Biodiversity and classification of microorganisms *Scope*

Topic	Breakdown of topic
Biodiversity and classification of microorganisms	Micro- organisms: basic structure and general characteristics of the following groups: - viruses - bacteria - Protista - fungi The roles that these groups play in maintaining balance in the environment and web of life Symbiotic relationships of bacteria such as nitrogen fixing bacteria in plants and E. coli in the human intestine The effect and management of one disease from each of the four groups: - viruses (rabies, HIV/AIDS, influenza) bacteria (blight, cholera, tuberculosis, anthrax) - protists (malaria) - fungi (rust, thrush, ringworm, athlete's foot) Immunity, including plants and animals' immune responses against the infecting micro-organisms. The use of drugs e.g., antibiotics; effect on micro-organisms Vaccinations (discuss briefly) The use of micro- organisms to produce medicines (e.g., insulin and antibiotics) Traditional technology to produce, e.g., beer, wine and cheese.

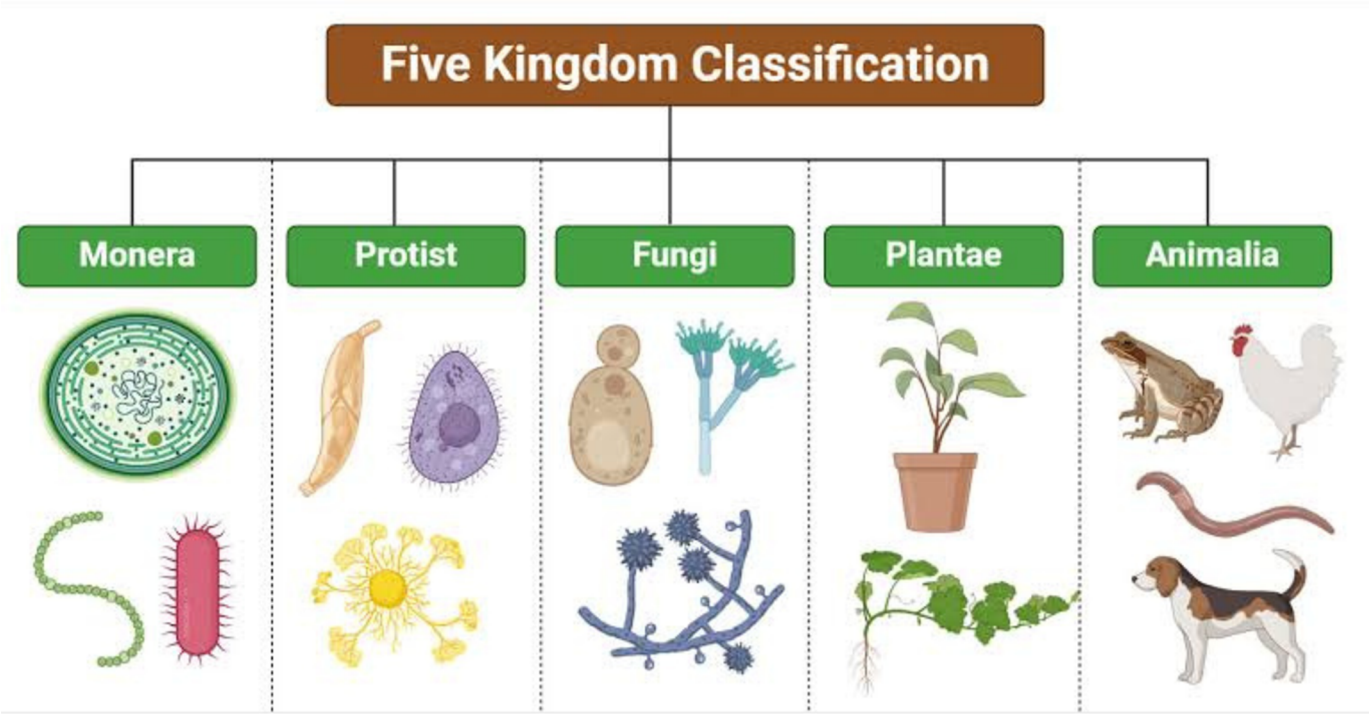
Biodiversity and classification of microorganisms Notes

Biodiversity refers to the wide variety of plants, animals and micro-organisms on Earth.

Organisms which are too small to be seen with the naked eye are referred to as micro-organisms. Micro-organisms can be unicellular or multicellular. Some are harmful and cause diseases whilst others are very useful in the environment and to human.

Scientists have placed all the organisms into specific.
There are five groups called kingdoms:

- Kingdom Monera – bacteria
- Kingdom Protista
- Kingdom Fungi
- Kingdom Plantae
- Kingdom Animalia



Biodiversity and classification of microorganisms

Viruses

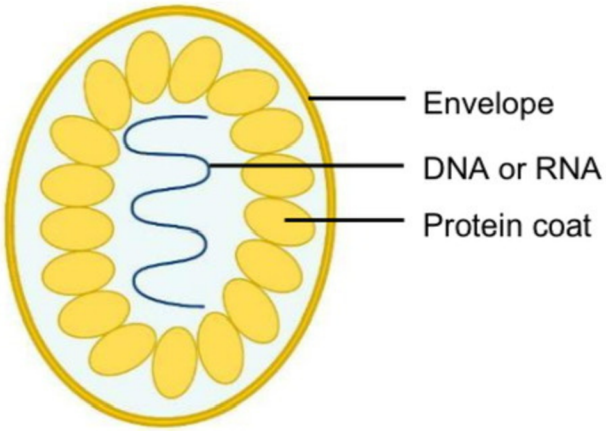
Viruses are placed in a separate group and not in a kingdom because they display some non-living as well as living characteristics.

Non-living characteristics

- Cannot reproduce on their own
- Do not respire
- Form crystals and can survive in that form for years

Living characteristics

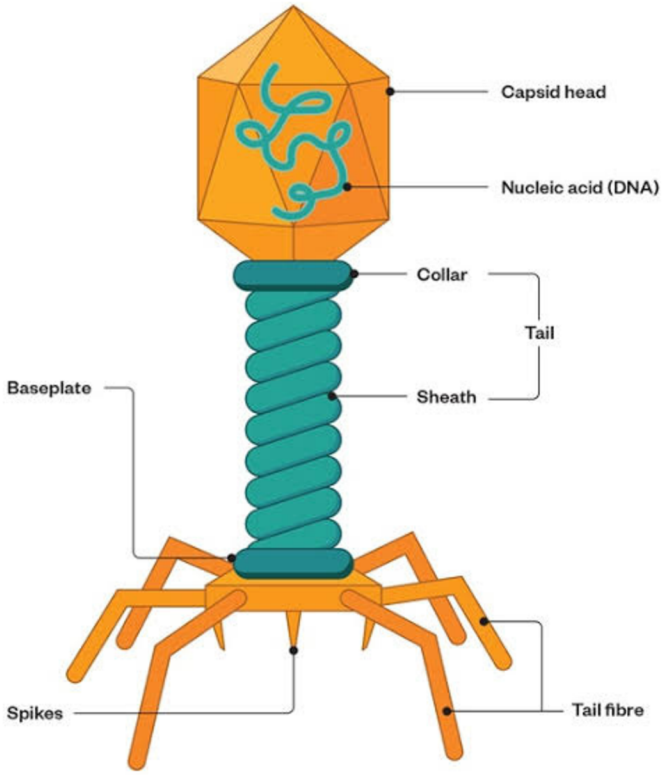
- Can reproduce within a living host



Characteristics of a virus

- Microscopic
- consist of a core of either DNA or RNA enclosed by a protein coat called a capsid
- Viruses are acellular.
- **do not have chlorophyll** and are therefore unable to make their own food by photosynthesis.
- All viruses are obligate internal parasites. This means that they cannot multiply without infecting another living organism or **host**.
- can infect bacteria, protists, plants and animals. Viruses that infect bacteria are called bacteriophages.
- causs diseases and are said to be pathogenic.

A Bacteriophage



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Virus

Terminology

Key terminology

capsid	a protein coat surrounding the nucleic material of a virus
acellular	non-cellular
obligate parasite	obligate = forced; a parasitic organism that cannot complete its life-cycle without exploiting a suitable host (if an obligate parasite cannot obtain a host it will fail to reproduce)
host	an organism that harbours a parasite
pathogenic	an organism that causes disease
bacteriophage	a type of virus that infects bacteria; the word "phage" means to eat"
nucleoid	an irregularly shaped region within the cell of a prokaryote that contains all or most of the genetic material

Biodiversity and classification of microorganisms

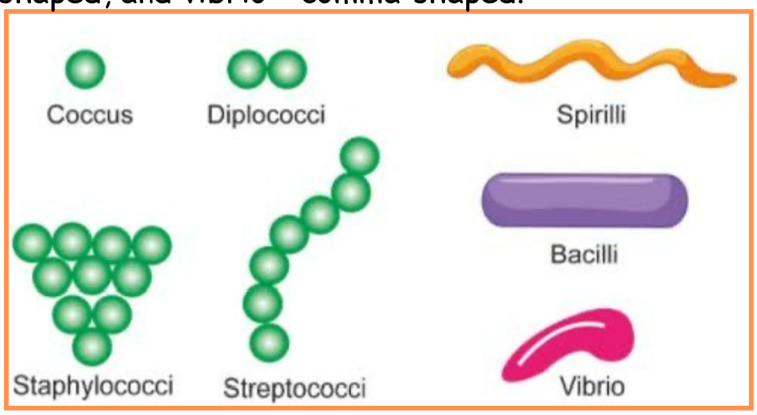
Bacteria

Bacteria belong to the Kingdom Monera. Bacteria are found everywhere on earth. Some are **pathogenic** and cause diseases such as tuberculosis, while most are useful.

characteristics

- are unicellular (one celled).
- Bacteria are larger than viruses and can be seen using a light microscope.
- Bacteria are distinguished from one another by their shape.

These shapes include: coccus – round, bacillus – rod-shaped, spirillum – spiral-shaped, and vibrio – comma-shaped.



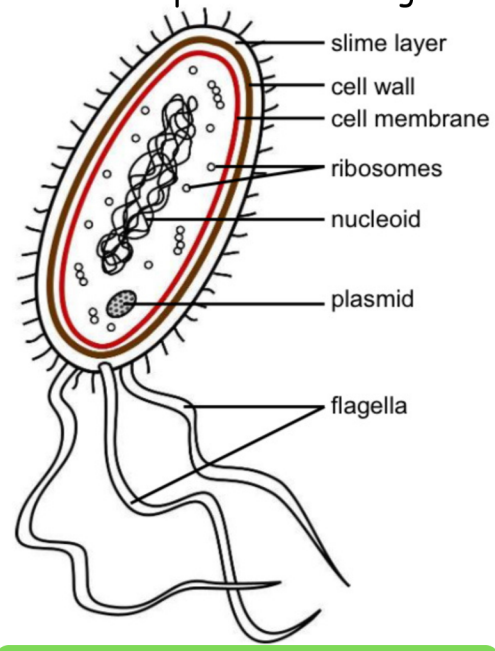
Nutrition

Autotrophic bacteria (their own food).
- Photosynthetic bacteria use sunlight energy
- Chemosynthetic bacteria get energy from chemical processes.

Heterotrophic bacteria (cannot own food).
- Parasitic bacteria (obtain food from other living organisms).
- Saprotrophic bacteria (decomposers).
- Mutualistic bacteria (form a mutually beneficial relationship with other organisms)

Structure

- Have a cell wall made up of polysaccharides.
- Some bacteria have a slime capsule to protect them from drying out.
- Cytoplasm surrounded by a cell membrane.
- No membrane-bound organelles (prokaryotic)
- The DNA is in the form of an irregular loop and is called a nucleoid.
- A plasmid, small, circular, double-stranded DNA molecule is also found in the cytoplasm of bacteria.
- Many bacteria have a whip-like flagellum which they can use to move in a liquid. The flagella can rotate to propel the organism forwards.



Bacteria multiply very quickly under favourable conditions. By **binary fission**.

Bacteria form **endospores** when conditions are unfavourable

Bacteria

Terminology

Key terminology

prokaryotic	an organism where the nuclear material is **not enclosed** in a membrane
eukaryotic	any single or multicellular group of organisms that have a **membrane-bound nucleus** containing genetic material
flagellum	a **whip-like**, protruding filaments that help cells or micro-organisms move; plural of flagellum is flagella
autotrophic	organisms which can synthesize their own food e.g. green plants, algae and some bacteria
heterotrophic	any organism that sources food from its environment because it cannot make its own food, e.g. animals, fungi, most bacteria
saprophytic	plant or fungal microorganisms that feeds on dead or decaying tissues of other organisms

binary fission	asexual reproduction of a single cell in which divides by mitosis; the cell regenerates as two or more separate cells having the same chromosomal identities as the parent cell
endospore	a tough, protective, non-reproductive bacteria structure that contains DNA and cytoplasm and lies dormant to survive unfavourable environmental conditions in order that it can germinate once conditions improve
plasmid	a plasmid is a small, circular, double-stranded DNA molecule that is distinct from a cell's chromosomal DNA

Biodiversity and classification of microorganisms

Protists

The Kingdom Protista is a collection of eukaryotic organisms. **Protists** do not fit into the plant, animal or fungi kingdoms.

characteristics

- simple unicellular or multicellular eukaryotic organisms
- no tissue differentiation
- found mainly in water
- autotrophic or heterotrophic
- usually microscopic but can be several meters in length for example the seaweeds
- some are sessile or free-floating while others can move using flagella (e.g. Euglena) or move using false feet called pseudopodia (e.g. Amoeba)
- they can reproduce both sexually and asexually

Plant-like

- mainly **unicellular** orga ism found in aquatic (water) environments
- most are **autotrophic**
- free floating aquatic plant-lik protists are called **phytoplankton**

Animal-like

- multicellular, macroscopic organisms commonly called seaweeds
- seaweeds contain various photosynthetic pigments which give them a green, red or brown colour
- seaweeds may be free-floating or sessile (attached to a substrate)

Algae

- mainly heterotrophic free-living unicellular animals living in an aquatic environment e.g. *Amoeba*
- some are parasitic and cause diseases such as malaria
- free-floating aquatic animal-like protists are called **zooplankton**

Terminology

Key terminology

aquatic	living in or around water
phytoplankton	very small plants (algae) that float on or near the surface of water
zooplankton	consisting of small animals and the immature stages of larger animals which float on or near the surface of the water
sessile	sessile organisms are usually permanently attached to something and can cannot move on their own but can move through outside sources (such as water currents)

Biodiversity and classification of microorganisms

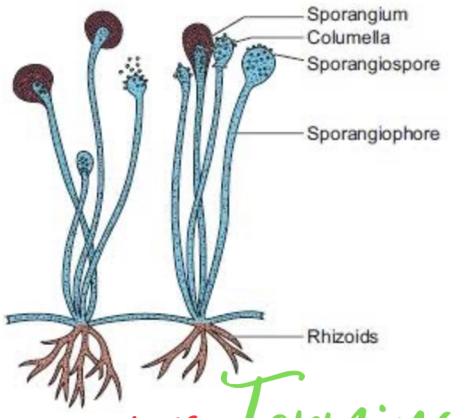
Fungi

The Kingdom **Fungi** includes moulds, yeasts, mildews, rusts, toadstools and mushrooms

characteristics

- Some are unicellular (yeasts) while others are multicellular (mushrooms).
- Eukaryotic (i.e. have a nuclear membrane).
- Heterotrophic since they lack chlorophyll. Fungi that live off dead organic matter are said to be saprotrophic. Parasitic fungi live off living organisms..
- Cell walls which contain chitin.
- The bodies are made up of threads called hyphae. All the hyphae together form a mycelium.
- Fungi reproduce both sexually and asexually.
- Asexual reproduction in unicellular fungi such as yeasts is by budding.
- In multicellular fungi asexual reproduction is by means of spores

Bread mould



scientific name: *Rhizopus stolonifer*

Terminology

Key terminology

chitin	a fibrous substance consisting of polysaccharides, which is the major constituent in the exoskeleton of arthropods and the cell walls of fungi
hyphae	a network of multi-celled threadlike filaments forming the mycelium of a fungus
mycelium	a vegetative mass or network of fungal hyphae found in and on soil or organic substrates
multinucleate	cells that have more than one nucleus per cell, i.e., multiple nuclei shared in one common cytoplasm
rhizoids	threadlike structures that anchor lower plants and fungi to a surface
budding	a form of asexual reproduction which involves the pinching off of offspring from the parent cell; the offspring cell is genetically identical to the parent

The role that micro-organisms play in maintaining a balance in the environment

Photosynthesis

Autotrophic bacteria, **phytoplankton** and algae can manufacture their own food by photosynthesis. The carbohydrates they produce are available to consumers

Organisms which break down dead organic matter to obtain nutrients are called **saprophytes**.

Decomposers

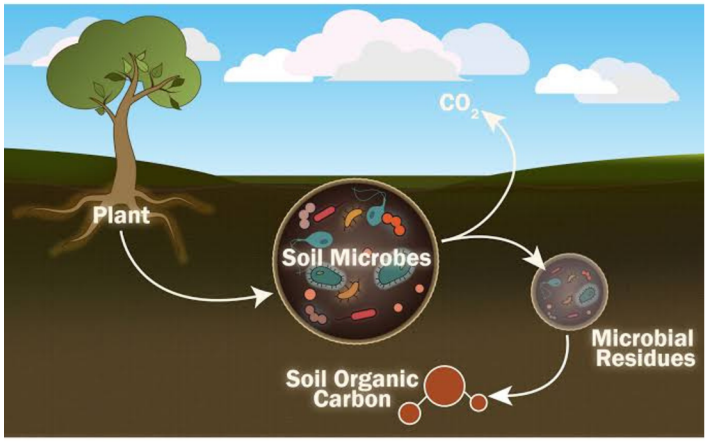
Bacteria and fungi are the main **decomposers**.

- They break down dead plant and animal remains and return the nutrients to the soil.

The nitrogen cycle

Bacteria play an important role in the nitrogen cycle.

- Free living bacteria can convert atmospheric nitrogen to ammonia and nitrates.
- Higher plants can only use nitrogen when it is in the form of nitrates, so they rely on bacteria for the conversion.
- Some plants form special relationships with nitrogen fixing bacteria.
- When plants and animals die, de-nitrifying bacteria return nitrogen to the atmosphere by a process called denitrification.



Symbiotic relationships

Symbiosis refers to the living together of two or more species of organism. A symbiotic relationship may benefit one or both members or it can be beneficial to one but harmful to the other one.

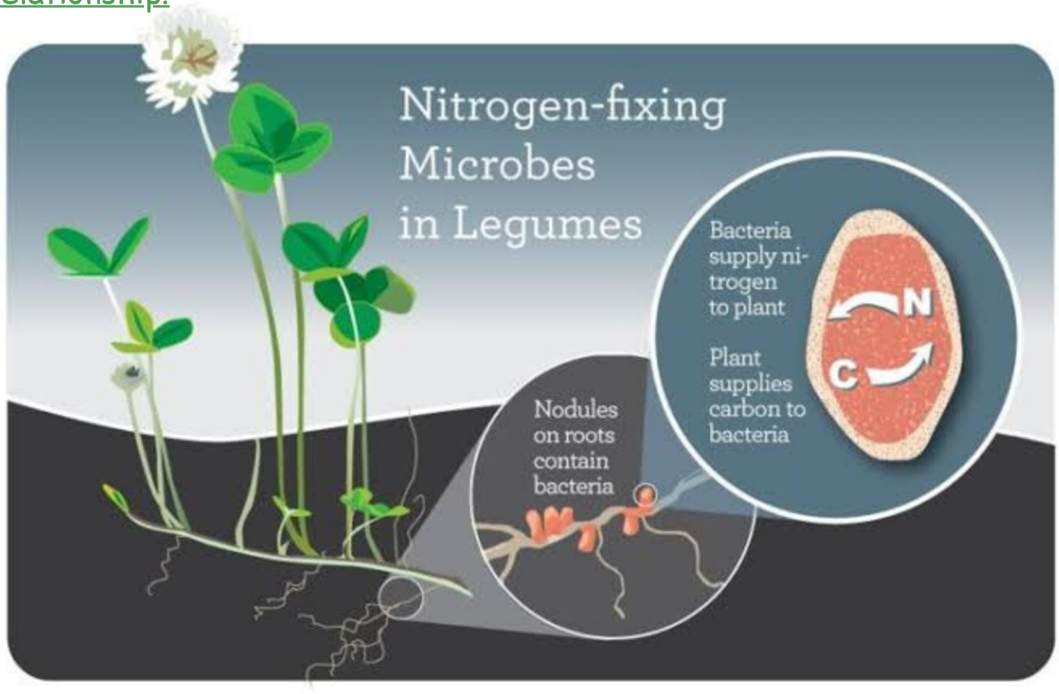
Three types of symbiosis occur:

- **mutualism** – both organisms benefit e.g. lichens
- **commensalism** – one species benefits whilst the other does not benefit, nor is it harmed
- **parasitism** – one species benefits whilst the other is harmed

Mutualistic relationships

Algae need a moist environment to survive and cannot live on dry land. They can, however, form a mutualistic relationship with a fungus and this called a **lichen**. The fungus provides the alga protection from the environment. Fungi however cannot produce food for themselves. They in turn obtain nutrients from the algae which can produce food by photosynthesis.

- Plants need nitrogen to make proteins and cannot absorb it as a gas.
- Some bacteria can convert free nitrogen to nitrates that can be used by plants.
- Some nitrogen-fixing bacteria produce nitrates for the plant while the plant provides the bacterium with a place to live. Both the plant and the bacteria benefit in this relationship.



The role that micro-organisms play in maintaining a balance in the environment

Terminology

Key terminology

decomposers	organisms that break down dead plant and animal (organic) material e.g. bacteria and fungi
saprophytes	organisms that live off dead organic matter

Symbiotic relationships

Terminology

Key terminology

mutualism	a symbiotic relationship where both organisms benefit
commensalism	a symbiotic relationship where one organism benefits without harming or affecting the other organism
parasitism	a symbiotic relationship where parasitic organisms benefit while causing harm to their hosts
lichens	composite organisms made up of fungi that grow symbiotically with algae or cyanobacteria
ruminant	an even-toed mammal that chews the cud regurgitated from its rumen e.g. cattle, sheep, antelopes, deer, giraffes, and their relatives.
mycorrhiza	The symbiotic association of fungi with the roots of trees.

Diseases

Organisms that cause diseases are called pathogens.

Disease	Organism responsible	Symptoms	Management and cure
rabies	rabies virus	headaches, nausea, fatigue, fever / dogs foam at mouth	vaccination, immunization, destroying infected animals
AIDS	HIV (virus)	loss of weight, secondary infections	anti-retrovirals, no cure, education
influenza	virus	coughing, sneezing, aching body, fever	proper diet, antibiotics have no effect
cholera	Bacterium *Vibrio cholerae*	diarrhoea	education regarding clean water, sanitation
tuberculosis	*Mycobacterium tuberculosis*	coughing, blood in sputum, weight loss, loss of appetite, fever and chills	antibiotics, education
anthrax	*Bacillus anthracis*	itchy bumps with a black centre, breathing problems	antibiotics and vaccines
malaria	*Plasmodium* spp.	fever, headaches, flu-like symptoms	prevention, anti-malaria medications, medication if infected
thrush	*Candida* spp.	white coating in the mouth	anti-fungal mouth wash, antibiotics
ringworm	fungus	scaly round spot on the skin	fungicide cream
athlete's foot	fungus	blistering of skin	fungicide cream or powder
rusts	fungus	loss of green colour in the leaf, raised rust-like spots on the underside	fungicide, remove and burn affected plant material
blight	bacterium	wilting and dying back	fungicide, remove and burn infected plant matter

Immunity

Immunity refers to the way in which a plant or animal is able to fight an infection

Plant immunity

The first line of defence in plants includes the waxy cuticle, bark and the closely packed epidermal cells which protects them from invading micro-organisms.
The second line of defence occurs when a plant becomes infected by a pathogen and its **natural immune response** is activated. It releases chemical compounds such as **salicylic acid** which are transported in the phloem to cells which are not affected.

Animal immunity

Animals have two types of immunity:
- Natural immunity (present at birth)
- Acquired immunity (develops after exposure to pathogens)

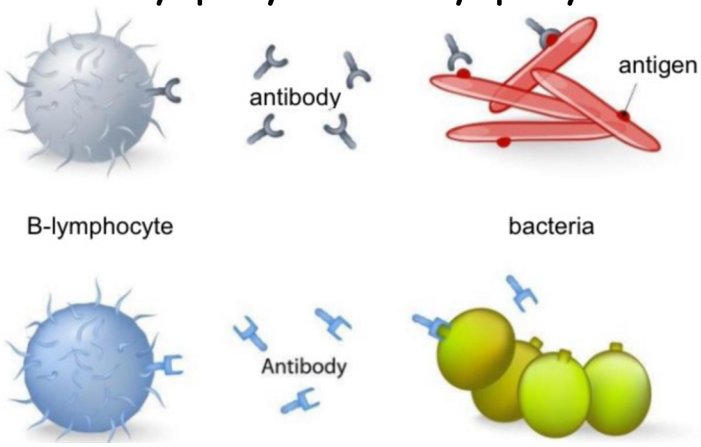
This is called the first line of defence prevents pathogen entry:
- a multi-layered skin
- antiseptic tears
- mucus lined air passages which trap pathogens
- enzymes (lysozyme) in the saliva
- ear wax in the ear canal

The second line of defence involves two responses should pathogens gain entry:
(i) **Primary response** – destroys pathogen & prevent spread. By swelling and redness of local areas and fever (raises body temperature)
(ii) **Secondary response** – this activates the immune system which:
- destroys the invading pathogens. It holds a memory of pathogens to reduce/prevent re-infection.

The immune system involves two groups of white blood cells viz. lymphocytes and phagocytes.

A **vaccine** is a weakened micro-organisms, that will stimulate the production of antibodies by the lymphocytes.

Two types of lymphocytes occur:
B-lymphocytes and **T-lymphocytes**.



B-lymphocytes recognise the antigens and make special proteins called **antibodies**

Antibodies destroy germs by:
- causing bacterial cells to burst.
- labelling the germs so that phagocytes can ingest them
- making germs clump together so that they are easy to recognize.
- neutralising bacterial toxins

T-lymphocytes are found mainly in the lymph glands. Two types occur:
1. *CD4 cells* – helper cells which start the response.
2. Killer T-cells which destroy body cells infected with viruses or parasites.

Macrophages (a type of phagocytic cells) identify bacteria and engulf them by as phagocytosis. Vacuoles filled with enzymes called lysosomes fuse with the vacuole containing the bacteria and destroy them.

The use of drugs

Antibiotics are drugs that fight infections caused by bacteria. Antibiotics cannot fight infections caused by viruses because viruses do not feed and therefore do not ingest the antibiotics.

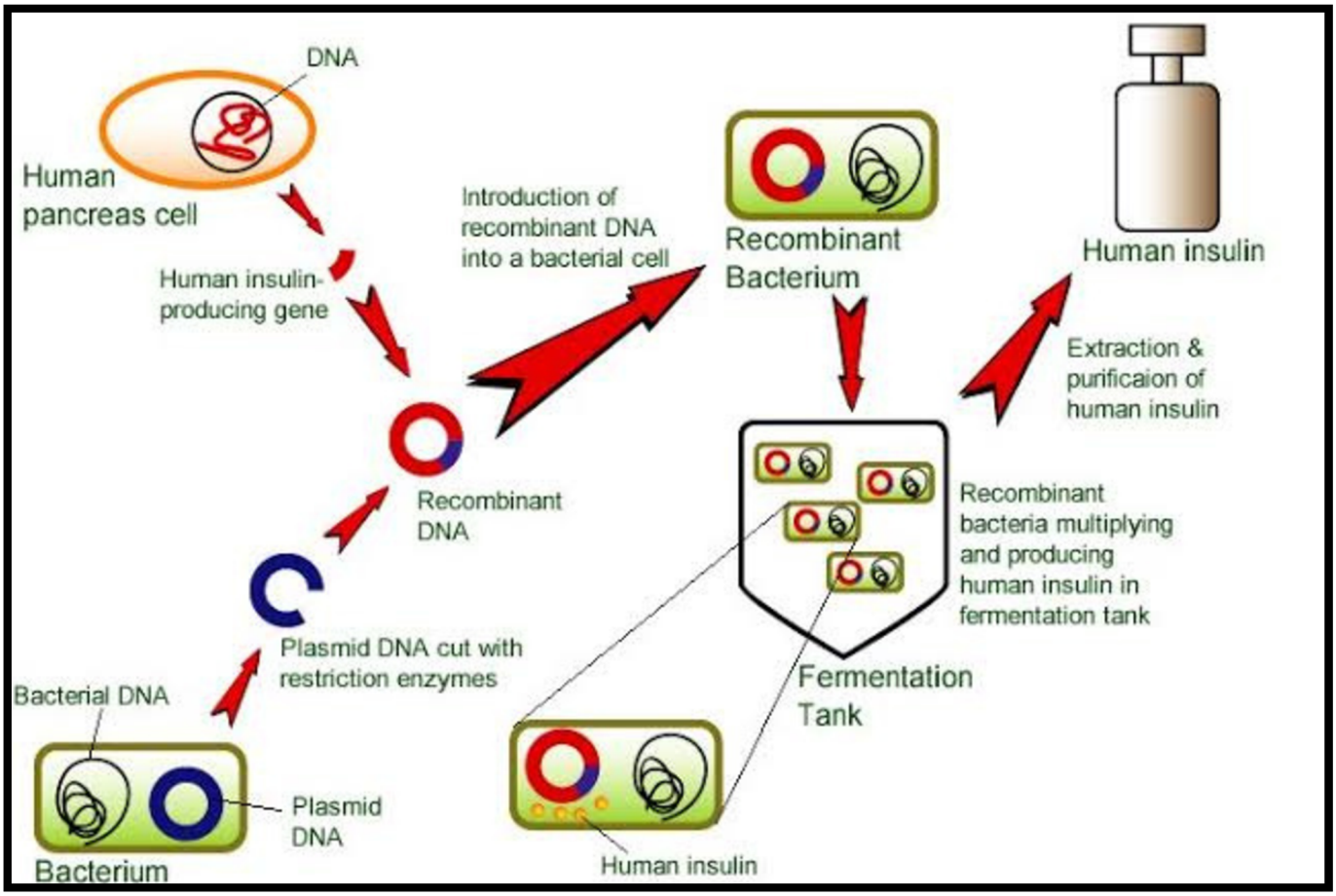
Antibiotics usually target a specific part of a bacterium. For example, they:

- prevent cell walls from forming.
- damage cell membranes.
- stop protein synthesis.

Bacteria are able to build up a *resistance* to antibiotics which is why it is important to always complete a course of antibiotics. The first dose of antibiotics usually kills all the weak bacteria. If the course is not completed, the stronger bacteria that are left behind multiply and become drug resistant.

Biotechnology: the use of micro-organisms to make substances which are useful to humans.

Making insulin



Immunity

Terminology

Key terminology

lymphocyte	white blood cell type which fight infection
antigen	a complex molecule that induces an immune response (or disease reaction) in the body
antibody	a protein made by the immune system to target and combine with a specific antigen (invader) and make it useless
phagocytosis	the process by which a cell engulfs a solid particle to form an internal compartment known as a phagosome (phago – eat, cyto – cell)
lysosome	an organelle containing digestive enzymes to break down bacterial or viral cell walls

vaccine	a biological preparation made from damaged virus or bacteria particles used to stimulate an immune response by the body's immune system against viral and bacterial infectious diseases
antibiotic	medicine e.g. penicillin which is developed from living organisms e.g. bacteria or fungi and used to fight infections caused by either bacteria or fungi
insulin	hormone made in the pancreas and released into the blood to help convert glucose to glycogen