TOPIC: DISEASE CONTROL

Key Knowledge:

- The difference between natural and artificial immunity, and active and passive acquired immunity
- The emergence of new pathogens and re-emergence of known pathogens in a globally connected world, including the impact of European arrival on Aboriginal and Torres Strait Islander peoples
- Scientific and social strategies employed to identify and control the spread of pathogens, including identification of pathogen and host, modes of transmission and measures to control transmission
- Vaccination programs and their role in maintaining herd immunity for diseases in populations
- Consequences of bacterial resistance and viral antigenic drift and shift in terms of ongoing challenges for treatment strategies and vaccination against pathogens
- The development of immunotherapy strategies, including the use of monoclonal antibodies for the treatment of autoimmune diseases and cancer

OUTBREAKS

Outbreaks are the sudden appearance of a disease within a population. If that outbreak is contained to a specific community or a restricted geographical area, it is classified as an **epidemic**. If the outbreak should spread rapidly over a wider geographical area (i.e. on a global scale), it is then classified as a **pandemic**.

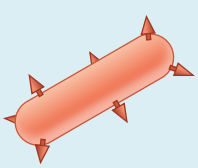
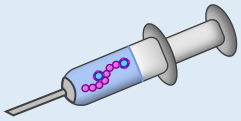
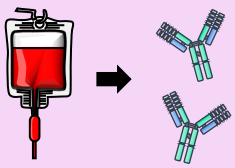
FIRST NATIONS

European settlement in Australia triggered a wave of epidemic diseases among Indigenous communities. This was because Aboriginal and Torres Strait Islander people had no prior exposure to certain pathogens (such as measles, smallpox and influenza) and hence lacked suitable natural immunity to these diseases. Additionally, colonisation impacted the normal behaviours of Indigenous populations, leading to higher rates of infection. For instance, the appropriation of land by the British resulted in the establishment of permanent camps, which lacked suitable sanitation and increased physical contact amongst the Indigenous Australians. Limited access to food sources also increased malnutrition, raising susceptibility to infection.

TYPES OF IMMUNITY

Immunity describes the capability of an organism to resist the disease symptoms associated with a harmful infectious agent. Immunity is typically achieved through the presence of **antibodies** to a specific pathogen. Immunity can be acquired by active or passive mechanisms, and can be naturally or artificially derived:

- **Active:** Production of antibodies by the body itself (with subsequence development of memory cells)
- **Passive:** Acquisition of antibodies from another source (with no associated memory cell development)

ACTIVE IMMUNITY		PASSIVE IMMUNITY	
Natural	**Artificial**	**Natural**	**Artificial**
			
Infection	*Vaccination*	*Maternal antibodies*	*Monoclonal antibodies*

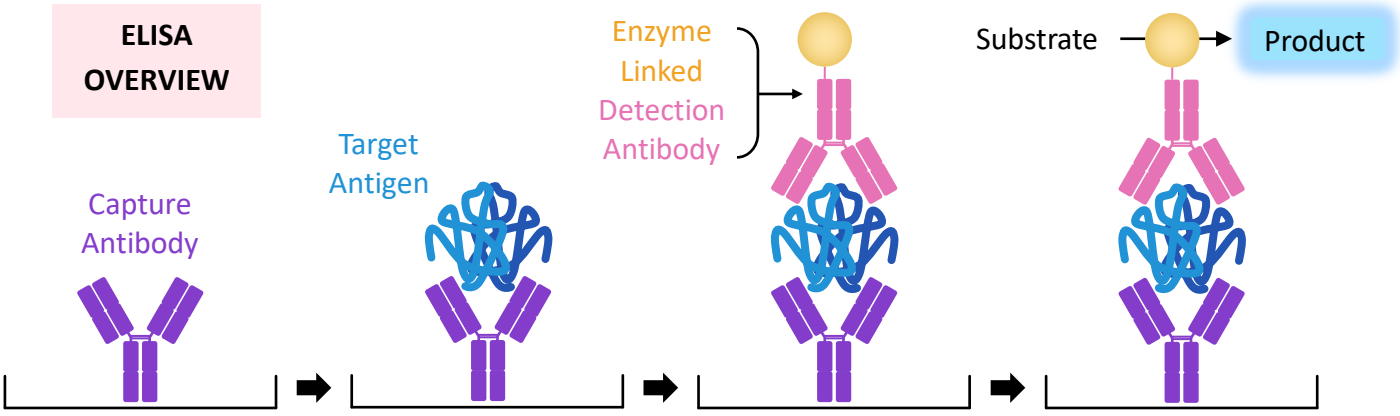
ARTIFICIAL IMMUNITY

As natural immunity involves the development of an immune response by the body itself, it takes time to initiate and confer ongoing protection. Consequently, while natural immunity will help prevent disease symptoms within the individual, it is less effective at preventing the spread of disease within a population. Artificial immune strategies can be utilised to provide more rapid protection and can even be employed pre-emptively (i.e. before initial exposure to the pathogen). Development of artificial immune strategies first requires the identification of specific pathogens within a host or population.

PATHOGEN IDENTIFICATION

Infectious pathogens can be detected using biotechnology. Examples of specific techniques include:

- **PCR Analysis:** PCR can be used to identify potential viral infections by using fluorescent primers that are specific to viral sequences. The PCR reaction can only proceed if the viral DNA has been integrated into the host cell, and so the amplification of fluorescently tagged viral sequences indicates infection
- **Gel Electrophoresis:** Proteins that are specific to a pathogen can be isolated using gel electrophoresis. Proteins are separated in a polyacrylamide gel and then transferred to a membrane that is then stained with monoclonal antibodies that are specific to target proteins (this process is called Western blotting).
- **Blood Cultures:** Pathologists can culture pathogens from samples of blood by spreading the sample on an agar plate and allowing the pathogen to grow. Further testing (including staining and microscopy) can be undertaken to determine the specific identity of the pathogen (cannot identify viral pathogens).
- **ELISA:** Enzyme-linked immunosorbent assays are used to identify specific antigens. This process uses capture antibodies to trap pathogens with specific antigens. Then enzyme-linked detection antibodies are added to provide positive identification (the will enzyme react with a colour changing substrate).



MODES OF TRANSMISSION

Transmission of infectious diseases can occur via either direct or indirect mechanisms:

- **Direct Transmission:** Via physical contact or droplet spread (i.e. exchange of body fluid, sneezing, etc.)
- **Indirect Transmission:** Via airborne transfer, non-living vehicles (food, fomites) or biological vectors

Diseases which are transferred from an animal host to a human host are called **zoonotic** diseases. Diseases which are transferred between human hosts by animal carriers are called **vector-borne** diseases. A human will be the *primary* host of the pathogen, while the vector functions as an *intermediate* host. In both cases, the animal can act as a reservoir for the pathogen, making it difficult to eradicate from human populations.

CONTROLLING SPREAD

Scientific and social strategies are employed to control the spread and distribution of pathogenic infection.

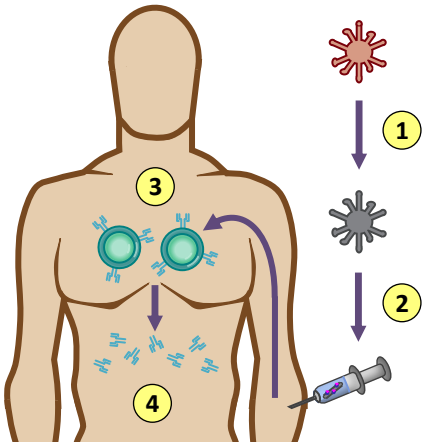
- **Scientific strategies** are interventions that act to reduce or stop the transmission of a given pathogen.
- **Social strategies** are the policies put in place to support the implementation of the scientific strategies.

Scientific strategies include vaccination programmes, the use of specific medications (antibiotics), contact tracing and quarantine protocols, health databases (for monitoring and modelling) and certain sterilisation procedures (such as water chlorination or fumigation). Biotechnology is also being used to limit the spread of certain pathogens by developing disease-resistant (or sterile) biological vectors via genetic engineering.

Social strategies involve the government legislations designed to support scientific interventions. This may include advertising campaigns or education programmes, funding scientific research and passing laws and mandates to ensure public compliance with specific directives (such as contentious vaccination mandates).

VACCINATION

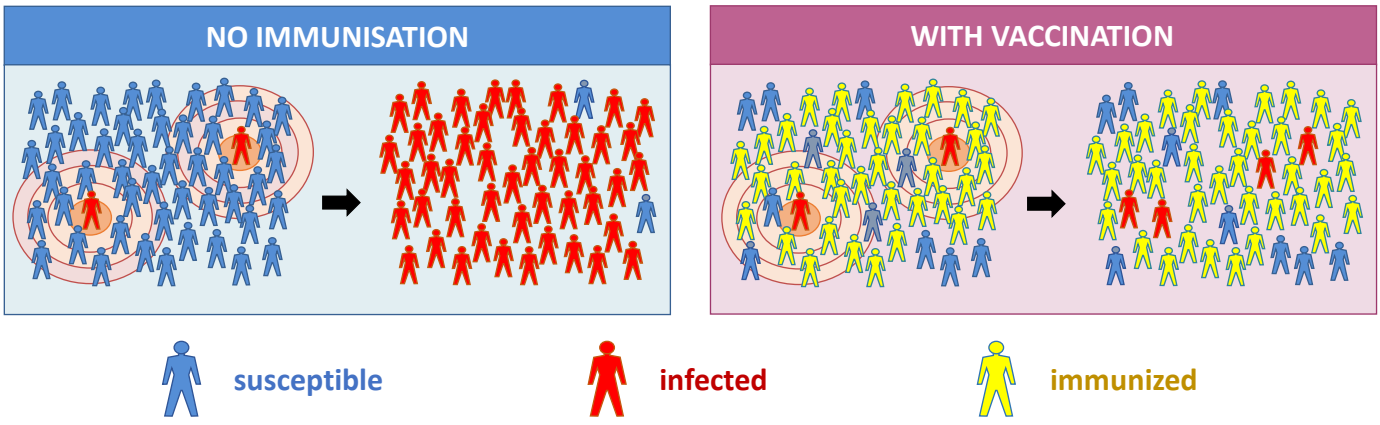
Vaccination involves the injection of a biological preparation (vaccine) to provide **active acquired immunity** to a particular infectious disease. Vaccines may consist of attenuated (weakened) pathogens, modified toxins or specific antigenic fragments. The preparation may also be conjugated to an **adjuvant** (functions to boost the immune response). The body responds to a vaccine by initiating a primary response that results in the production of memory cells. When an individual is then exposed to the actual pathogen, the memory cells will trigger a more potent secondary immune response that prevents disease symptoms from developing (the individual is now immune to the pathogen). The length of time immunity lasts following vaccination depends on how long the memory cells survive for – individuals may need subsequent **booster shots** to maintain immunity over prolonged periods of time.



1) Attenuate
2) Adjuvant
3) Memory cell
4) Antibodies

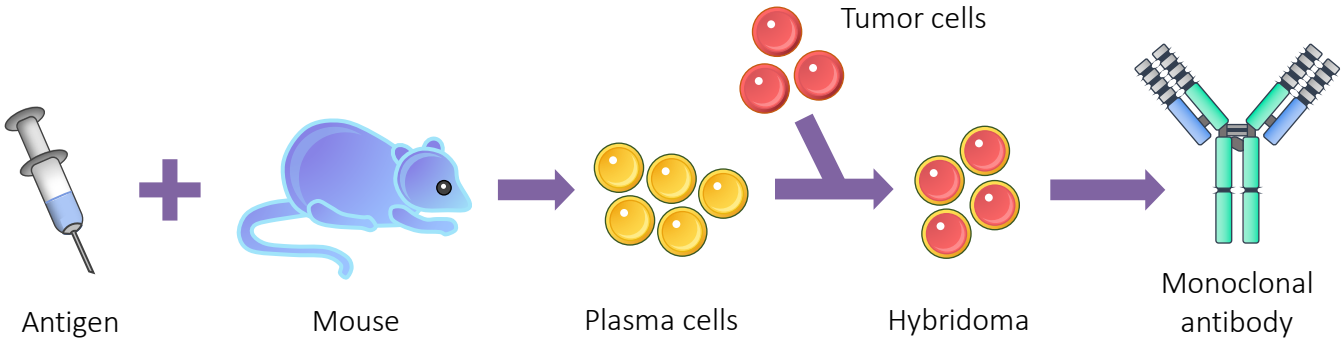
HERD IMMUNITY

Vaccinations confer immunity to vaccinated individuals but also indirectly protects non-vaccinated people via herd immunity. When a sufficiently large percentage of the population is immune to an infection (95%), there is a reduced risk of infection for individuals who lack immunity. Herd immunity limits the spread of a pathogen to individuals who are particularly elderly, extremely young or may be immune compromised.



MONOCLONAL ANTIBODIES

Monoclonal antibodies are antibodies that are artificially derived from a single B cell clone and can be used to confer **passive acquired immunity**. They are produced when an animal (typically a mouse) is injected with an antigen to produce antigen-specific plasma cells. These cells are removed and fused (hybridised) to tumour cells that are capable of endless divisions. The resulting **hybridoma** cell is capable of synthesising large quantities of antibody in relative perpetuity.

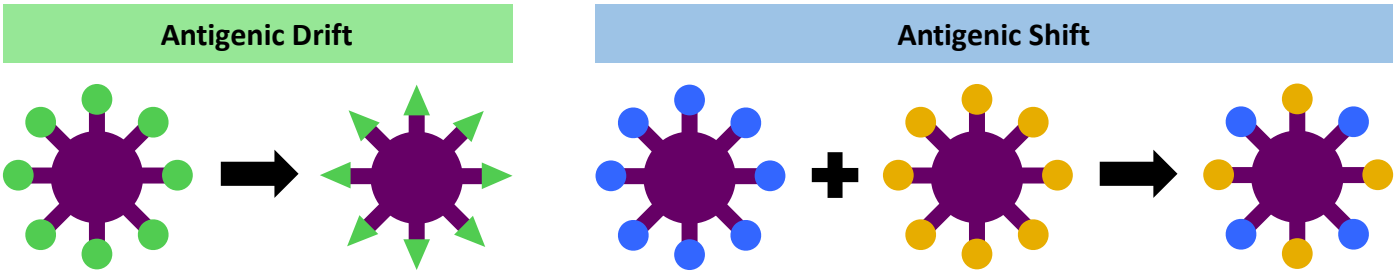


MONOCLONAL ANTIBODY TREATMENTS

Monoclonal antibodies can be used in the treatment of cancers or autoimmune diseases. Cancers are the result of uncontrolled cell division, while autoimmunity occurs when the immune system fails to recognise body cells as 'self' and begins to target its own cells and tissues. As both diseases are caused by defective body cells that are not foreign, natural immunity is typically ineffective. Monoclonal antibodies can be generated to target features that are unique to the defective body cells or by occluding the structures required by the cells to carry out the abnormal functions (and hence prevent the progression of disease).

ANTIGENIC DRIFT VS SHIFT

New viral strains emerge in communities if current strains alter their structure to develop new antigenicity. **Antigenic drift** occurs when the accumulation of point mutations leads to gradual changes in the surface proteins of a virus, such that pre-existing antibodies no longer recognise the virus. Antigenic shift occurs in viruses with segmented genomes, and results when an individual is infected with multiple viral strains that get reassorted to form new viral sub-types. **Antigenic drift** will lead to seasonal reoccurrences of viruses (requiring new booster shots), while antigenic shift leads to massive outbreaks (epidemics or pandemics).



Point mutations cause minor change

Exchange of gene segments causes major change

ANTIBIOTIC RESISTANCE

Bacterial pathogens can be treating with compounds that specifically target prokaryotic features (e.g. 70S ribosomes). These compounds are called **antibiotics**. Some bacteria have developed antibiotic resistance genes (via mutations), that enable them to survive antibiotic treatment. The bacteria can even pass these genes to susceptible colonies by bacterial conjugation (plasmid exchange), making antibiotics ineffective.