

Industrial Applications: Both types of bacteria are used in industrial processes. Aerobic bacteria are used in wastewater treatment, while anaerobic bacteria are used in biogas production and fermentation processes.



Bacterial Growth

Given a suitable environment and conditions bacteria have an incredible capacity to increase in numbers vastly over a short period of time.

Nutrients, pH, Moisture, Temperature

Various factors affect the growth of bacteria:

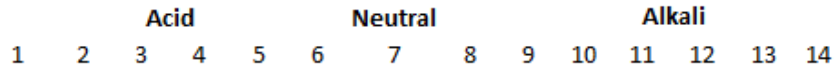
Nutrients (food)

Bacteria require nutrients as a source of energy and to make new cells. These include carbohydrates, protein, vitamins and minerals.

Foods such as milk, cream and meat provide an ideal growth media for bacterial growth.

pH

The pH of a substance refers to its acidity or alkalinity on a scale of 1-14:



pH Scale

Acidic foods have a pH below 7, and alkaline foods a pH of above 7. Water has a neutral pH of 7. Most bacteria prefer a pH of about 7.0 (neutral). Few bacteria grow below pH 4.5. Moulds and yeast are less sensitive to pH then bacteria.

Moisture

Bacteria require moisture to stay alive.

Most foods, even if not appearing to be *wet*, do contain sufficient moisture to enable bacteria to thrive; for example, cooked meat. Thus dry foods; for example, floor, do not provide a good medium for bacterial growth, although bacteria may be present as spores, which will germinate to form bacteria when later encountering moisture.

The degree of moisture available to bacteria in food is usually referred to a *water activity* (Aw). The Aw of pure water is 1.0. This figure decreases to about 0.98 in cooked food. Bacteria usually need an Aw of 0.95 or above to grow.

Temperature

Bacteria have a range of growth temperatures and an optimum growth temperature. For example, particular bacteria may have a growth range of 20°c to 40°c (the temperature range within which it will grow), with an optimum growth temperature of 37°c (the temperature at which maximum growth occurs.

Bacterial Groups

Bacteria are usually placed into one of four groups depending on their properties in relation to temperature. These are:

Psychrophiles Bactria with an o.g.t in the range of -20°c to 10°c. Includes many spoilage bacteria.

Mesophiles Bactria with an o.g.t in the range of 20°c and 45°c. Includes most pathogens.

Thermophiles Bacteria with an o.g.t greater than 45°c. Includes bacteria which cause problems in the canning industry.

Psychrotrophs These bacteria are capable of surviving or even thriving in a cold environment. They are responsible for spoiling refrigerated foods. Psychrotrophic bacteria are of particular concern to the dairy industry. Most are killed by pasteurisation; however, they can be present in milk as post-pasteurisation contaminants due to less than adequate sanitation practices. Psychrotrophs are capable of growth at temperatures at or less than 7°c. At freezing temperatures, growth of psychrotrophic bacteria becomes negligible or virtually stops

Oxygen Requirements

Most bacteria need oxygen to grow, but some can multiply in low levels of oxygen, or do not need oxygen at all.

Obligate Aerobes Organisms that must have oxygen present, for example, Bacillus Cereus.

Obligate Anaerobes Organisms that grow without oxygen, for example, Clostridium Perfringens and Clostridium Botulinum.

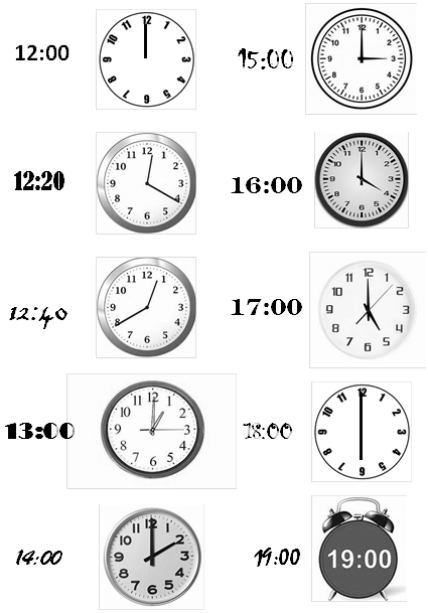
Facultative Anaerobes Organisms that can survive with or without oxygen; for example, Salmonella and Staphylococcus.

Binary Fission

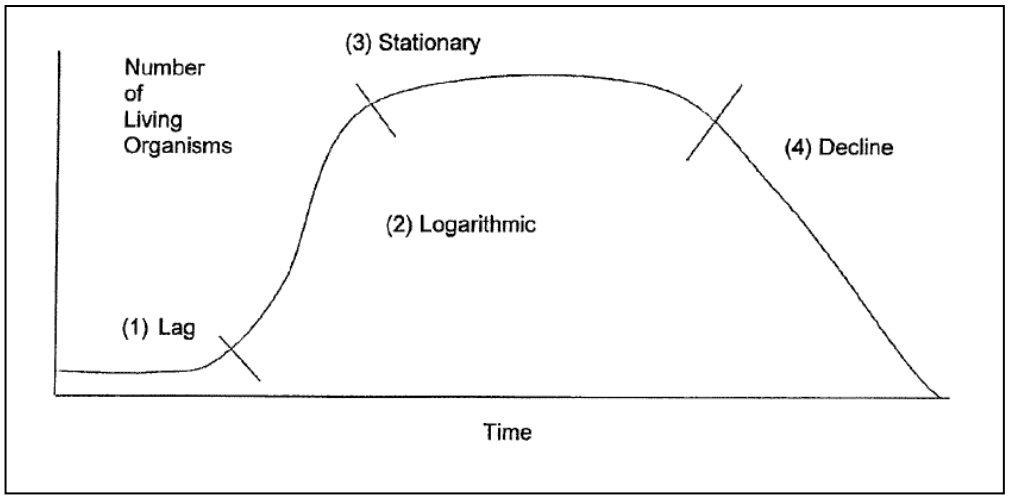
Bacteria multiply by an asexual process known as Binary Fission, **a process where bacteria will grow to maturity then divide in two**, **and in turn, each of these two mature and go through the same process**, with the process being repeated over and over.

The period between each division is known as **the generation time**. Given ideal conditions this may be as frequent as **every 20 minutes**. Clostridium Perfringens can reproduce every 10 minutes at 46°c.

Competition is used to describe the presence of other bacteria competing for the right conditions, for example, in food. A single bacterium at 12:00 hours could result in over 2 million[5] by 19:00 hours.



Phases of growth of micro-organisms



[5] **Bacteria**. 2,097,152.

Spore Formation

Certain bacteria, (for example, Clostridia (anaerobic) and Bacillus (aerobic) species), have the ability to form spores as an aid to survival.

Spores can be seen as growths within the normal bacteria cell (or vegetative cell) and are highly durable structures that are resistant to heat, starvation and disinfectants etc. They are often referred to as endospores.

If a normal spore-bearing bacteria enters unfavourable conditions; for example, extreme heat, it may form a spore. The original bacteria may die but the spore will survive and will germinate to form another bacteria on encountering favourable environmental conditions. Spores in food are not destroyed by cooking. Therefore, food saved for later use must be cooled quickly and refrigerated to prevent the germination of any spores present.

Notes:

Destruction of Bacteria

With an understanding of the nature of bacteria, measures can be taken to control or limit the growth of bacteria in food; for example, freezing or dehydration. Some measures will actually destroy the bacteria present; for example, extremes heat or chemicals. It is important to stress, however, that such measures should not be used as a substitute for good hygiene, but as reinforcement.

Heat	Temperatures above 63°c kill bacteria. However, it is essential that sufficient time is allowed for the food to reach the required temperature, and sufficient time is allowed to enable the heat to kill the bacteria. It is important to note that although vegetative bacteria may be destroyed, spores (for example, from Clostridium and Bacillus species) can resist high temperatures. These may survive and subsequently develop into vegetative cells when lower, more suitable temperatures are achieved. To ensure the destruction of all organisms, spores and toxins (i.e. to ensure sterilisation) extreme temperatures have to be used. In practice, this has to be achieved by using steam under pressure to achieve a temperature of 121°c. Even at this temperature and pressure 15 minutes is required to ensure sterilisation.
Chemicals	Chemicals of a wide variety are used in food preparation in different ways in order to control or destroy unwanted organisms. In this way, the safety and quality of food can be maintained. For example, salt, sugar and additives such as nitrites, nitrates and sulphur dioxide. Chemicals used on premises or equipment are usually described as disinfectants or sanitisers: **Disinfection**. The removal or destruction of micro-organisms to a safe level (i.e. all pathogens destroyed). **Sterilisation**. The removal or destruction of *all* living matter, including viruses and spores. It is not possible to achieve sterilisation of food premises.
Irradiation	Ultraviolet (UV) Light. Commonly used as a sterilising agent. **Gamma irradiation**. Irradiation of food with small doses of gamma rays will kill bacteria; in particular, Salmonella in foods such as boneless meat, animal feeds and dried and frozen egg products.

Toxins

Mycotoxins

These are the toxic product of moulds: mycotoxicosis. For example, Aflatoxin produced by moulds: Aspergillus flavus and Aspergillus parasiticus found on groundnuts, rice, cotton seeds and animal feeds.

Affected feed can lead to affected milk from cows.

Symptoms include jaundice, anorexia, depression, diarrhoea and liver damage. Mycotoxins are controlled by keeping stored products clean and dry.

Toxin Formation

During growth and multiplication, bacteria, like other cells, produce waste products which are secreted from the cell. These waste products may then result in food poisoning. The poisonous waste products are called *toxins*.

Entero and Neuro Toxins

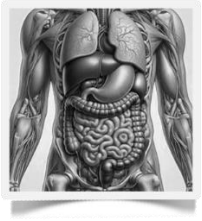
The term **enterotoxin** is a general term used to describe bacterial toxins causing illness related to the **digestive system**.

The term **neurotoxin** describes toxins affecting the **nervous system**.

Exo and Endo Toxins

Exotoxins are **formed by bacteria while multiplying** and passed out into the food; the toxin is thus eaten with the food. Any cooking may kill the bacteria, but the exotoxin may not be destroyed by the cooking process. The presence of bacteria producing exotoxins in food results in a rapid onset of food poisoning as toxins are in the food on ingestion; for example, staphylococcus aureus, which has an incubation period of 2-6 hours, and induced vomiting as a reaction to rid the body of the toxin.

Endotoxins are toxins produced in the bacterial cell which are only **released by the death of the cell or spore formation**. This usually occurs within the body; the bacteria being eaten on contaminated food. As digestion occurs, the bacteria cells are either broken down or spores are produced. In either case the endotoxins are released, causing gastroenteritis. The presence of bacteria producing endotoxins results in a slower onset of food poisoning as the bacterial cells need to be digested before the endotoxins are released; for example, clostridium Perfringens, which has an incubation period of 8-12 hours, and which main symptom is diarrhoea.



Food industry related bacteria

(See also ‘Food-borne illnesses’ and ‘Food-borne diseases’)

Escherichia coli (E. coli)

Escherichia coli (E. coli) is a type of bacteria commonly found in the intestines of humans and animals. While most strains are harmless, some can cause serious foodborne illnesses. Here are some key points about E. coli:

Symptoms

- Severe abdominal cramps
- Diarrhoea (which can be bloody)
- Nausea and vomiting
- Fever
- Loss of appetite

Causes

- E. coli infections can occur through:
- Consuming contaminated food or water
- Eating undercooked meat or unpasteurised milk
- Person-to-person contact, especially with unwashed hands

Risk Factors

- Young children and the elderly
- Individuals with weakened immune systems
- Those with decreased stomach acid levels

Prevention

Cook meat thoroughly

Avoid raw milk

Wash fruits and vegetables well

Practice good hand hygiene

Staphylococcus aureus (S. aureus)

Staphylococcus aureus (S. aureus), often referred to as 'Staph,' is a type of bacteria commonly found on the skin and in the noses of healthy people. While it usually doesn't cause harm, it can lead to infections if it enters the body through cuts or other openings.

Common Infections

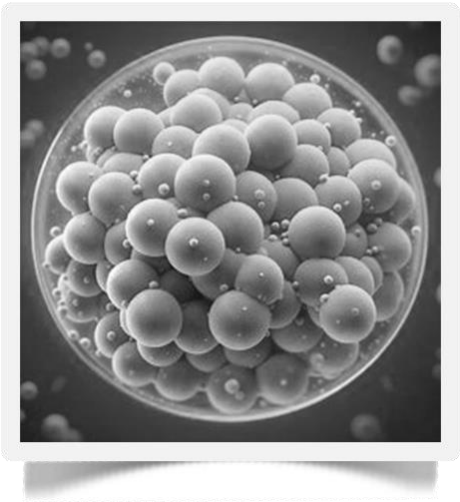
- Skin Infections: Boils, impetigo, cellulitis, and abscesses
- Respiratory Infections: Sinusitis and pneumonia
- Food Poisoning: Caused by toxins produced by the bacteria

Serious Infections

- Bacteraemia: Bloodstream infections
- Endocarditis: Infection of the heart valves
- Osteomyelitis: Bone infections
- Toxic Shock Syndrome: A rare but life-threatening condition

Prevention

- Hand Hygiene: Regular hand washing with soap and water
- Wound Care: Keeping cuts and abrasions clean and covered
- Avoid Sharing Personal Items: Towels, razors, and other personal items



Listeria monocytogenes

Listeria monocytogenes is a type of bacteria that causes the infection known as listeriosis. Here are some key points about it:

Characteristics

- Gram-positive: This means it has a thick cell wall.
- Facultative anaerobe: It can survive with or without oxygen.
- Motility: It can move using flagella at lower temperatures.
- Sources of Infection

Listeria can be found in:

- Soil, water, and vegetation
- Contaminated food, especially unpasteurized dairy products, raw vegetables, and ready-to-eat meats

Symptoms

- Mild Symptoms: Fever, muscle aches, nausea, and diarrhoea.
- Severe Symptoms: Headache, stiff neck, confusion, loss of balance, and convulsions. In severe cases, it can lead to meningitis or septicaemia

High-Risk Groups

- Pregnant women (risk of miscarriage or stillbirth)
- Newborns
- Elderly individuals
- People with weakened immune systems

Prevention

- Food Safety: Avoid unpasteurized dairy products, cook meats thoroughly, and wash fruits and vegetables well
- Hygiene: Practice good hand hygiene, especially after handling raw foods

Salmonella

Salmonella is a group of bacteria that commonly cause foodborne illnesses. Here are some key points about Salmonella:

Symptoms

- Gastroenteritis: Diarrhoea, stomach cramps, nausea, vomiting, and fever.
- Incubation Period: Symptoms typically appear 12-36 hours after exposure

Causes

- Contaminated Food: Often found in raw or undercooked meat, poultry, eggs, and unpasteurized milk
- Contact with Infected Animals: Especially reptiles, birds, and pets

Risk Factors

- Young Children and Elderly: More susceptible to severe illness
- Weakened Immune Systems: Higher risk of complications

Prevention

- Food Safety: Cook meat thoroughly, avoid raw eggs, and practice good kitchen hygiene
- Hand Hygiene: Wash hands after handling raw food or animals

Treatment

- Hydration: Drink plenty of fluids to prevent dehydration

Clostridium botulinum

Clostridium botulinum is a bacterium known for producing botulinum toxin, one of the most potent toxins known. Here are some key points about it:

Characteristics

- Gram-positive: It has a thick cell wall.
- Rod-shaped: The bacteria are elongated.
- Anaerobic: It thrives in environments without oxygen.
- Spore-forming: It can produce spores that survive in harsh conditions

Types of Botulism

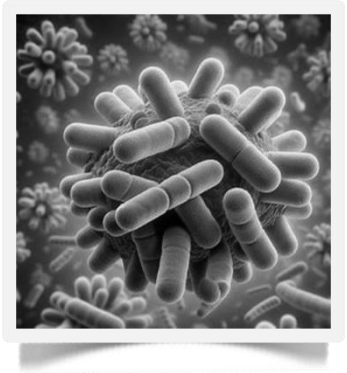
- Foodborne Botulism: Caused by consuming food contaminated with the toxin
- Wound Botulism: Occurs when the bacteria infect a wound
- Infant Botulism: Happens when infants ingest spores that then grow in their intestines

Symptoms

- Early Symptoms: Nausea, vomiting, and abdominal cramps.
- Neurological Symptoms: Double vision, drooping eyelids, difficulty swallowing, and muscle weakness. In severe cases, it can lead to paralysis

Prevention

- Food Safety: Proper canning and cooking of food to destroy spores.
- Wound Care: Keeping wounds clean and properly treated



Clostridium difficile

Clostridium difficile (C. difficile or C. diff) is a bacterium that can cause infections in the bowel, leading to symptoms such as diarrhoea and abdominal pain. Here are some key points about it:

Symptoms

- Mild to Moderate: Watery diarrhoea, mild abdominal cramping, and tenderness
- Severe: Watery diarrhoea 10-15 times a day, severe abdominal pain, fever, nausea, dehydration, and loss of appetite

Causes

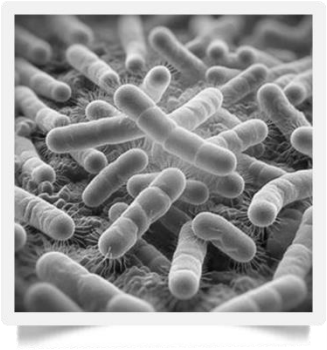
- Antibiotic Use: Long-term use of antibiotics can disrupt the normal bacterial balance in the intestines, allowing C. difficile to overgrow
- Transmission: It can spread through contaminated surfaces, food, and water

Risk Factors

- Hospitalization: Staying in healthcare facilities for extended periods
- Age: People over 65 years old
- Weakened Immune System: Conditions like diabetes, cancer, or treatments like chemotherapy

Prevention

- Hand Hygiene: Wash hands thoroughly, especially after using the bathroom
- Antibiotic Stewardship: Only take antibiotics as prescribed by a healthcare provider
- Cleanliness: Keep surfaces and objects clean, especially in healthcare settings



Clostridium perfringens

Clostridium perfringens is a bacterium known for causing foodborne illnesses and other infections. Here are some key points about it:

Characteristics

- Gram-positive: It has a thick cell wall
- Rod-shaped: The bacteria are elongated
- Anaerobic: It thrives in environments without oxygen
- Spore-forming: It can produce spores that survive in harsh conditions

Types of Infections

- Foodborne Illness: Often results in diarrhoea and abdominal cramps within 6-24 hours after consuming contaminated food
- Gas Gangrene: A severe infection that causes tissue death, often associated with traumatic injuries

Symptoms

- Foodborne Illness: Diarrhoea, abdominal cramps, and nausea
- Gas Gangrene: Severe pain, swelling, and tissue death in the affected area

Prevention

- Food Safety: Cook food thoroughly, especially meat, and refrigerate leftovers promptly
- Wound Care: Keep wounds clean and properly treated to prevent infection

Notes:

Bacillus cereus

Bacillus cereus is a type of bacteria that can cause foodborne illnesses. Here are some key points about it:

Characteristics

- Gram-positive: It has a thick cell wall
- Rod-shaped: The bacteria are elongated
- Facultative Anaerobe: It can survive with or without oxygen
- Spore-forming: It can produce spores that survive in harsh conditions

Types of Infections

- Foodborne Illness: There are two forms:
- Diarrheal Syndrome: Caused by enterotoxins produced in the intestines after consuming contaminated food
- Emetic Syndrome: Caused by toxins formed in food before consumption, often associated with rice
- Non-intestinal Infections: Can affect the eyes, respiratory system, and wounds

Symptoms

- Diarrheal Syndrome: Diarrhoea, abdominal cramps, and nausea, typically appearing 6-15 hours after eating contaminated food
- Emetic Syndrome: Nausea and vomiting, usually within 1-6 hours after eating

Prevention

- Food Safety: Cook food thoroughly, especially rice and other starchy foods, and refrigerate leftovers promptly
- Hygiene: Practice good hand hygiene and keep kitchen surfaces clean

Prevention of food contamination: Raw Foods

Raw food is often contaminated. However, while raw foods should always be considered a potential hazard, hygienic production methods can reduce that contamination.

Meats

- Overcrowded, dirty sheds encourage the spread of infection
- Infected animals should be kept separated from healthy animals
- Short transportation reduces the risk of salmonella (through excreta)
- Laying hens should be vaccinated against salmonella
- Gutting should take place as soon as possible to prevent migration of bacteria from gut to flesh
- Cross-contamination of external packaging of raw meats can occur (3% found to be contaminated)

Fish and Shellfish

- Rapid gutting is essential
- Very cold storage required, for example, on ice. (3°c is necessary to prevent Scombrotoxin)
- Use only reputable suppliers
- Good source, i.e. location

Eggs

- Properties of albumen usually limit growth of salmonella for 21 days at temperatures up to 20°c
- Imported eggs are twice as likely to contain salmonella
- Cracked eggs should be avoided
- 'At risk' groups (those pregnant, young, elderly or infirm) should avoid raw egg
- Pasteurised egg may be an option for 'At risk' groups

Milk Contamination of milk could come from:

- Animals
- Humans
- Unclean pipework
- Unclean tanks

Milk from animals with mastitis should not be used (due to potential harm from Staphylococcus Aureus). Herds should be tested for Brucellosis and Tuberculosis.

Moulds (Fungi)

Moulds cause most food spoilage. They are often thread-like in appearance, forming a network of fine strands that are barely visible. The strands secrete enzymes that breakdown plant or animal matter and absorb the digested food. The fruiting body of moulds are often easily seen, for example, toadstools and mushrooms. Some moulds are pathogenic to man, for example, ringworm.

Moulds require moisture, and usually water. They can and do grow at low temperatures. Moulds usually grow on the outside of food and do not usually make the food harmful; so in most cases it is acceptable to trim mould off.

Black Moulds

- Black moulds are found on meats and may cause taints if extensive. Black moulds may also penetrate the surface. The main reason black mould grows on surfaces is condensation and humidity. Generally, black mould spores are always in the air. They land on condensation that forms on surfaces and start growing. Humid air has a lot of moisture and warmer air holds more moisture in it. When the warm air cools down by touching cold surfaces like walls and ceilings, it forms condemnation and eventually black moulds.

White Moulds

- These are found on the surface of foods only. White mould look like whiskers and do not harm food unless extensive

Blue Moulds

- Blue moulds are often present in food that is also putrefying

Yeasts

These are single celled fungi. They are used in bread-making and brewing.

Viruses

Extremely small, most viruses can only be seen with an electronic microscope. They are 10 to 100 times smaller than bacteria. They can only reproduce in a living host cell. Their presence in the host cell causes the host to be ill.

Viruses are common contaminants of shellfish; for example, 'Small Round Structured Viruses (SRSVs) such as the Norwalk virus.

Norovirus infections are characterised by nausea, explosive vomiting, watery diarrhoea and abdominal pain. Hepatitis A virus can cause long-lasting liver disease and spreads typically through raw or undercooked seafood or contaminated raw produce. Infected food handlers are often the source of food contamination.

Norovirus is a highly contagious virus that causes gastroenteritis, which is an inflammation of the stomach and intestines. Here are some key points about it:

Symptoms

- Gastrointestinal: Sudden onset of nausea, vomiting, diarrhoea, and stomach cramps
- Other Symptoms: Fever, headache, and body aches

Transmission

- Person-to-Person: Through direct contact with an infected person
- Contaminated Surfaces: Touching surfaces or objects contaminated with the virus
- Food and Water: Consuming contaminated food or water

Prevention

- Hand Hygiene: Wash hands thoroughly with soap and water, especially after using the bathroom and before eating
- Disinfection: Clean and disinfect surfaces, especially in areas where food is prepared
- Isolation: Stay home if you are infected to avoid spreading the virus

Viruses cannot multiply on food but can survive for some time and are normally destroyed by cooking. Rotaviruses and Parvoviruses commonly cause gastro-enteritis. The infective dose is thought to be small, and the common source is infected food handlers and shellfish. Therefore, the use of reputable suppliers is advised. The incubation period is 24-48 hours, and the duration is usually 24 hours. Symptoms are the usual food poisoning symptoms. The virus is spread by the faecal/oral route, food-borne or respiratory route (rotaviruses). Norwalk virus has causes very debilitating symptoms and often large outbreaks. The life of the Norwalk virus is prolonged in cold, wet conditions, is difficult to detect and often traced to shellfish.

Prions

Prions, infectious agents composed of protein, are unique in that they are associated with specific forms of neurodegenerative disease. Bovine spongiform encephalopathy (BSE, or 'mad cow disease') is a prion disease in cattle, associated with the variant Creutzfeldt-Jakob Disease (vCJD) in humans. Consuming bovine products containing specified risk material, e.g. brain tissue, is the most likely route of transmission of the prion agent to humans.

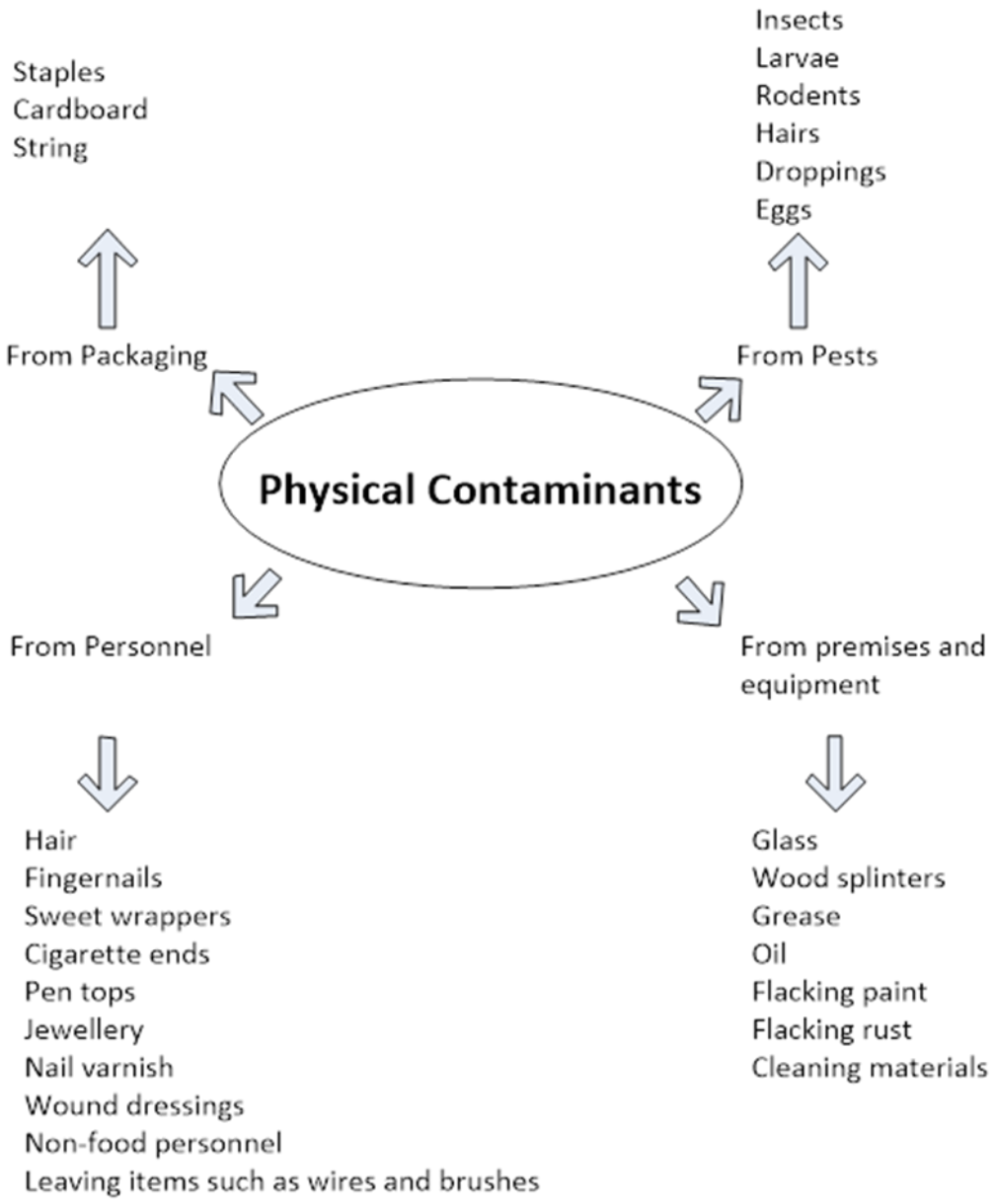
Parasites

Some parasites, such as fish-borne trematodes, are only transmitted through food. Others, for example tapeworms like Echinococcus, or Taenia Solium, may infect people through food or direct contact with animals. Other parasites, such as Ascaris, Cryptosporidium, Entamoeba histolytica or Giardia, enter the food web via water or soil and can contaminate fresh produce.

Notes:

Physical contamination

Physical contamination occurs when foreign objects are introduced into food products. These contaminants can cause injury or illness if ingested.



Sources of physical contamination

Human Sources:

- Hair: Hair can fall into food during preparation or packaging
- Jewellery: Rings, earrings, and other jewellery can break and fall into food
- Fingernails: Broken fingernails can end up in food

Environmental Sources:

- Building Materials: Flakes of paint, plaster, or ceiling tiles can contaminate food
- Pests: Insects, rodents, and their droppings can contaminate food

Equipment and Utensils:

- Metal Shavings: From worn-out equipment or machinery
- Plastic Pieces: From broken containers or utensils
- Glass Fragments: From broken light bulbs or containers

Packaging Materials:

- Plastic: Pieces from packaging materials
- Paper: Fragments from labels or packaging

Prevention of physical contaminants

Good Manufacturing Practices (GMP): Implementing GMP can help minimise physical contamination. This includes regular maintenance of equipment, proper storage of materials, and ensuring a clean working environment.

From premises and equipment

- Adequate maintenance and repair schedule
- Avoidance of temporary repairs
- Use of food-grade oil
- Use of self-locking nuts
- Avoidance of unsuitable materials such as metals and wood
- Satisfactory state of décor
- Good lighting

Personal Hygiene: Workers should follow strict personal hygiene practices, including wearing hairnets, gloves, and clean uniforms.

From personnel

- Adequate staff training; including non-food handlers
- Prohibition of jewellery, sweets and cigarettes
- Use of PPE

Pest Control: Regular pest control measures should be in place to prevent contamination from insects and rodents.

Inspection and Monitoring: Regular inspection of raw materials, equipment, and finished products can help identify and remove physical contaminants.

From raw materials

- Use of reputable suppliers
- Care taken when unpacking
- Liquids filtered
- Powders sieved
- Inspection belts, spotters, metal detectors and scanners

Sources of Environmental Pollution

Environmental pollution can significantly impact food safety and quality. The main sources of environmental pollution include:

Air pollution: Industrial Emissions: Factories release pollutants like sulphur dioxide, nitrogen oxides, and particulate matter into the air.

Vehicle emissions: Cars and trucks emit pollutants such as carbon monoxide, hydrocarbons, and nitrogen oxides.

Water pollution: Agricultural Runoff: Pesticides, fertilizers, and animal waste can contaminate water bodies.

Industrial discharges: Factories may release chemicals and heavy metals into rivers and lakes.

Sewage and wastewater: Untreated or inadequately treated sewage can pollute water sources.

Soil pollution: Pesticides and Herbicides: Chemicals used in agriculture can persist in the soil and contaminate crops.

Industrial waste: Improper disposal of industrial waste can lead to soil contamination with heavy metals and toxic chemicals.

Noise Pollution: Industrial Activities: Factories and construction sites generate noise pollution.

Transportation: Traffic noise from vehicles, trains, and airplanes contributes to noise pollution.

Notes:

Chemical Contaminants: Pollutants from air, water, and soil can introduce harmful chemicals into the food web. These include heavy metals, pesticides, and industrial chemicals.

Microbial Contaminants: Polluted water and soil can harbour harmful microorganisms that contaminate food.

Physical Contaminants: Environmental pollution can also introduce physical contaminants like dust and debris into food products.

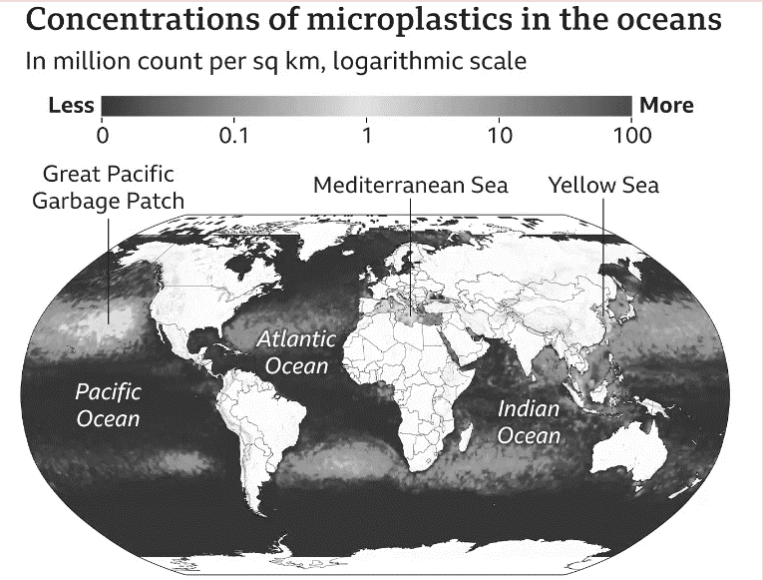
Article 1 'Oceans littered with plastic'

Oceans littered with 171 trillion plastic pieces, Rannard, BBC 2023

More than 171 trillion pieces of plastic are now estimated to be floating in the world's oceans, according to scientists. Plastic kills fish and sea animals and takes hundreds of years to break down into less harmful materials. The concentration of plastics in the oceans has increased from 16 trillion pieces in 2005, data suggests. It could nearly triple by 2040 if no action is taken, scientists warn.

Last week, nations signed the historic UN High Seas treaty aiming to protect 30% of the oceans.
To produce this new estimate, external, a group of scientists analysed records starting in 1979 and added recent data collected on expeditions that trawl the seas with nets to collect plastics. The plastic counted in nets is then added to a mathematical model to produce a global estimate.

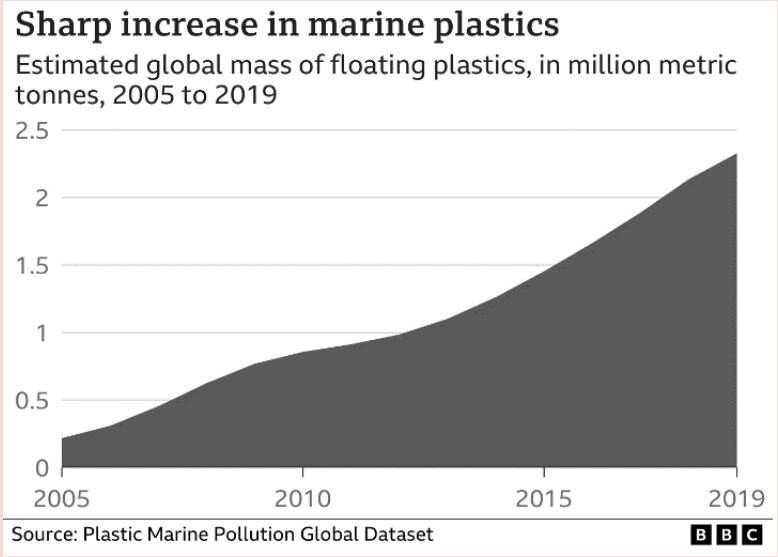
The 171 trillion pieces are made up of both recently discarded plastics and older pieces that have broken down, […a…] lead author […] from the 5 Gyres Institute told BBC News.



Single-use plastics like bottles, packaging, fishing equipment or other items break down over time into smaller pieces due to sunlight or mechanical degradation. Wildlife like whales, seabirds, turtles and fish mistake plastic for their prey and can die of starvation as plastic fills their stomachs.

They also make their way into our drinking water, and microplastics have been found in human lungs, veins and the placenta. Scientists say we do not yet know enough about whether microplastics negatively affect human health.

The concentration of plastics in the oceans has significantly increased from around 16 trillion pieces in 2005 to 171 trillion in 2019.



Before 2005 the concentrations fluctuated. Dr Eriksen says scientists are not sure why this is, but it could be explained by stronger legislation being replaced by voluntary agreements, the breakdown of plastics, or the fact that less data was collected.

Prof Richard Thompson at Plymouth university, who was not involved in the study, said the estimate adds to what scientists know about marine pollution. 'We are all agreed there is too much plastic in the ocean. We urgently need to move to solutions-focused research,' he told BBC News.

The highest concentration of ocean plastic is currently in the Mediterranean Sea, with some large floating masses found elsewhere including the Great Pacific Garbage Patch. The authors also suggest that the changing levels of pollution before 2000 may be due to the effectiveness of treaties or policies that govern pollution.

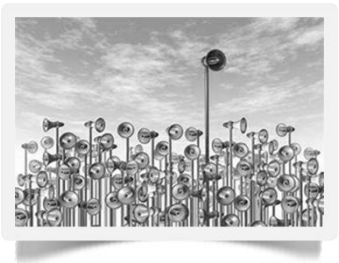
In the 1980s several legally binding international agreements mandated countries to stop discarding fishing and naval plastics in the oceans, as well as to clean up certain amounts. These were later followed by voluntary agreements which the authors say may have been less effective and could explain the rise in plastics from around 2000 onwards.

Regulations and policies: Governments should enforce strict regulations to control emissions from industries and vehicles. Policies promoting sustainable agricultural practices can reduce pollution from farming activities.

Waste management: Proper disposal and treatment of industrial waste, sewage, and agricultural runoff can minimise environmental pollution.

Sustainable practices: Adopting sustainable practices in agriculture, industry, and transportation can help reduce pollution. This includes using eco-friendly pesticides, reducing emissions, and promoting renewable energy sources.

Public awareness: Educating the public about the impacts of environmental pollution and encouraging eco-friendly practices can contribute to reducing pollution.



Sources and preventative measures

Staff	Preventative Action
Blowing into bags, licking fingers, picking nose Coughing and sneezing Handling open food Smoking Cuts and sores Clothing	Regular training sessions and effective supervision Turn away from food Hand hygiene Use of clean tongs Prohibition of smoking Exclusion Waterproof dressings Hand hygiene PPE. E.g. Mobcap or hat Effective training and compliance (Discipline)
Customers	**Preventative Action**
Coughing and sneezing Smoking Animals	Covered food Sneeze screens Restricted access Pre-wrapped product 'No Smoking' notices Deny animal access Food stored at higher locations

Food Spoilage

Causes of food spoilage

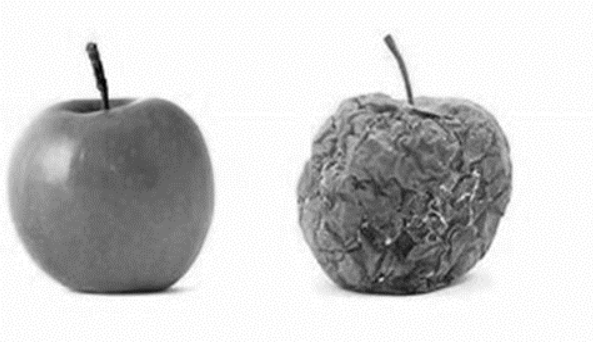
- Mould
- Yeast
- Bacteria
- Enzymes
- Physical damage
- Chemical contamination

Effects of food spoilage

Food spoilage refers to food that is not fit to eat due to:

- Smell
- Taste
- Appearance
- Texture

Food can become spoiled due to the process of decomposition, attacks by pests, contamination by chemicals, or through physical damage (for example, poor handling resulting in bruising).



Cost of poor food hygiene

- Loss of working days and productivity due to illness
- Customer complaints resulting in loss of reputation
- Loss of business
- Civil action taken by those affected by food poisoning
- Fines and cost of legal action
- Food loss due to premature spoilage or infestation
- Pest infestation
- Higher staff turnover
- Closure of the premises

Benefits of good food hygiene

- Enhanced reputation
- Increased productivity
- Compliance with the law
- Increased shelf-life
- Reduced risk of food-borne diseases
- Higher staff moral
- Lower staff turnover

Notes:

Milk preservation

❖ **Pasteurisation**	71.7°c	15 minutes
❖ **Sterilisation**	100°c	20 minutes
❖ **Ultra Heat Treatment** (UHT)	132°c	15 seconds

Notes: