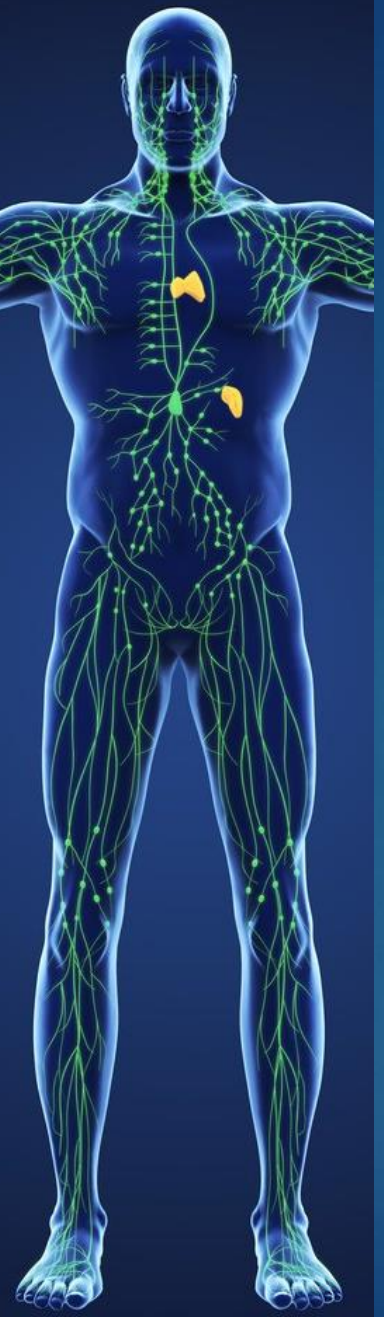
The Human Immune System and Homeostasis

MR. GILLAM HOLY HEART



The lymphatic System

- The lymphatic system is a network of tissues and organs that help rid the body of toxins, waste and other unwanted materials.
- The primary function of the lymphatic system is to transport lymph, a fluid containing infection-fighting white blood cells, throughout the body
- Lymph is either colourless or pale yellow and, in composition, is much like the plasma of blood.

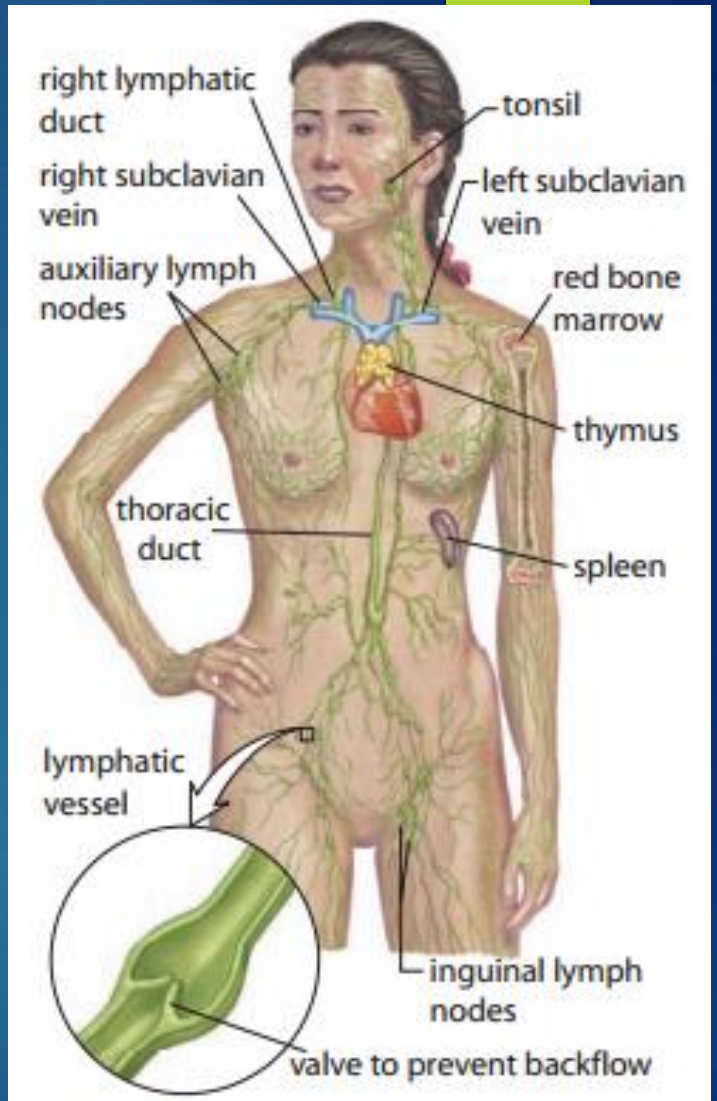
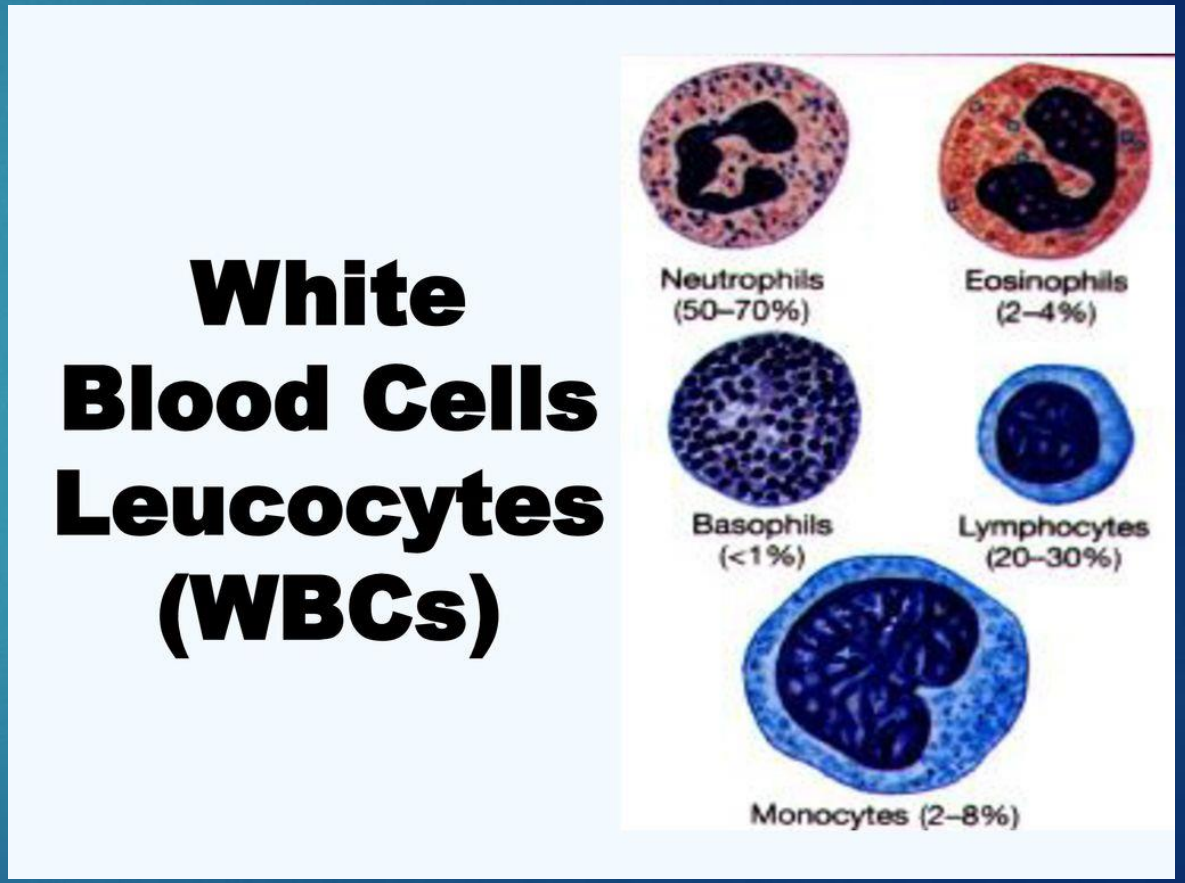


Figure 8.25 The human lymphatic system is spread throughout the body. Its largest vessels are in the region of the abdomen and thoracic cavity.

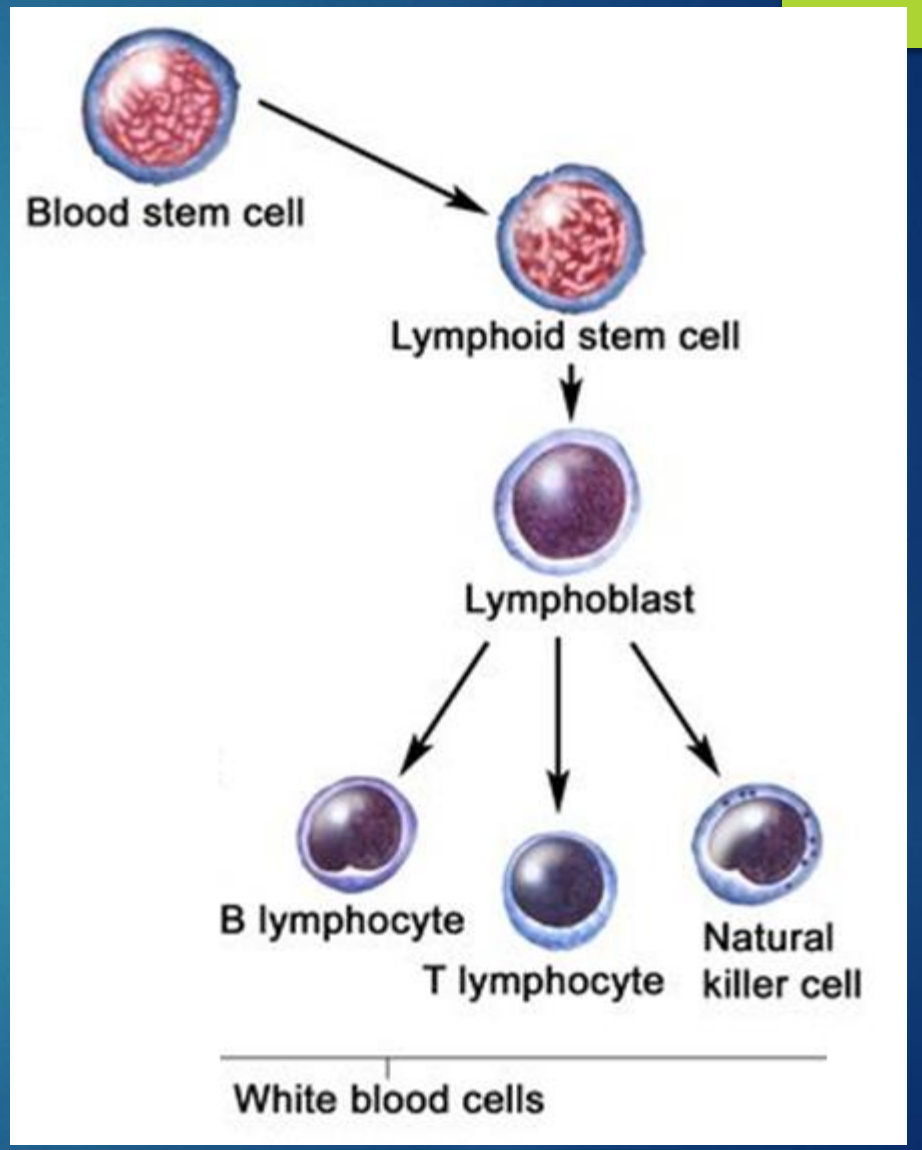
The lymphatic System

- White blood cells, also called leucocytes, are part of the body's response to infection.
- Leucocytes can be divided into three groups: granulocytes, monocytes, and lymphocytes.
- Granulocytes consist of neutrophils, basophils, and eosinophils



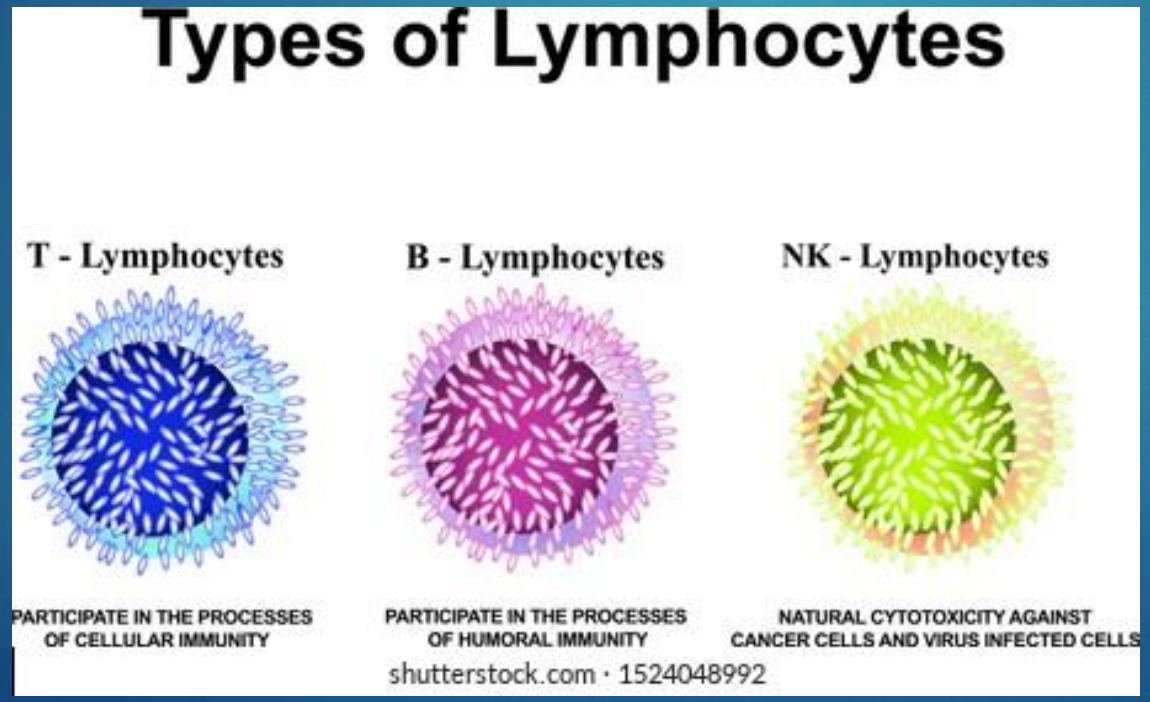
Lymphocytes

- Lymphocytes are white blood cells that are also one of the body's main types of immune cells. They are made in the bone marrow and found in the blood and lymph tissue.



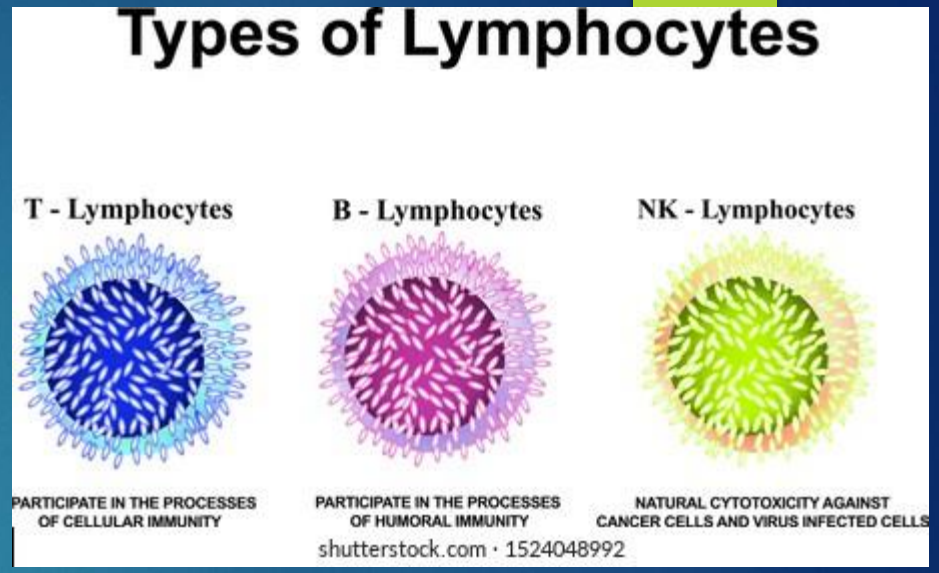
Lymphocytes

- T cells (also called T lymphocytes) are one of the major components of the adaptive immune system.
- Their roles include directly killing infected host cells, activating other immune cells, producing cytokines and regulating the immune response.



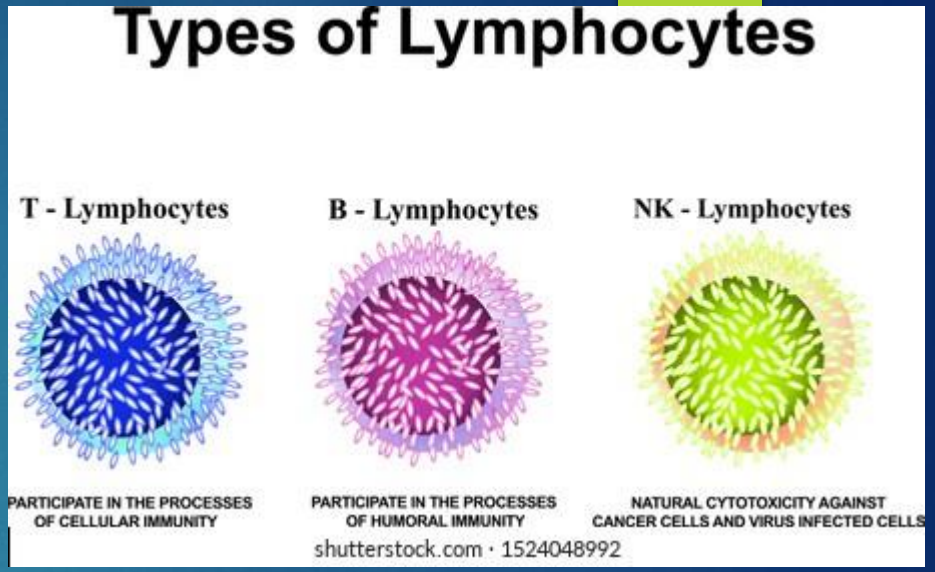
Lymphocytes

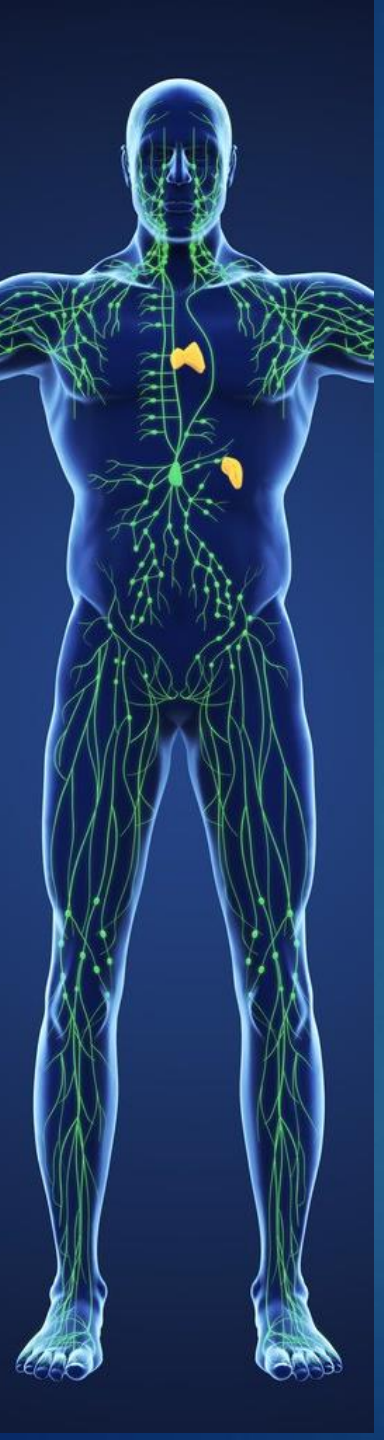
- B cells, also known as B lymphocytes, are a type of white blood cell of the lymphocyte subtype. They function in the humoral immunity component of the adaptive immune system by secreting antibodies.



Lymphocytes

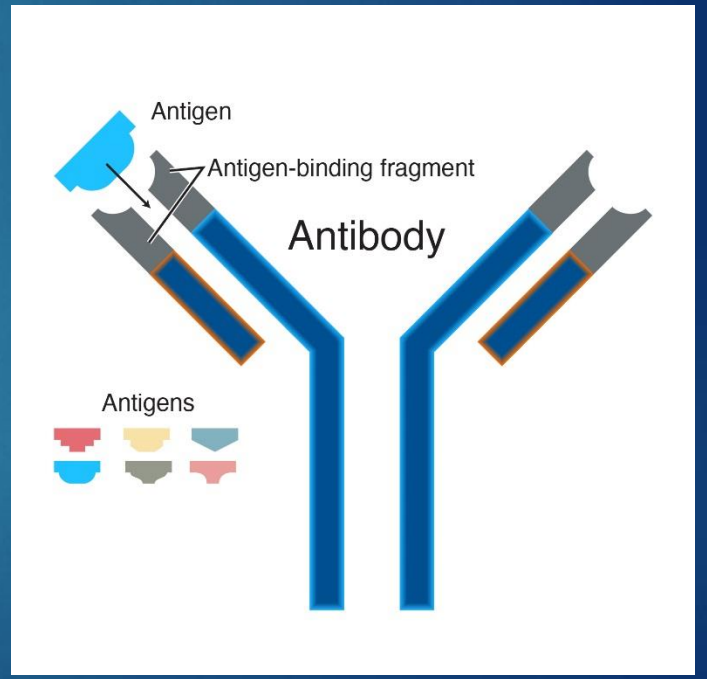
- Natural Killer (NK) Cells are NK cells are classified as group I Innate Lymphocytes (ILCs) and respond quickly to a wide variety of pathological challenges.





Lymphocytes

- Antibodies are specialized, Y-shaped proteins that bind like a lock-and-key to the body's foreign invaders — whether they are viruses, bacteria, fungi or parasites. When these proteins bind to the body's foreign invaders they signal the immune system to get to work.
- Antigens are molecules that are found on the surface of the cells and on pathogens.

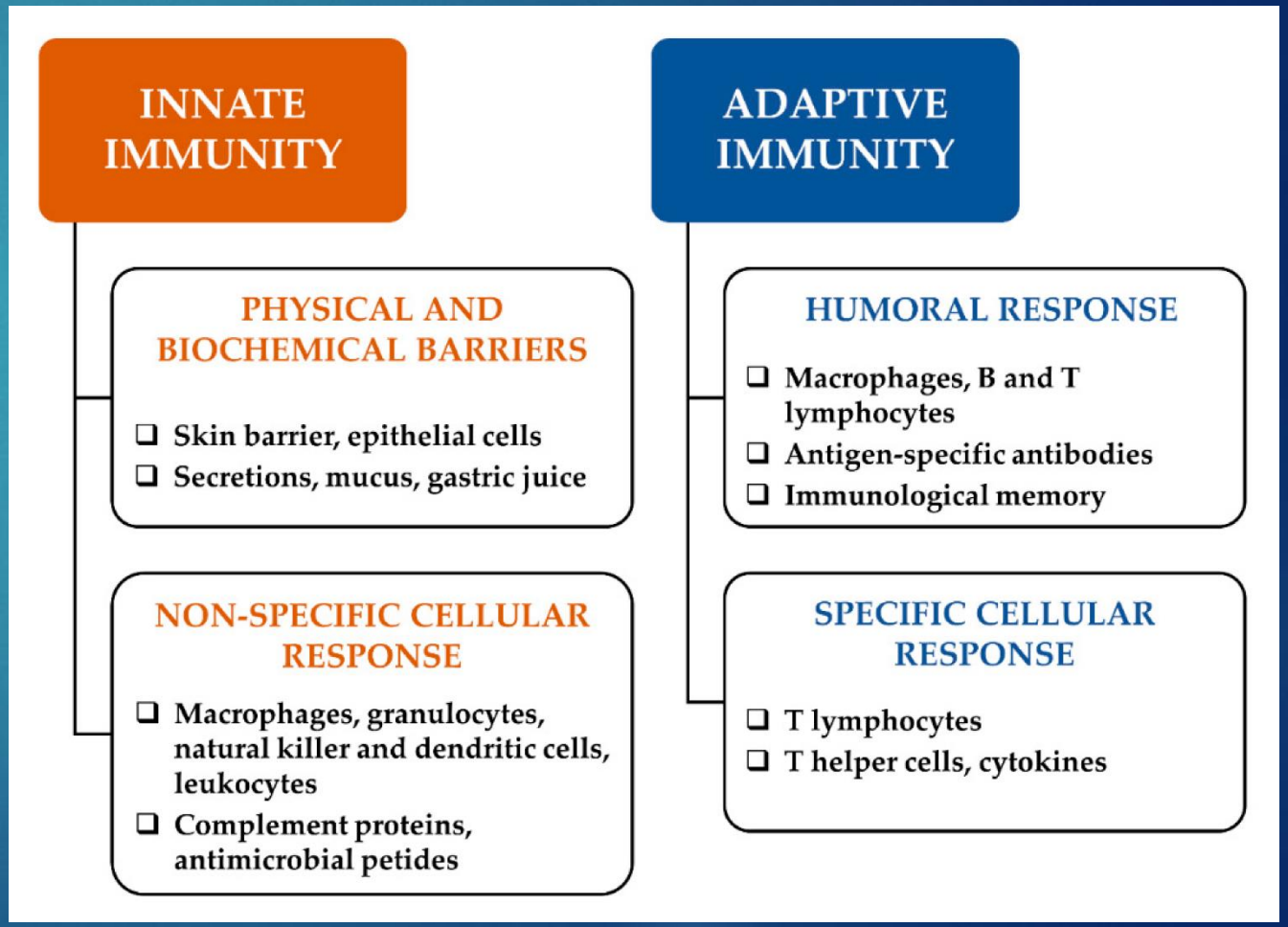


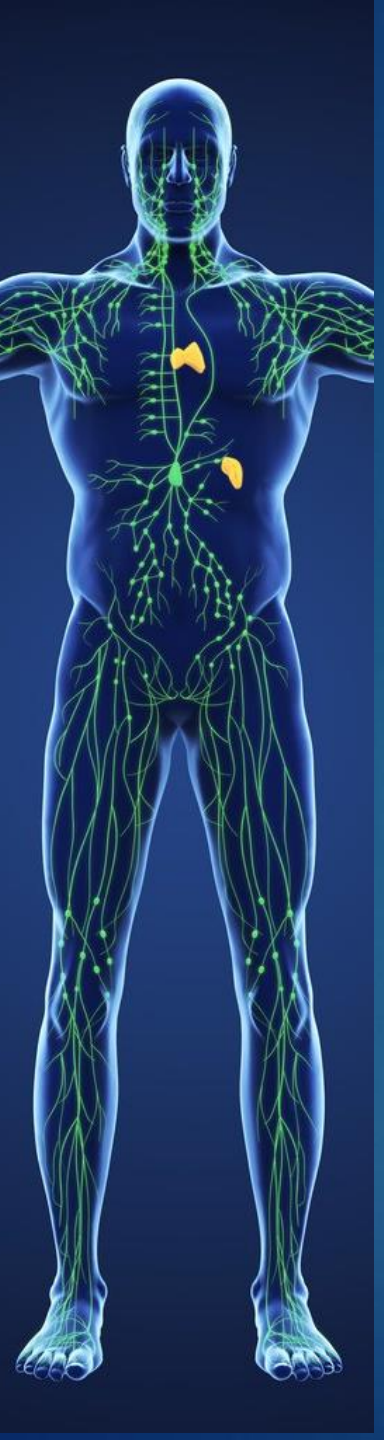
Macrophage

- Macrophage is a type of phagocyte, which is a cell responsible for detecting, engulfing and destroying pathogens and apoptotic cells.
- Macrophages are produced through the differentiation of monocytes, which turn into macrophages when they leave the blood.
- The bacterium is taken into the macrophage in a vacuole, which then fuses with a lysosome.
- The lysosome contents break down the macromolecules in the bacterium, killing it.

The Defense System

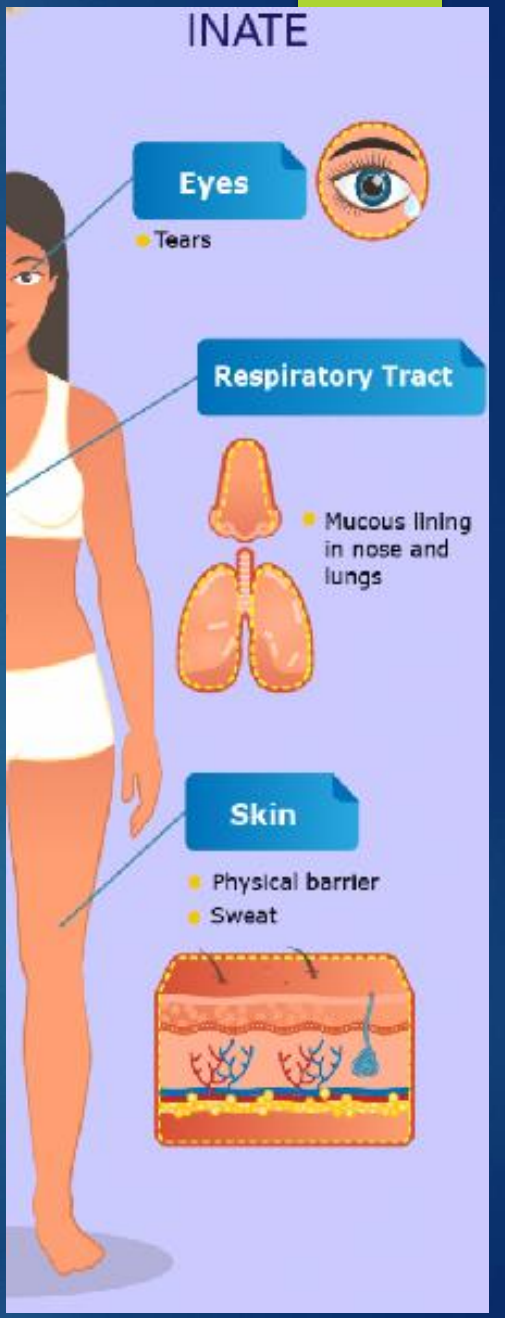
- These defences can be divided into three groups:
- 1) barriers (innate)to keep pathogens out
- 2) non-specific (innate) defences against a wide variety of pathogens
- 3) specific defences (adaptive) against particular pathogens





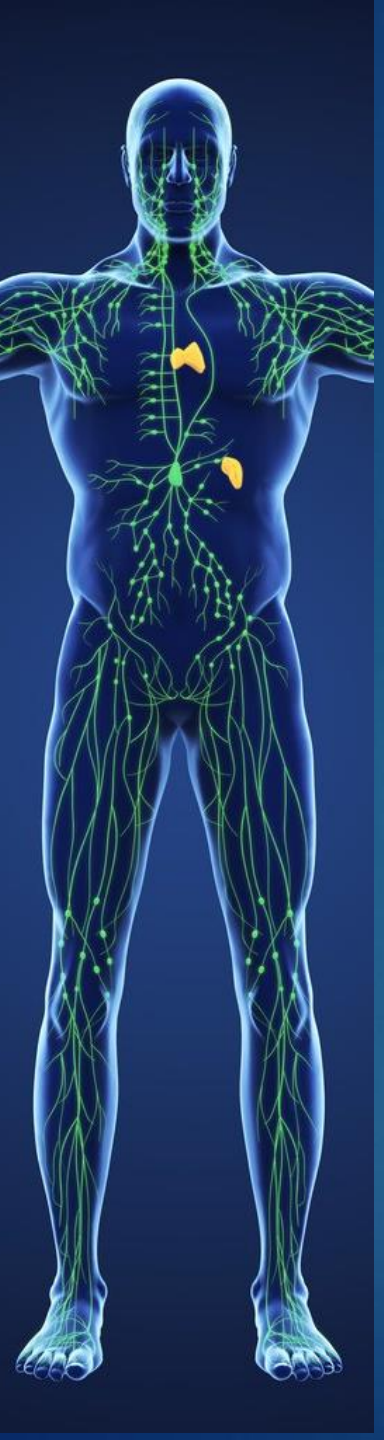
Barriers (Innate)

- The first lines of defence are all of the physical and chemical barriers of the body, such as eyelashes, the cilia of the respiratory tract, tears, and stomach acid.
- The largest barrier is the skin. It is a hostile environment for the survival of many micro-organisms.
- The outer layer of the skin is dry and contains large amounts of tough, relatively indigestible keratin.
- The skin's oil contains bactericides, and perspiration forms an acidic layer that is inhospitable for microbial growth.



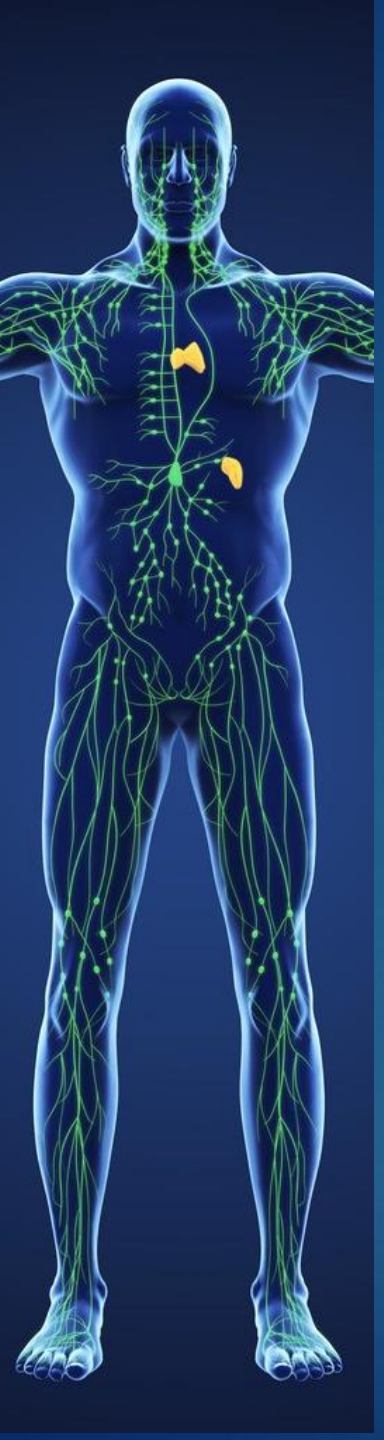
Non-specific (Innate, Cell Mediated)

- The second line of defence is the non-specific defences, which include three types of white blood cells—macrophages, neutrophils, and monocytes—and so is called cell-mediated immunity.
- Neutrophils and monocytes are white blood cells that kill bacteria using phagocytosis, a process in which they ingest the bacteria.
- Macrophages, which develop from monocytes, also use phagocytosis. They are found in the liver, spleen, brain, and lungs, and circulate in the blood and interstitial fluid.
- Non-specific defence also includes natural killer cells, which target body cells that have become cancerous or infected by viruses.



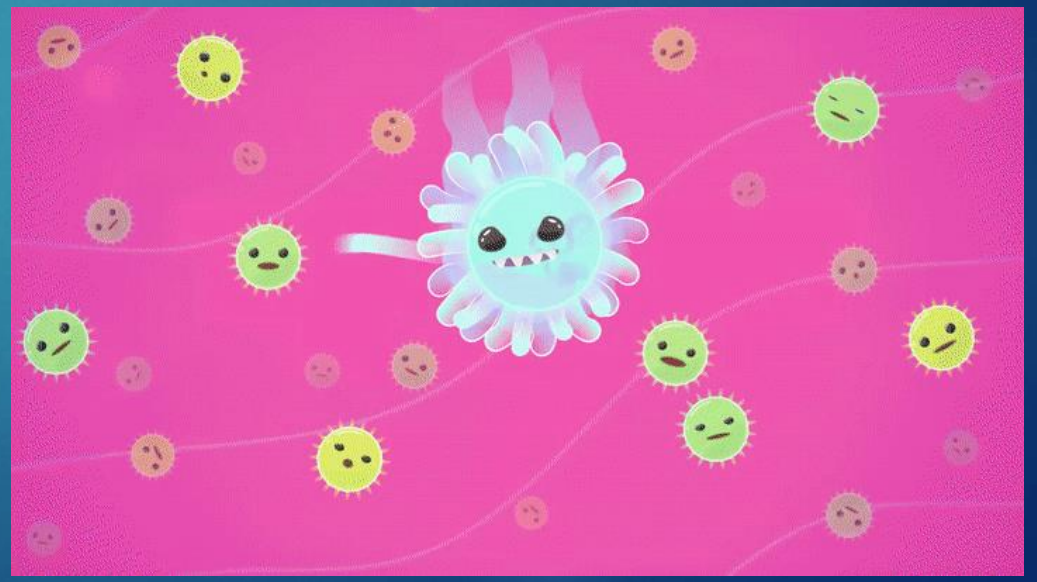
Specific Defenses (adaptive)

- The third line of defence is immunity.
- Immunity is developed by the actions of the specific defences, using antibodies, and so is called antibody-mediated immunity.
- Antibodies are proteins that recognize foreign substances and act to neutralize or destroy them. Because of exposure to foreign substances over time, as well as variations in genetic make-up, each person develops an immune system that is unique in its ability to deal with a wide variety of possible infections.



Specific Defenses (adaptive)

- We are not all exposed to the same diseases, and some diseases require a stronger response than others because they are more virulent than others.
- The specific immune system is primarily a function of the lymphocytes in the circulatory system. The lymphocytes are divided into two specialized groups, depending on where they mature. B lymphocytes, or B cells, mature in the bone marrow. T lymphocytes, or T cells, mature in the thymus gland, which is located near the heart.



A After the pathogens have breached the first line of defence, in this case the skin, they trigger the body's immune response. The second line of defence is the arrival of non-phagocytic leucocytes at the infection site. These cells release histamine, which causes blood vessels at the site to dilate and become more permeable to fluid and leucocytes. The increased blood flow and accumulation of fluid makes the area swollen and hot. The increase in temperature alone may be enough to destroy or neutralize some pathogens.

B Phagocytic macrophages engulf and destroy invading bacteria. The accumulation of dead macrophages and bacteria is visible as pus at the site of the infection.

C The third line of defence begins after a pathogen has been destroyed; the antigens from the pathogen protrude from the cell membrane of the macrophage.

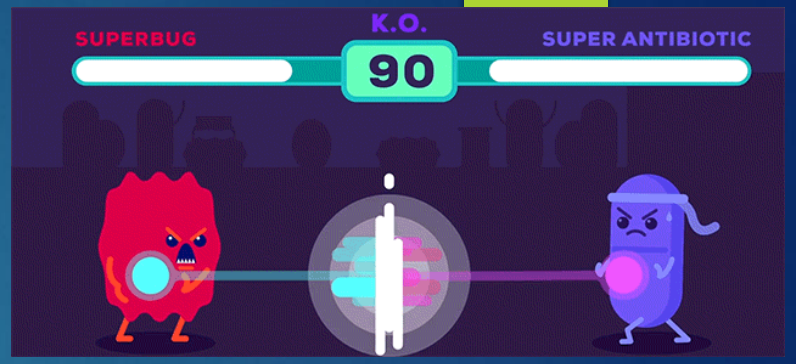
D Receptor sites on the surface of helper T cells bind to the antigens on the surface of the macrophage. This union triggers the release of chemical messengers from both cells. These messengers cause T cells to multiply. Some of these T cells destroy infected tissue cells, breaking the reproductive cycle of the pathogen.

E The antibodies on B cells bind to the antigens, contributing to the destruction of the pathogens.

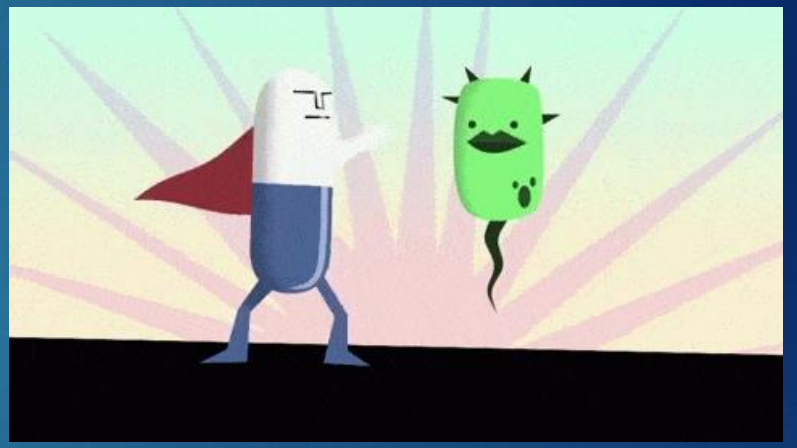
F T cells bind to the B cell antibody-antigen complex. This union of T and B cells activates the B cell, causing it to enlarge and divide, which produces plasma cells and memory cells.

G The plasma cells produce antibodies at a rate of 2000 per second, and release them into the blood stream. Antibodies and memory B cells remain in the blood, ready to fight a new infection by the same pathogen.

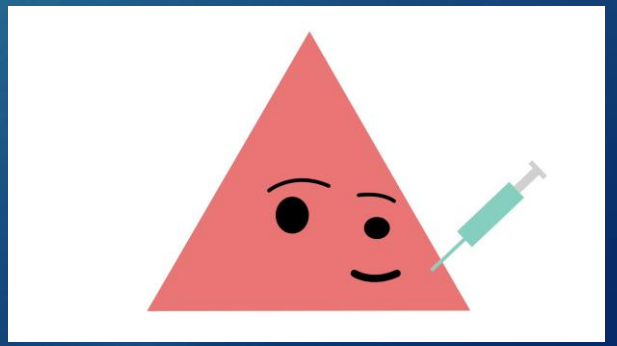
Antibiotics/Vaccinations and a Healthy Society

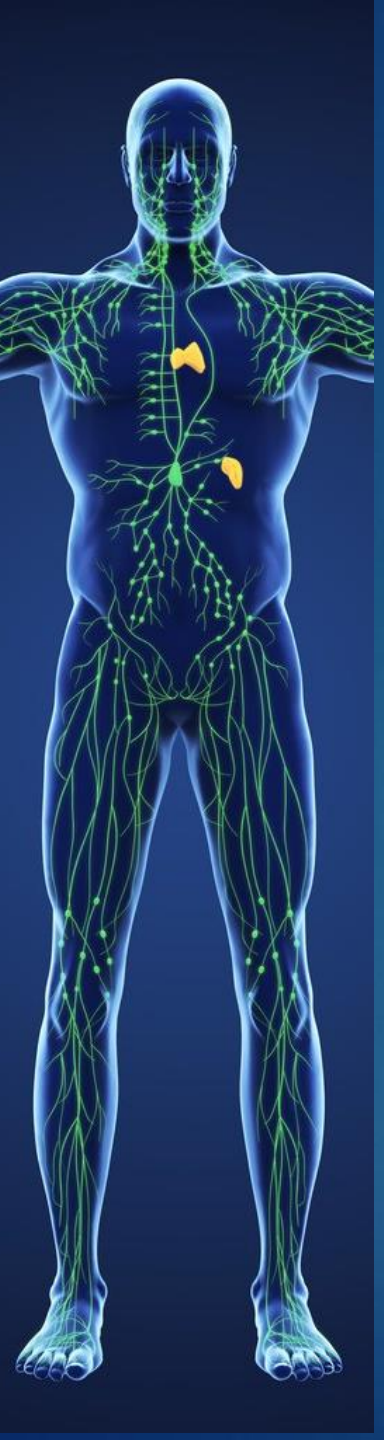


- Antibiotics are medicines that fight bacterial infections in people and animals. They work by killing the bacteria or by making it hard for the bacteria to grow and multiply.



- Vaccine a substance used to stimulate the production of antibodies and provide immunity against one or several diseases, prepared from the causative agent of a disease, its products, or a synthetic substitute, treated to act as an antigen without inducing the disease.





Antibiotics History

- Antibiotics have been used for millennia to treat infections, although until the last century or so people did not know the infections were caused by bacteria.
- the ancient Egyptians, for example, applied mouldy bread to infected wounds.
- **pneumonia and diarrhoea** – that are caused by bacteria, were the number one cause of human death in the developed world.
- In 1909, Paul Ehrlich discovered that a chemical called **arsphenamine** was an effective treatment for **syphilis.** This became the first modern antibiotic, although Ehrlich himself referred to his discovery as 'chemotherapy'.
- The word 'antibiotics' was first used over 30 years later by the Ukrainian-American inventor and microbiologist Selman Waksman, who in his lifetime discovered over 20 antibiotics.

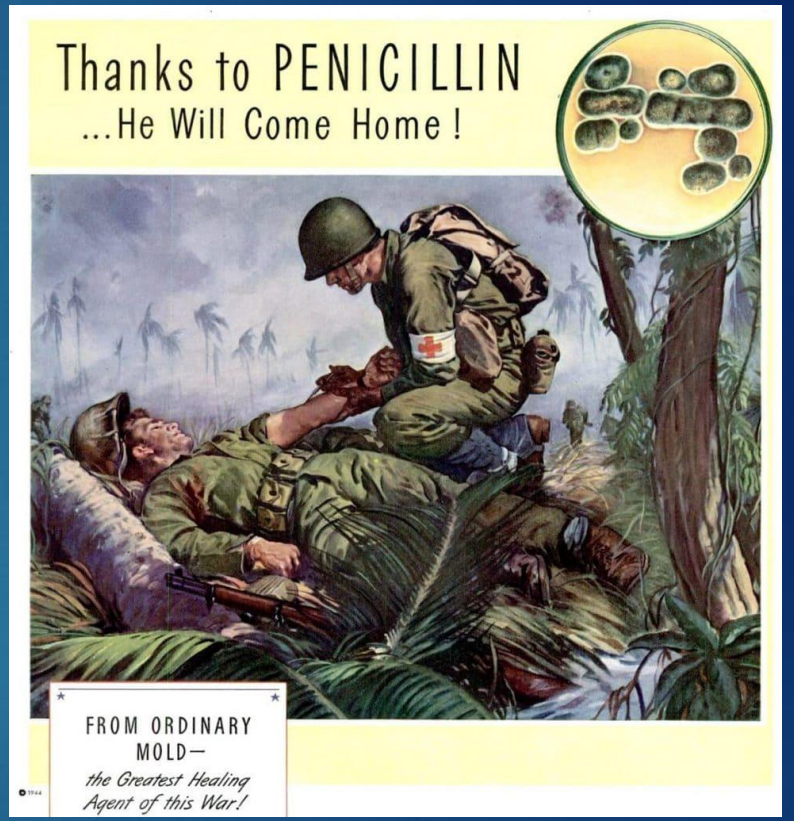
Antibiotics History

Alexander Fleming was, it seems, a bit disorderly in his work and accidentally discovered penicillin. Upon returning from a holiday in Suffolk in 1928, he noticed that a fungus, *Penicillium notatum*, had contaminated a culture plate of *Staphylococcus* bacteria he had accidentally left uncovered.

The fungus had created bacteria-free zones wherever it grew on the plate. Fleming isolated and grew the mould in pure culture. He found that *P. notatum* proved extremely effective even at very low concentrations, preventing *Staphylococcus* growth even when diluted 800 times, and was less toxic than the disinfectants used at the time.

Antibiotics History

- **By D-Day in 1944, penicillin was being widely used to treat troops for infections both in the field and in hospitals throughout Europe. By the end of World War II, penicillin was nicknamed 'the wonder drug' and had saved many lives.**
- Scientists in Oxford were instrumental in developing the mass production process, and Howard Florey and Ernst Chain shared the 1945 Nobel Prize in Medicine with Alexander Fleming for their role in creating the first mass-produced antibiotic.



Vaccine History

- The practice of immunisation dates back hundreds of years. Buddhist monks drank snake venom to confer immunity to snake bite and variolation (smearing of a skin tear with cowpox to confer immunity to smallpox) was practiced in 17th century China.
- Edward Jenner is considered the founder of vaccinology in the West in 1796, after he inoculated a 13 year-old-boy with vaccinia virus (cowpox), and demonstrated immunity to smallpox. In 1798, the first smallpox vaccine was developed. Over the 18th and 19th centuries, systematic implementation of mass smallpox immunisation culminated in its global eradication in 1979.

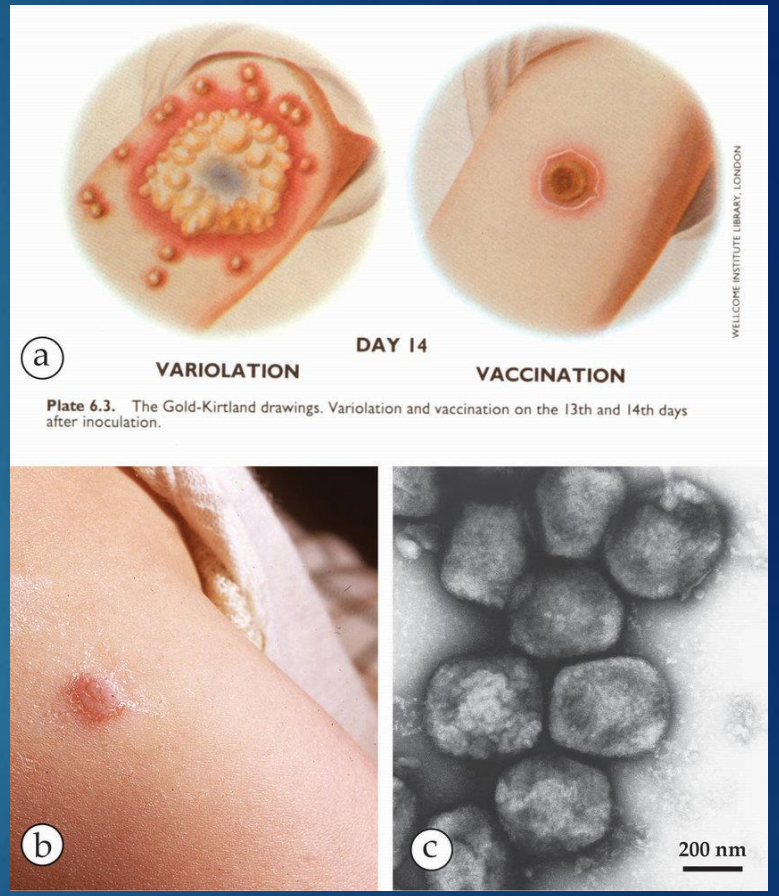
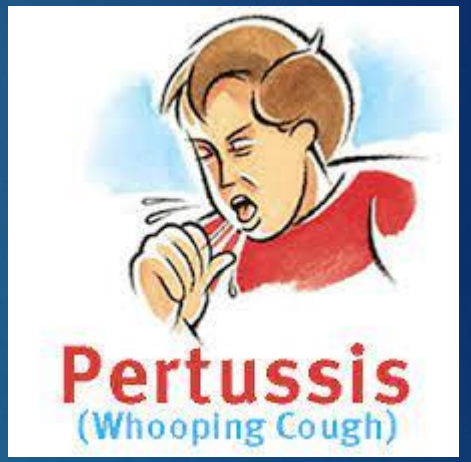


Plate 6.3. The Gold-Kirtland drawings. Variolation and vaccination on the 13th and 14th days after inoculation.

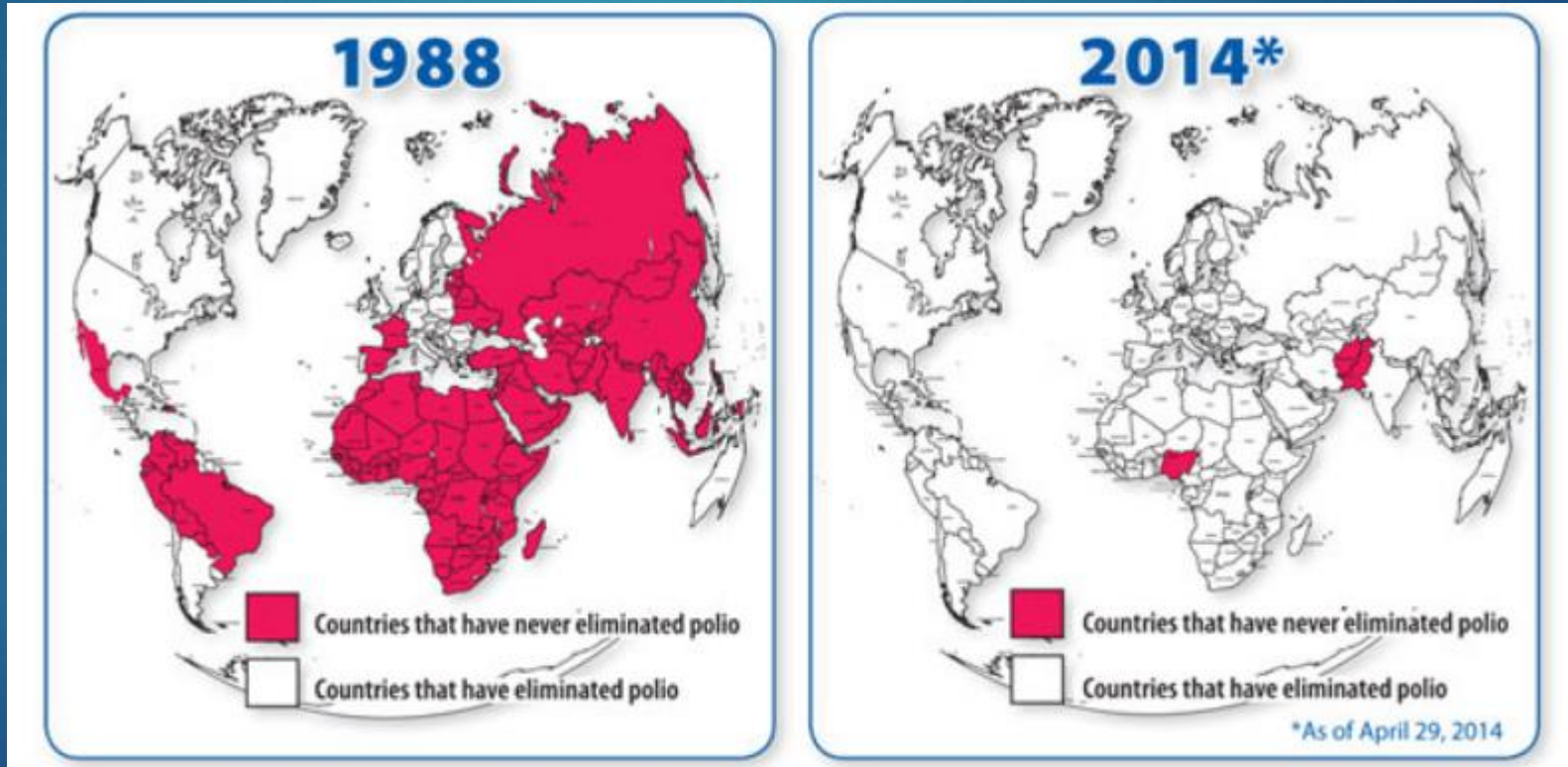
Vaccine History

- Louis Pasteur's experiments spearheaded the development of live attenuated cholera vaccine and inactivated anthrax vaccine in humans (1897 and 1904, respectively).
- Plague vaccine was also invented in the late 19th Century. Between 1890 and 1950, bacterial vaccine development proliferated, including the Bacillis-Calmette-Guerin (BCG) vaccination, which is still in use today.
- In 1923, Alexander Glenny perfected a method to inactivate tetanus toxin with formaldehyde. The same method was used to develop a vaccine against diphtheria in 1926.
- Pertussis (whooping cough) vaccine development took considerably longer, with a whole cell vaccine first licensed for use in the US in 1948.



Vaccine History

- Viral tissue culture methods developed from 1950-1985, and led to the advent of the Salk (inactivated) polio vaccine and the Sabin (live attenuated oral) polio vaccine. Mass polio immunisation has now eradicated the disease from many regions around the world

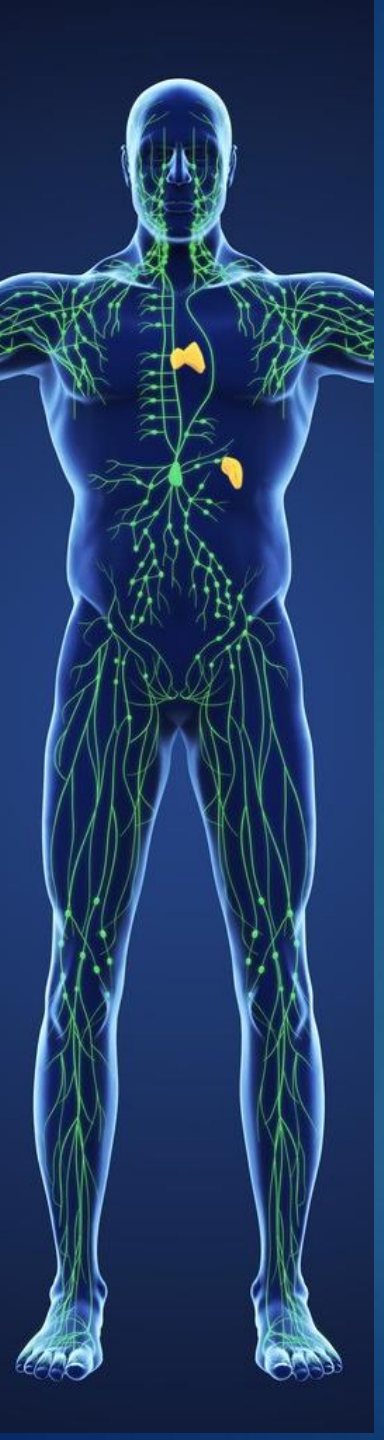


Progess of polio elimination 1988 and 2014
Image:CDC

Vaccine History

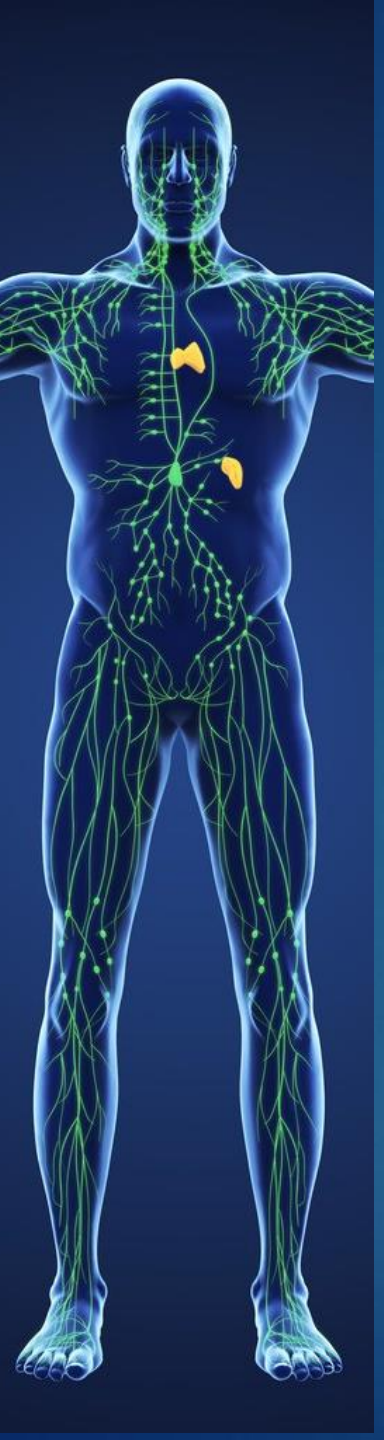
- Molecular Genetics (Bio 3201)
- The past two decades have seen the application of molecular genetics and its increased insights into immunology, microbiology and genomics applied to vaccinology. Current successes include the development of recombinant hepatitis B vaccines, the less reactogenic acellular pertussis vaccine, and new techniques for seasonal influenza vaccine manufacture.
- Molecular genetics sets the scene for a bright future for vaccinology, including the development of new vaccine delivery systems (e.g. DNA vaccines, viral vectors, plant vaccines and topical formulations), new adjuvants, the development of more effective tuberculosis vaccines, and vaccines against cytomegalovirus (CMV), herpes simplex virus (HSV), respiratory syncytial virus (RSV), staphylococcal disease, streptococcal disease, pandemic influenza, shigella, HIV and schistosomiasis among others. Therapeutic vaccines may also soon be available for allergies, autoimmune diseases and addictions.

- https://www.historyofvaccines.org/timeline/all



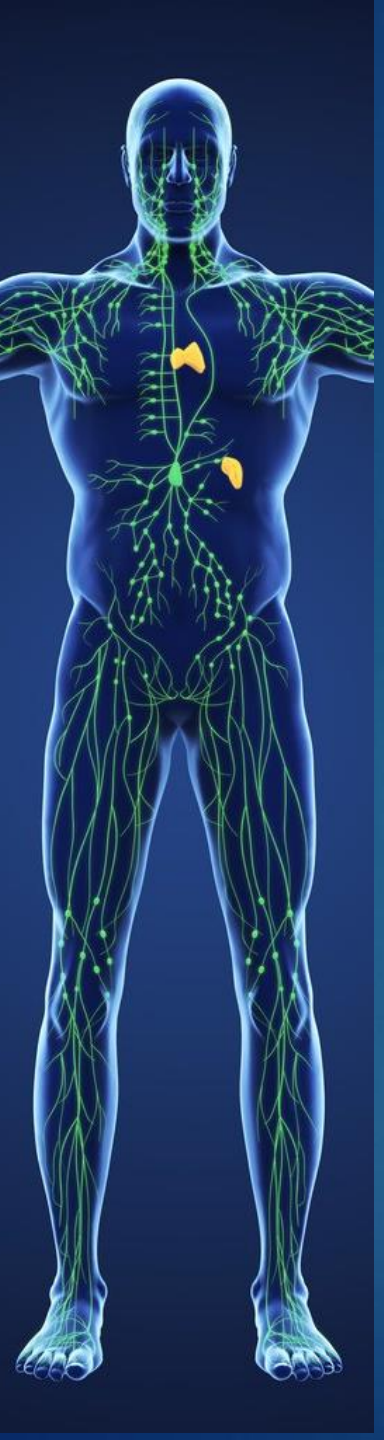
How the Immune System Maintains Homeostasis

- The immune response contributes to homeostasis by preparing the body to fight off infection and to help the healing process in case harm occurs.
- During infection, the immune system will cause the body to develop a fever.
- The immune system also causes an increase in blood flow to bring oxygen and other immune cells to sites of infection.
- In addition, the immune system helps in wound healing, so that proper barriers in organs can be reformed such that those organs can correctly participate in homeostasis.



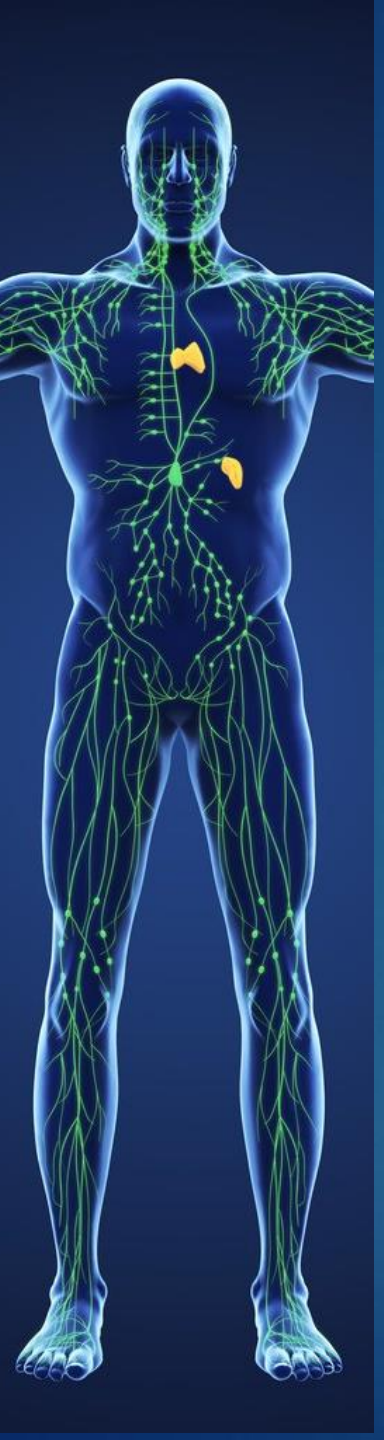
Fever

- When a body is infected by bacteria or viruses, the body must invest a lot of energy to fight off the invaders.
- There is no point in maintaining homeostasis of hydration levels and the many other systems the body regulates if the whole organism is going to die from infection.
- Pyrogens are released by infected cells or infectious agents.
- Their presence alerts the brain to increase body temperature, which it does by ordering the body to retain heat.
- This results in a fever. Fevers' function is to slow down bacteria and viruses, which do not like high temperatures. This buys more time for the immune cells to find and eliminate the invaders.



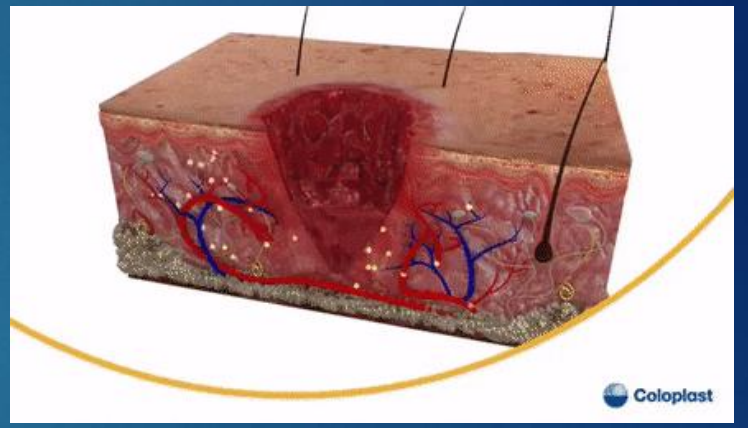
Increase in Blood Flow

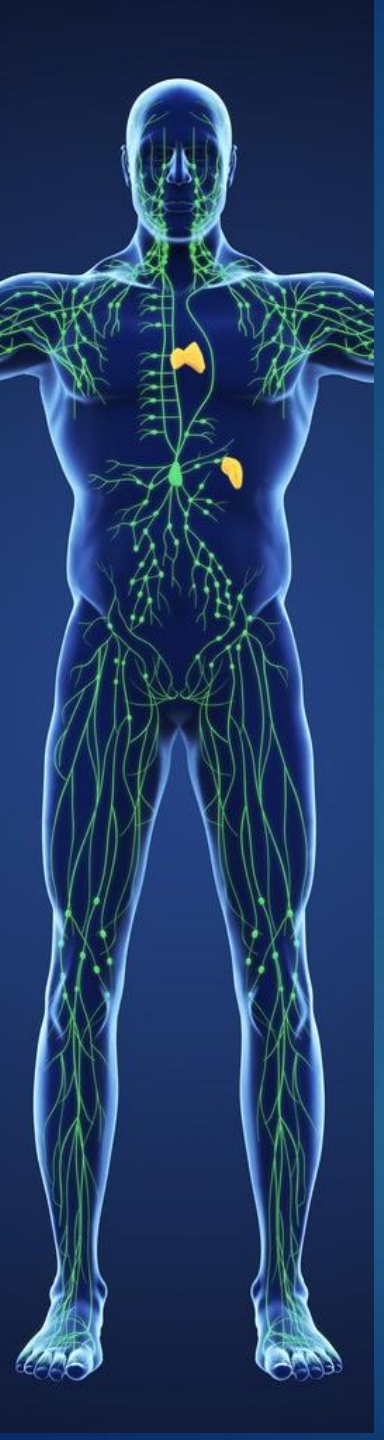
- The site of an injury or infection will turn red, swell, and feel tender and warm.
- These are the symptoms of what is called inflammation.
- Immune cells rush to the site and release chemicals that cause these symptoms.
- Mast cells are immune cells which release chemicals that enlarge, or dilate, the blood vessels at the site of a bruise or a cut.
- This dilation brings more blood to the site of injury, including more oxygen to sustain the burst of repair activity, and more immune cells to help.
- Increased blood flow means faster repair.
- Faster repair means the body can get back to normal faster.



Wound Healing

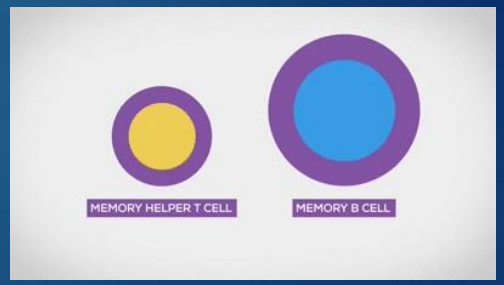
- Wound healing is the process in which a damaged tissue is repaired.
- At the site of damage, dead or broken cells are eaten by immune cells called macrophages.
- In damaged skeletal muscle, macrophages accumulate at the site of injury and release a protein that causes muscle cells to regrow.
- In damaged skin, macrophages fill up the wound and release chemicals that cause new blood vessels to form.
- These blood vessels will be necessary to bring nutrients to and remove wastes from the new skin cells that will form.
- Until the wound is repaired, the body is at higher risk of infection and homeostasis cannot be fully attained.

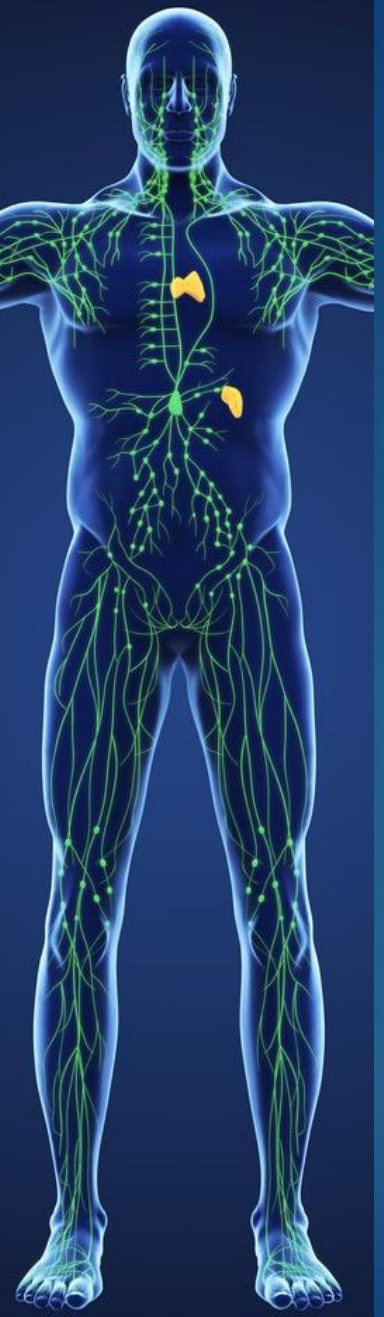




Memory Cells

- Immune cells called T or B lymphocytes become activated for battle after they encounter foreign proteins that were captured from invading organisms. After finding a protein molecule from a particular type of foreign invader, T and B cells train themselves to fight against this invader. T and B cells can undergo what is called clonal selection, which is the process in which they divide to make two different types of copies of themselves. One type of copied cell is called the effector cells, which go right into battle fighting invaders. The other type of copied cell is called memory cells, which stay inactive in the body for a long time, waiting to encounter the same invader in the future so that they can mount a faster attack the second time around. Memory cells make the body better prepared for future invasions, which makes it easier to maintain homeostasis in the future.





- Circulatory/Immune System Poster Assignment