ARULMIGU PALANIANDAVAR ARTS COLLEGE FOR WOMEN

PALANI

PG DEPARTMENT OF ZOOLOGY

LEARNING RESOURCES

IMMUNOLOGY

IMMUNOLOGY

"The study of the immune system, the cell-mediated and humoral aspects of immunity and immune responses."

Immunology is a branch of biology involved with the study of the immune system, components of the immune system, its biological processes, the physiological functioning of the immune system, types, its disorders and a lot more.

The immune system acts as a body's defence system by protecting our body cells, tissues and organs from invading infections through various lines of defence. Overall, the immune system functions by recognising and destroying foreign antigens including harmful microorganisms and other disease-causing microbes.

Under certain conditions, when our immune system is weak or stops functioning, this results in various infectious diseases, such as fever and flu, and may also lead to dreadful diseases like cancer AIDS, etc.

Immune System

Immune system consists of different types of cells and organs which protect our body against pathogens. Pathogens are defined as microorganisms that cause infections in the body such as bacteria, fungi, viruses and protozoans. Antigens are molecules that elicit antibody generation. They can be everything that does not belong to our body, from parasites to fungi, bacteria, viruses, and haptens. Haptens are molecules that can elicit an immune response when combined with a carrier molecule. All the cells and molecules of the immune system are distributed in all the tissues of the body as well as lymphoid organs which eliminate microbial infectious diseases, decrease the growth of tumours and starts the repairing process of damaged tissues.

The tissues and organs of the immune system act as security forces where cells act as the security guards while molecules act as the guns & bullets and use the communication system to protect you.

Types of Immune System

We, humans, have two types of Immune system and are classified based on whether they are present at the time of birth or not.

1. Innate Immune System.
2. Adaptive Immune System.

Innate Immune System

Immune System fights against microbes and prevent their entry inside the body.

Innate Immune System is composed of cells and proteins that are always present and are ready to fight against microbes in the infection area. Innate Immune System is present from the time of our birth.

Main elements of the innate immune system are –

- Dendritic cells.
- Phagocytic leukocytes.
- Natural killer (NK) cell.
- Physical epithelial barriers.
- Circulating plasma proteins.

Adaptive Immune System

The adaptive immune system is required to fight against pathogens that cannot be controlled by innate immune defences. It is also referred to as the acquired immune system because it is acquired during the course of life. They are specific to the type of pathogen invading the body.

All the components of the adaptive immune system are generally inactive however when activated these components adjust to the presence of all the infectious agents by proliferating and developing a potent mechanism for eliminating the microbes.

Two Types of adaptive responses are – humoral immunity moderated by antibodies which are developed by B lymphocytes and cell-mediated immunity, moderated by T Lymphocytes.

Immunology and Diseases

Immunological diseases are caused by defects in immune system. The immune system may be hyperactivated to release antibodies and other chemicals. This results in allergy and anaphylaxis. Sometimes the immune system fails to differentiate self cells from no-self cells, resulting in autoimmune diseases. In this situation, the immune system is challenged and evoke responses that damage cells and tissues rather than protecting. All the immunodeficiency diseases increase the risk of tumours and infections and are caused by malnutrition, immune suppresents, gene mutations, and viruses such as HIV.

Symptoms of Immune Dysfunction

- Bowel disorders.
- Parasite infections.
- Candida overgrowth.
- Allergies and Asthma.
- Frequent colds and flu.
- Autoimmune disorders.
- Painful joints and muscles.
- Herpes (cold sore) outbreak.
- HPV and abnormal PAP smears.
- Rhinitis or a constant runny nose.

- Psoriasis, eczema, hives or rashes.

Immunology Techniques

This is an experimental method used for studying the structure and functions of the immune system. There are different techniques, which includes:

- ELISA.
- ELISPOT.
- Immune cell isolation.
- Immuno-histo-chemistry.
- Generation of Antibodies.
- Immuno-blotting and precipitation.
- Isolation and Purification of Antibodies.

Applications of Immunology

Immunology is widely used in numerous disciplines, including medicine, in the fields of organ transplantation, bacteriology, oncology, virology, parasitology, rheumatic diseases, psychiatric disorders, and dermatology. The Immunology of transplantation mainly deals with the process of transplantation from a donor to the recipient, so that the recipient's body does not reject the organ.

ANTIGEN

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.

Properties of Antigens

The properties of antigens are as follows:

1. The antigen should be a foreign substance to induce an immune response.
2. The antigens have a molecular mass of 14,000 to 6,00,000 Da.
3. They are mainly proteins and polysaccharides.
4. The more chemically complex they are, the more immunogenic they will be.
5. Antigens are species-specific.
6. The age influences the immunogenicity. Very young and very old people exhibit very low immunogenicity.

Types of Antigens

On the basis of Origin

There are different types of antigens on the basis of origin:

Exogenous Antigens

Exogenous antigens are the external antigens that enter the body from outside, e.g. inhalation, injection, etc. These include food allergen, pollen, aerosols, etc. and are the most common type of antigens.

Endogenous Antigens

Endogenous antigens are generated inside the body due to viral or bacterial infections or cellular metabolism.

Autoantigens

Autoantigens are the ‘self’ proteins or nucleic acids that due to some genetic or environmental alterations get attacked by their own immune system causing autoimmune diseases.

Tumour Antigens

It is an antigenic substance present on the surface of tumour cells that induces an immune response in the host, e.g. MHC-I and MHC-II. Many tumours develop a mechanism to evade the immune system of the body.

Native Antigens

An antigen that is not yet processed by an antigen-presenting cell is known as native antigens.

On the Basis of Immune Response

On the basis of the immune response, antigens can be classified as:

Immunogen

These may be proteins or polysaccharides and can generate an immune response on their own.

Hapten

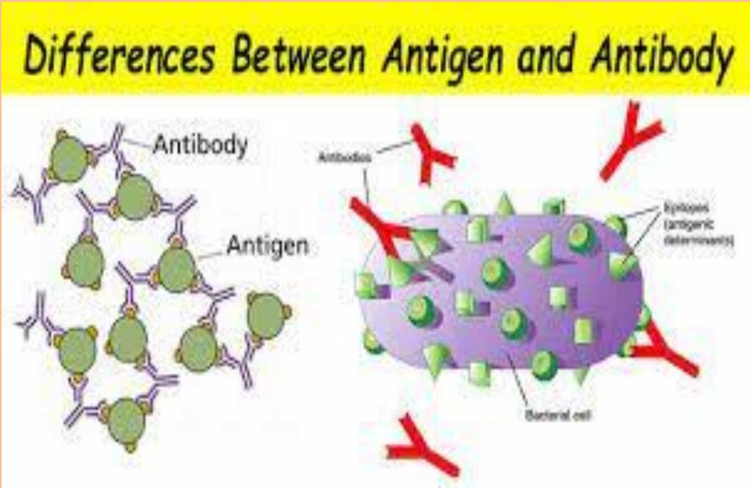
These are non-protein, foreign substances that require a carrier molecule to induce an immune response.

Structure of Antigens

The epitopes or antigenic determinants are the components of antigen. Every antigen has several epitopes. An antibody has at least two binding sites that can bind to specific epitopes on antigens.

The antigens combine with the antibody according to the lock and key mechanism.

The ability of the body to act against the disease-causing agents and antigens by the immune system is termed as the immunity. This immunity may be either inborn or acquired from vaccinations.



MONOCLONAL ANTIBODY

Monoclonal antibodies are a specific, single type of antibody. The prefix 'mono-' means 'one', and the ending 'clonal' indicates that these antibodies are clones of each other; they are all the same. Scientists can clone B cells to produce monoclonal antibodies, where each antibody is produced from copies of the same cell.

Monoclonal antibodies are produced 'naturally' in the body during the immune response, specifically the **humoral response**. Here, monoclonal antibodies are produced by one type of B cell (B lymphocyte), which synthesises the specific antibody that is complementary to the antigen of the pathogen being responded to. You can learn more about how and why B cells produce antibodies in our article on the **humoral** response.

Monoclonal antibodies can also be manufactured in laboratories for use in scientific research and medicine. In medical environments, they can be produced using hybridoma techniques.

A **hybridoma** is a hybrid cell used for the production of antibodies. It is a hybrid between a tumour cell and an antibody-producing lymphocyte.

In this process, a mouse is injected with an antigen for which a complementary antibody is being produced. This triggers a natural immune response in the mouse. The mouse's lymphocytes produce antibodies specific to the antigen.

Then, the **spleen cells** of the mouse, which synthesise the antibody-producing lymphocytes, are removed in a small operation.

These spleen cells are fused with human myeloma cells, which are cancerous white blood cells. The point of using cancerous cells is that they divide rapidly, and so many copies of this fused cell can be created in a short amount of time.

This fusion forms hybridoma cells that indefinitely divide to produce millions of antibodies. These antibodies are all identical to one another and specific to the original antigen.

USES

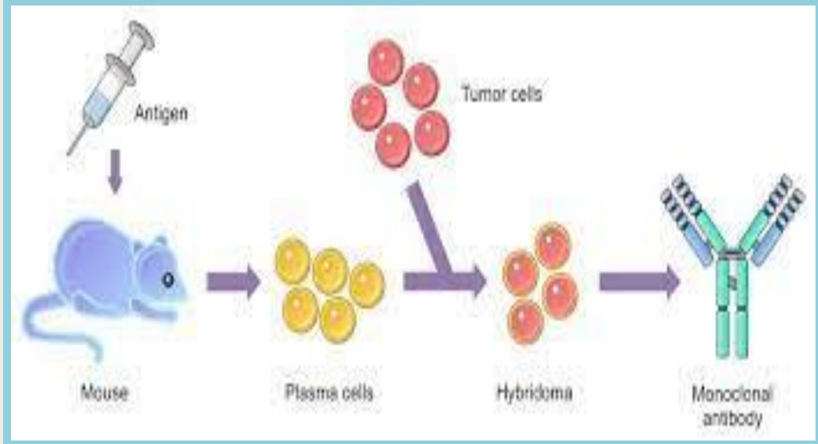
Monoclonal antibodies have significant value in science and medicine, where they can be used for testing for specific disease-causing antigens and for delivering targeted medication.

Monoclonal antibodies are used to diagnose diseases such as HIV and conditions such as pregnancy.

Using monoclonal antibodies for medical diagnosis

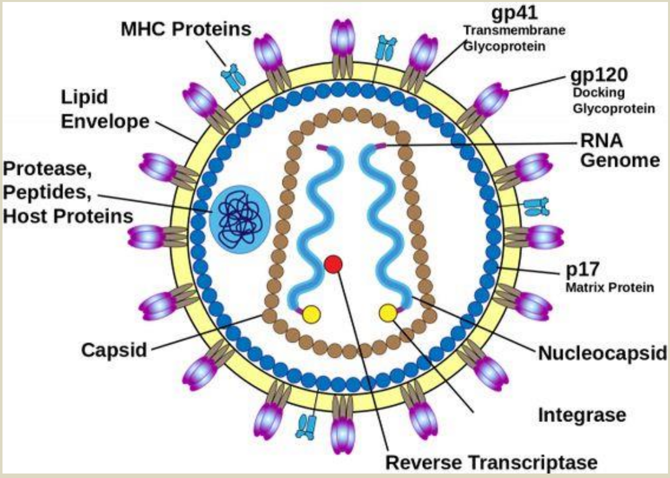
Monoclonal antibodies are used in over a hundred different diagnostic products. This includes the **ELISA** test (Enzyme-linked immunosorbent assay), which has been developed to diagnose several diseases, including HIV and hepatitis B and C. Monoclonal antibodies are also used to diagnose diseases, such as influenza and chlamydia.

Monoclonal antibodies are important in helping to identify the presence of certain cancers, such as prostate cancer. Men with prostate cancer often produce a higher amount of a prostate-specific antigen (PSA). Doctors can use specific monoclonal antibodies to measure the amount of PSA in a person's blood. If this is unusually high, it may indicate the presence of cancer in the prostate, and give evidence for further diagnostic tests.



HIV

HIV (*human immunodeficiency virus*) is a virus that attacks cells that help the body fight infection, making a person more vulnerable to other infections and diseases. It is spread by contact with certain bodily fluids of a person with HIV, most commonly during unprotected sex (sex without a condom or HIV medicine to prevent or treat HIV), or through sharing injection drug equipment.



If left untreated, HIV can lead to the disease AIDS (*acquired immunodeficiency syndrome*).

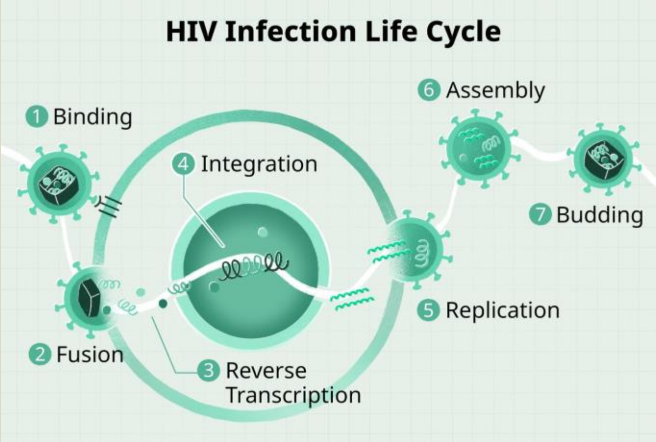
The human body can't get rid of HIV and no effective HIV cure exists. So, once you have HIV, you have it for life. If taken as prescribed, HIV medicine can reduce the amount of HIV in the blood (also called the viral load) to a very low level. This is called viral suppression. If a person's viral load is so low that a standard lab can't detect it, this is called having an undetectable viral load. People with HIV who take HIV medicine as prescribed and get and keep an undetectable viral load can **live long and healthy lives** and **will not transmit HIV to their HIV-negative partners through sex**.

AIDS

AIDS is the late stage of HIV infection that occurs when the body's immune system is badly damaged because of the virus.

In the U.S., most people with HIV do not develop AIDS because taking HIV medicine as prescribed stops the progression of the disease.

A person with HIV is considered to have progressed to AIDS when:



- the number of their CD4 cells falls below 200 cells per cubic millimeter of blood (200 cells/mm3). (In someone with a healthy immune system, CD4 counts are between 500 and 1,600 cells/mm3.) OR
- they develop one or more opportunistic infections regardless of their CD4 count.

Without HIV medicine, people with AIDS typically survive about 3 years. Once someone has a dangerous opportunistic illness, life expectancy without treatment falls to about 1 year. HIV medicine can still help people at this stage of HIV infection, and it can even be lifesaving. But people who start HIV medicine soon after they get HIV experience more benefits—that's why HIV testing is so important.

TRANSMISSION

You can only get HIV by coming into direct contact with certain body fluids from a person with HIV who has a detectable viral load. These fluids are:

- Blood
- Semen (*cum*) and pre-seminal fluid *(pre-cum)*
- Rectal fluids
- Vaginal fluids
- Breast milk

For transmission to occur, the HIV in these fluids must get into the bloodstream of an HIV-negative person through a mucous membrane (found in the rectum, vagina, mouth, or tip of the penis), through open cuts or sores, or by direct injection (from a needle or syringe).

People with HIV who take HIV medicine as prescribed and get and keep an undetectable viral load can **live long and healthy lives** and **will not transmit HIV to their HIV-negative partners through sex**.

HIV can only be spread through specific activities. In the United States, the most common ways are:

- Having vaginal or anal sex with someone who has HIV without using a condom the right way every time or taking medicines to prevent or treat HIV. Anal sex is riskier than vaginal sex for HIV transmission. Learn more about the HIV risk associated with specific sexual activities.

- Sharing injection drug equipment, such as needles, syringes, or other drug injection equipment ("works") with someone who has HIV because these items may have blood in them, and blood can carry HIV. People who inject hormones, silicone, or steroids can also get or transmit HIV by sharing needles, syringes, or other injection equipment. Learn more about HIV and injection drug use.

Less common ways are:

- An HIV-positive person transmitting HIV to their baby during pregnancy, birth, or breastfeeding.
- Being exposed to HIV through a needlestick or sharps injury. This is a risk mainly for health care workers. The risk is very low.

HIV is spread only in extremely rare cases by:

- **Having oral sex.** Oral sex carries little to no risk for getting or transmitting HIV**.** Theoretically, it is possible if an HIV-positive man ejaculates in his partner's mouth during oral sex. Factors that may increase the risk of transmitting HIV through oral sex are oral ulcers, bleeding gums, genital sores, and the presence of other sexually transmitted diseases (STDs), which may or may not be visible. However, the risk is still extremely low, and much lower than with anal or vaginal sex.
- **Receiving blood transfusions, blood products, or organ/tissue transplants that are contaminated with HIV.** The risk is extremely small these days because of rigorous testing of the U.S. blood supply and donated organs and tissues. (And you can't get HIV from *donating* blood. Blood collection procedures are highly regular and very safe.)
- **Being bitten by a person with HIV.** Each of the very small number of documented cases has involved severe trauma with extensive tissue damage and the presence of blood. This rare transmission can occur through contact between broken skin, wounds, or mucous membranes and blood or body fluids from a person who has HIV. There is no risk of transmission if the skin is not broken. There are no documented cases of HIV being transmitted through spitting as HIV is not transmitted through saliva.
- **Deep, open-mouth kissing if both partners have sores or bleeding gums and blood from the HIV-positive partner gets into the bloodstream of the HIV-negative partner.** HIV is not spread through saliva.
- **Eating food that has been pre-chewed by a person with HIV.** The only known cases are among infants. HIV transmission can occur when the blood from an HIV-positive caregiver's mouth mixes with food while chewing and an infant eats it. However, you can't get HIV by consuming food handled by someone with HIV.

Stage 1: Acute HIV Infection

Within 2 to 4 weeks after infection with HIV, about two-thirds of people will have a flu-like illness. This is the body's natural response to HIV infection.

Flu-like symptoms can include:

- Fever
- Chills
- Rash
- Night sweats
- Muscle aches
- Sore throat
- Fatigue
- Swollen lymph nodes
- Mouth ulcers

These symptoms can last anywhere from a few days to several weeks. But some people do not have any symptoms at all during this early stage of HIV.

Find an HIV testing site near you—You can get an HIV test at your primary care provider's office, your local health department, a health clinic, or many other places. Use the HIV Services Locator to find an HIV testing site near you.

- Request an HIV test for recent infection—Most HIV tests detect antibodies (proteins your body makes as a reaction to HIV), not HIV itself. But it can take a few weeks after you have HIV for your body to produce these antibodies. There are other types of tests that can detect HIV infection sooner. Tell your doctor or clinic if you think you were recently exposed to HIV and ask if their tests can detect early infection.
- Know your status—After you get tested, be sure to learn your test results. If you're HIV-positive, see a health care provider as soon as possible so you can start treatment with HIV medicine. And be aware: when you are in the early stage of infection, you are at very high risk of transmitting HIV to others. It is important to take steps to reduce your risk of transmission. If you are HIV-negative, there are prevention tools like pre-exposure prophylaxis (PrEP) that can help you stay negative.

Stage 2: Clinical Latency

In this stage, the virus still multiplies, but at very low levels. People in this stage may not feel sick or have any symptoms. This stage is also called chronic HIV infection.

Without HIV treatment, people can stay in this stage for 10 or 15 years, but some move through this stage faster.

If you take HIV medicine exactly as prescribed and get and keep an undetectable viral load, you can live and long and healthy life and will not transmit HIV to your HIV-negative partners through sex.

But if your viral load is detectable, you *can* transmit HIV during this stage, even when you have no symptoms. It's important to see your health care provider regularly to get your viral load checked.

Stage 3: AIDS

If you have HIV and you are not on HIV treatment, eventually the virus will weaken your body's immune system and you will progress to AIDS (*acquired immunodeficiency syndrome).*

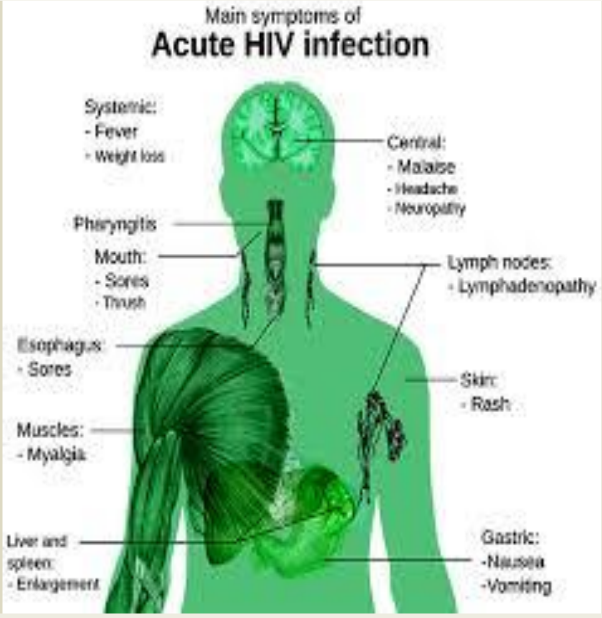
This is the late stage of HIV infection.

Symptoms of AIDS can include:

- Rapid weight loss
- Recurring fever or profuse night sweats
- Extreme and unexplained tiredness
- Prolonged swelling of the lymph glands in the armpits, groin, or neck
- Diarrhea that lasts for more than a week
- Sores of the mouth, anus, or genitals
- Pneumonia
- Red, brown, pink, or purplish blotches on or under the skin or inside the mouth, nose, or eyelids
- Memory loss, depression, and other neurologic disorders

Each of these symptoms can also be related to other illnesses. The only way to know for sure if you have HIV is to get tested. If you are HIV-positive, a health care provider will diagnose if your HIV has progressed to stage 3 (AIDS) based on certain medical criteria.

Many of the severe symptoms and illnesses of HIV disease come from the opportunistic infections that occur because your body's immune system has been damaged. See your health care provider if you are experiencing any of these symptoms.




Early symptoms of HIV
Fever & chills
Headaches and mood swings
Sore throat, swollen lymph nodes, & mouth ulcers
Pneumonia, cough with phlegm, shortness of breath and chest pain
Muscle fatigue and aches
High heart rate and low blood pressure
Nausea, vomiting and loss of appetite
Clamminess, Rashes and blueness Of the skin
Joint pain
Women: changes in menstruation, lower belly pain, and vaginal yeast infection (later stages of infection)

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Immune system

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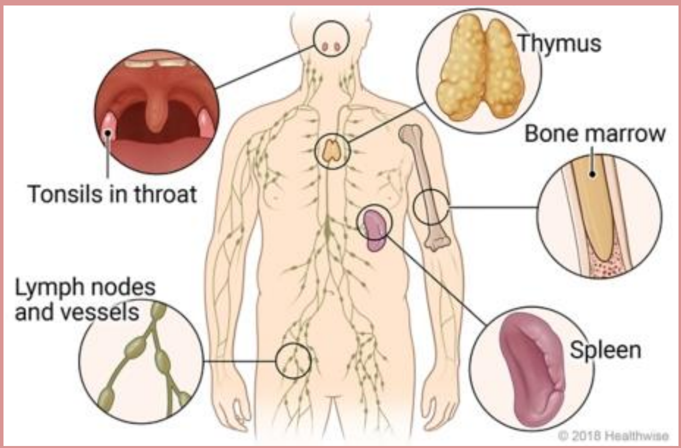

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Immunology is widely used in numerous disciplines, including medicine, in the fields of organ transplantation, bacteriology, oncology, virology, parasitology, rheumatic diseases, psychiatric disorders, and dermatology. The Immunology of transplantation mainly deals with the process of transplantation from a donor to the recipient, so that the recipient's body does not reject the organ. Enzyme-Linked ImmunoSorbent Assay is known as ELISA. It uses antibodies to detect the presence of certain proteins in the sample. ELISA is used as a diagnostic tool. Hay fever is the allergic response to certain allergens from the environment such as pollens, dust mites and fur. Graft rejection is the immune response happening in the recipient's body, that attack and destroys the donated organ. Histocompatibility is the property of having similar alleles in the Major Histocompatibility Complex [MHC]. It is required for organ transplantation. The thymus is active till puberty and after that, it slowly degenerates and is replaced by fat tissues.

"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. B cells and T cells are the white blood cells of the immune system that are responsible for adaptive immune response in an organism. Both the cells are made in the bone marrow. B cells mature in the bone marrow while the T cells travel to the thymus and mature there. These cells are structurally similar and are involved in adaptive immune response in an organism. These cells mature in the bone marrow and produce antibodies in response to the antigens. B cells are involved in humoral response. As soon as B cells come across the antigens, they produce plasma cells and memory B cells. T cells originate in the bone marow and mature in the thymus. These can be further divided into T helper cells and T cytotoxic cells. They are responsible for removing the pathogens from the body. As soon as the foreign antigen enters the cells, T cells trigger the B cells to develop plasma cells and activates T killer cells that kill the cells affected by the invaders. Both B and T cells originate in the bone marrow. These cells are involved in adaptive immunity. They are a type of lymphocytes. The cells are nucleated and motile. Both protect the body’s immune system and help fighting infections. Both the cells are non-phagocytic and are a part of lymphatic system.

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 defence mechanism is called 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 defence mechanisms that keep foreign particles out of the body.

Innate immunity refers to the body’s defence 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.

It is a long-term immunity in which our body produces the antibodies on its own. Our body has few natural barriers to prevent the entry of pathogens.

Types of Barriers

The four types of barriers are:

Physical barrier

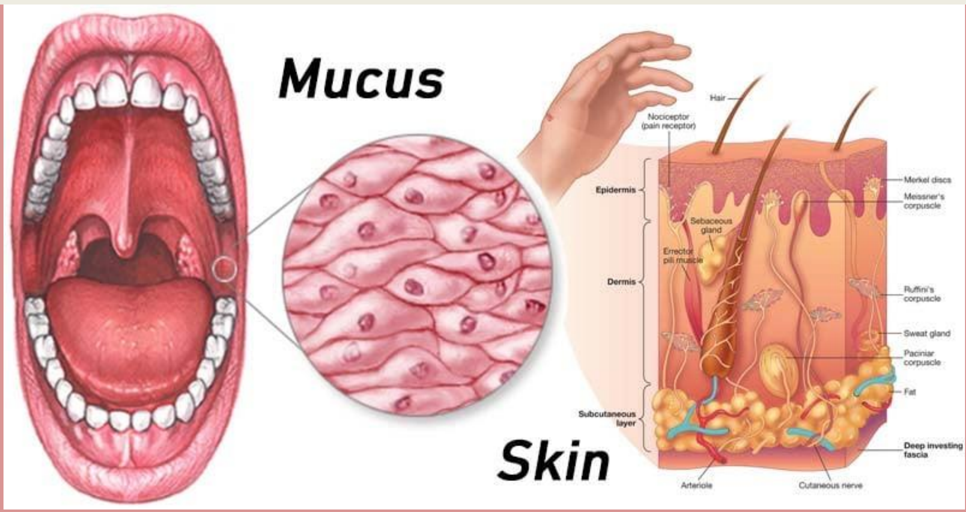
These include the skin, body hair, cilia, eyelashes, the respiratory tract, and the gastrointestinal tract. These form the first line of defence.

The skin does more than providing us with fair or dark complexions. Our skin acts as a physical barrier to the entry of pathogens. The mucus coating in our nose and ear is a protective barrier which traps the pathogen before it gets inside.

Physiological barriers

We know that our stomach uses hydrochloric acid to break down the food molecules. Due to such a strongly acidic environment, most of the germs that enter our body along with the food are killed before the further process is carried on.

Saliva in our mouth and tears in our eyes also have the antibiotic property that does not allow the growth of pathogens even though they are exposed all day.



Cellular barriers

In spite of the physical and physiological barriers, certain pathogens manage to enter our body. The cells involved in this barrier are leukocytes (WBC), neutrophils, lymphocytes, basophil, eosinophil, and monocytes. All these cells are all present in the blood and tissues.

Cytokine barriers

The cells in our body are smarter than we give them credit for. For instance, in case a cell in our body experiences a virus invasion, it automatically secretes proteins called interferons which forms a coating around the infected cell and prevents the cells around it from further infections.

Cells Involved In Innate Immunity

- **Phagocytes**: These circulate through the body and look for any foreign substance. They engulf and destroy it defending the body against that pathogen.
- **Macrophages**: These have the ability to move across the walls of the circulatory system. They release certain signals as cytokines to recruit other cells at the site of infections.
- **Mast Cells**: These are important for healing wounds and defence against infections.
- **Neutrophils**: These contain granules that are toxic in nature and kill any pathogen that comes in contact.
- **Eosinophils**: These contain highly toxic proteins that kill any bacteria or parasite in contact.
- **Basophils**: These attack multicellular parasites. Like the mast cells, these release histamine.
- **Natural Killer Cells**: These stop the spread of infections by destroying the infected host cells.

- **Dendritic Cells**: These are located in the tissues that are the points for initial infections. These cells sense the infection and send the message to the rest of the immune system by antigen presentation.

Acquired Immunity

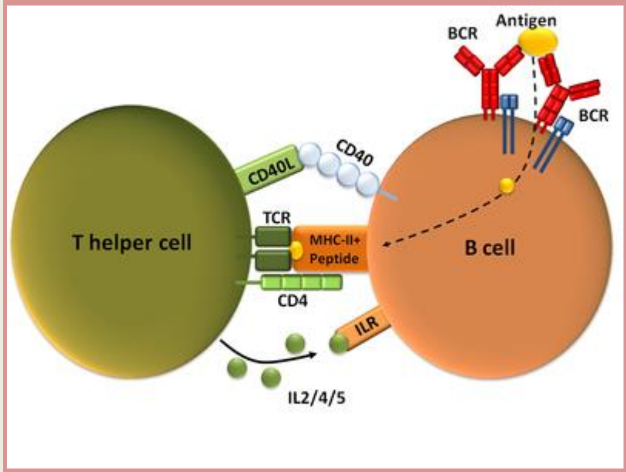
Acquired immunity or adaptive immunity is the immunity that our body acquires or gains over time. Unlike the innate immunity, this is not present by birth.

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.



It mainly consists of an advanced lymphatic defence system which functions by recognizing the own body cells and not reacting to them.

he immune system of our body identifies the pathogens which have encountered in the past. It is mainly caused when a person comes in contact with the pathogen or its antigen.

Our body starts producing antibodies to engulf the pathogen and destroy its antigen.

When it encounters for the first time, it is called a primary response. Once a body gets used to these pathogens, antibodies are ready to attack them for the second time and are known as naturally acquired immunity.

The acquired immunity in our body has certain special features.

Features of Acquired Immunity

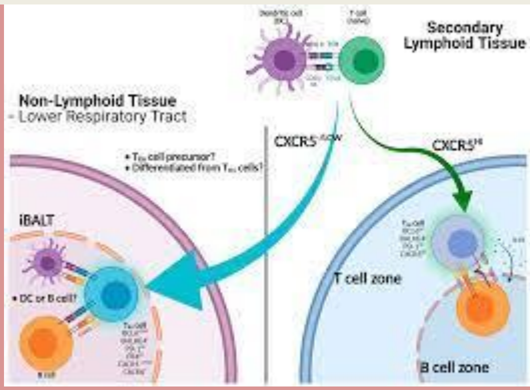
- **Specificity**: Our body has the ability to differentiate between different types of pathogens, whether it is harmful or not, and devise ways to destroy them.
- **Diversity**: Our body can detect vast varieties of pathogens, ranging from protozoa to viruses.
- **Differentiate between self and non-self**: 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.

B-cells

- They develop in the bone marrow.
- These cells are activated on their encounter with foreign agents. These foreign particles act as foreign markers.
- The B-cells immediately differentiate into plasma cells which produce antibodies specific to that foreign particle or so-called antigen.
- These antibodies attach to the surface of the antigen/foreign agent.
- These antibodies detect any antigen in the body and destroy it.
- The immunity dependent on B-cells is called humoral immunity.

T-cells

- They originate in the bone marrow and develop in the thymus.
- T-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.

- 
Secondary
Lymphoid Tissue
Non-Lymphoid Tissue
- Lower Respiratory Tract
CXCR5
CXCR5
iBALT
• DC or B cell?
T cell zone
B cell zone