BHARATHIDASAN UNIVERSITY

Tiruchirappalli – 620 024,
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Programme: M.Sc., Biotechnology (Marine)

Course Title : Immunology

Course Code : 21 CC7

Unit : I
Infection and Immunity

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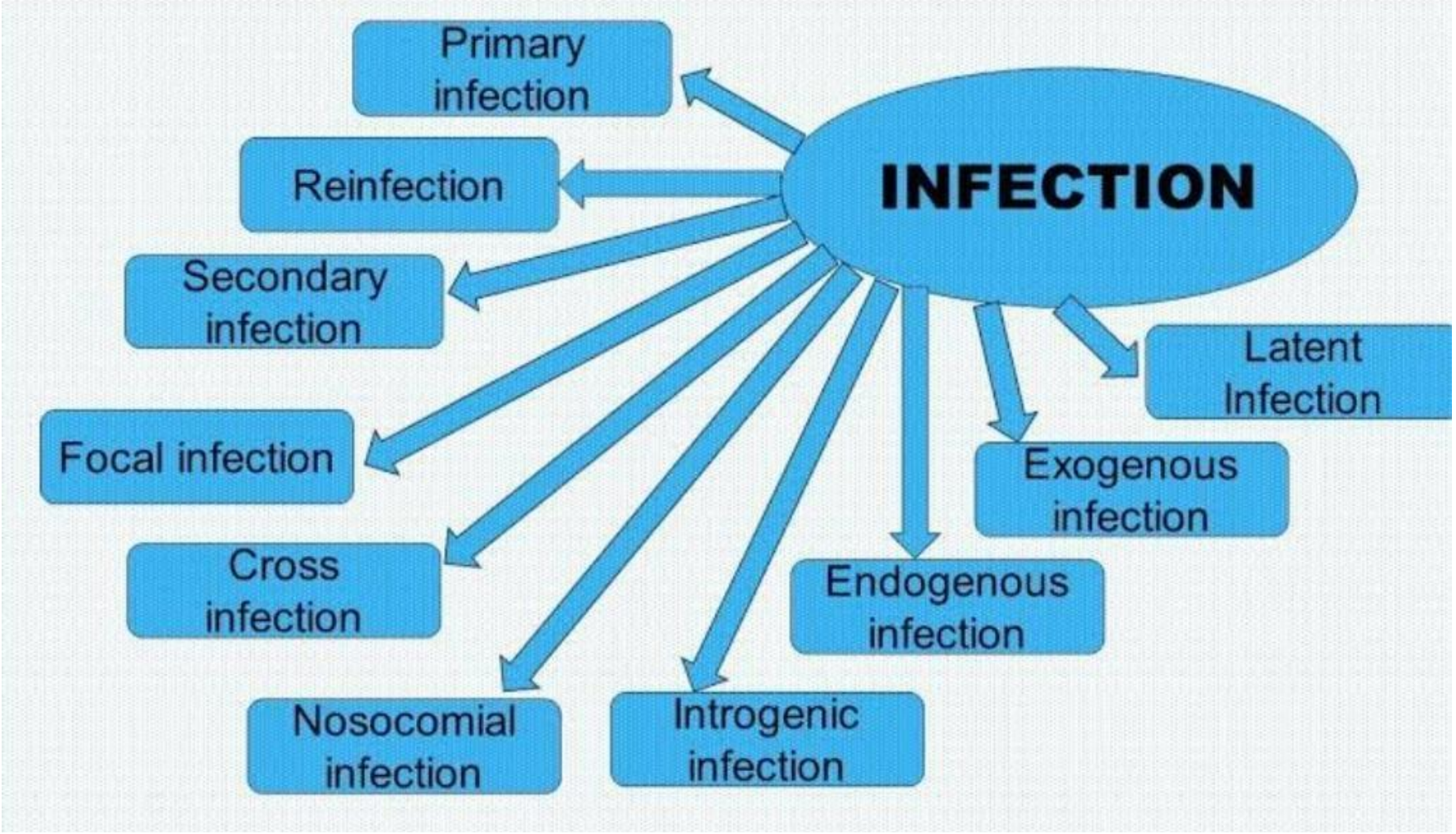
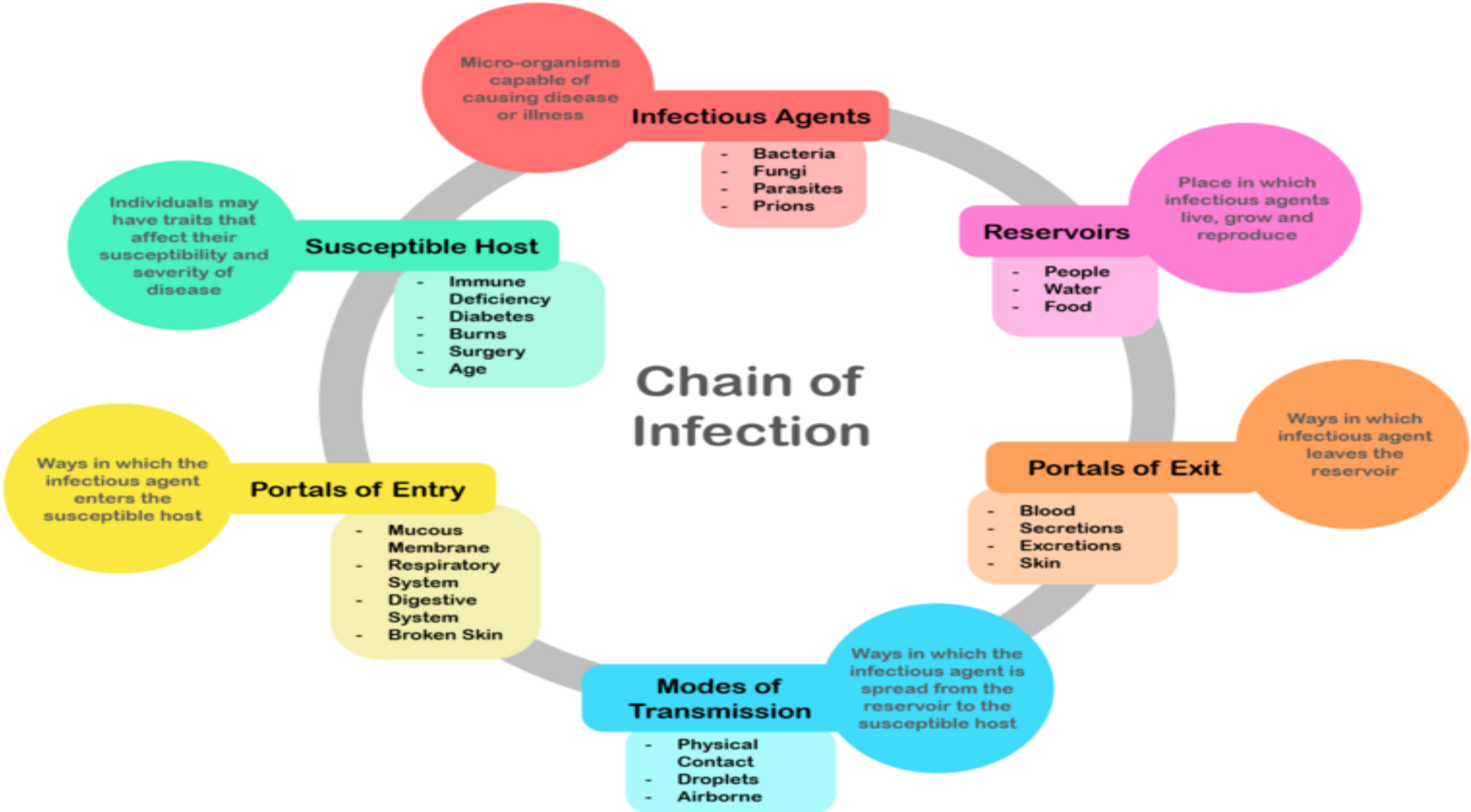
Infection

- The invasion and multiplication of a microorganism within the body of a human or animal is referred to as infection.
- During an infection, microorganisms such as bacteria, viruses, fungi, or parasites enter the body, multiply, and may disrupt normal physiological functions.
- Infections can lead to various immune responses, including inflammation, to eliminate the invading pathogens and restore the body to a healthy state.

Classification of infection




Chain of Infection
Micro-organisms capable of causing disease or illness
Infectious Agents
- Bacteria
- Fungi
- Parasites
- Prions
Place in which infectious agents live, grow and reproduce
Reservoirs
- People
- Water
- Food
Ways in which infectious agent leaves the reservoir
Portals of Exit
- Blood
- Secretions
- Excretions
- Skin
Ways in which the infectious agent is spread from the reservoir to the susceptible host
Modes of Transmission
- Physical Contact
- Droplets
- Airborne
Ways in which the infectious agent enters the susceptible host
Portals of Entry
- Mucous Membrane
- Respiratory System
- Digestive System
- Broken Skin
Individuals may have traits that affect their susceptibility and severity of disease
Susceptible Host
- Immune Deficiency
- Diabetes
- Burns
- Surgery
- Age

How are pathogens spread

food and water

insect bites

airborne droplets

direct contact

indirect contact

How are pathogens spread

food and water

airborne droplets

insect bites

direct contact

indirect contact

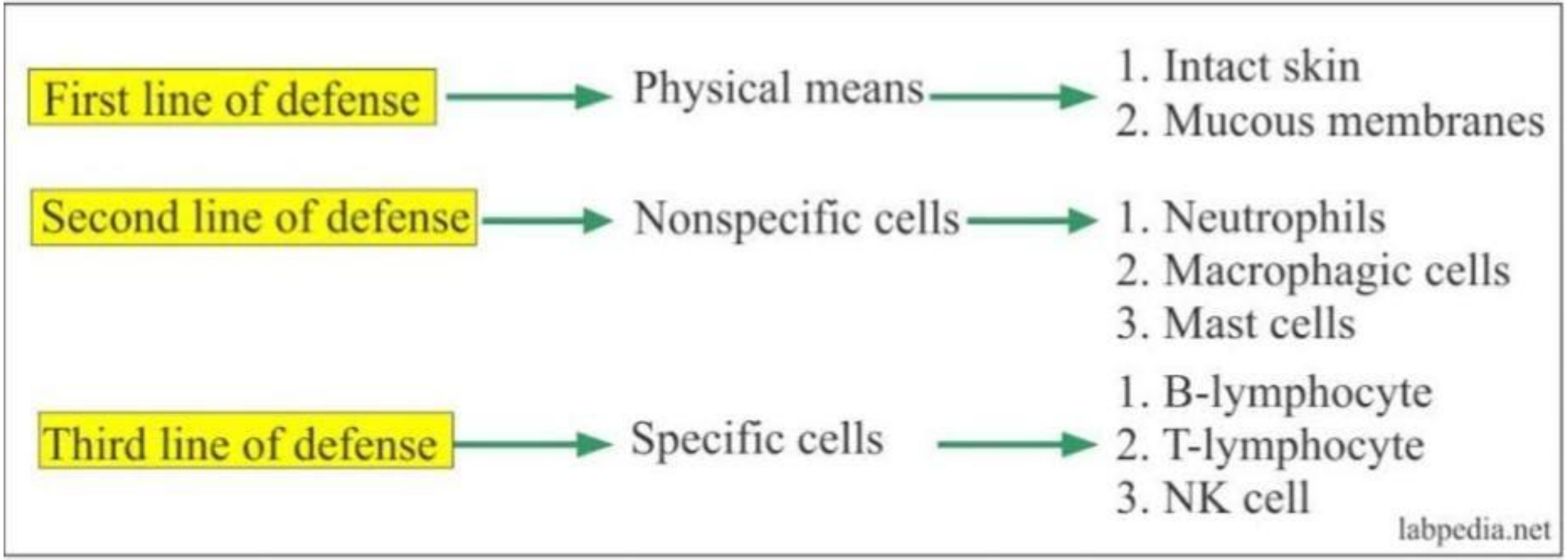
Immunity

- The term immunity is derived from 'LATIN' word **immunis** which **means free of burden**.
- Immunity refers to the general ability of a HOST to resist a particular infection or disease.

Immune system:

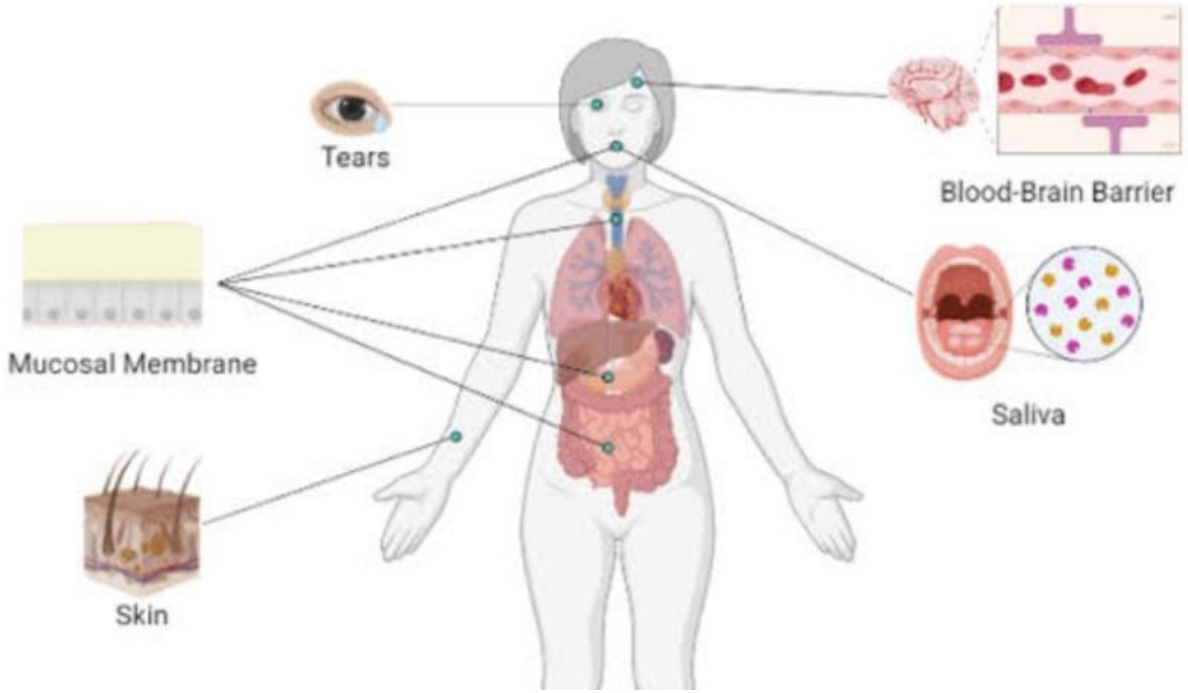
The organs and process of the body that provide resistance to infection and toxins

Body's natural defence mechanisms



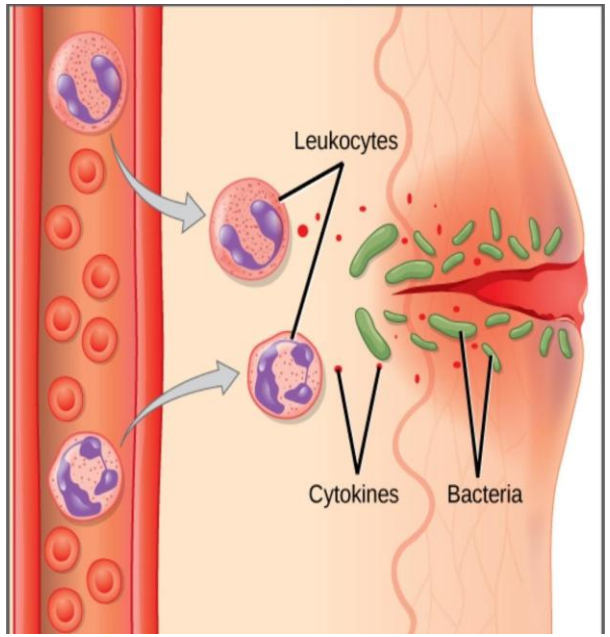
First line of defense

- The body's most important nonspecific defense is the skin, which acts as a physical barrier to keep pathogens out.
- Even openings in the skin (such as the mouth and eyes) are protected by saliva, mucus, and tears, which contain an enzyme that breaks down bacterial cell walls.



Second line of defense

- If a pathogen does make it into the body, there are secondary nonspecific defenses that take place.
- An inflammatory response begins when a pathogen stimulates an increase in blood flow to the infected area. Blood vessels in that area expand, and white blood cells leak from the vessels to invade the infected tissue.
- These white blood cells, called phagocytes engulf and destroy bacteria. The area often becomes red, swollen, and painful during an inflammatory response.
- When a pathogen has invaded, the immune system may also release chemicals that increase body temperature, producing a fever.
- Increased body temperature may slow or stop pathogens from growing and helps speed up the immune response.



Third line of defense

- **Lymphocytes**: Lymphocytes are a type of white blood cell found in blood or lymph nodes and made by bone marrow. There are several types of lymphocyte, including:
- **T-lymphocytes**: recognize antigens on pathogens and either attack them directly or co-ordinate the activity of other cells of the immune system.
- **B-lymphocytes**: recognize antigens and produce special chemicals called antibodies. Antibodies are special Y-shaped proteins produced by B-lymphocytes in response to antigens. Antibodies work by binding to antigens on pathogens.

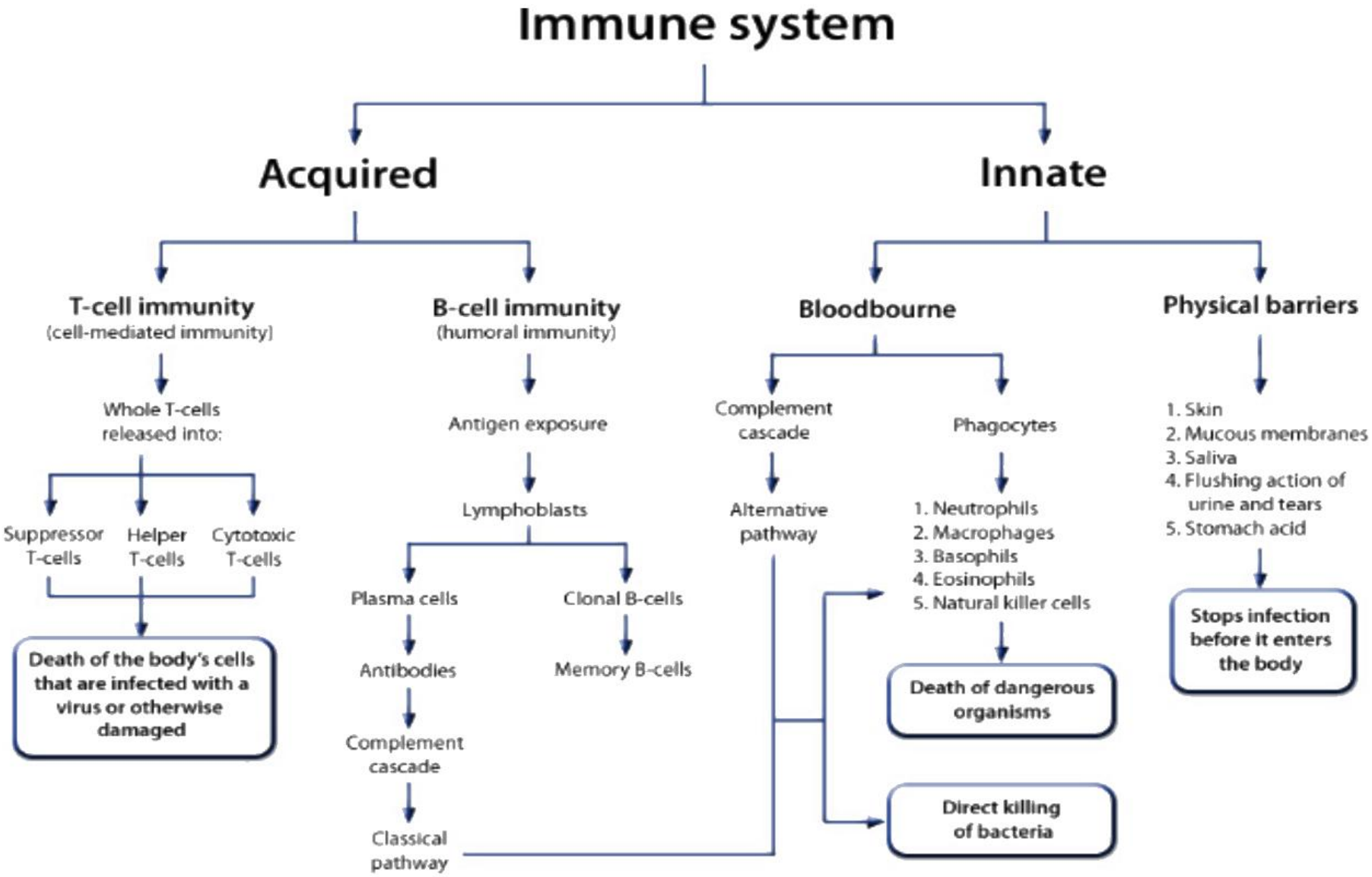
Delayed response

- The B-lymphocyte that produces the correct antibody antigen begins dividing to produce many more antibody- producing cells. It takes a few days to produce enough antibodies to destroy the pathogen. This means there is delay between infection and the person beginning to feel better.
- Once a pathogen has been destroyed, a few memory cells remain. These recognize the pathogen if it re-infects, and make the immune response much quicker and more effective. This is called active immunity.

Immunity

- Immunity is the ability of the body to defend itself against disease-causing organisms. Everyday our body comes in contact with several pathogens, but only a few results into diseases.
- The reason is, our body has the ability to release antibodies against these pathogens and protects the body against diseases.
- This defense mechanism is called immunity

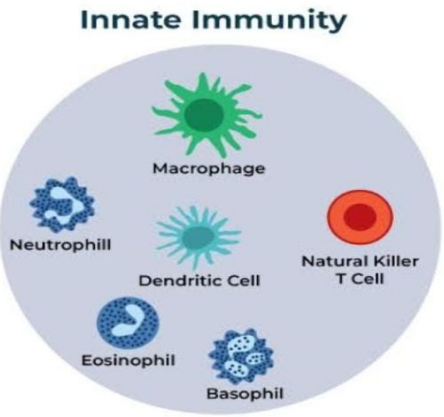
Types of immunity



Source: https://www.slideshare.net/slideshow/acute-allograft-rejection-in-kidney-transplantation-2017-chaken/85815981

Innate Immunity

- This type of immunity is present in an organism by birth.
- This is activated immediately when the pathogen attacks. Innate immunity includes certain barriers and defense mechanisms that keep foreign particles out of the body.
- Innate immunity refers to the body’s defense system.
- This immunity helps us by providing the natural resistance components including salivary enzymes, natural killer cells, intact skin and neutrophils, etc. which produce an initial response against the infections at birth prior to exposure to a pathogen or antigens.

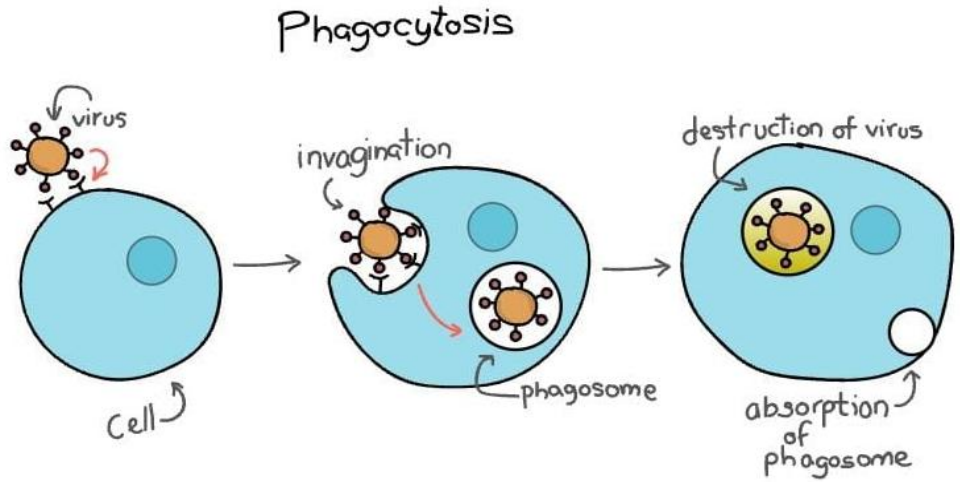


Cells of the Innate Immune System

There are many types of white blood cells, or leukocytes, that work to defend and protect the human body. In order to patrol the entire body.

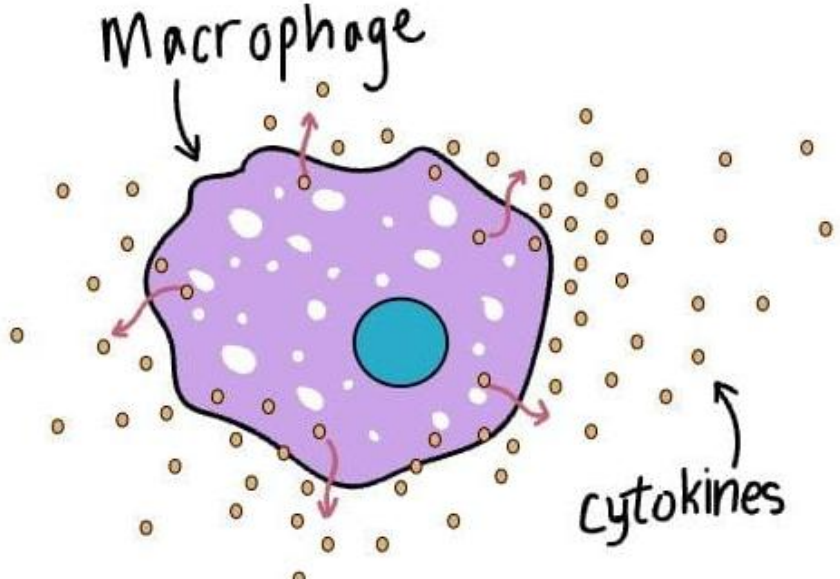
1) Phagocytic cells: Phagocyte means “eating cell”, which describes what role phagocytes play in the immune response.

2) Phagocytes circulate throughout the body, looking for potential threats, like bacteria and viruses, to engulf and destroy.



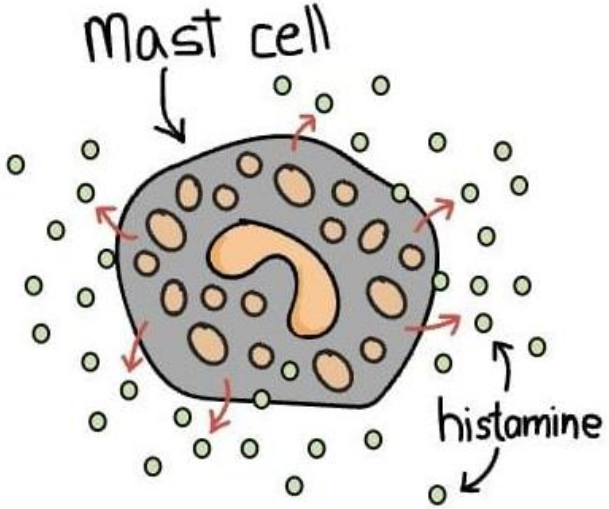
Macrophages

- Macrophages, are efficient phagocytic cells that can leave the circulatory system by moving across the walls of capillary vessels.
- The ability to roam outside of the circulatory system is important, because it allows macrophages to hunt pathogens with less limits.
- Macrophages can also release cytokines in order to signal and recruit other cells to an area with pathogens.



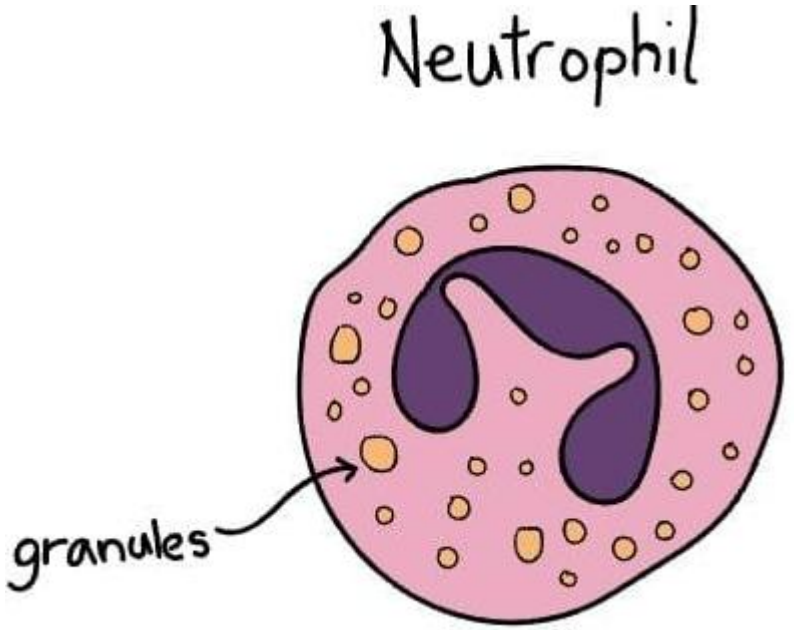
Mast cells

- Mast cells are found in mucous membranes and connective tissues, and are important for wound healing and defense against pathogens via the inflammatory response.
- When mast cells are activated, they release cytokines and granules that contain chemical molecules to create an inflammatory cascade.
- Mediators, such as histamine, cause blood vessels to dilate, increasing blood flow and cell trafficking to the area of infection.
- The cytokines released during this process act as a messenger service, alerting other immune cells, like neutrophils and macrophages, to make their way to the area of infection, or to be on alert for circulating threats.



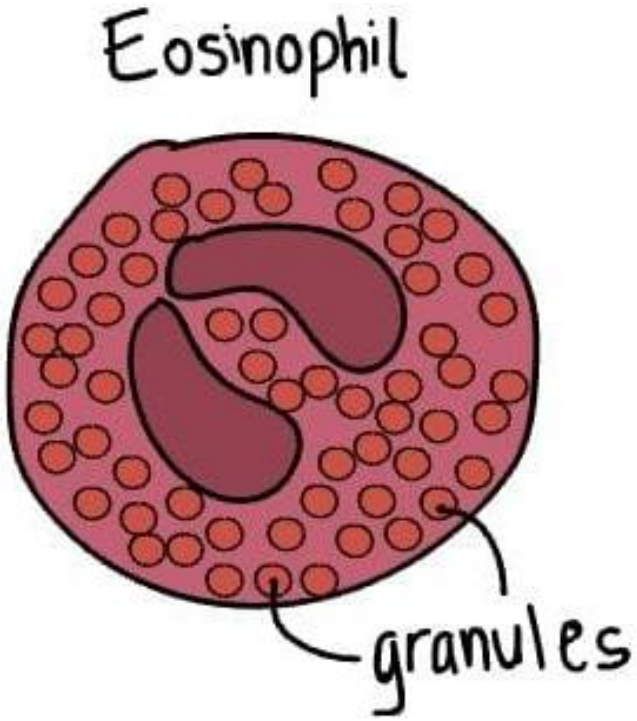
Neutrophils

- Neutrophils are phagocytic cells that are also classified as granulocytes because they contain granules in their cytoplasm.
- These granules are very toxic to bacteria and fungi, and cause them to stop proliferating or die on contact.
- The bone marrow of an average healthy adult makes approximately 100 billion new neutrophils per day.
- Neutrophils are typically the first cells to arrive at the site of an infection because there are so many of them in circulation at any given time.



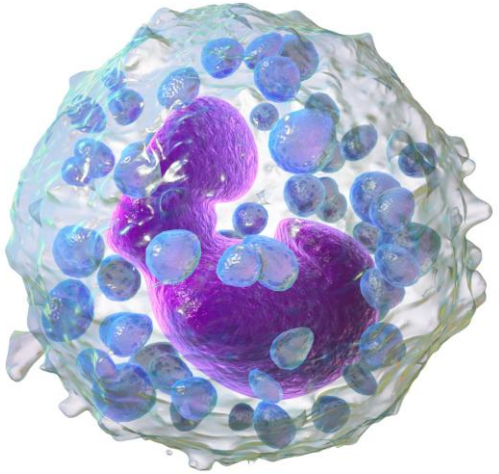
Eosinophils

- Eosinophils are granulocytes target multicellular parasites. Eosinophils secrete a range of highly toxic proteins and free radicals that kill bacteria and parasites.
- The use of toxic proteins and free radicals also causes tissue damage during allergic reactions, so activation and toxin release by eosinophils is highly regulated to prevent any unnecessary tissue damage.
- While eosinophils only make up 1-6% of the white blood cells, they are found in many locations, including the thymus, lower gastrointestinal tract, ovaries, uterus, spleen, and lymph nodes.



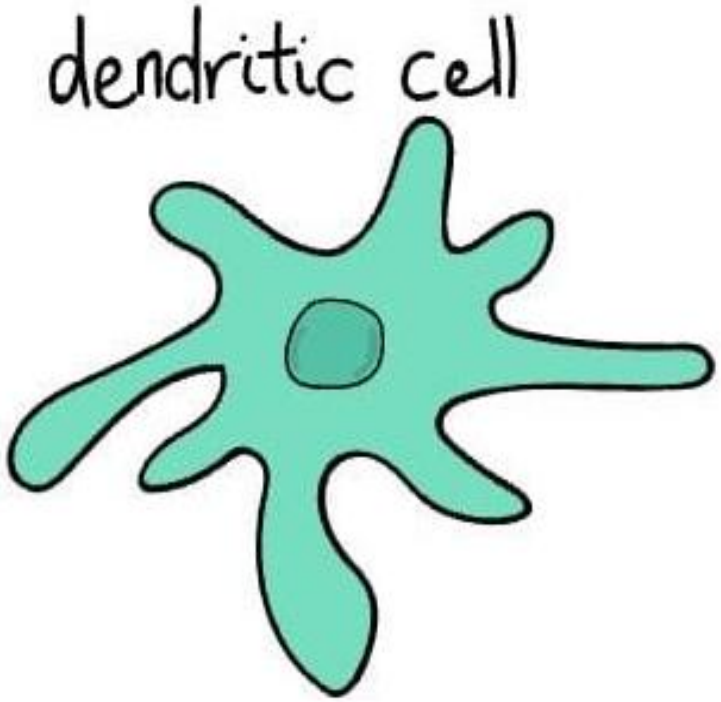
Basophils

- Basophils are also granulocytes that attack multicellular parasites. Basophils release histamine, much like mast cells.
- The use of histamine makes basophils and mast cells key players in mounting an allergic response.
- Natural Killer cells: Natural Killer cells (NK cells), do not attack pathogens directly.
- Instead, natural killer cells destroy infected host cells in order to stop the spread of an infection. Infected or compromised host cells can signal natural kill cells for destruction through the expression of specific receptors and antigen presentation.



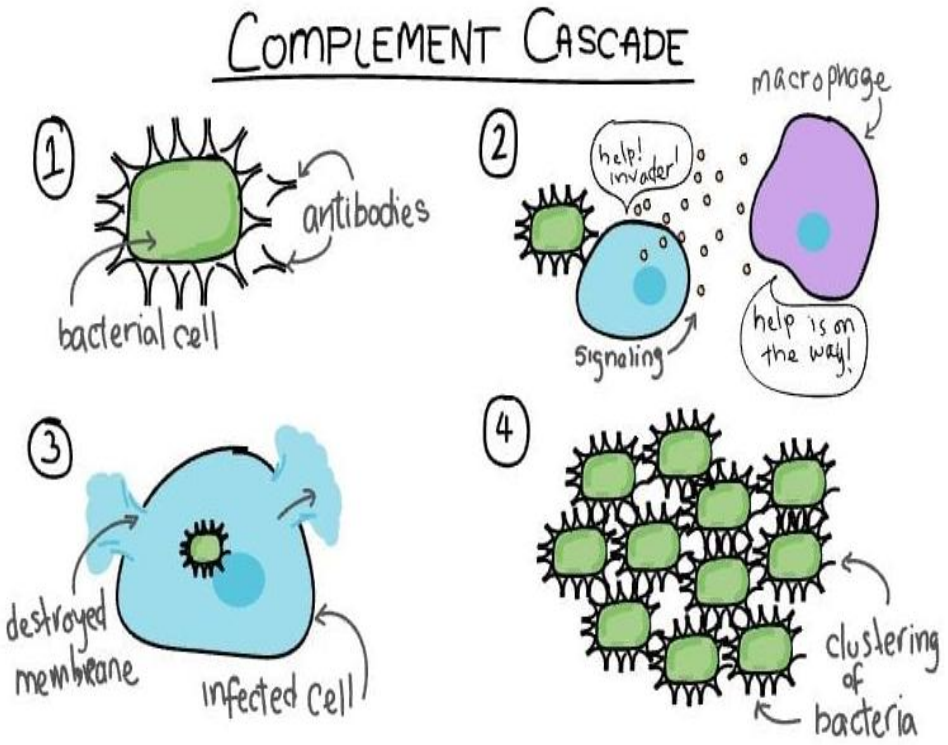
Dendritic cells

- Dendritic cells are antigen-presenting cells that are located in tissues, and can contact external environments through the skin, the inner mucosal lining of the nose, lungs, stomach, and intestines.
- Since dendritic cells are located in tissues that are common points for initial infection, they can identify threats and act as messengers for the rest of the immune system by antigen presentation.
- Dendritic cells also act as bridge between the innate immune system and the adaptive immune system.



The Complement System

- The complement system (also called the complement cascade) is a mechanism that complements other aspects of the immune response.
- Typically, the complement system acts as a part of the innate immune system, but it can work with the adaptive immune system if necessary.



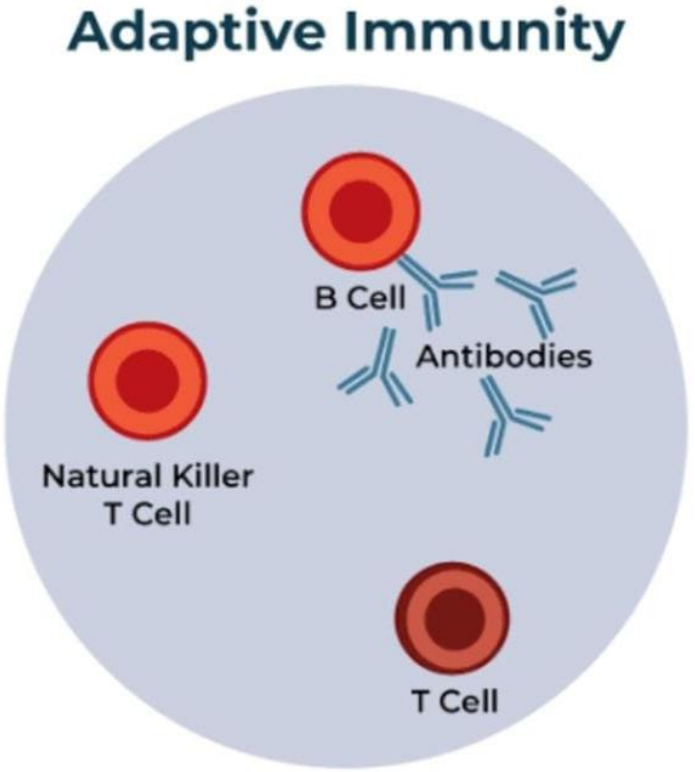
- Opsonization: Opsonization is a process in which foreign particles are marked for phagocytosis. All of the pathways require an antigen to signal that there is a threat present.
- Opsonization tags infected cells and identifies circulating pathogens expressing the same antigens.
- Chemotaxis: Chemotaxis is the attraction and movement of macrophages to a chemical signal. Chemotaxis uses cytokines and chemokines to attract macrophages and neutrophils to the site of infection, ensuring that pathogens in the area will be destroyed. By bringing immune cells to an area with identified pathogens, it improves the likelihood that the threats will be destroyed and the infection will be treated.

- Cell Lysis: Lysis is the breaking down or destruction of the membrane of a cell. The proteins of the complement system puncture the membranes of foreign cells, destroying the integrity of the pathogen. Destroying the membrane of foreign cells or pathogens weakens their ability to proliferate, and helps to stop the spread of infection.

- Agglutination: Agglutination uses antibodies to cluster and bind pathogens together, much like a cowboy rounds up his cattle. By bringing as many pathogens together in the same area, the cells of the immune system can mount an attack and weaken the infection. Other innate immune system cells continue to circulate throughout the body in order to track down any other pathogens that have not been clustered and bound for destruction.

Adaptive immunity

- Adaptive immunity is the immunity that our body acquires or gains over time. Unlike the innate immunity, this is not present by birth.
- The ability of the immune system to adapt itself to disease and to generate pathogen-specific immunity is termed as acquired immunity. It is also known as adaptive immunity.
- An individual acquires the immunity after the birth, hence is called as the acquired immunity.
- It is specific and mediated by antibodies or lymphocytes which make the antigen harmless.
- The main function of acquired immunity is to relieve the victim of the infectious disease and also prevent its attack in future.

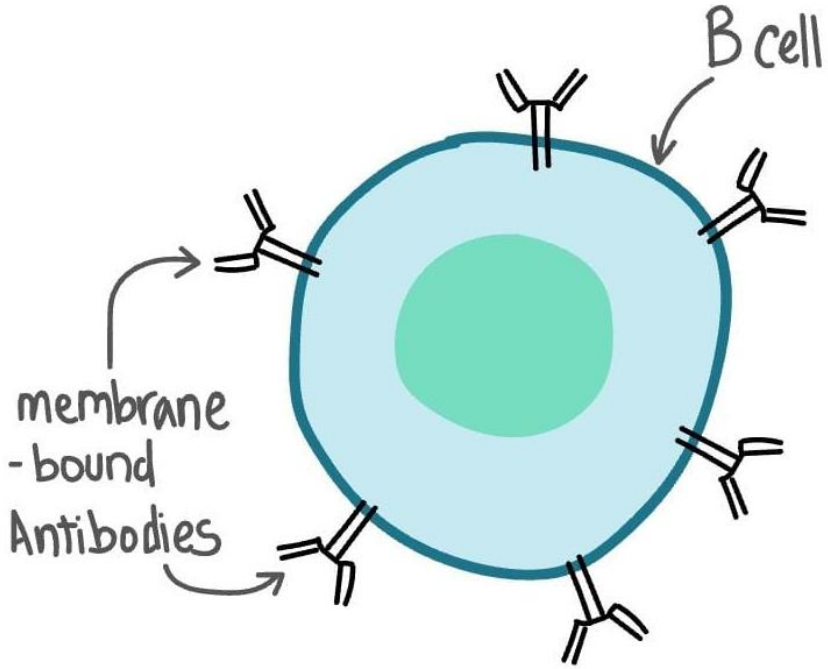


Features

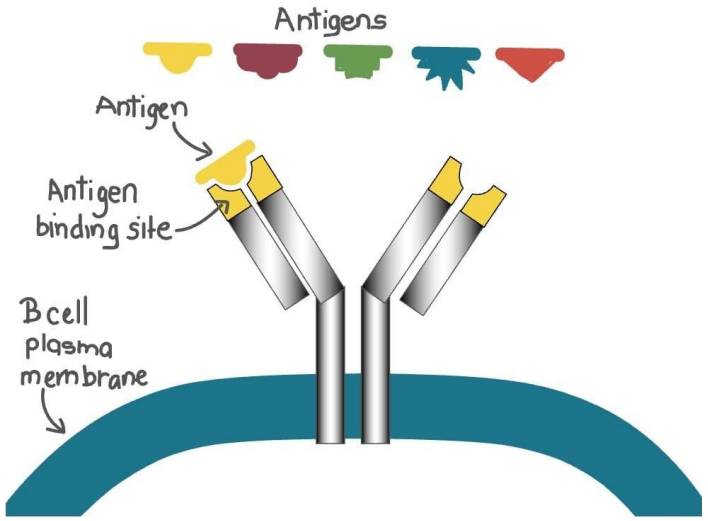
- **Specificity:** Our body has the ability to differentiate between different types of pathogens, whether it is harmful or not, and devise ways to destroy them.
- **Diversity:** Our body can detect vast varieties of pathogens, ranging from protozoa to viruses.
- **Differentiate between self and non-self:** Our body has the unique ability to differentiate between its own cells and foreign cells. It immediately starts rejecting any foreign cell in the body.
- **Memory:** Once our body encounters a pathogen, it activates the immune system to destroy it. It also remembers what antibodies were released in response to that pathogen, so that, the next time it enters, a similar procedure is followed by the body to eliminate it.

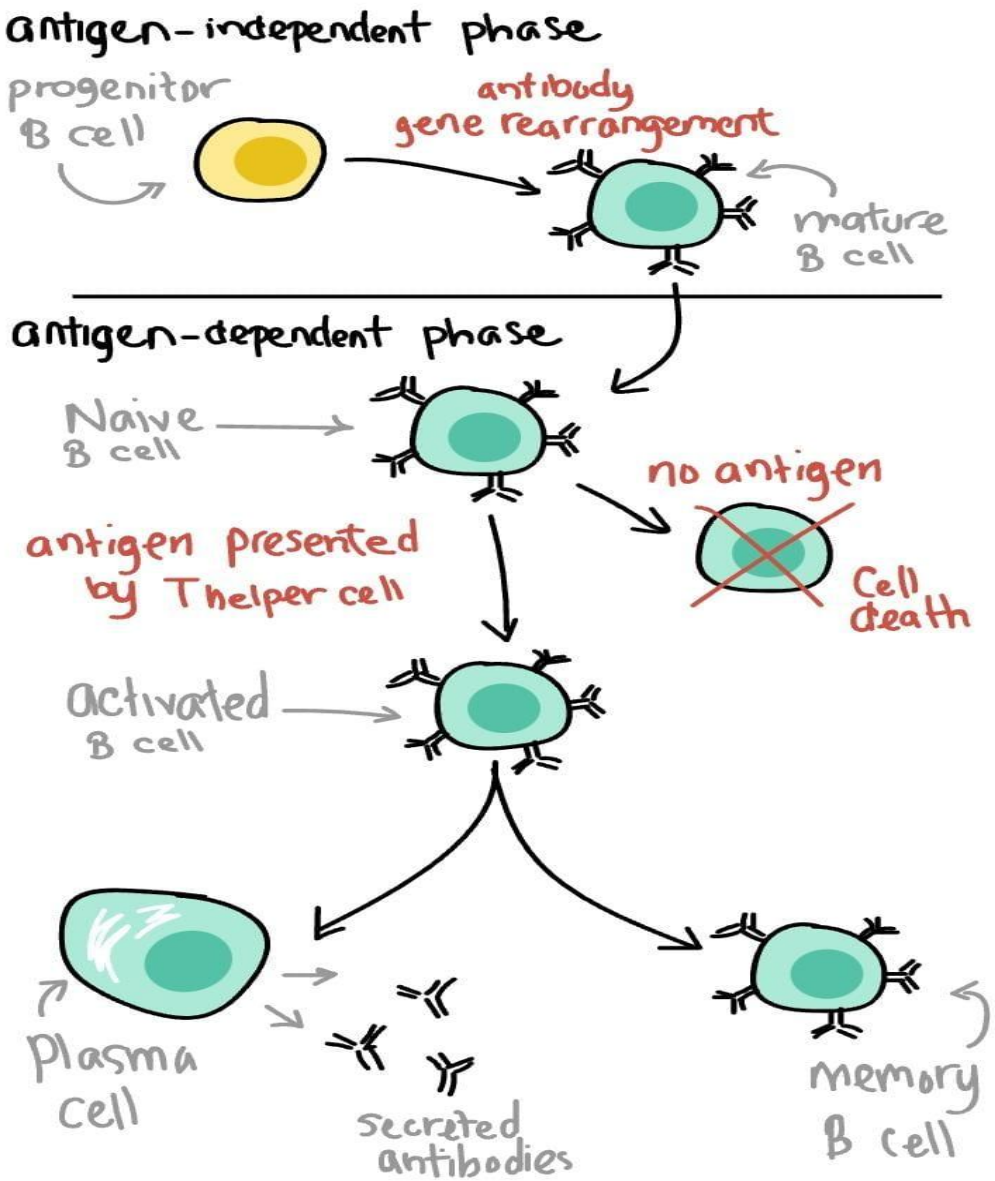
Cells of the adaptive immune system

- Unlike the innate immune system, the adaptive immune system relies on fewer types of cells to carry out its tasks: B cells and T cells.
- B cells: After formation and maturation in the bone marrow (hence the name “B cell”), the naive B cells move into the lymphatic system to circulate throughout the body



- When a naive B cell encounters an antigen that fits or matches its membrane-bound antibody, it quickly divides in order to become either a memory B cell or an effector B cell, which is also called a plasma cell. Antibodies can bind to antigens directly.
- The antigen must effectively bind with a naive B cell's membrane-bound antibody in order to set off differentiation, or the process of becoming one of the new forms of a B cell.



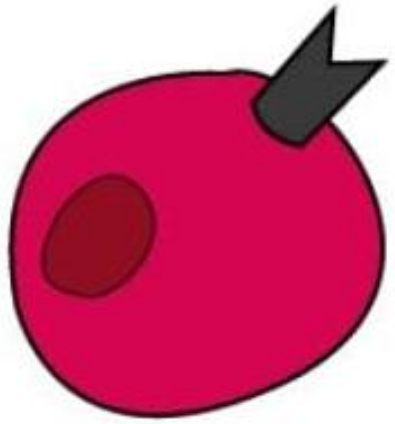


Source: https://www.slideshare.net/slideshow/immunology-226489067/226489067

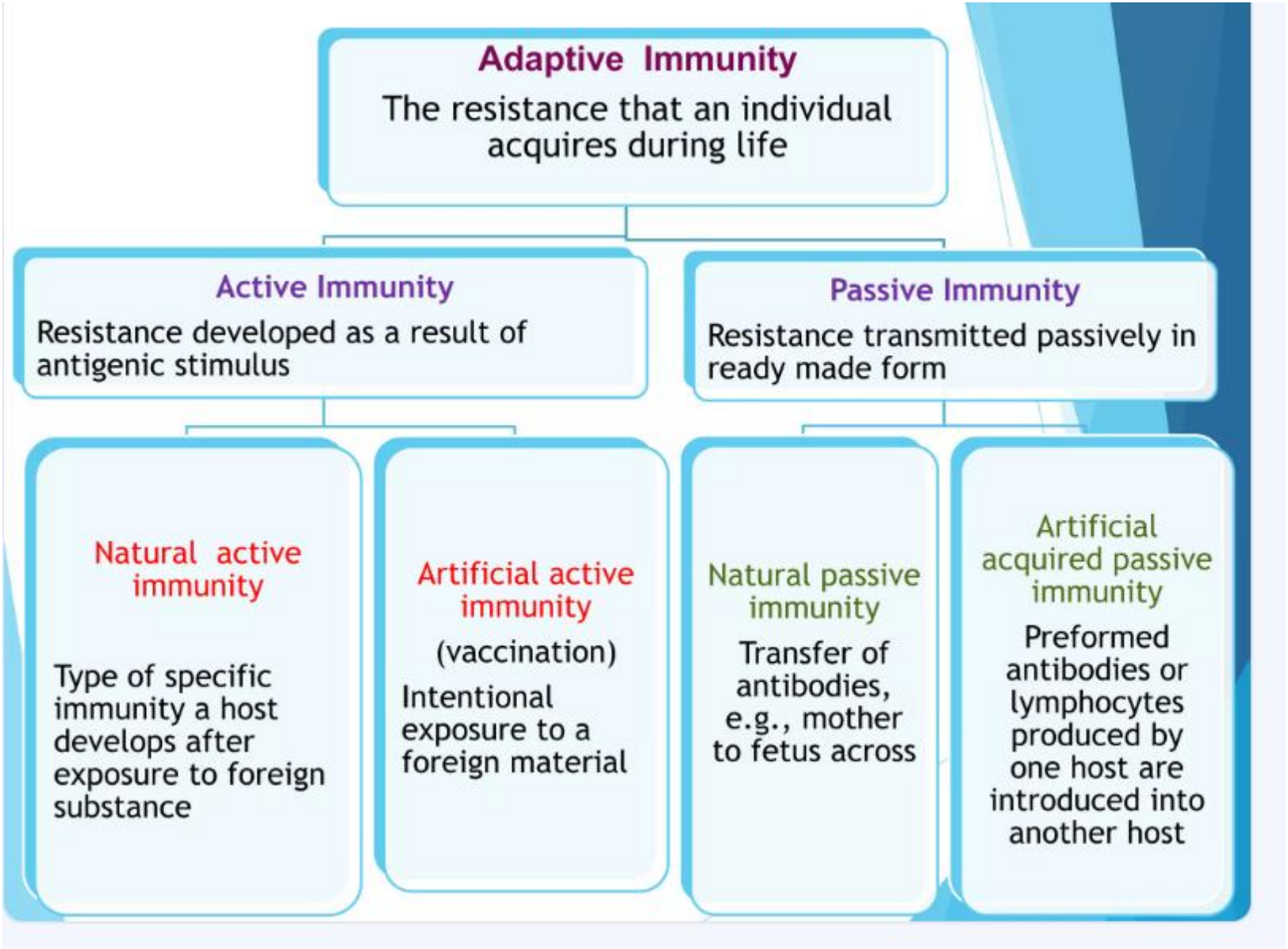
- Memory B cells express the same membrane-bound antibody as the original naive B cell, or the “parent B cell”.
- Plasma B cells produce the same antibody as the parent B cell, but they aren’t membrane bound. Instead, plasma B cells can secrete antibodies. Secreted antibodies work to identify free pathogens that are circulating throughout the body.
- When the naive B cell divides and differentiates, both plasma cells and memory B cells are made cells also express a specialized receptor, called the B cell receptor (BCR).
- B cell receptors assist with antigen binding, as well as internalization and processing of the antigen. B cell receptors also play an important role in signaling pathways.
- After the antigen is internalized and processed, the B cell can initiate signaling pathways, such as cytokine release, to communicate with other cells of the immune system

T-cells

- They originate in the bone marrow and develop in the thymus- cells differentiate into helper cells, cytotoxic cells, and regulatory cells.
- These cells are released into the bloodstream. When these cells are triggered by an antigen, helper T-cells release cytokines that act as messengers.
- These cytokines initiate the differentiation of B-cells into plasma cells which release antibodies against the antigens.
- The cytotoxic T-cells kills the cancer cells. Regulatory T-cells regulate immune reactions.



Types of adaptive immunity



Types of Acquired Immune Response

Humoral Immune Response

- The antibodies produced by B-lymphocytes are present in the blood cells and they are transported all over the body. This is why it is called the humoral immune response as it consists of an antibody produced by the lymphocytes. It depends upon the action of antibodies circulating in the body.
- When an antibody on a B-cell binds with an antigen, humoral immunity comes into play. The antigen is internalized by the B cell and presented on the helper T cell.

Types of Acquired Immune Response

Humoral Immune Response

- This activates the B-cell. The activated B cells grow and produce plasma cells. These plasma cells release antibodies in the bloodstream.
- The memory B cells retain the information about the pathogen to prevent any disease caused by that pathogen in the near future.

Cell-mediated Immune Response

- Cell-mediated immunity is initiated by the T helper cells. The cytotoxic T cells eliminate the infected cells from the body by releasing toxins, thereby, promoting apoptosis or programmed cell death. The T helper cells help to activate other immune cells.
- Cell-mediated immunity becomes clear in the case of transplant patients. When any of our sense organs stop functioning, it can be transplanted to replace the malfunctioning organs. But it is not that simple with the immune response.

Cell-mediated Immune Response

- It appears that T-lymphocytes are capable of recognizing whether tissue or an organ is from our body or foreign bodies. This is the reason why we cannot transplant and implant the organs into our body even if we find the donor with the same blood group because our body might reject the transplanted organ.
- The T-cells quickly recognize that the tissue or an organ as a foreign and do not allow it to become a part of the body. This is why transplant receivers have to take immunosuppressant medication for the rest of their lives. This response is controlled by the T-lymphocytes.

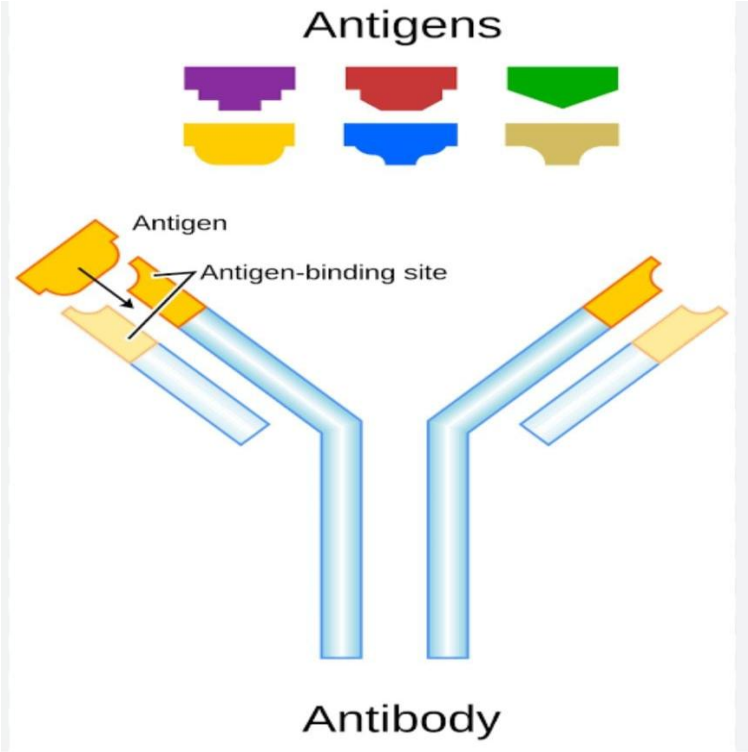
Terminology & definition antigen immunogen & Hapten

Terminology

Terminology is a group of specialized words and respective meanings in a particular field, and also the study of such terms and their use; the latter meaning is also known as terminology science.

Antigen

Antigen, substance that is capable of stimulating an immune response, specifically activating lymphocytes, which are the body's infection-fighting white blood cells.

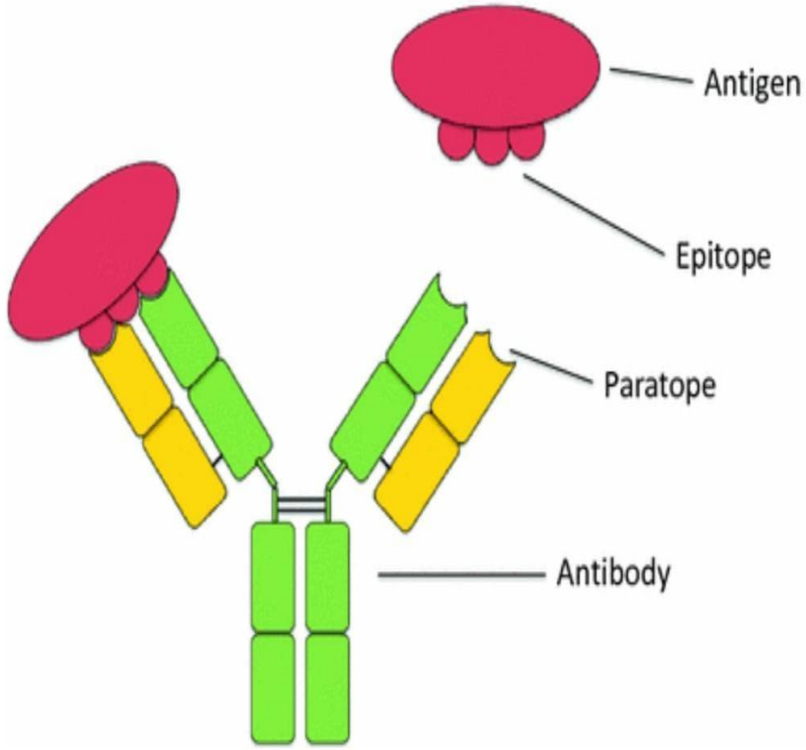


Antigen

- An antigen is a molecule that initiates the production of an antibody and causes an immune response.
- Antigens are large molecules of proteins, present on the surface of the pathogen- such as bacteria, fungi viruses, and other foreign particles.
- When these harmful agents enter the body, it induces an immune response in the body for the production of antibodies. For example: When a common cold virus enters the body, it causes the body to produce antibodies to prevent from getting sick.

Epitope

A molecular region on the surface of an antigen capable of eliciting an immune response and of combining with the specific antibody produced by such a response called also determinant, antigenic determinant.



Hapten

A small separable part of an antigen that reacts specifically with an antibody but is incapable of stimulating antibody production except in combination with a carrier protein molecule.

Haptens are low molecular weight molecules

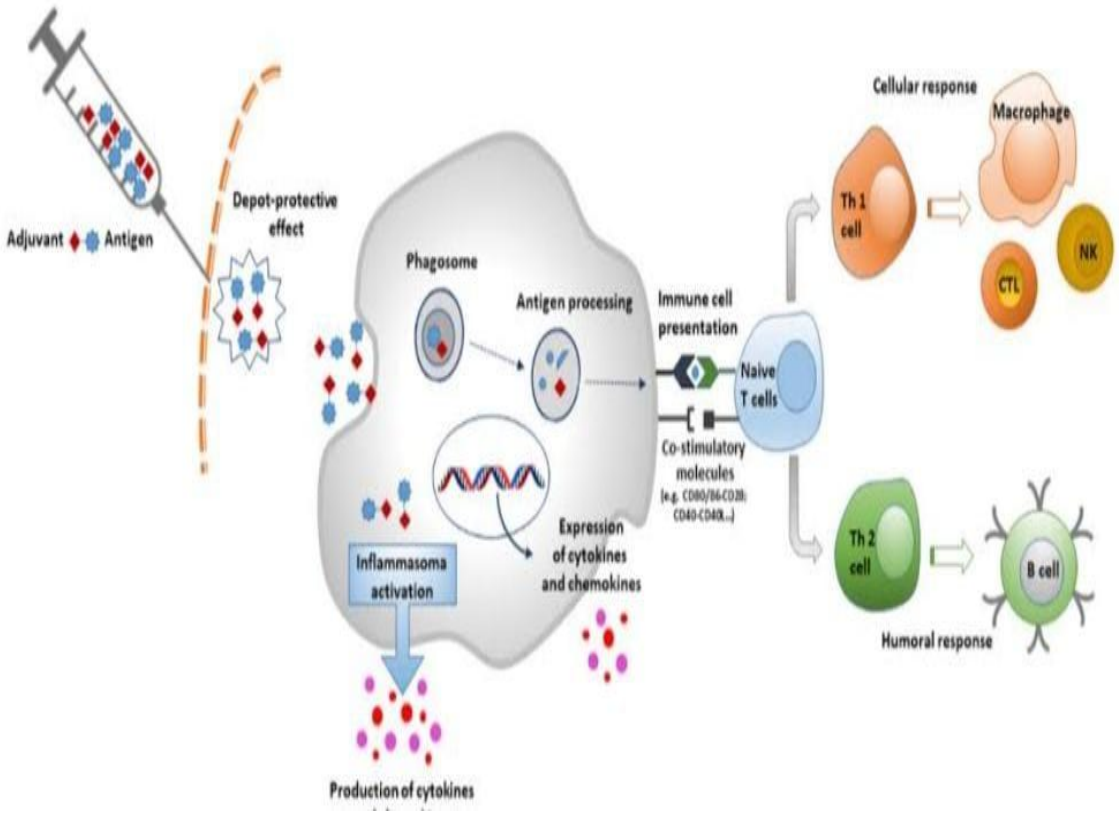
Small organic molecule that are antigenic but not immunogenic

Which means that they can bind to immune cells but fail to induce Humoral or cell mediated immune response.

Hence no antibodies are raised against them

Carrier protein

Carrier Proteins make small antigens, Immunogenic by themselves, carrier proteins are easily detected antigens. The immune system will develop antibodies against these proteins very quickly so that they may be targeted by macrophages as foreign particles.

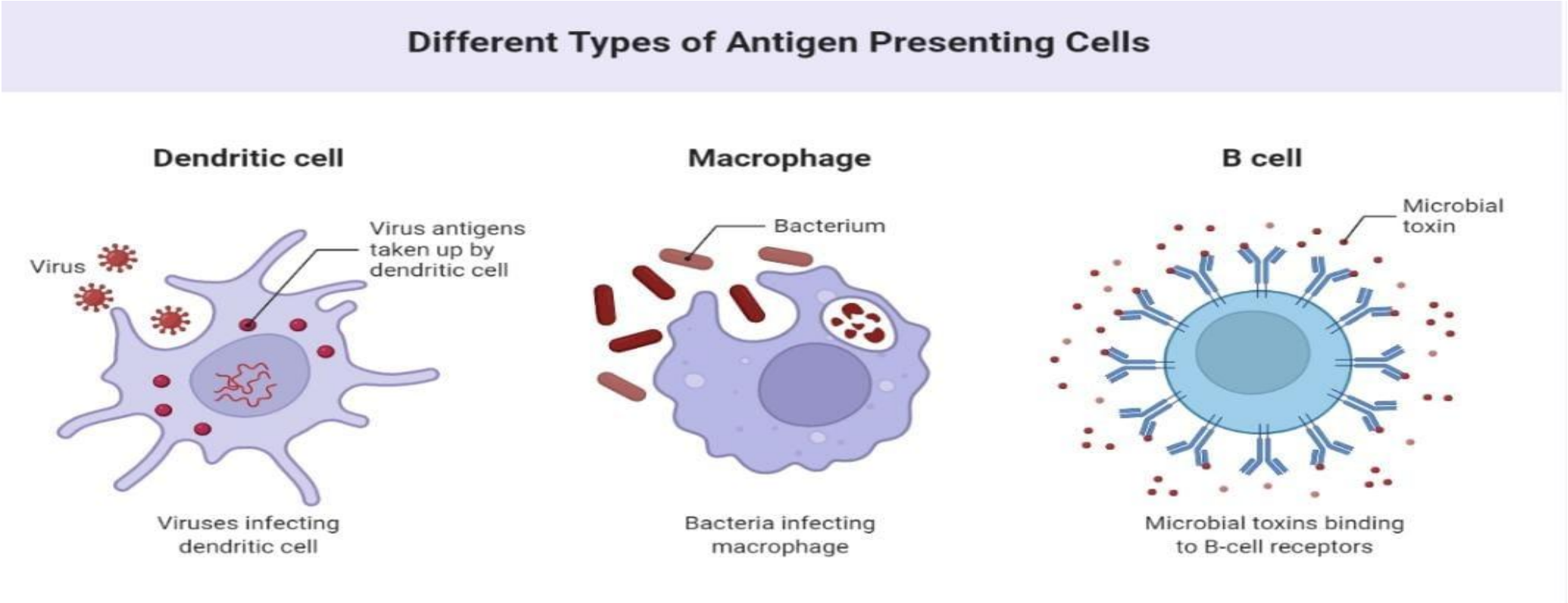


Adjuvant

An adjuvant is a substance that enhances the immune system's response to the presence of an antigen. They are commonly used to improve the effectiveness of a vaccine. Generally, they are injected alongside an antigen to help the immune system generate antibodies that fight the antigen.

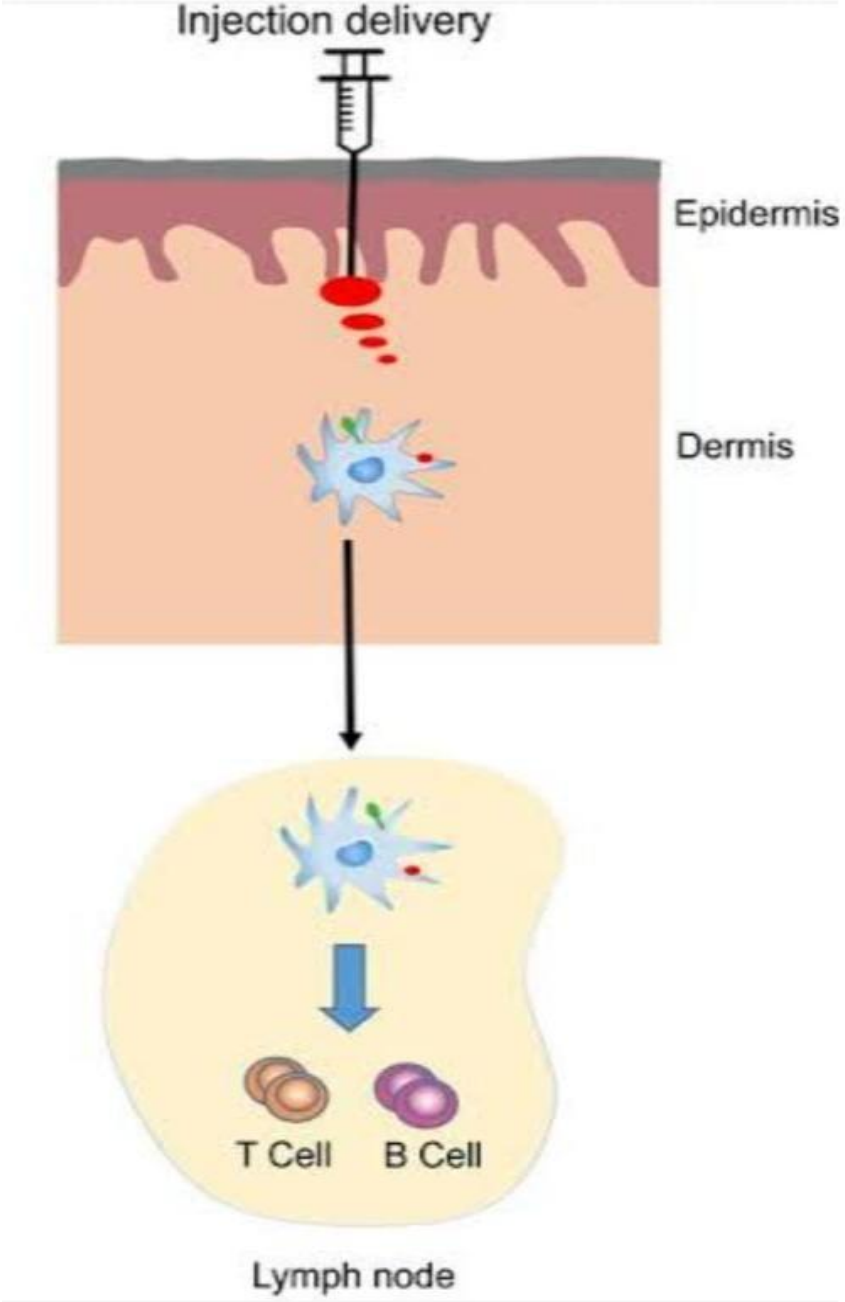
Antigen presenting cells

- Antigen presenting cells (APCs) are a large group of various cells that trigger the cellular immune response by processing an antigen and exposing it in a form recognizable by T cells in the process known as antigen presentation.



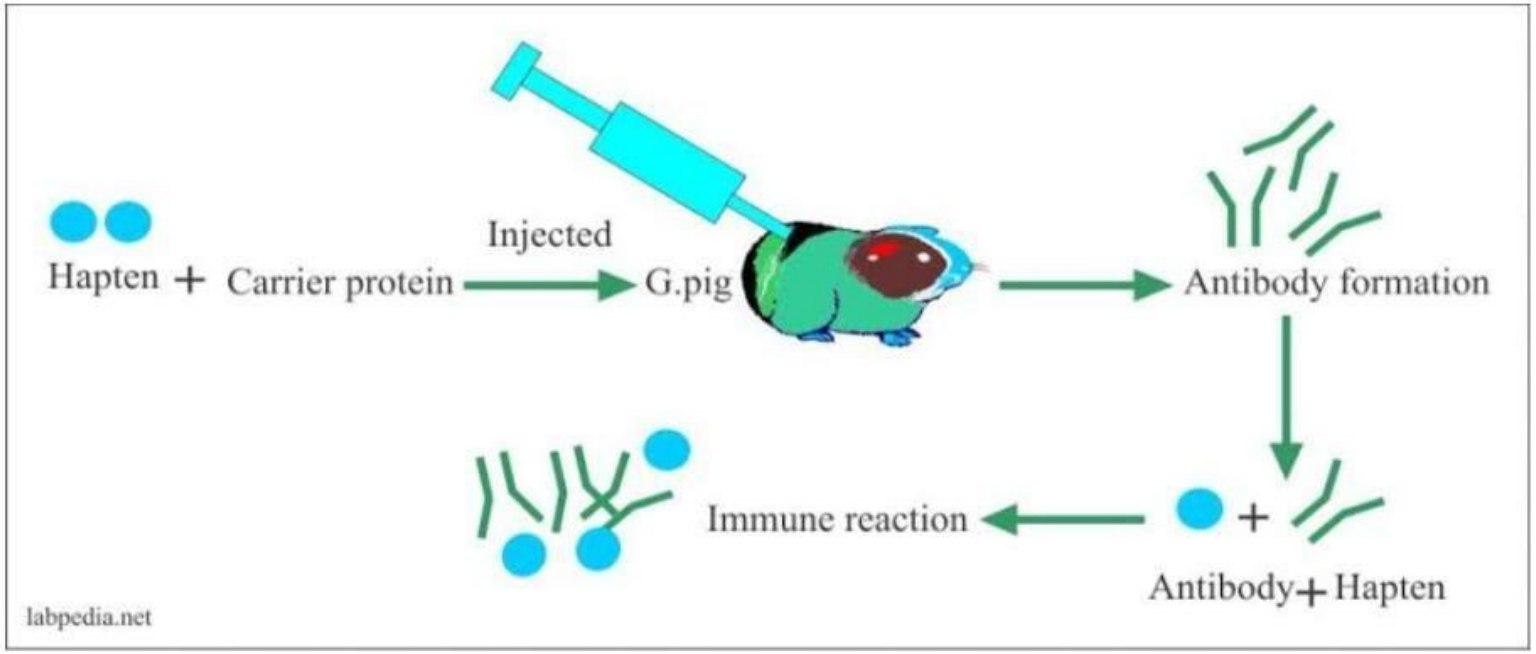
Immunogenicity

- Immunogenicity is the ability of a foreign substance to enter a person's body and cause an immune response.
- A great example of immunogenicity is a vaccination.
- When a person gets vaccinated, they are injected with a very tiny amount of a specific disease.



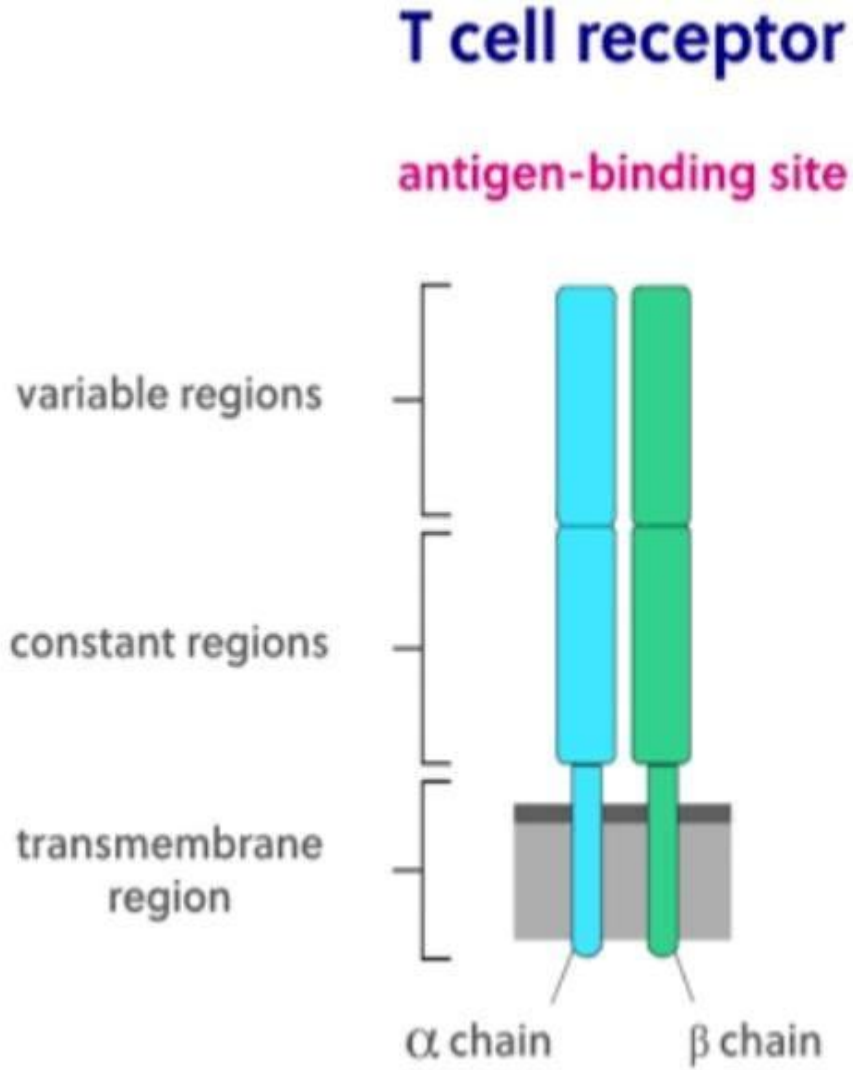
Immunogen

- An immunogen refers to a molecule that is capable of eliciting an immune response by an organism's immune system. An immunogen is necessarily an antigen, but an antigen may not necessarily be an immunogen.



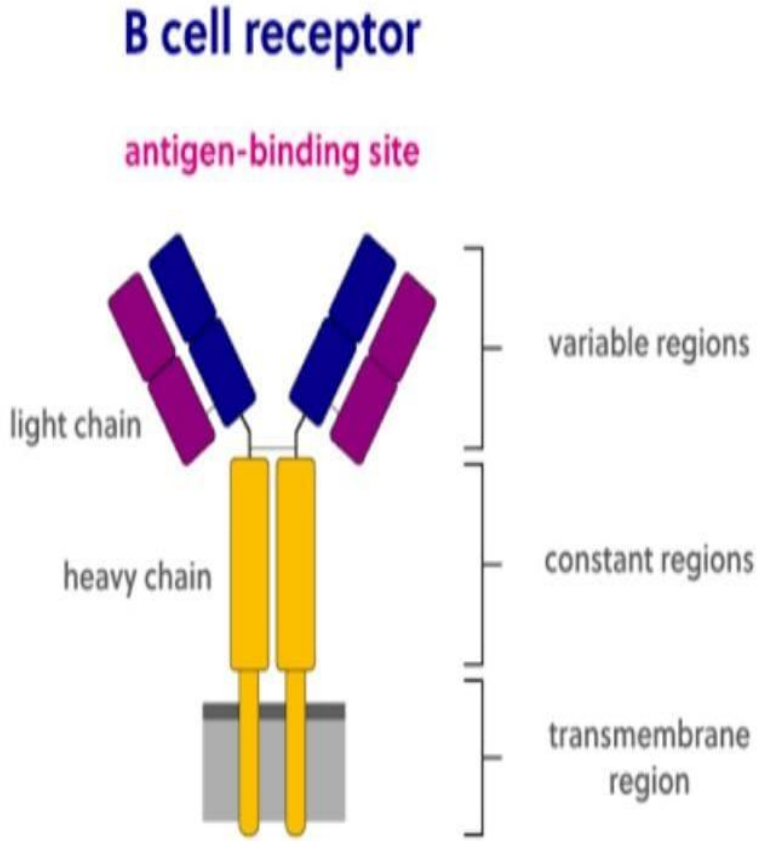
T-cell receptor

- A group of proteins found on T cells (a type of immune cell that recognizes and binds to foreign substances).
- T-cell receptors bind to certain antigens (proteins) found on abnormal cells, cancer cells, cells from other organisms, and cells infected with a virus or another microorganism.
- This interaction causes the T cells to attack these cells and helps the body fight infection, cancer, or other diseases. Also called TCR.



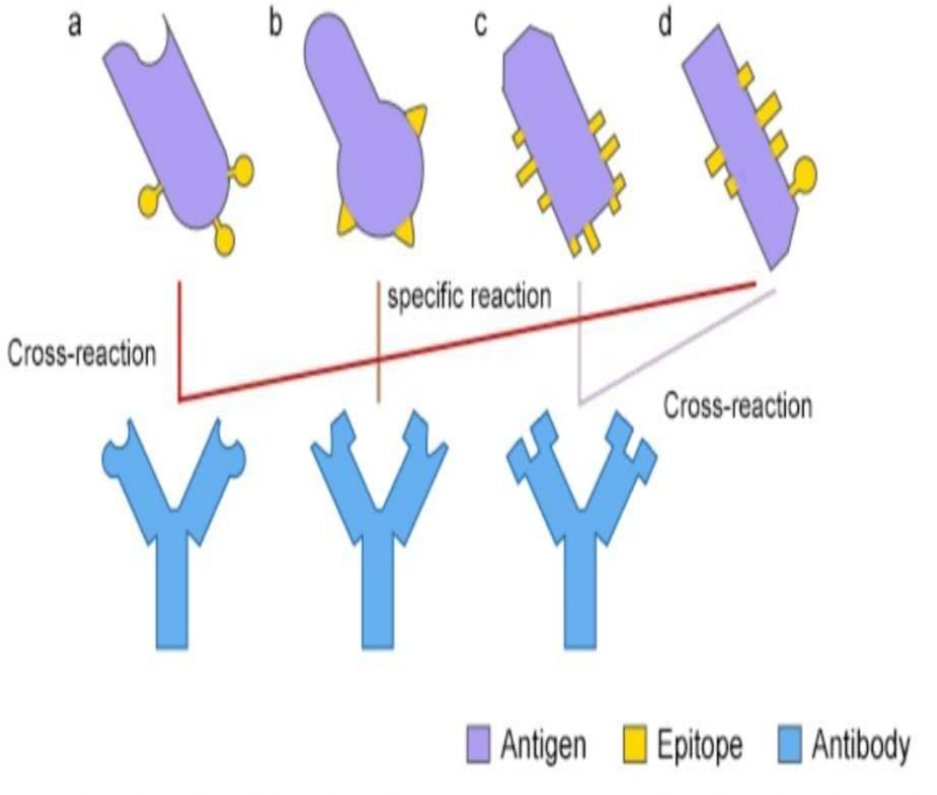
B -cell receptor

- The B-cell receptor (BCR) is a transmembrane protein on the surface of a B cell.
- A B-cell receptor is composed of a membrane-bound immunoglobulin molecule and a signal transduction moiety.
- The former forms a type 1 transmembrane receptor protein, and is typically located on the outer surface of these lymphocyte cells.



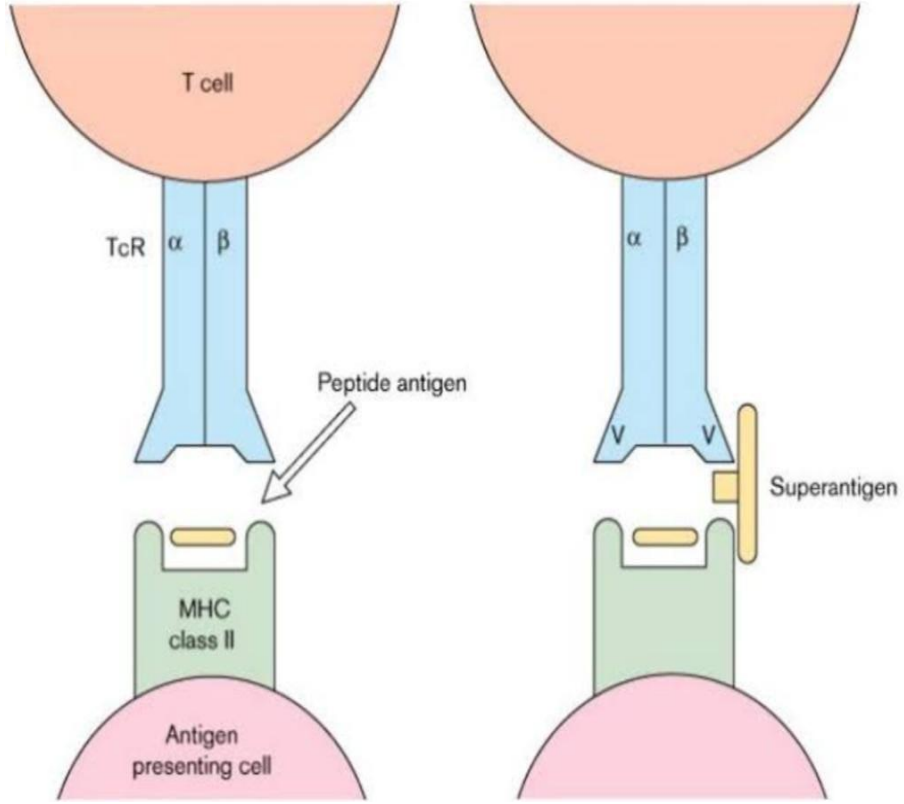
Cross reactivity

- Cross-reactivity measures the extent to which different antigens appear similar to the immune system.
- The molecular determinants of specificity and cross-reactivity define the nature of antigenic variation and the selective processes that shape the distribution of variants in populations.



Superantigen

- Superantigens (SAgs) are a class of antigens that result in excessive activation of the immune system.
- Specifically they cause non-specific activation of T-cells resulting in polyclonal T cell activation and massive cytokine release.



Immunogen

An immunogen is a molecule capable of eliciting an immune response when injected into an animal. An immunogen and antigen may have many different sites at which antibodies may bind.