Infectious Diseases

10.1 Infectious Diseases

A disease is an illness or disorder of the body or mind that leads to poor health.

Infectious diseases: are caused by pathogens and are transmissible which means that it can be spread between individuals within a population. Some diseases may even be transmitted without the person showing any symptoms – called carrier.

Signs	Symptoms
Signs are indicative factors which the doctor sees.	Symptoms are conditions & characters which the person feels.
Signs are objective. They are visible & can be quantified & verified.	Symptoms are subjective. They are not physically visible & cannot be verified.
E.g. High Temperature, Rapid Pulse Rate, Low Blood Pressure, Wound etc. are the signs of a disease.	E.g. Chills, Shivering, Nausea, Shaking, Dizziness, Tiredness are the symptoms of the disease.

Term	Definition	Example
Infectious, or communicable disease	Diseases caused by pathogens that can be transmitted from infected to uninfected people. Some can transmit from animals to people, or people to animals (1 host to another) in a transmission cycle.	Cholera Tuberculosis (TB) Malaria HIV/AIDS
Non-infectious disease	Diseases that are not caused by pathogens, but that may instead be inherited, or related to lifestyle factors or life events.	Lung cancer Sickle cell disease Depression Coronary heart disease

Endemic: Describing a disease that is always present in a population

Epidemic: An epidemic is the rapid spread of disease to a large number of people in a given population within a short period of time.

Incidence: The number of people diagnosed with a disease over a period of time.

Prevalence: The number of people with the disease at any one time.

Pandemic: An increase in number of cases throughout a continent or across the world.

Disease	Pathogen	Type of organism	Method of transmission
Cholera	Vibrio Cholerae	Bacterium	Contaminated water or faeces.
Malaria	Plasmodium Falciparum, Plasmodium Malariae, Plasmodium Ovale, Plasmodium Vivax	Protist	Mosquitos female anopheles species which bites & drinks blood of an infected person & then passes on the protocitistamin in its saliva.
Dengue	Aedes Agypti	Virus	Mosquitos female anopheles species which bites & drinks blood of an infected person & then passes on the virus in its saliva.
TB	Mycobacterium Tuberculosis, Mycobacterium Bovis	Bacterium	Tuberculosis (TB) spreads through the air when people with active TB disease of the lungs or throat cough, speak, sing, or sneeze, releasing tiny droplets containing the bacteria.
Leptospirosis	Spirochaete	Bacterium	Mammals pass it to bodies of water such as ponds, rivers & lakes through urine. Humans wash or bathe in infected water encountering it.
HIV/AIDS	Human Immunodeficiency Virus (HIV)	Virus	Exchange of bodily fluids during Coitus. Blood Transfusions, drug users sharing needles, blood reaching the fetus through the placenta.
Rabies	Neurotropic Virus of Rhabdoviridae family	Virus	Mammals pass it on in its saliva by bites.
Gastro-Enteritis	Norovirus Rotavirus Enteric Adenovirus	Bacterium	Housefly picks up infected material from feces or rotting food & then passes it onto human food as it feeds.
Measles	Morbillivirus in the Paramyxoviridae Family	Virus	Measles primarily spreads through airborne transmission via respiratory droplets from coughing or sneezing, and by direct contact with infected respiratory secretions or contaminated surfaces.
Chicken Pox	Varicella-Zoster Virus	Virus	Chickenpox spreads primarily through airborne respiratory droplets from coughing or sneezing,

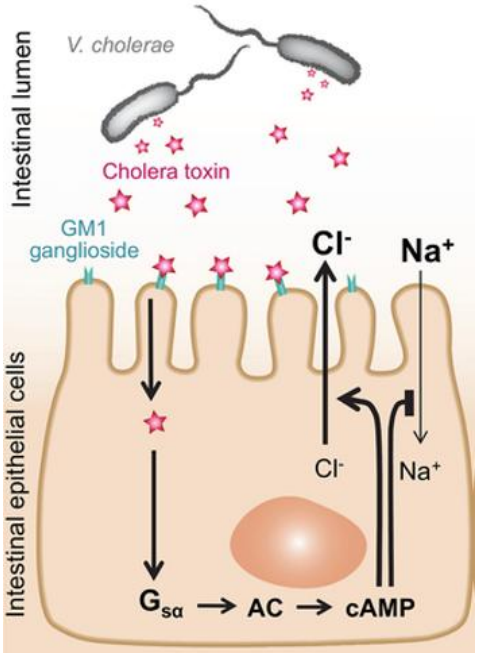
			and also by direct contact with the fluid of blisters or contaminated items.

Infectious	Contagious
Infectious diseases refers to diseases caused by pathogenic micro-organisms like viruses, bacteria & parasites.	Contagious diseases refer to diseases that spread from 1 organism to another, through direct of indirect contact.
Spread through direct or indirect contact with infected people, food & water contamination or insect vectors, etc.	Spread through direct or indirect contact with infected people.
Food Poisoning, Lyme disease & Urinary tract infection are infectious, but not contagious.	Common Cold, Flu, TB, Chickenpox, Measles, SARS & Covid-19 are contagious.

Cholera: Cholera is an acute diarrheal illness caused by infection of the intestine with the bacteria vibrio cholera. Diarrhoea is the loss of watery feces from the anus. If it is severe and continues for a long time it can lead to death. Severe diarrhoea can cause the loss of significant amounts of water & ions from the body, causing the tissues and organs to stop working properly. It is spread by ingestion of contaminated food or water, housefly picking up infected material from feces or contaminated food & then passing it onto human food, & consuming fish or seafood from contaminated water. It is mostly distributed in Asia, Africa & Latin America.

Symptoms: Incubation period is 2 hours – 5 days.

- Dehydration
- Vomiting
- Diarrhoea
- Leg cramps and restlessness
- Weakness
- Loss of fluid & salts
- Stomach cramps
- Sunken eyes & cheeks
- Thirst



Tests:

- Stool culture specimens and microscopic examination.
- Dipstick test of rectal swab.

How the Bacteria Acts:

- Bacteria attaches to the wall of the small intestine/alimentary canal.
- Bacteria is digested & multiplies.

- The bacteria releases choleragen toxin.
- The toxin stimulates the epithelial cells lining the intestine to release chloride ions from inside the cells into the lumen of the intestine.
- The chloride ions accumulate in the lumen of the small intestine and lower the water potential there.
- The osmotic balance is disrupted.
- Once the water potential is lower (due to the loss of salt) than that of the cells lining the intestine, water starts to move out of the cells & into the intestine by osmosis.
- Large quantities of water are lost from the body in the form of watery feces.
- The blood contains too little chloride ions and water.
- This disease is endemic in areas with poor sanitation.

Preventions:

- Development of sewage system.
- Effective sewage management plants.
- Contact tracing of cholera to its grass roots.
- Drink and use safe boiled water.
- Introduce chlorine tablets into water bodies.
- Wash hands and do not defecate in water bodies. Clean up safely.
- Cook well, prevent raw meat and eat it hot.
- Vaccination

Treatment:

- Rehydration: oral (ORS) or intravenous.
- Antimicrobial therapy period
- Use of glucose.
- Antibiotics (only in severe cases reducing chances of resistance): Doxycycline, Ciprofloxacin.

Global Factors affecting the distribution of Cholera:

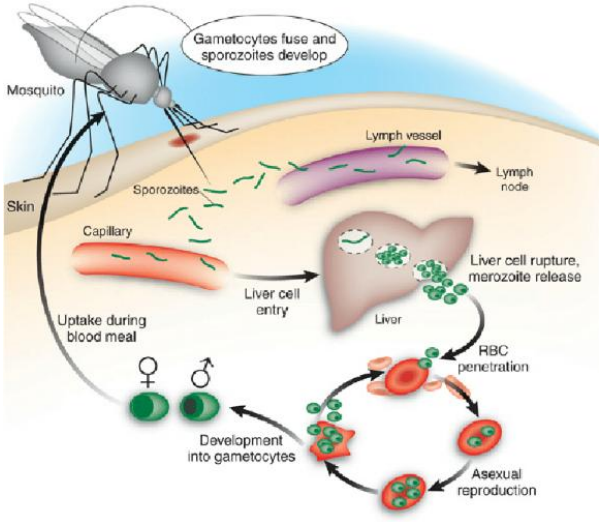
- Lack of access to safe drinking water and proper sanitation facilities is the primary driver of cholera outbreaks, as contaminated water sources readily facilitate the spread of the bacteria causing cholera.
- Extreme weather events like floods and droughts can disrupt water systems, leading to contamination and increased cholera transmission.

- Mass migration due to conflict, natural disasters, or economic reasons can rapidly spread cholera to new areas, especially when sanitation conditions are poor in refugee camps.
- Poverty, lack of awareness about hygiene practices, and inadequate healthcare access can contribute to the severity and spread of cholera outbreaks.
- Warm, humid climates and poor sewage management systems can create favorable environments for the cholera bacteria to thrive.

Malaria: Malaria is caused by a protozoan parasite called plasmodium which is transmitted from person to person by the bites of an infected mosquitoes of the genus anopheles species. The site of actions is the liver, RBS's, & brain. It may also be transmitted through the placenta to the fetus & by blood transfusions. It is mostly distributed in the tropics.

Symptoms: Incubation period is 7 – 365 days.

- High Grade Fever
- Violent Shivering
- Profuse sweating
- Chills
- Body aches
- Weakness



Tests:

- Microscopic examination of blood.
- Dipstick test containing antibodies.

How the Protist acts:

- Anopheles Mosquitoes feed on infected human blood.
- Pathogen gametes taken up–fuses in the mosquito's gut – enters the salivary gland.
- When an Anopheles Mosquito bite a human, it insert sits sharp, pointed mouth parts to the skin till they reach capillary, injecting saliva containing anticoagulant preventing a blood clot.
- An infected mosquito will inject hundreds of malarial parasites. The parasites reached delivered via this circulation and burrow into the liver cells where they reproduce. 1-2 weeks later, the daughter cells break out of the liver cells and invade the red blood cells.

- They rapidly reproduce & escape from original red blood cells to invade others in 2-3 days. Each time the daughter plasmodia are released simultaneously from thousands of the RBC's, the patient experiences chills, accompanied by violent shivering followed by a fever and profuse sweating.
- A person with sickle cell anemia is naturally and affected by malaria do cell shape, however malaria destroying so many RBCS can make one become anemic. If a mosquito sucks blood from an infected person it will take up the parasite in the RBC. The parasites reproduce in the mosquito and finally invade the salivary glands, ready to infect the next human.
- The protist plasmodium multiplies in both humans & the mosquito.
- The protist can alter a mosquito's behavior, physiology, fitness, reducing their lifespan & ability to transmit the disease.

<u>Preventions:</u>

- Providing adequate sewage treatment infrastructure.
- The provision of clean, piped water that has been chlorinated to kill bacteria. This strategy means that cholera is very rare in developed countries.
- Vaccination programs in areas where cholera is common.
- Killing Mosquitoes in their larval stage.
    - Spraying living areas with insecticides:
    - Spreading oil over the surface of water bodies & stagnant water in which mosquitoes breed.
    - Draining marshes, swamps & other unnecessary bodies of water
    - Ensuring ponds & irrigation or drainage ditches are stocked with fish that feed on mosquito larvae.
    - Unfortunately, mosquitoes lay eggs in even very small puddles and pools of water and therefore it is practically impossible to control all breeding sites.
- Avoid Getting Bitten:
    - Sleep under bed nets, which can also be soaked periodically in insecticide to increase effectiveness,
    - People should avoid exposing their skin at dusk when mosquitoes are most active.
    - Avoid wearing dark clothes as it attracts mosquitos allowing them to camouflage.
    - Use mosquito repellents.

- Killing Adult Mosquitoes:
    - Spraying insecticides like DDT sprays in their resting places.
- Using drugs to prevent *Plasmodium* infecting humans. Drugs, such as chloroquine and mefloquine, are taken before, during and after a visit to a location where malaria is prevalent.

Control:

- Ready access to treatments such as oral rehydration therapy; a solution containing glucose, salts and water.
- Monitoring programmes by the World Health Organisation (WHO).
- Using antibiotics in severe cases (preventing resistance).
- WHO & the governments are focusing more on:
    - Working within health systems to improve diagnosis.
    - Improving the supply of effective drugs.
    - Using drugs in combination to reduce drug resistance.
    - Promoting appropriate methods to prevent transmission, such as the use of biological controls to target the larvae and insecticide-treated bed nets.
    - The entire *Plasmodium* genome has been sequenced.
    - The approval of two effective malaria vaccines which have been decades in development; these can now be rolled out in affected areas.

Treatment:

- Anti-malarial/ Prophylactic (preventive) drug: Quinine, Mefloquine.
- Chloroquine (inhibits protein synthesis of parasite).
- Strains of drug resistant plasmodium have developed (one resisting Mefloquine appear in Thailand-Laos border).
- Some doctors can misdiagnose initial malaria symptom as influenza.
- Some people do not realize they lose immunity when they re-enter their home country after years of being away.

Global Factors affecting the distribution of Malaria:

- Malaria is caused by one of four species of the protoctist Plasmodium but these protoctists are transmitted to humans by an insect vector (female Anopheles mosquitoes).
- The Anopheles mosquitoes favour habitats that have high rainfall, high temperatures and high humidity.

- This means malaria can occur where these mosquitoes are present and, as a result, is found throughout the tropics and sub-tropics (about 80% of cases are in Africa).
- The Anopheles mosquitoes found in Africa also have longer lifespans and prefer biting humans than animals.

Human Immunodeficiency Virus/ Acquired Immunodeficiency Virus: is a syndrome caused by a retrovirus (contains RNA not DNA) as it contains reverse transcriptase. Human immunodeficiency virus (HIV), is having that attacks the cells of a body's immune system leading to a disease called AIDS Acquired Immunodeficiency syndrome. Immunodeficiency refer to how the virus weakens a person's immunity or the special cells of the immune system called the CDA cells which help the lymphocytes to protect against pathogen. Once the virus enters the bloodstream it inserts its own genes into the CD_4 Cells producing more copies of the virus. HIV uses CD_4 cells (cluster of differentiation 4 cells) to make thousands of copies of itself in the process of killing cells. This continues until the CD_4 cells fall so low that the immune system stops working efficiently. This makes a person more vulnerable to infections.

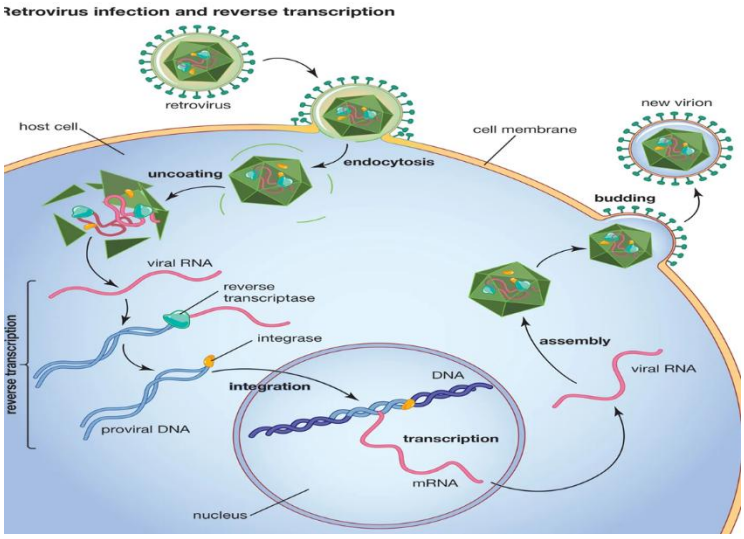
<u>Symptoms:</u> Incubation period is 2 – 12 weeks.

- Flu-like symptoms
- Rapid weight loss
- Swollen glands & lymph nodes
- Recurring fever
- Profuse night sweats & Rash
- Joint pain
- Extreme weakness & fatigue & unexplained tiredness
- Prolonged swelling of the lymph glands in the armpits, groin, or neck
- Diarrhea that lasts for more than a week
- Sores of the mouth, anus, or genitals
- Chronic yeast infections
- Pneumonia

<u>Tests:</u>

- Antigen/ Antibody Test

- NAT Test
- Dipstick Test Containing Antibodies
- Preliminary Antigen Test
- Final Confirmatory Test



Stages:

- Acute HIV Infection
- Chronic HIV Infection
- AIDS: Acquired Immunodeficiency Virus

How the Virus Acts:

- Once inside a host cell, the viral RNA is converted 'back' to DNA (hence 'retro') to be incorporated into human chromosomes.
- The virus infects and destroys cells of the body's immune system so that their numbers gradually decrease.
- These cells, known as helper T cells, control the immune system's response to infection.
- When the numbers of these cells are low, the body is unable to defend itself against infection, so allowing a range of pathogens to cause a variety of opportunistic infections.
- AIDS is not a disease; it is a collection of these opportunistic diseases associated with immunodeficiency caused by HIV infection.
- Since HIV is an infective agent, AIDS is called an acquired immunodeficiency to distinguish it from other types – for example, an inherited form.
- Infects and destroy T-helper cells of the immune system.
- The immune system therefore do not respond effectively making it vulnerable to other diseases – common cold and TB.
- AIDs – is a conglomeration of opportunistic disease.

Transmission: HIV is not transmitted by a vector as its unable to survive outside the human/ host's body.

- Unprotected Coitus with an infected person – exchange of bodily fluids such as semen & vaginal fluids, but not saliva (because a combination of antibodies and enzymes found naturally in saliva prevent HIV infecting new cells).
- Blood-to-Blood contact when drug users share an infected Needle or Syringes.
- Infected blood is given through blood transfusion.

- Viral Particles can be found in breast milk.
- HIV+ woman can transmit the virus to her baby during pregnancy or birth.

Preventions: Preventing the spread of HIV is very difficult as the virus has a long latent stage, which results in it being transmitted by people who have the virus but show no symptoms, and so may not know they are infected. This occurs because the virus can change its surface proteins, making it difficult for the human immune system to recognize it and for a vaccine to be developed.

- Blood donations can be screened for HIV and heat-treated to kill any viruses.
- HIV-positive mothers and their babies can be treated with drugs.
- Condoms, femidoms & dental dams can be used to decrease the infection risk during coitus & oral sex by forming a physical barrier between body & fluids.
- Education programs about how the virus is transmitted can be introduced to encourage people to have HIV tests & to avoid unprotected coitus.
- Intravenous drug users encouraged not to share needles.
- Improving healthcare facilities so doctors do not reuse syringes at local clinics.

Control:

- Contact tracing (and the subsequent testing of those contacts for the virus).
- Screening blood donations.
- Public health measures, such as widespread HIV testing of the population and education programs.
- Needle-exchange schemes have been set up in some places to exchange used needles for new, sterile ones.
- Encouraging individuals to be tested for HIV.
- Using anti-retroviral drugs.
- The socio-economic status of a person or country with HIV can determine how it is controlled.
- For example, HIV-positive mothers are advised not to breastfeed & opt for bottle feed instead in high income countries, however, in low & middle income-countries breastfeeding is more affordable, & offers protection against other diseases like cholera, due to the presence of antibodies in the colostrum.

Treatment or Management:

- Cannot be cured rather managed or slowed down.
- Post-exposure prophylaxis (PEP) means taking HIV medicines within 72 hours (3 days) after a possible exposure to HIV to prevent HIV.

- Using variety of anti-viral drugs (problems here are side effects & cost) with effective treatment/management for opportunistic infections has increased the avg. time b/w HIV infections & the onset of AIDS.
- Increasing life expectancy.
- The drugs are similar to DNA nucleotides (E.g. Zidovudine is similar to the nucleotide that contains the base thymine). Zidovudine binds to the viral enzyme reverse transcriptase and blocks its action. This stops the replication of the viral genetic material and leads to an increase in some of the body's lymphocytes.
- HIV can be managed with HAART (Highly Active Anti-Retroviral Therapy) & a combination of anti-HIV medications that strengthen Immunity.

Global Factors affecting the distribution of HIV:

- HIV/AIDS has a worldwide global distribution but is especially prevalent in sub-Saharan Africa and South-East Asia, mainly due to a lack of education about how the virus is transmitted & a lack of access to items that offer protection from the virus during sexual intercourse such as condoms and femidoms.
- 70% of the world's deaths from AIDS occur in Africa
- AIDS is widespread throughout sub-Sahara Africa and is a serious public health problem because HIV infection makes people more vulnerable to existing diseases such as malnutrition, TB and malaria, which are all prevalent there.

Tuberculosis: caused by Mycobacterium Tuberculosis or Mycobacterium Bovis spreads through the air when people with active TB disease of the lungs or throat cough, speak, sing, or sneeze, releasing tiny droplets containing the bacteria. It can also be spread by undercooked meat & unpasteurized milk. The site of actions is primarily in the lungs & secondarily in lymph nodes, bones & gut. It is distributed worldwide, but more commonly found in developing countries with high population.

Symptoms: Incubation period is a few weeks – years.

- Coughing blood
- Coughs
- Chest pain
- Shortness of breath
- Fever
- Profuse Sweating

- Unexplained Weight Loss

Tests:

- Microscopic Examination of the sputum.
- Chest X-Ray

How the Bacteria Acts:

- Myobacterium TB usually enters the human body by entering the lungs through inhaled air, where it can multiply and spread to other parts of the body via the bloodstream.
- Once in the lungs, the bacteria can establish themselves in the lung tissue, causing inflammation and damage to the air sacs.
- The body's immune system attempts to fight the bacteria by forming granulomas (encapsulated lesions) around the infection site, but sometimes the bacteria can evade this response and continue to multiply.
- If not contained in the lungs, Mycobacterium can spread through the bloodstream to other organs like the kidneys, spine, brain, and lymph nodes, causing disease in those areas.
- If left untreated, it can potentially lead to severe illness such as lung damage, bone infections, neurological complications & even death.
- A significant portion of people infected with Mycobacterium tuberculosis develop a "latent" infection, meaning the bacteria are present in the body but are not actively causing disease symptoms.

Transmission:

- Airborne disease – in aerosol droplets.
- Infect the malnourished.
- Those living in overcrowded conditions – at risk.
- Opportunistic infection of AIDs.
- TB transmission can come from cattle milk/ meat.
    - 1940s: introduction of Streptomycin.
    - 1950s: Introduction of Vaccines.
- The disease was thought to have been eradicated, now it's on the rise.

Preventions:

BCG Vaccine.

Protects 70-80% of people receiving it.

Effectiveness of vaccine reduces with age unless exposed to TB.

TB can still be transmitted between cattle and human – cattle are tested on routines, milk is always pasteurized.

Control:

- Contact tracing (and the subsequent testing of those contacts for the bacteria).
- Affected use masks & are isolated or put in quarantine.

Treatment:

- Uses several bacterial drugs to ensure death to the bacteria.
- 6–9 months long treatment course.
- The bacteria – slow growing and not sensitive to drugs
- The patient must complete the whole course of drug or risk the bacteria becoming resistant.
    - Some bacteria survive the treatment, mutate and become drug resistant.
    - DOTS (Direct Observational Treatment Program) used to ensure complete process in the course of treatment.
    - Isoniazid/ Rifampicin used.
    - Some species of TB is now resistant to Isoniazid and Rifampicin.
- MDR-TB (Multiple-Drug-Resistant) are on the rise.

Global Factors affecting the distribution of TB:

- TB spreads more quickly among people in overcrowded conditions.
- People who sleep close together in large numbers are at a high risk.
- TB primarily affects the homeless and people who live in poor, standard housing.
- Some people may be infected with TB but do not show symptoms. However if the person infected with HIV is malnourished they can become infectious thus contributing to the spread of TB.
- High rates of TB can also be found in cities with population of migrants from countries where TB is common example parts of London have much higher TB rates than the rest of the UK.

10.2 Antibiotics

Antimicrobials: is a wider berm uses that includes all agents that act against microorganisms, namely bacteria, fungi, viruses & protozoa.

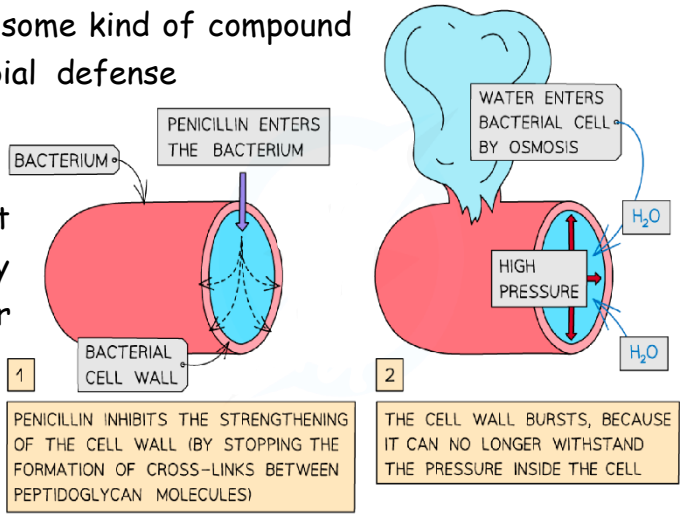
Antibiotics/ Antibacterial	Bacteria	Drugs for bacterial pneumonia
Antivirals	Virus	Drugs for herpes & HIV
Antiparasitic	Parasites	Drugs for malaria

Antifungals	Fungi	Drugs for yeast infections

Antibiotics: Antibiotics are important medicines for the treatment of bacterial infections in humans & animals. Since their introduction in the 1940's antibiotics have saved countless lives & has made many medical techniques possible or safer. They are selective toxins that kill or disable pathogen without harming the host. They only work on bacteria & are derived from living organisms. They are Bacteriostatic which means they stop/ prevent bacterial growth. They target a variety of processes like:

- Synthesis of bacterial cell walls.
- Activity of proteins in bacterial cell surface membranes.
- Bacterial enzyme action.
- Bacterial DNA synthesis.
- Bacterial protein synthesis.

Penicillin: Penicillin the penicillin mold secreted some kind of compound that was killing the bacteria & had a microbial defense system. The penicillum mold constantly produces penicillin in order to defend itself from threats, such as nearby bacterial colonies that might consume its resources. Penicillin destroys many types of bacteria by disrupting synthesis of their cell walls. These cell walls get their strength from a thick protective mesh of sugars & amino acids that are constantly being broken down & rebuilt. Penicillin lands to 1 of the compounds that weaves this mesh together & prevents the walls from being reconstructed at a critical phase. Meanwhile, penicillin stimulates the release of highly reactive molecules that causes additional damage. Eventually, the cell's structure breaks down completely.



- Bacterial cell walls are composed of peptidoglycan.
- Peptidoglycan molecules are held together by cross-links.
- When a new bacterial cell is growing it secretes enzymes known as autolysins that create small holes in the bacterial cell wall.
- These holes allow the bacterial cell wall to stretch as the cell grows, and new peptidoglycan molecules then join up via the cross-links described above.

- Penicillin stops these cross-links forming by inhibiting the enzymes that catalyse their formation.
- However, the autolysins keep creating holes in the bacterial cell wall, making the walls weaker & weaker.
- As bacteria live in watery environments and take up water by osmosis, their weakened cell walls eventually burst as they can no longer withstand the pressure exerted on them from within the cell.
- This means penicillin is only effective against bacteria that are still growing, as autolysins no longer create holes and no more cross-links form once the growth of a bacterium is complete.
- Antibiotics, such as penicillin, do not affect viruses as they do not have cells and therefore cannot be targeted in any of the ways that an antibiotic targets a bacterial cell.
- When a virus replicates, it uses the host cell's mechanisms for transcription and translation, so not even these processes can be targeted.
- Penicillin is not effective against all bacteria due to:
    - Thick cell walls which reduce permeability to penicillin.
    - Enzymes which break down penicillin.
- When one antibiotic is not effective against a particular bacterial species, an antibiotic with a different mechanism of action can be used.
- Allergy the appeared rash is often blamed on penicillin, while the more like culprit is the original infection, or a reaction b/w the infection & the antibiotic. Genuine allergies are rare but dangerous, however, it can can outgrows in 10 years.

Antibiotic Resistance:

Within a bacterial population, genetic variation exists between individuals; this is the result of random mutation.

- Bacteria is smart, evolves & becomes resistant to medicine if too much is used too often. A chance mutation might give rise to a new allele that causes some bacteria to become resistant to an antibiotic. This resistance spreads when antibiotics are given to food producing animals & crops/livestock. Animals develop drug-resistance bacteria in their gut. Drug-resistant bacteria reaches humans through food, environment (air, water, soil) or by direct human-animal contact.

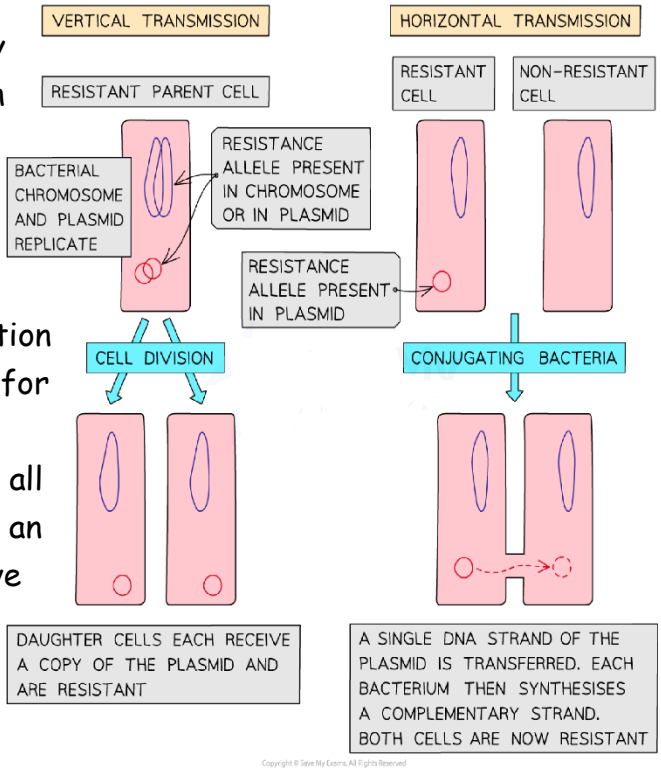
- Drug-resistant bacteria spreads to the general public. It spreads by Travelling & pollution.
- Antibiotics are given to patients, which can result in drug-resistant bacteria developing in their gut.
- Patients attends hospital or clinic & Drug-resistant bacteria spreads to other patients through poor hygiene & unclean facilities. Drug-resistant bacteria spreads to the general public.

- MRSA (Methicillin-Resistant Staphylococcus Aureus): is a super bug which is an evolved form of bug that is resistant to several antibiotics & is difficult to treat.
- Some pathogenic bacteria have become resistant to penicillin as they have acquired an allele that codes for the production of the enzyme β-lactamase (also known as penicillinase), which breaks down penicillin.
- When the bacterial population is treated with this antibiotic, the bacteria with the resistance allele do not die.
- The antibiotic acts as a selection pressure, effectively selecting the resistant bacteria.
- This means the resistant bacteria can continue to reproduce with less competition from the nonresistant bacteria, which are now dead.
- Therefore the allele for antibiotic resistance is passed on with much greater frequency to the next generation.
- As bacteria only have one allele of each gene, a new allele will have an immediate effect; it cannot be masked by a second allele, as it might be in eukaryotes.
- Over time, the antibiotic resistance allele increases in frequency, and a higher proportion of the bacterial population is resistant to the antibiotic.
- This is an example of evolution by natural selection.
- Tuberculosis has impermeable wall and has an enzyme that can break down penicillin.
- Bacterial membranes can sometimes pump out antibiotics. Eg. Enzyme beta-lactamase can be found in soil bacteria which grow in unfavorable condition – this enzyme can break down penicillin – it is transmitted via horizontal and vertical transmission to other bacteria.
- Pathogens can develop resistance to antibiotics.
- Developing enzymes for destroying penicillin.

- Can develop if people misuse antibiotic.
- There are two ways by which resistance can be transmitted – vertical and horizontal.

Vertical Transmission:

- Bacteria can evolve by natural selection very quickly, b/c reproduce very fast through asexual binary fission, carrying out what is known as vertical gene transmission where genes are passed from one generation to the next.
- Frequent DNA replication means that mutation rate is high, so the probability of an allele for resistance arising is increased.
- In asexual binary fission the o spring are all clones of the parent, so all the o spring of an individual with a resistance allele will also have the resistance allele.
- Bacteria can divide as often as every 20 minutes, so the number of individuals with a new resistance allele can increase very fast.



Horizontal Transmission:

- Plasmids may contain antibiotic-resistant genes.
- These plasmids are frequently transferred between bacterial individuals in the same generation.
- This can occur between bacteria of the same species, or bacteria of different species known as conjugation.
- In this way, a bacterium containing an allele for antibiotic resistance could pass the allele on to other bacteria.

Effective Using of Antibiotics to reduce Resistance: Widespread use of antibiotic can lead to bacteria developing multiple resistance (one plasmid carrying resistance for many antibiotics).

- Should be used sparingly.
- Only use against bacteria and not virus.
- Tighter controls in countries where antibiotics are sold without a prescription.

- Doctors prescribing antibiotics only when needed, e.g. antibiotics not being used for viral infections.
- Avoiding the blanket use of 'wide-spectrum' antibiotic, and instead prescribing specific antibiotics for different types of infection tighter control of antibiotics in agriculture.
- The spread of already-resistant strains can be limited by ensuring good hygiene practices, such as hand-washing and the use of hand sanitizers, especially in clinical environments.
- Isolating infected patients to prevent the spread of resistant strains, in particular in surgical wards where MRSA can infect surgical wounds.
- Scientists need to find new antibiotics to which bacteria have not yet been exposed, as well as antibiotic alternatives, but this process is expensive and time-consuming
- Take antibiotics as prescribed & complete the entire course, even if you feel better.
- Do not save antibiotics for future use.
- Do not use someone else's antibiotics.