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# Chapter 1

## Basic Microbiology

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### Chapter Outline

- List the various types of micro-organisms.
- Describe the elements required for microbial growth.
- Describe how micro-organisms multiply and spread, and the subsequent infection process.
- List the ways in which micro-organisms spread.
- Describe what is meant by direct and indirect contact.
- Understand what is meant by resident and transient micro-organisms.
- Understand the Chain of Infection.
- Briefly describe sources of potential infection within your own workplace.
- Understand the importance of patient susceptibility and the need for vigilance and safe practice at all times.
- Understand how to eradicate micro-organisms from the environment.

- Explain the term 'antibiotic resistance' and understand the importance of correct and safe antibiotic usage.
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## Microbiology



Microbiology is the study of tiny living things called micro-organisms. Micro-organisms include bacteria, viruses and fungi, and are found everywhere, for example in and on people and animals, and in water, soil, food and air. Most micro-organisms are not harmful and

live in and on the human body without causing any harm. Many play a valuable role in digestion and in protecting the body against invasion by other harmful micro-organisms.

Common uses of micro-organisms:

1. Moulds are used in the manufacture of antibiotics (e.g. penicillin).
2. Some bacteria are used to make cheese and yoghurts.
3. Viruses are used in medical research.
4. Yeast is used in the manufacture of beer.

## Pathogens

Micro-organisms can also be harmful and a few species are capable of causing disease when they enter the body. This may include a minor infection which stays in one part of the body or spreads throughout the body like flu. Some infections are easily dealt with but others may sometimes cause serious problems. Micro-organisms that are able to invade the body and cause disease are called pathogens and the capacity of a micro-organism to cause disease is referred to as pathogenicity.

Pathogens can be present on the body without invading tissue or causing infection. This is known as **colonisation**. Colonisation has no adverse effect on the individual concerned but it provides a source from which the pathogen can be readily transferred to another person and subsequently cause infection.

### **Opportunistic Pathogens**

Some pathogens will cause infection if they gain access to the human body, but the severity of the disease may depend on the vulnerability

of the host, such as the elderly, very young, immunocompromised and pregnant women. For example, the bacteria *Shigella* causes dysentery, an acute diarrhoeal illness, which tends to be most serious in debilitated individuals. Other micro-organisms are only able to cause disease in individuals with impaired defences and these are known as opportunistic pathogens. Methicillin-resistant *Staphylococcus aureus*, more commonly known as MRSA, may be described as an opportunistic pathogen as those at greatest risk are older people; very young people; those with reduced immunity to infection (including people living with HIV or undergoing anti-cancer therapies); those who have had surgery recently; and long-term residents of healthcare facilities.

## Types of Micro-organisms

Micro-organisms include bacteria, viruses and fungi (moulds and yeasts).

### **Bacteria**





Bacteria are very tiny living things which are too small to be seen by the naked eye and can only be viewed under a microscope. They come in three main shapes – spiral shaped, rod shaped and spherical shaped. In the healthcare environment microbiological hazards must be reduced to a safe level in order to avoid the spread of infection and disease. Common healthcare associated bacterial infections are MRSA, Clostridium difficile (C. diff.), legionnaire's disease (Legionella), Pseudomonas aeruginosa, vancomycin-resistant Enterococcus (VRE) and tuberculosis (TB). Bacterial hazards in the kitchen include Escherichia coli (E. coli), Salmonella, Listeria and Campylobacter.

In order to prevent the growth and multiplication of pathogenic bacteria, it is necessary to understand the requirements for bacterial growth. Just like all other living creatures, bacteria need food and water to grow and multiply. Most will not survive for long on clean, dry surfaces but will readily multiply on poorly cleaned equipment, in dirty water and even in solutions of disinfectant.

In a process known as binary fission, bacteria will split in two approximately every 20 minutes under the right conditions. This is known as an asexual form of reproduction as it does not involve both a male cell and a female cell. Each cell will produce an identical cell which in turn will split in two if conditions remain favourable. The requirements for bacterial growth are time, warmth, oxygen, food and moisture (TWOFM).

1. *Time*: In a 10-hour period one single cell of bacteria will become 1 billion bacterial cells if the conditions are right.
2. *Warmth*: For each species of bacteria there is a definite range within which growth takes place. Some will grow very well at room temperature or even body temperature (37°C).

3. *Oxygen*: Some bacteria are aerobic (they need oxygen to survive) and others are anaerobic (they can survive in the absence of oxygen).
4. *Food*: Like humans, bacteria require food to thrive and grow.
5. *Moisture*: Bacteria require moist conditions in order to multiply. Bacteria will not multiply on dry surfaces or equipment.

## **Viruses**

Viruses differ from bacteria in that they are much smaller in size and are too small to be seen under an ordinary light microscope. They are also more difficult to kill. However, the main difference between viruses and bacteria is the way in which they reproduce. Viruses cannot reproduce by themselves as bacteria do and can only replicate inside a living cell; therefore, they are dependent on the host cell for growth. They can infect plants, animals and even bacteria and are responsible



for a wide range of infections. Common healthcare associated viruses include norovirus, hepatitis B, hepatitis C and HIV (human immunodeficiency virus).

## **Fungi**

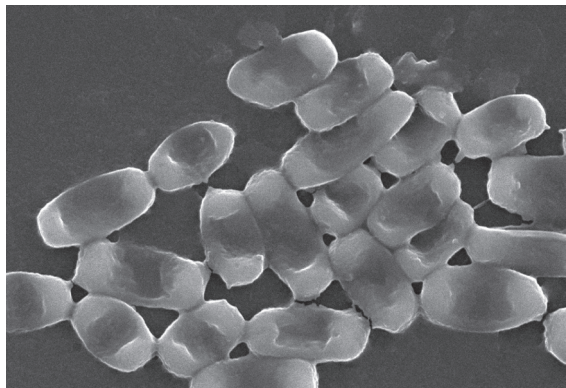
Fungi are another type of micro-organism. Some fungi, like mushrooms, are visible to the naked eye and others can only be seen under a microscope. Infection caused by fungi, called mycosis, can be superficial and affect body surfaces, for example skin, hair and



nails; these include athlete's foot, thrush and ringworm. However, in those with a compromised immune system, fungal infections (for example, *Aspergillus*) can invade the lungs and other tissues of the body and can very often be fatal.

## **Spores**

Some species of bacteria develop highly resistant structures called spores when they are exposed to adverse conditions. Spores are resistant to disinfectants as well as to high and low temperatures. They may remain viable for several years, but when the environmental conditions improve, the spores germinate and the bacterial cell inside



starts to multiply again. Bacterial spores can survive in dust for long periods of time, for example in the case of *C. diff.* Environmental contamination from *C. diff.* patients has been positively identified as the source of infection in reported outbreaks in healthcare settings.

## Spread of Micro-organisms

In the healthcare environment micro-organisms can be spread either directly or indirectly.



**Direct contact** is when micro-organisms are transferred from one infected person to another by direct contact between body surfaces, for example through the blood, other bodily fluids or sexual contact. Puncture wounds from sharps (needles, syringes and razor blades) that have been contaminated by blood from an infected patient can lead to viral infections, such as hepatitis B and hepatitis C which both cause inflammation of the liver. HIV can also be contracted through needle stick injury from an infected patient.

**Indirect contact** involves the transfer of a micro-organism by means of a vehicle i.e. a contaminated object or equipment (fomites). Micro-organisms can be indirectly transferred by means of the following vehicles.

## **Hands**

Healthcare assistants can carry pathogenic bacteria on their hands through contact with contaminated surfaces or bodily fluids and these can be transferred to the next person or object that they touch. The spread of pathogenic bacteria in this manner can be easily prevented by carrying out the correct level of hand hygiene.

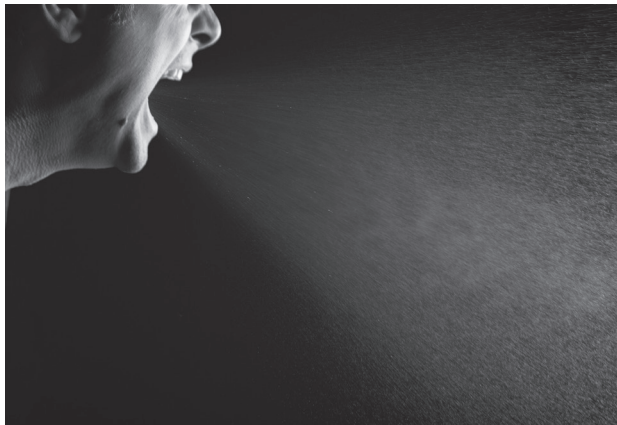


## ***Equipment and Inanimate Objects***

Micro-organisms can be carried on equipment such as wheels of trolleys, wheelchairs, cleaning equipment and beds, and other inanimate objects such as door handles, telephones, wash basins, taps and other unclean surfaces.



## ***Airborne Particles***





Pathogenic micro-organisms can be carried on airborne particles such as respiratory droplets, water and dust. Droplets of moisture are expelled from the respiratory tract during sneezing, coughing or talking and can be carried through the air.

## **Vectors**

Animals and insects carry harmful bacteria on their feet, coats, fur and bodies and are very often involved in the transmission of infection to humans.



## **Food and Water**



Some foods either in their ready-to-eat or raw state will harbour pathogenic bacteria which can cause food poisoning when consumed by vulnerable patients. Common food poisoning bacteria include

Salmonella, E. coli, Listeria and Campylobacter. Food workers suffering from gastrointestinal infection should not work with food as harmful bacteria can be transmitted via the hands to patients and co-workers. Micro-organisms can also be transmitted through contaminated water as in the case of Cryptosporidium. Hepatitis A is an example of a waterborne illness, which is associated with countries that have poor sanitation and hygiene standards.

## Transient and Resident Micro-organisms

**Transient micro-organisms** are found on the skin's surface and live for only a short period of time. They can be easily passed from one person to another and cause infection unless removed. Transient micro-organisms may be carried on the hands of healthcare assistants and also on equipment; thus, they are commonly connected to healthcare associated infections (HCAIs). The correct level of hand hygiene removes the risk of HCAIs.

**Resident micro-organisms** live much deeper in the skin or in the nose and most are harmless. They are part of our immune system, protecting us from infection, and they are not normally associated with HCAIs. They can, however, cause infection in patients who are vulnerable to infection.

## What Is Infection?

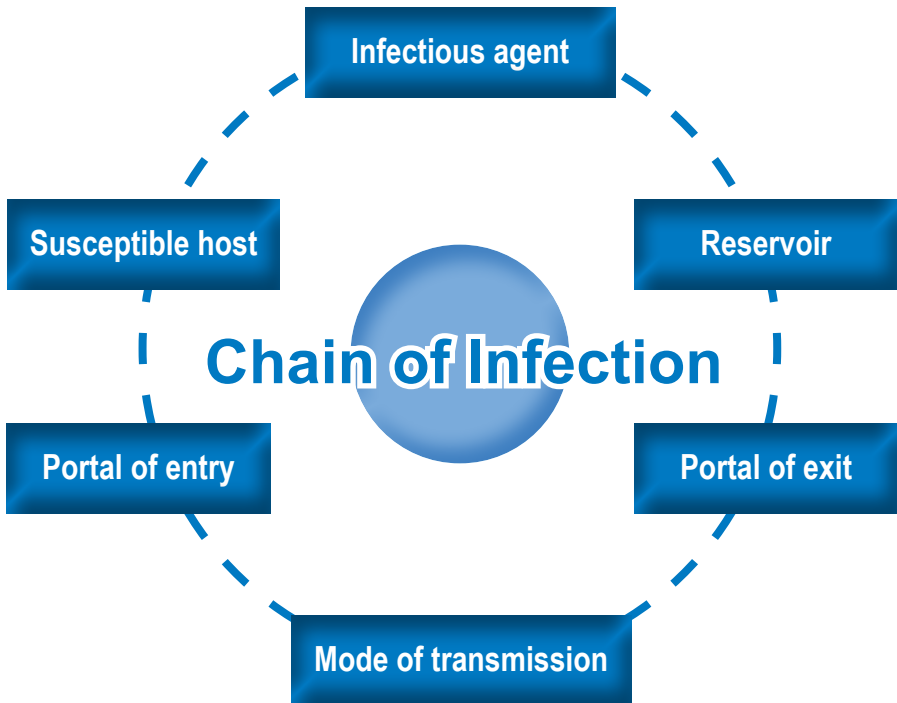
An infection is an invasion of harmful micro-organisms into the body resulting in illness and disease. Transmission of micro-organisms can be via the faecal-oral route, vehicles (for example, equipment), droplets, non-human carriers, blood, bodily fluids and air.

Micro-organisms can enter the body and from here they will grow and multiply, and signs and symptoms of infection will become apparent. In order for infection to occur, a series of events must happen. This series of events is known as the Chain of Infection. There are six links in the Chain of Infection and each link must connect for an infection to occur. In the healthcare environment the aim is to break the Chain of Infection to stop infection from occurring.



## Chain of Infection

To break the Chain of Infection it is important to first understand each link and how they connect to cause infection in the host.



1. *Infectious agent*: This can be a bacterium, virus, fungus or parasite. Basically, any micro-organism is capable of causing infection if all the links are present. Micro-organisms are found everywhere in the environment and also on human and animal carriers.
2. *Reservoir*: This is the place where an infectious agent lives and reproduces in such a manner that it can be easily transmitted. A reservoir can be people, water, food, animals or insects.

3. *Portal of exit*: This is the means by which the infectious agent leaves the host. This can be through the respiratory tract (coughing, sneezing and talking), gastrointestinal tract (vomiting and diarrhoea), non-intact skin (draining wounds etc.) or mucous membranes (eyes, nose and mouth).
4. *Mode of transmission*: This is the way in which the micro-organisms travel from the reservoir to the host. The mode of transmission can be either direct or indirect (via a vehicle).
5. *Portal of entry*: This is the point where the infectious agent enters a new host. This process is facilitated by the respiratory tract, gastrointestinal tract, non-intact skin or mucous membranes. It can also be introduced through exposure to a contaminated sharp object like a needle or syringe (parenteral).
6. *Susceptible host*: This is the person who is about to become infected by the infectious agent. Individuals who have never been exposed to the micro-organism can become ill because they do not have the antibodies to protect them, either through immunisation or through previous infection. Certain groups are considered more vulnerable to infection and these include the elderly, the very young, pregnant women and those with underlying health problems.

The Chain of Infection can be broken in the following ways:

- Correct hand washing technique
- Segregation of healthcare linen
- Segregation of healthcare risk and non-risk waste
- Control of dust
- Cleaning of equipment and environmental cleaning

- Use of appropriate personal protective equipment (PPE)
- Pest control.

## Sources of Potential Infection and Patient Susceptibility

The body has a range of defences designed to protect it against invasion by pathogens. For example, intact skin cannot be penetrated by micro-organisms but they can gain entry via damaged skin; the respiratory tract is protected by cilia (fine hair-like structures) and the cough reflex. If these defences are damaged, micro-organisms may gain access more easily.



Patients are particularly vulnerable to infection if they have pre-existing conditions. Patients receiving treatments of steroids and chemotherapy will have a lowered immune system which can affect the body's ability to deal with infection. Other underlying conditions include diabetes, renal disease, nutritional diseases (caused by malnutrition), mobility issues and general ill health. Skin lesions (wounds, burns, ulceration etc.) will also assist pathogenic micro-organisms to bypass the body's natural defences and this may lead to infection in the host.

## Antibiotic Resistance

The terms **sensitive** and **resistant** are used to distinguish when a micro-organism is susceptible to or unaffected by a particular antibiotic. A sensitive micro-organism is killed, or its growth inhibited by the drug, while a resistant one survives in its presence. Antibiotic resistance is the ability of a micro-organism to withstand the effects of an antibiotic.



Resistance to antibiotics is increasing in many pathogens, and the unnecessary and inappropriate use of antibiotics has been recognised as a widespread and international problem for many years. At the present time MRSA and VRE are causing particular concern in the healthcare sector.

The most common abuse and misuse of antibiotics are:

1. Physicians prescribing antibiotics for viral infections.
2. Not finishing the full dosage of the antibiotic. When an antibiotic prescription is not finished (even leaving one or two pills), it leaves some bacteria alive and resistant to future antibiotic treatment.

Patients often demand that doctors prescribe antibiotics when they are not needed. Healthcare professionals must ensure that antibiotics are only prescribed when a bacterial infection is present as they are not effective against viral infections.

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## Revision Questions

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1. List three types of micro-organisms. Name one benefit and one harm caused by each micro-organism.
2. Distinguish between 'direct' and 'indirect' contact in the spread of micro-organisms. Give two examples of each type of contact.
3. What is the main difference between bacteria and viruses?
4. List the six links in the Chain of Infection. Give a brief description of each link.
5. Briefly describe potential sources of infection within your own workplace.