Biology Year 12

Module 7- Infectious Disease

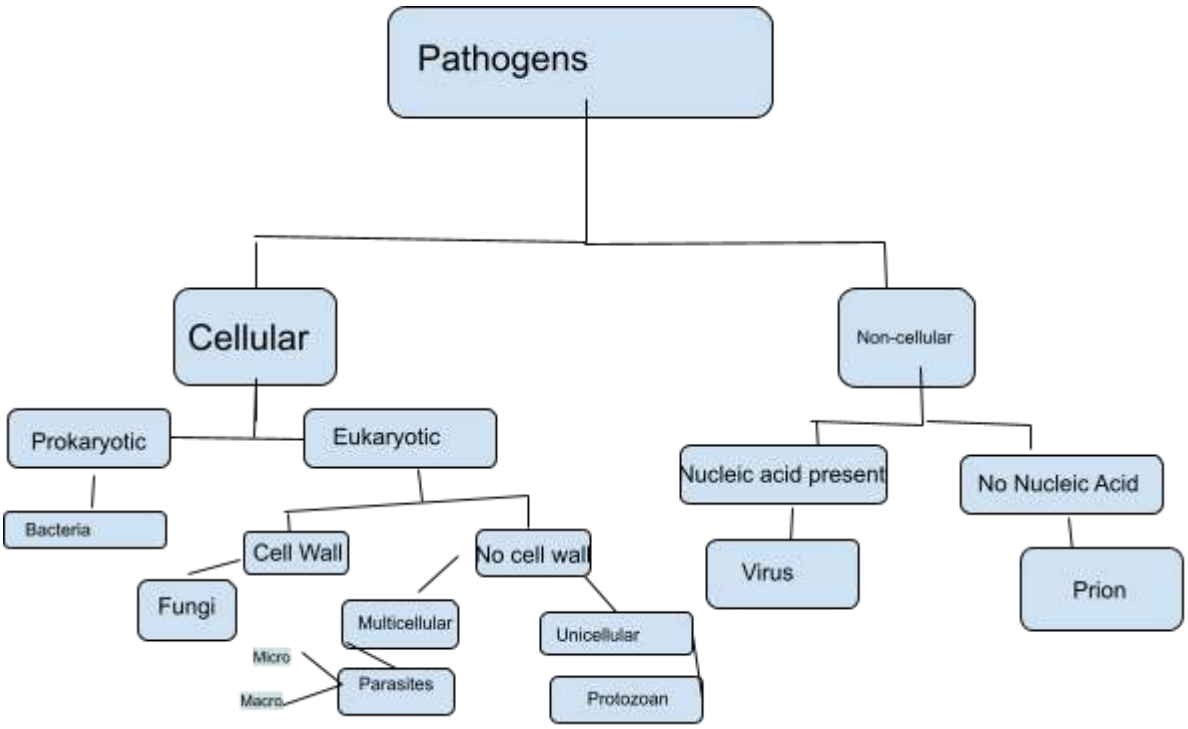
Causes of Infectious Disease

Inquiry question: How are diseases transmitted?

1. *Infectious Diseases caused by pathogens*

Infectious diseases are those caused by a pathogen. A pathogen is therefore an agent of infection.

Pathogens can be classified as follows:



Pathogen Examples:

Pathogen and Size range	Example	Features	Mode of Transmission
Prion: an abnormal protein that causes disease of the CNS. (Misfolded proteins) Approx- 1nm (nanometer)	Kuru	Also called 'spongiform' disease as it causes 'holes' to form in brain tissue. The abnormal folding of proteins spreads in the body. Symptoms- headaches, tremors, loss of coordination. No cure currently available	Kuru was transmitted in Papua New Guinea when brain tissue infected with prions were ingested. The brain tissue contained the code that caused the mutation of proteins. They can form spontaneously as well. Prion diseases can e transmitted via surgery or transplants
Virus (non-cellular):	Rotavirus	Symptoms include	Direct contact with

Approx- 100nm		vomiting, diarrhoea and fever. No treatment + vaccine available	faeces of infected person. Contact with bedding of infected person ingesting contaminated food/water
Protozoa-unicellular eukaryotes lack cell walls Approx- 5 to 600 micrometer	Malaria- *Plasmodium* species (protozoan parasite- complex life cycle in 2 hosts)	Symptoms include fever and flu-like illness, muscle aches, tiredness, chills, vomiting, diarrhea. May cause anemia and jaundice. Mainly affect red blood cells. It can be treated and there is a vaccine available	Transmitted by Anopheles mosquito, which is the primary host and vector. Humans are the secondary hosts. Once infected via a mosquito bite.
Fungi - unicellular or multicellular eukaryotes, cell wall present. Varies considerably Approx 5 micrometers to 20cm	Athlete's foot- *Tinea Pedis*	Highly contagious. Symptoms- itchy, flaky skin on the feet	Spread by skin to skin contact or indirectly through towels clothes or floors
Macro- parasite Varies considerably	Tapeworm disease- *Taenia Saginata*	Can show few symptoms, although infection may be associated with epigastric pain, diarrhea and weight loss	Humans are infected by ingestion of raw or undercooked beef infected with *Cysticercus bovis*, the larval stage of *T. saginata*. In humans, the adult tapeworm develops in the intestine over 2–3 months. The cycle of infection repeats when infectious eggs are passed in the faeces and later ingested by cattle, slowly migrating into the flesh and transforming into the larval stage
Bacteria - a prokaryotic organism, most have a cell wall	Whooping cough- pertussis	A bacterial infection caused by *Bordetella pertussis.* Symptoms - fever, uncontrolled bouts	Whooping cough is highly contagious. It spreads when an infected person coughs or sneezes

Approx- 1 micrometre		of coughing that sounds like a 'whoop' or are followed by a 'whooping' noise, vomiting after coughing	and you breathe it in.

Question: *List 2 features of prions that distinguish them from Protozoans:*
Prions are proteins that have not folded in the correct way and are approximately 1 nanometer in size. They are non-cellular in nature whereas protozoans are. Protozoans are significantly larger than prions being measured in micrometres rather than nanometers. Protozoans can be easily killed from heating however a prion can not be when it is in the organism's body.
Question: *A new product has been designed to kill pathogens in drinking water. Design an experiment to test its effectiveness. 4mks*
The experiment should have a water source that contains pathogens

Investigation: Microbial Testing of Water
Aim: To investigate the effect of boiling water samples on the presence of microbes.
Hypothesis: The boiled samples will contain fewer microbes.
Variables:

- **Independent:** Whether the water is boiled or not. (Water Treatment)
- **Dependent:** The amount of microbial growth
- **Controlled:** Incubation temp, size of the sample used, duration of boiling, same agar batch

Risk Assessment:

Hazard	**Risk**	**Precaution**
Microbes	Infection and cause illness	Wash hands Seal plates and do not reopen Sterilise hands Disposal done by lab tech
Bunsen Burner	Burns	Use caution Use appropriate equipment when handling hot material

Method:

1) Collect the water samples to be tested
2) Collect 10 agar plates. Seal 2 immediately as 'controls'
3) Boil the selected samples for 2 minutes. Allow to cool
4) Use an inoculating loop to sweep a sample of each water source across the agar
5) Incubate for 3 days at 30 degrees.

Site	Treatment	No. of Colony types present	% SA coverage
Control (not opened)	None	1 bacterial	< 1
Creek 1 Creek 1	None Boiled	1 bacterial 4 bacterial	96
Creek 2	None	9 (8 bacterial/fungal)	82

Creek 2	Boiled	3	1.5
Pond 1 Pond 1	None Boiled	3 1	12 <1
Pond2 Pond 2	None Boiled	6 2	72 <1

Note: use a grid to determine percentage coverage in order to create precision

Discussion:

The microbes present in the agar can be identified as either fungal (fuzzy outline) or bacterial (shiny appearance). Other features can also be used like the elevation shape and margin shape. Using a grid is helpful to determine the surface area coverage. The smaller the grid used, the higher the precision.

Without adequate staining techniques, there is no way of identifying specific microbes and there is, therefore, no way of knowing if they are pathogenic.

Overall from the data obtained it appears that in many cases, boiling the water does reduce the microbes present in the sample eg.

2. *Investigating the work of Robert Koch and Louis Pasteur to explain the causes and transmissions of infectious disease*

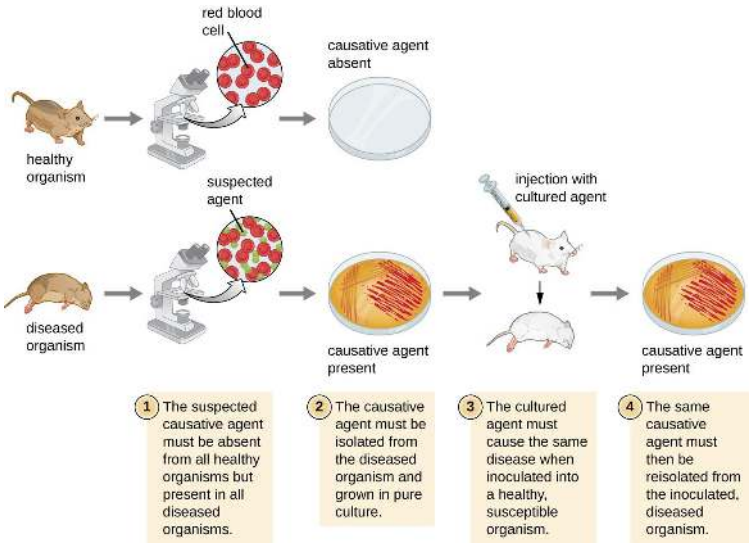
Koch's Postulates

Robert Koch was a German bacteriologist who found ways to identify many pathogens. He developed four conditions of identification of Pathogens known as Koch's Postulates:

1. The pathogen must be found in all animals suffering from the disease but not in healthy animals.
2. The germ must be able to be isolated from a host containing the disease and grown/cultured outside the body.
3. The cultured pathogen should cause disease when introduced into a healthy animal.
4. The pathogen must be re-isolated from the experimentally infected animal

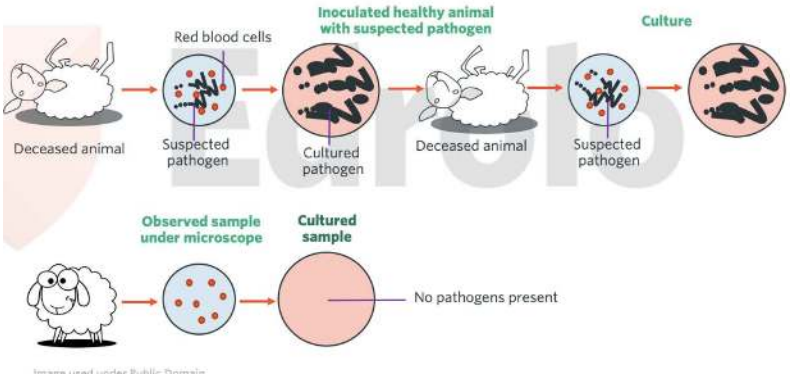
Example: Through this method, it was discovered that Vibrio cholera was a causative pathogen of cholera.

After this method was developed we can now isolate the pathogen causes which disease and target specific treatment to that disease



Koch predicted that specific microscopic pathogens cause specific disease.

Aim: To demonstrate that infectious diseases are caused by specific microscopic pathogens.



Louis Pasteur

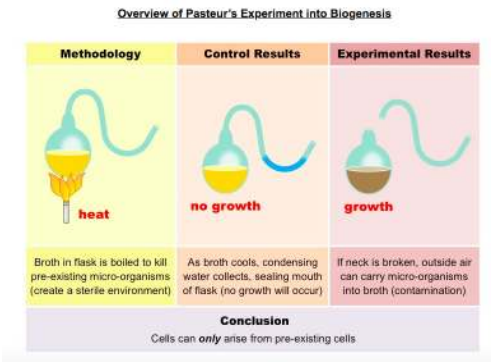
Louis Pasteur worked in the agricultural industry and found ways for vaccination, microbial fermentation and pasteurisation, and developed vaccines such as Amthrax vaccines to help prevent the disease anthrax caused by the bacterium Bacillus Anthracis infecting livestock.
Biogenesis describes the principle that living things only arise from other living things by reproduction (not spontaneous generation)

The law of biogenesis is largely attributed to Louis Pasteur, who demonstrated that emergent bacterial growth in nutrient broths was due to contamination by pre-existing cells

- Broths were stored in vessels that contained long tubings (swan neck ducts) that did not allow external dust particles to pass
- The broths were boiled to kill any micro-organisms present in the growth medium (sterilisation)
- Growth only occurred in the broth if the flask was broken open, exposing the contents to contaminants from the outside
- From this it was concluded that emergent bacterial growth came from external contaminants and did not spontaneously occur

Louis Pasteur had also invented Pasteurisation which involved heating liquids to a high temperature (60-100 degrees) to kill microorganisms that cause spoilage or disease).

- Louis Pasteur set out to disprove spontaneous generation with an now-classic experiment that both firmly established the cell theory beyond doubt (cells come from other cells) and solidified the basic steps of the modern scientific method.



Experiment: Swan-neck flask experiment

Aim: To model the famous swan-neck experiment by Louis Pasteur.

Hypothesis: The flask exposed to the air will show signs of contamination whereas the other flask will not.

Variables:

Independent: The shape of the neck of the flask

Dependent: The microbial growth/ contamination

Control (min 3): The type and volume of beef broth, the amount of time it takes to boil, the temperature of the area it is put in, type of flask, age of the broth, the environment in which the flasks are kept

Method:

1) Place the broth equally between 4 flasks and boil for 5 minutes
2) Top 2 flasks with a curved glass tube and the other flasks with a straight glass tube
3) Allow to sit in a shaded area for 2 weeks and observe for signs of contamination- cloudiness, colour change, colony growth.

Results:

	Observations
Curved Tube	No noticeable change after 2 weeks
Straight Tube	Significant discolouration - Fungal colonies on both surfaces - Broth cloudy - Up to 4 different colonies on one surface

Discussion:

1) **Why was the broth boiled first?**
   The Broth was boiled first to ensure that there was no risk of pre-contamination and microbes present that could affect the validity of the experiment.
2) **How does this experiment compare with the original swan flask experiment**
   Similarities: Both boiled, used meat broth, had growth occurring in the flask that had more air exposure.
   Differences: didn't complete the second part of the experiment where Pasteur tipped the flask so that the solution could reach the condensation of the swan-neck where the microbes would be trapped, showing that whatever had been there had affected the microbial growth, his experimental design was also slightly different.
3) **What is the purpose of the two different tubes on the flasks?**

The straight tube allowed complete air exposure, however, the curved tube allowed for the microbes to be trapped. Showing some time of contamination in the air causing the disease, not spontaneous. Showed clearly that microbes are associated with disease.

Conclusion- Was the hypothesis supported?

The hypothesis of this experiment is supported as, from the observations, the flask with the straight tube showed a large amount of microbial growth and contamination compared to the curved tube which showed no signs of contamination.

Outbreaks, Epidemics and Pandemics

Key Terminology (World Health Organisations' definitions)

- Outbreak: a situation where the case numbers of disease are in excess of what is typically expected. Eg. Giardia outbreak due to a contaminated water supply.
- Epidemic: The occurrence in a community or region of cases of an illness in clear excess of normal expectancy. It differs from an outbreak when the disease moves into other geographical areas. Eg. Ebola epidemic in Africa.
- Pandemic: An epidemic that occurs worldwide or over very large geographic areas
- Endemic: a disease that is always present in the community eg. influenza.

Case Study: Ebola Epidemic

	Ebola
Geographical Area Impacted	While the epidemic spread to parts of Africa, Europe and the United States, the largest impact was Guinea, Sierra Leone, and Liberia, the epicentre of the epidemic
Cause	EVD is caused by the Ebola virus. Its origin or how it started is unknown. Scientists believe that it is animal-borne and most likely comes from bats, which transmit the Ebola virus to other animals and humans.
Symptoms	Initial symptoms include Pain areas: in abdomen, chest, joints or muscles Whole Body: chills, dehydration, fatigue, fever, loss of appetite, malaise, or sweating. Gastrointestinal: diarrhoea, nausea, vomiting, or vomiting blood Also common: coughing up blood, eye redness, headache, mental confusion, red spots on the skin, or sore throat.
Transmission	The virus is spread through direct contact (such as through broken skin or mucous membranes in the eyes, nose, or mouth). This could be through - Blood/Body Fluid - Objects - Infected fruit bats of non-human primates - Semen from a man who recovered from EVD → however there is no evidence of it being spread through vaginal fluids
Management	**Providing fluids and electrolytes (body salts) orally or through infusion into the vein (intravenously)**. Using medication to support blood pressure, reduce vomiting and diarrhoea, and manage fever and pain. Treating other infections, if they occur.
Future Controls	Strategies to Prevent Ebola Outbreak **Prevention and Vaccine** ● Avoid contact with blood and body fluids (such as urine, faeces, saliva, sweat, vomit, breast milk, amniotic fluid, semen, and vaginal fluids) of people who are sick. ● Avoid contact with semen from a man who has recovered from EVD, until testing shows that the virus is gone from his semen.

3. *Causes and effects of disease on agricultural productions including plant and animal diseases*

Exotic Disease: Diseases that aren't native to Australia and are introduced from the outside eg. aviant influenza, Newcastle disease: a highly contagious disease affecting birds caused by a virus.

- Plant diseases: are typically caused by various fungi and bacteria and can have a large scale effect on agricultural production. Eg. Panama Disease is caused by fungus *Fusarium oxysporum* . The Pathogen is resistant to fungicide and cannot be controlled chemically.
- Animal Diseases: Caused by various viruses and bacteria and can have a large scale effect on agricultural production. Eg. Anthrax: is caused by the bacterium *Bacillus Anthracis.* It affects a wide variety of domestic and wild animals.

Case Study of Diseases in Agriculture:

	Pink Eye in Cattle	Wheat leaf Rust
Disease and Pathogen name	Infectious Bovine Keratoconjunctivitis (IBK) *Moraxella Bovis*	Puccinia trichina (disease and pathogen name)
Pathogen Classification	Bacterium	Fungus
Transmission	Vehicle transmission and Direct transmission: Predisposition to this disease is through irritation to dust, bright sunlight, physical irritation to the eye(eg. a thistle) and flies. This irritation causes tear production which attracts flies. The flies feed on infected secretions and move from animal to animal spreading bacteria.	Vehicle Transmission: This disease transmits via billions of wind-carried spores. The spores can only survive a short-term period. It is infected when a spore of the pathogen lands on a wheat leaf, it germinates and grows a tube-like thread until it penetrates the leaf via an open stomate. Once inside, it develops a different thread-like structure that can penetrate a leaf cell and begin feeding
Symptoms	The Bacterium produces a toxin that attacks the surface of the eye (cornea) and the surrounding membranes (conjunctivae), causing severe inflammation.	Causes rust-coloured, powdery spots on the infected leaves. It is an economically significant disease and if not controlled could cause a reduction of 20% or more in the yield of an infected crop
Management and prevention strategies used	In order to manage this disease, the carrier or infected cattle should be isolated from the rest of the herd to prevent further spreading of the bacterium, treatment to the infected cattle should then be given treatment for the infection. Treatments include topical Anti-biotics such as Orbenin-containing penicillin, eye patches and an intramuscular antibiotic. Prevention strategies include fly control, weed control and also trying to get cattle that are less susceptible	Resistance can be achieved when the fungal cells release a variety of proteins. If the wheat plant has "R-genes" receptive to the fungal proteins apoptosis (Apoptosis is the process of programmed cell death) occurs to kill the unwanted cells and continues the process in nearby cells as well. In other circumstances, Foliar sprays may suppress the disease in infected crops for three to five weeks depending on fungicide, rate and local conditions.

	to pink eye, such as the ones that have hooded eye confirmation that offers protection from sunlight and physical damage	

4. The Adaptations of different pathogens that facilitate their entry into and transmission between hosts

Many pathogens are termed intracellular as they enter cells and it is here that they survive and multiply. The ability to cause disease in a host is called pathogenicity and virulence is the degree to which the pathogen causes disease. A pathogen with high virulence has properties that enable it to bring abroad a high level of disease in a host.

Adaptations:

- Using a vector
- Attachment to host tissue
- Ability to withstand harsh environments
- Biofilms (secreting a layer of slime-like substance to protect themselves)
- Producing toxins
- Binding to molecules on the surface of host cells
- Ability to survive inside white blood cells
- Altering the behaviour of the host organism (causing the person to have symptoms eg. making the person sneeze)
- Changing antigens on the surface of the microbe so that white blood cells don't recognise them
- Drug resistance
- Avoiding white blood cells (Phagocytes)

Adaptation	How it works	Example
Attachment to Tissue	Once inside the host the pathogen attaches to host cells or to tissue so that food moving through the intestine or urine doesn't expel them from the body.	Macro parasite: Tapeworm has a specially adapted head with strong suckers and hooks for attachment to the lining of the small intestine so it can absorb nutrients
Biofilms	Colonies of bacteria produce a slime-like substance surrounding themselves which makes it difficult to identify and makes them more resistant to antibiotics	Bacterium: Staph. Aureus causing sinus infections
Producing Toxins	Pathogens produce toxins that destroy cells resulting in difficulty in clearing the infection.	Bacterium: H.Pylori produces a toxin that destroys the cells lining the stomach thereby causing an ulcer.
Altering the behaviour of the	By inducing symptoms and	Virus: Influenza and Rhinovirus

host organism	altering the behaviour of the host to assist the spread of the microbe to other hosts.	will cause the host to cough and sneeze that expel virus particles through direct/droplet transmission inhaled by others spreading the disease.

Responses to Pathogens

Inquiry question: How does a plant or animal respond to infection?

5. Responses of plants to pathogens

Investigating Plant Diseases:

While plants do not have a specific immune system like animals, they do have a number of defences against pathogens. Plant defences can be placed into 2 categories:

1) Passive responses- these include
   - **Physical barriers:** having thick, waxy cuticles on the leaves can make a pathogen entry difficult. Other examples include- bark on the outer surfaces, sap in the phloem and vertical hanging leaves (reduces water sitting on leaf surfaces).
   - **Chemical barriers**: chemical compounds produced by the plant can reduce fungal and bacterial growth eg. Saponins, a bitter-tasting compound produced by some plants that can repel macroparasites
   - **Chemical signals** can be produced to encourage stomates to close, reducing means of pathogen entry
2) Active responses - When passive barriers are breached, plants have more active defence systems that can be more targeted-
   - **Pathogen Recognition:** plants have the ability to detect pathogens by the chemicals present eg. on the cell wall of bacteria
   - **Rapid response (minutes to hours):** Plants have the ability to change their cell membrane permeability hindering pathogen entry. They can also release a burst of hydrogen peroxide that kills microbes.
   - **Cell Apoptosis:** can also occur. This means dead plant cells cluster around the pathogen to isolate it.
   - **Delayed Response (days):** repairing wounds and secreting lysozymes that have an antimicrobial action.

Case Study:

	Fungal Infection- Pathogen: *Armillaria root rot*
Plant Species Affected	Eucalyptus (many species), Wattles
Symptoms	Yellowing of foliage, dieback of the limbs and branches, presence of large sheets of fungal growth behind the ark (mycelial fans)
Plant Response to Infection	Enters through the roots and avoids the physical barriers. Once passive barriers are breached, the plant launches a sophisticated defence response involving phytohormones such as salicylic acid.
Transmission	Contacts from the infected roots come into contact with uninfected roots, fungal spores dispersed and land on wood surfaces initiating infection

6. ***Analyse responses to the presence of pathogens by assessing physical and chemical changes that occur in the host animals' cells and tissues***

Animal Responses to Pathogens:

When an animal is exposed to a pathogen, an immune response is triggered that involves a range of physical and chemical changes in order to counteract and eliminate the pathogen.

Overview:

Body Defence/Immune response

Innate: inherited and non-specific to a specific pathogen

Ist Line- physical and chemical barriers

2nd Line- inflammation (physical and chemical responses)

Adaptive: acquired and specific

3rd Line- Chemical responses

First line of defence:

This line of defence is present from birth and is genetically determined. Its response to pathogens is non-specific (response is the same and doesn't involve specific targetted responses eg. antibodies). This line of defence involves both physical and chemical barriers. Many are summarised as follows:

- **Skin:** (Epithelial Tissue)
    - Composed of 3 layers: (Out to In) Epidermis, dermal, subcutaneous
    - The skin is well supplied with blood vessels and this contributes to its defence- white blood cells and platelets are immediately available.
    - The epidermis contains keratin which provides a sort of 'waterproofing'. Keratin also provides protection against some bacterial enzymes
- **Sphincters-** a circular ring of muscle that can constrict and close off different areas eg. between the oesophagus and stomach.
    - Sphincters can reduce the movement of pathogens
- **Mucous Membrane:** the cells in the membrane secrete mucous that physically trap pathogens.
    - Located in the mouth, nose, stomach, urethra and vagina. They are an important barrier for areas that are more exposed to pathogens is often an early sign of infection.
    - An increase in mucous production is often an early sign of infection.
- **Physical Responses:**
    - The human body can react to pathogen exposure in ways to prevent further exposure or reduce exposure. These include vomiting and diarrhoea that assist in expelling the pathogens.
    - Increased urination is another response to flush pathogens
    - Wound healing is also crucial to reduce further infection. Platelets cause blood clotting and fibrin (a protein that helps heal wounds.)
- **Chemical Defences:**
    - Urine: pH between 5.5-8. Contains peptides that prevent bacteria from attaching to the urethral wall.
    - Sebum (oil) and sweat: Sebum lubricates the skin to prevent cracking. The skin is typically slightly acidic (approx. 5.5) due to oil and sweat and this makes it inhospitable to many pathogens. Sweat contains lysozyme(enzyme) that breaks down bacterial walls.

Note: The body's microflora also plays a significant role in reducing pathogens. They reside in our intestinal tract and skin, helping to reduce the likelihood of detrimental microflora.

- **Recognition of self:**
    - Self-recognition is achieved through our major histocompatibility complex (MHC). Genes on chromosome 6 code for MHC proteins that attach to the surface of cells.

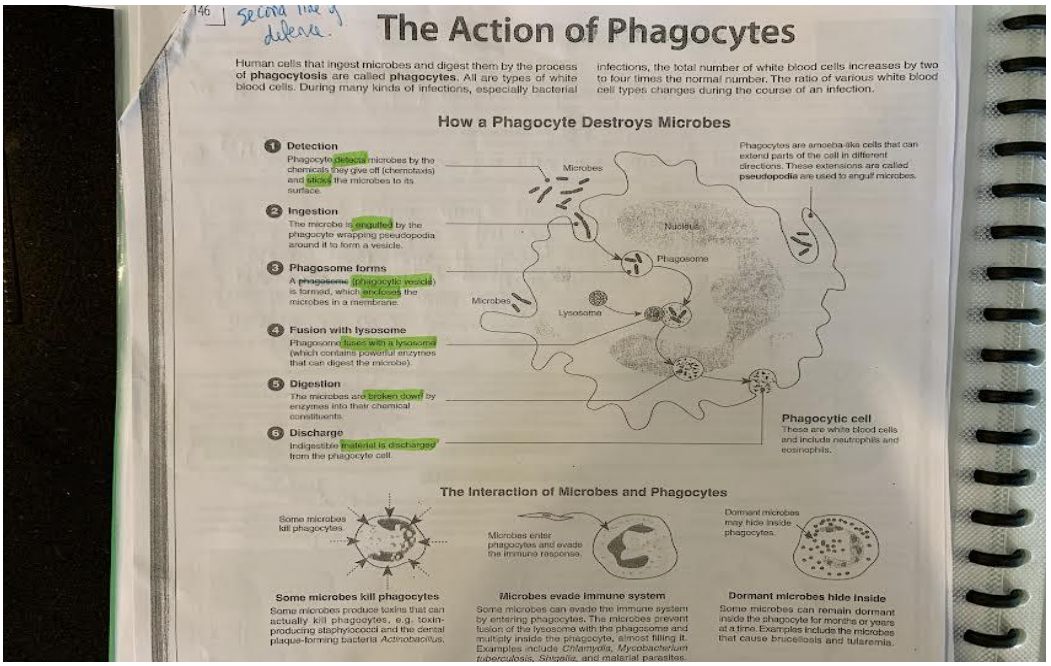
They are used by the immune system for self-recognition. The surface proteins act as a chemical signature and are often called MHC antigens.

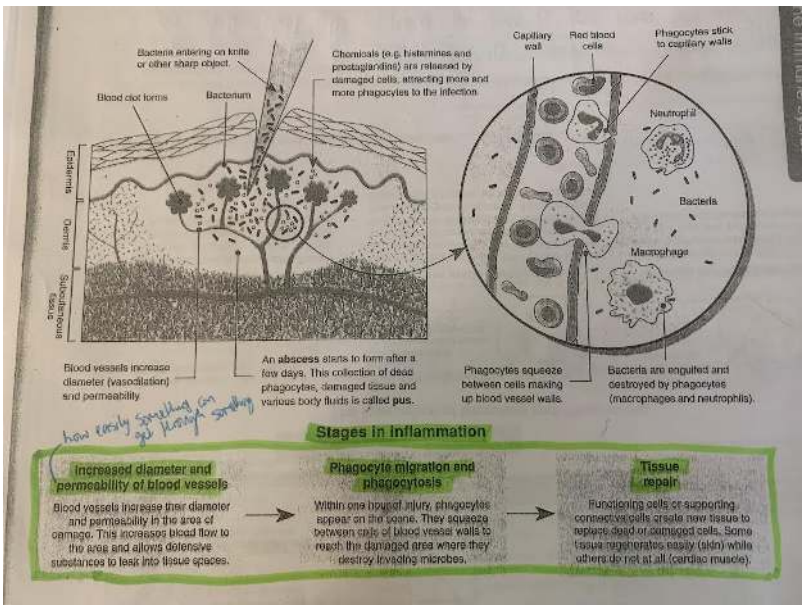
Second Line of Defence: *Covered mostly in sheet*

Defence mechanisms inside the body to inhibit or destroy pathogens. These responses react to the presence of a pathogen regardless of its species and include non-specific white blood cells. The second line of defence includes

1) Blood clotting and defence
    - Maintains blood flow, the volume of blood and prevents further bleeding(haemostasis)
    - Seals the wound to prevent further infection/pathogen exposure
    - Process:

      1. Injury to the lining of blood vessels exposes collagen fibres to the blood where platelets can stick
      2. Platelet releases chemicals that make the surrounding platelets sticky
      3. Platelets clump together which forms a plug against blood loss
      4. Formation of a fibrin clot that reinforces the seal and forms a scab
2) The action of Phagocytes: Phagocytes destroy microbes by ingesting them using the following steps:



3) Inflammation: 

4) Fever: occurs with a rise in body temperature which causes the metabolism to speed up so that damaged cells are repaired. It releases a protein called interleukin that increases the production of T-cells that help fight the specific infection, another protein that is intensified is interferon which is an antiviral protein that inhibits the growth of viruses

Cytokine is a small protein that has the function of cell signalling in the immune system

<u>Important Anatomical structures of the immune system:</u>

- Bone Marrow
    - immune cell production site
- Thymus gland
    - where lymphocytes mature before entering the bloodstream.
- Spleen
    - Site of antigen presentation
    - Blood filtration- removal of old cells and pathogens
    - Red blood cell storage
- Liver
    - site of antigen presentation (this means the place where white blood cells go to present the pathogen triggering third defence response
- Lymph nodes
    - Filter's lymph fluid
    - Site of antigen presentation
- Lymph fluid
    - This is the excess fluid that is filtered and returned to bloodstream transports lymphocytes

Note: Lymphocytes are a specific class of leukocytes (white blood cells). They include natural killer cells, T-cells and B-cells.

<u>Cells of the Immune System:</u>

<u>Granulocytes</u> (a family of white blood cells)

1) Neutrophils (kinda like the bridge between innate and adaptive immune response)
    - Present in high quantities
    - Use phagocytosis against all infections
    - Present antigens to adaptive immune system
2) Eosinophils

- act against multicellular parasites by destroying cell surface

3) Basophils
    - Play a key role in inflammation by releasing histamines to trigger whole inflammation response

Monocytes and Macrophages: Large cells involved in phagocytosis and antigen presentation

1) Monocytes
    - they have roles in phagocytosis, antigen presentation and cytokine production(a protein important in cell signalling)
2) Macrophages(big eater)
    - Tidy up any pathogens, foreign debris and old or dead cells from their tissues using phagocytosis. Also, perform antigen presentation and can activate memory cells.
3) Dendritic cells (professional antigen-presenting cells)
    - Activating T-helper cells and memory cells
    - Phagocytose pathogens before migrating to lymph nodes where they present antigens on their cell surfaces

Lymphocytes: Small specialised white blood cells. Apart of the Adaptive Immune Response.

1) B cells
2) T cells
3) Natural Killer cells

Immunity

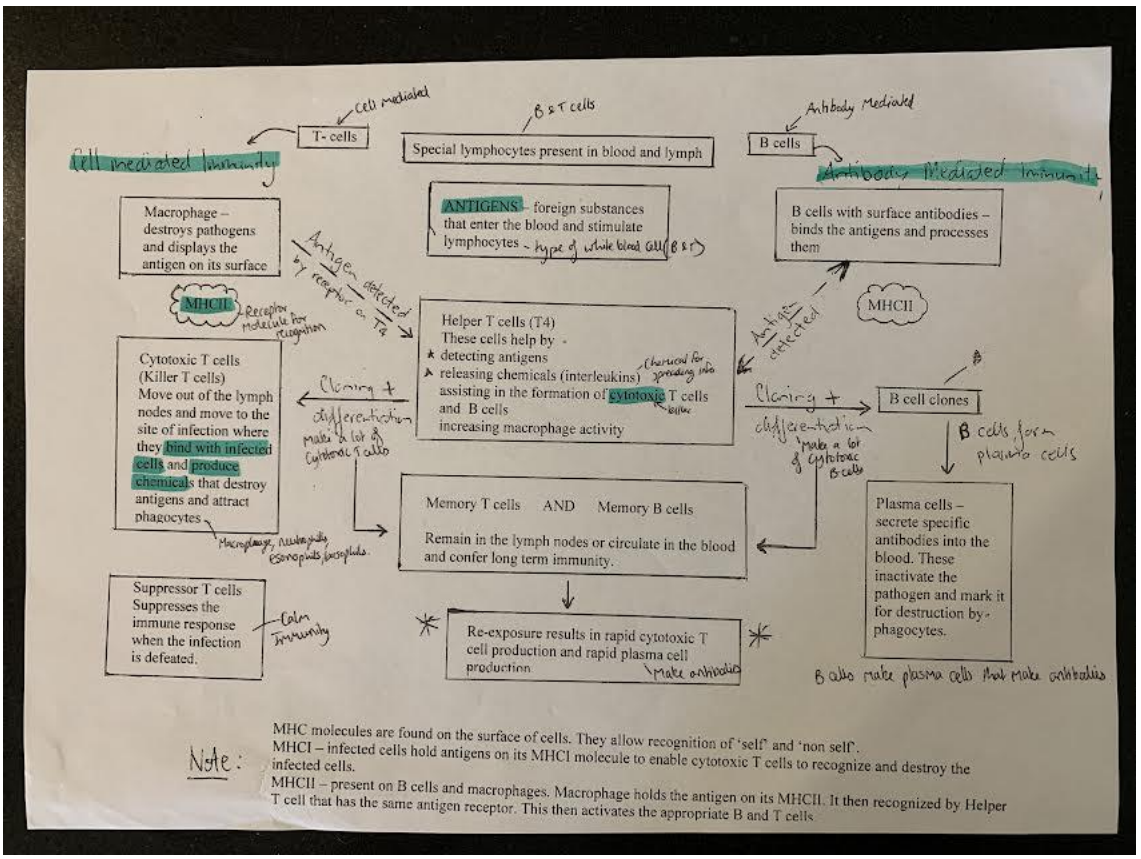
Inquiry question: How does the human immune system respond to exposure to a pathogen?

7. Innate and adaptive immune systems in the human body

Comparison of Innate and adaptive immune systems:

Innate	Adaptive
Immediate response	Slow/delayed (3-5 days from primary exposure-*first time exposed to pathogen*). 72-96hrs to generate antibodies
No memory	Builds memory- antigen-specific due to memory B and T cells. B memory cells make plasma cells that make antibodies
Encoded in our genome	Generated by an exposure
Present at birth	Acquired throughout life
Receptors recognise general ‘non-self’ markers	Receptors are antigen-specific (specific pathogens)

Adaptive immune system summary:



<u>The complement system- a number of proteins that enhance the immune system (apart of both innate and adaptive and is an immediate response)</u>

C3 triggers the start of the complement cascade, marks and disables enemies

A group of proteins that assist the immune system. They can do this in a number of ways including:

- Assisting the inflammation process
- Attaching to the surface of a pathogen to help phagocytes take hold of it for destruction
- Creating holes or pores in some pathogens (eg. Bacteria) causing them to rupture

8. How the immune system responds after the primary exposure to a pathogen, innate and acquired immunity

Innate Immune Response: Inflammation, Fever, Leukocytes such as neutrophils, basophils, eosinophils, macrophages and monocytes, compliment system

Adaptive Immune Response: Antigens presented, T and B cells

Prevention, Treatment and Control

9. Range of interrelated factors involved in limiting local, regional and global spread of an infectious disease

<u>Limiting the spread of disease:</u>

There are 3 levels of monitoring and controlling the spread of infectious disease.

1. Local: this relates to villages, cities or towns. The spread of a disease can be directly related to the methods used for waste disposal, sewage, water sources and living densities
2. Regional: states or countries. The spread of a disease can relate to movement throughout local areas, geography and trade
3. Global: increased movement across the world has had a direct impact on the spread and control of infectious diseases. The ease of travel means greater opportunities for diseases to spread from region to region. The overuse of antibiotics in many countries is also a global issue as some strains of bacteria are becoming resistant. In terms of control, the internet has made it easier for information to be shared and gathered by researchers.

Case Study: Covid-19

Covid-19 or coronavirus is an infectious disease caused by the SARS-CoV-2 virus. The main mode of transmission is through direct contact and droplet transmission spread from an infected person's mouth or nose through a cough, sneeze, breath or speech. It can also be spread through indirect contact by touching a contaminated surface and then touching your face, nose, eyes or mouth. The virus tends to spread easier indoors and in crowded settings. Covid-19 has 5 so far identified different adaptations and variants of concern including Alpha, Beta, Gamma, Delta and Omicron. The Delta variant has caused the most severe symptoms whereas Omicron has been more contagious and easily spread.

Factors affecting-

Local spread:

- Social distancing was a way to prevent contraction of the disease by staying 1.5m away from each other and proved to be effective as it avioided many potential covid cases especially as the transmission of the disease is through direct/droplet contact.
- Mask wearing protects the wearer from droplets and sprays from an infected person and somewhat filters the air depending on the type of mask. It also helps to trap any germs from an infected person wearing a mask. If worn correctly, washed and not touching your face after wearing the mask, they can be quite effective in preventing the local spread of disease
- Hand sanitizing: the effectiveness of hand sanitizing is based on the alcohol content in the substance, the ones with at least 60% alcohol are most effective in killing the germs from an infected Covid-19 person.

Regional spread:

- Lockdown measures prevented people within an area from travelling to another region where they could potentially spread the virus. This was effective as it slowed down the rate of infection and prevented as many people from contracting the disease, however, it had a large impact on the economy as people were not able to operate and interact with businesses.
- Fines for breaches were in place so that people were less likely to travel and potentially spread the virus to another region which therefore was effective in slowing down the rate of infection

Global Spread:

- Prevention of travel between countries- large impact on the economy (especially tourism industry)- the spread of disease slowed however after being introduced had spread on a regional and local level- goods still being shipped around the world which could have potentially carried the disease(however quarantine methods would have mostly prevented this)- slow receiving of supplies due to quarantine and not being able to get goods from some areas-slower rate of trying to find a vaccine cause of this global issue- internet was effective in informing people of the disease and for countries to communicate on travel and trade agreements.

10. Procedures employed to prevent the spread of disease

<u>Acquired immunity (part of third line of defence or adaptive immunity)</u>

Naturally acquired

- **Active:**
  - Antigens enter the body naturally through microbes that cause the person to catch the disease where the body produces antibodies and specialised lymphocytes (B, T and natural killer cells)
- **Passive**
  - Antibodies are passed from mother to fetus through the placenta and breast milk

Artificially acquired

- **Active**
  - Antigens(weakened or dead are introduced in vaccines and the body produced antibodies and specialised lymphocytes

- **Passive**
    - Antibodies are injected into the body and the body does not produce its own antibodies (e.g. antivenom)

- Vaccination (artificially acquired active immunity) helps prevent the spread of disease as the disease is not able to be spread from person to person as quickly as a vaccinated person's immune system will have a memory of the particular antigen to be able to fight the foreign substance more effectively and will not be as affected by it. Plus vaccination gives protection to unvaccinated people as having herd immunity prevents the fast spread of disease.
- Hygiene: Hygiene practices such as washing hands and coughing and sneezing into a tissue that is then thrown out help prevent and slow the spread of disease as it washes away and/or kills the microbes and germs that could be transmitted and eliminates an easy pathway from host to host.
- Quarantine: Quarantine is when an infected organism is isolated from healthy organisms and is restricted in coming into contact with others or vectors in order to prevent the spread and passing of disease to another.
- Pesticides: Pesticides eliminate microbes and bugs that may cause disease if consumed and also eliminate vectors that carry disease
- Public health campaigns: Targets populations and informs them of the disease and how it is transmitted therefore helping them remain safe and overall preventing the spread of disease. Also reminds people to practice good hygiene
- Genetic engineering (genetically modifying mosquitoes to be infertile): Genetically modifying vectors giving them the ability to fight pathogens or causing vectors to become infertile, making pest-resistant crops and plants so that disease is not transmitted through food consumption, GMO's for waste management.

11. ***Effectiveness of pharmaceuticals as treatment strategies for the control of infectious disease***

Antibiotic:
Antibiotics target bacteria, it is a type of medication such as penicillin that inhibits the growth of or destroys bacteria by damaging their cell walls or by stopping the production of proteins that bacteria need.

Antiviral:
Antivirals target Viruses and make virus infections less severe by reducing virus replication however they have to be given in a certain timeframe in order to be effective.

Vaccine: A way of exposing your body to an inactive or weakened form of a pathogen which makes the body launch an immune response which includes the production of antibodies against the pathogens, hence the immune system retains memory against the pathogen

Antibiotic and Antiviral Resistance: Bacteria and Viruses can mutate to resist medication used to control them

	Antibiotic	Antiviral
Pros	-Slow the growth/kill many bacterial infections -Fast-acting (some work within a few hours) -Easy to consume	-Once developed and common are less costly and widely available -May make a viral infection less severe

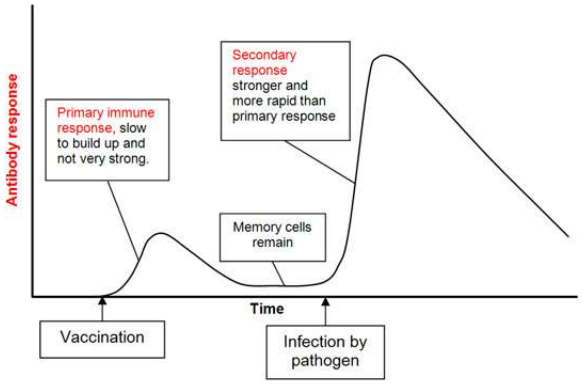
	Can prevent infection before surgery -Don't damage other cells	-Convience -Shorten infection length and viral load, also you're less likely to spread it to others
Cons	-May have side effects such as allergic reaction which could lead to fungal infections -If treatment is for a long time period it may damage immune system -May develop resistance (eg. Staph infection) -Can reduce beneficial microflora of the body	-Must be inflicted in a short time frame -Can't treat other pathogens -Certain populations can't receive eg. Immunocompromised and pregnant -Damage body cells

Antibodies:

Antibodies are molecules produced by plasma cells in response to a specific pathogen. However, antibodies can vary in shape and quantity/concentration. There are 5 classes of antibodies called immunoglobins and they are represented by the letters Ig (text pg.402). They vary in action as well-

- Neutralisation: Antibodies bind to the pathogen, blocking activity
- Agglutination: clumping together neutralised pathogens that are then surrounded by more antibodies
- Oposination: Tag the pathogen for destruction, (a macrophage might then come and eat it)

Antibody production graph:



12. *Environmental management and quarantine methods to control epidemic and pandemic*

Methods to control a pandemic- COVID-19

A number of methods have been utilized throughout the world to control the spread of Covid-19 since it first started in China at the end of 2019. Covid 19 is an infectious disease caused by the SARS-CoV-2 virus

Method of Control	Evaluation
Border closures	When strictly enforced, border closures are very effective. In Australia, WA closed its borders to both domestic and international travellers for 697 days. The borders closed in early April 2020 and

	since then there have been very low Covid numbers in WA. Even when borders reopened, case numbers are relatively low.
Mask Mandates	Not very effective in Australia due to the use of low-quality masks and improper use. If high-quality masks were used, the mandate would have been more effective.
Contact tracing	The use of QR codes to check-in was effective in terms of being able to track case numbers and inform people of exposure risk
Social Distancing	If enforced and followed it can be very effective. However, it requires a degree of personal responsibility that makes it difficult.
Quarantine/isolation	Very effective as it removes the host from the general population, therefore limiting the capacity for the pathogen to spread
Vaccine mandates	When vaccination levels are high and herd immunity is achieved, vaccines are very effective at controlling a pandemic. Enforcing vaccine mandates helps keep our most vulnerable people safer.

13. Data related to incidence and prevalence

Incidence and Prevalence of a disease

The accumulation of real-time data relating to the incidence, prevalence and mobility of a disease is crucial when it comes to the control of the spread of disease. This has been made easier with the rise of digital technology→ social media, the capacity to file share and the speed at which information can be shared.

Incidence: The number of new cases in a specific time frame.

$$\frac{\text{No. of new cases}}{\text{Total population at start of the monitoring period}} \times 100$$

Stated as a percentage eg. 1000 students in a school 25 cases on one day, incidence = 25/1000 x 100
= 2.5%

Prevalence: the proportion of the population that has the disease at any given time.

$$\frac{\text{All new and previous cases}}{\text{Total population}} \times 100$$

Eg. Over 3 months of winter, in a school of 1000 students, a total of 150 students were diagnosed with influenza
Prevalence = 150/1000 x 100 = 15.0%

Mobility: determines how easily disease is spread. The greater an infected person travels, the more likely they can spread the disease and increase its mobility

14. Historical, culturally diverse and current strategies to predict and control disease spread

John Snow (the father of Epidemiology)

-developed the hypothesis that cholera was transmitted through contaminated water
-planned an investigation that showed the correlation between contaminated water and cholera where he did house to house surveys looking at the source of water used by cholera victims
-The Southwark company used water that had been polluted with the cholera bacteria coming from the Thames in London, whereas the Lambeth company took its water from a clean stretch of the Thames before it had entered London.

15. ***Contemporary application of aboriginal protocols in the development of particular medicines and biological materials and how recognition and protection of indigenous cultural and intellectual property is important***

Indigenous Australian Medicine

Indigenous Australian traditional medicine or 'bush medicine' is still poorly understood by many in Australia.
The knowledge developed by Indigenous Australians over thousands of years is vast and needs to be preserved for future generations.
Indigenous knowledge in Australia has been shared through song, dance and the spoken word. Very little has been recorded or documented in writing.
This makes recognising the intellectual property rights of indigenous Australians challenging when considered from a westernised viewpoint.
Traditional medicine often involved treating both the physical cause of illness as well as the 'spiritual' cause.
Australia is moving towards protecting against 'biopiracy' which is the use of biological resources or knowledge without consent.
Example:
Emu Bush: leaves are used to cleanse surface wounds, gargled as a brewed tea to treat sore throats and burnt to produce smoke for inhalation.
The plant is believed to have antibacterial and antifungal properties.
Researches in SA are trailing its use to sterilise prosthetic implants.
Tea-tree oil
Used by Indigenous communities along the NSW coast. Leaves and bark crushed and applied to wounds and made into a tea for sore throats. Well recognised today for its antiseptic properties and a treatment for fungal infections eg. Tinea