IMMUNITY

ABSTRACT

The human body has a complex immune system that fights infections. However, infectious diseases remain a major global health concern, particularly in developing countries where limited healthcare access, poor sanitation, and inadequate vaccination programs contribute to their spread. Immunity is the host's natural defense against infections. It plays a crucial role in maintaining overall health by protecting the body from pathogens such as bacteria, viruses, fungi, and parasites. A strong immune system helps to prevent illnesses, speeds up recovery, and contributes to long-term well-being. This chapter explores the classification, factors, and mechanism of immunity.

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I. INTRODUCTION

The human body is constantly under threat from a wide variety of microbial pathogens. Immunity is a term for describing a defense mechanism that saves an individual from pathogenic bacteria, viruses, fungi, and other parasites. It is a well-coordinated interplay of cells, tissues, and organs in recognition of foreign invaders, their neutralization, and their systematic elimination from the host. The ability of the immune system lies in recognizing self from non-self; thus, it mounts such responses that neutralize or destroy the potentially injurious agents without destroying its own cells.

The human immune system consists of 3 lines of defense.

- First line of defense– It includes mechanical (skin), chemical (acidic pH of stomach) & biological (normal flora)
- Second line of defense – Innate immunity
- Third line of defense– Adaptive immunity

II. CLASSIFICATION OF IMMUNITY

Immunity can be classified into two types

1. Innate Immunity (Native Immunity)

a) Non-specific
   - Species
   - Racial
   - Individual

b) Specific
   - Species
   - Racial
   - Individual

2. Acquired Immunity (Adaptive Immunity)

a) Active Immunity.
   - Natural
   - Artificial

b) Passive immunity
   - Natural
   - Artificial

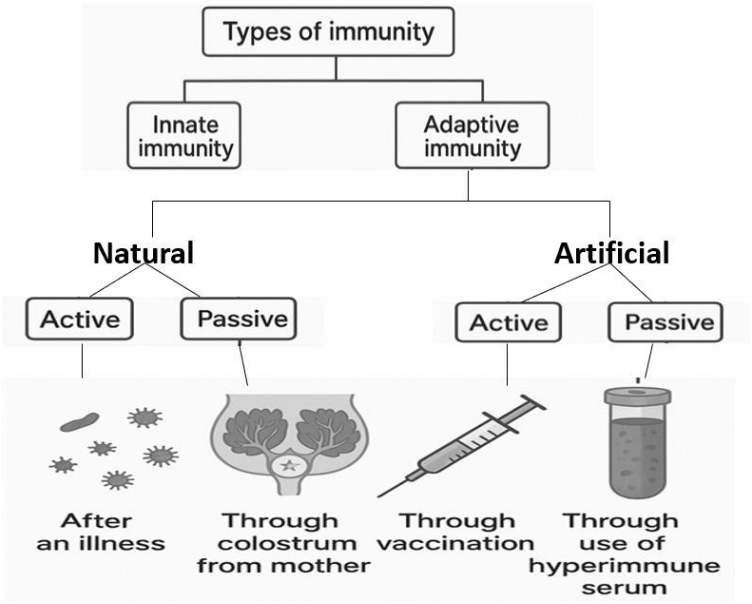

Figure 7: Types of Immunity

Innate Immunity

It is defined as the body's "natural" defense system and serves as the first line of defense against infectious agents. It refers to the resistance that is manifested by the host against infections or pathogens, mainly influenced by the genetic or constitutional peculiarities of the individual. Unlike adaptive immunity, innate immunity does not show any form of improvement following successive infections. It may be further classified into non-specific and specific immunity.

Nonspecific immunity is a general type of resistance that the body gives to a wide variety of pathogens without targeting a particular one. It deals with different physical and chemical barriers, immune cells including macrophages and neutrophils that respond to the wide array of threats. **Specific immunity,** however, is constituent under an adaptive immune response- speaks about the resistance acquired or developed by the body, which acts against a particular pathogenic compound that improves with the repeats of the same infection. However, innate immunity is mainly generalized and non-specific in orientation; it does not target any individual entity with particular importance.

Species Immunity

Susceptibility (lack of resistance) or resistance to infection or infectious agents can vary from one species of animal to another.

Examples;

- All human beings are totally unacceptable to plant pathogens and to many animals' pathogens such as rinderplast or distemper.
- Rat is highly resistant to diphtheria, whereas the guinea pig and humans are highly susceptible.

Racial Immunity

This is also known as ethnic immunity in which Within a species, different racial groups may show differential level of susceptibility of resistance to infections based on their genetic makeup, historical exposure to pathogens etc.

Examples;

- The classic example of racial immunity is that Algerian sheep is highly resistant to anthrax.
- In USA, the Negroid origin peoples more susceptible, then the Caucasians to tuberculosis.

Factors Influencing Innate Immunity

Age: Both very young and very old individuals are more vulnerable to infectious diseases compared to others. The fetus in the womb is typically shielded from infections by the placental barrier. However, certain pathogens, such as **Rubella** and **Herpes**, have the ability to cross this barrier, leading to severe infections that can result in fetal death or developmental complications.

Hormonal Influences: Endocrine disorders like diabetes, hypothyroidism, and adrenal dysfunction can increase the risk of infections. In diabetes, for instance, the high levels of carbohydrates in tissues may make individuals more susceptible to staphylococcal sepsis. Additionally, corticosteroids play a significant role in how the body responds to infections, often weakening the immune system. The increased levels of steroids during pregnancy may contribute to pregnant women being more vulnerable to infections. Similarly, stress can boost the release of steroids, which may explain why stress is linked to a higher risk of infections.

Nutrition: Malnutrition has a complex impact on immunity, it weakens both the humoral (antibody-mediated) and cell-mediated immune responses.

Mechanisms of Innate Immunity

1. **Epithelial &Mucosal Barrier:** The skin and mucous membranes serve as a strong barrier, helping to protect the body from microbial infections. Continuously dividing and constant sloughing of the superficial epidermal layer removes microbes that are attached on surfaces. Mucous membrane of gastrointestinal, respiratory & urogenital cavities contains mucous secreting cells (goblet cells). Mucous has antimicrobial properties.

2. **Saliva, Gastric & Lachrymal Secretion:** The **mouth** is constantly rinsed with saliva, which helps to inhibit microbial growth. Particles in the mouth are swallowed and exposed to digestive juices, where stomach's acidity kill most bacteria. As food moves through the intestines, the pH gradually becomes more alkaline from the duodenum to the ileum.

   The **conjunctiva** is free of foreign particles because of flushing action of lachrymal secretions. When lachrymal secretion become low or absent than the eyes become more susceptible to infection. The tears contain an antibacterial substance lysozyme.

3. The flushing action of urine removes microbes from the urethra. Presence of Spermine and zinc in semen carry out antibacterial activity.

4. **Microbial Antagonisms:** The normal microbial flora of skin and mucosal surfaces is very important in order to prevent the colonization by harmful pathogens. Invasion can be easily achieved by the pathogenic microorganisms in this tissue site once the disturbance or imbalance of resident flora has occurred, and will result in serious infections.

5. **Antibacterial Substances in Blood and Tissues:** The human body has a variety of antibacterial substances that are essential for defending against bacterial infections. These substances can be found in blood, tissue, and other bodily fluids, where they play a critical role in recognizing, neutralizing, and eliminating pathogens. Some examples are –

   - The complement system is a group of proteins present in blood plasma that work together to defend the body against bacterial pathogens. The system consists of more than 30 proteins that circulate in an inactive form and become activated in response to infection.
   - Beta lysine is a thermostable substance having bactericidal activity against anthrax and other bacilli.

- Acidic compounds, such as lactic acid, are found in muscle tissue and inflammatory areas of the body. These acids lower pH in the environment, and thereby inhibit the growth of most pathogens, contributing to the body's defenses during an infection or tissue injury.

6. **Antimicrobial Peptides:** Antimicrobial peptides are small proteins found in various tissues and body fluids and have direct antibacterial actions. These peptides, produced by a variety of cells including epithelial cells, neutrophils, and macrophages, among others, are part of the innate immune system. AMPs exhibit broad-spectrum activities, defending against a wide range of pathogens, including Gram-positive and Gram-negative bacteria, fungi, and viruses.

   - **Defensins:** Small, cationic peptides that bind to bacterial membranes, creating pores that disrupt the integrity of the membrane and lead to bacterial death. Defensins are found in the skin, respiratory tract and intestines.
   - **Cathelicidins:** Produced by neutrophils and epithelial cells, these peptides also disrupt bacterial membranes and can neutralize bacterial toxins.
   - **Lactoferrin:** A glycoprotein found in blood, saliva, and mucosal secretions, lactoferrin binds to iron, depriving bacteria of this essential nutrient and inhibiting bacterial growth. It also has direct antimicrobial properties.

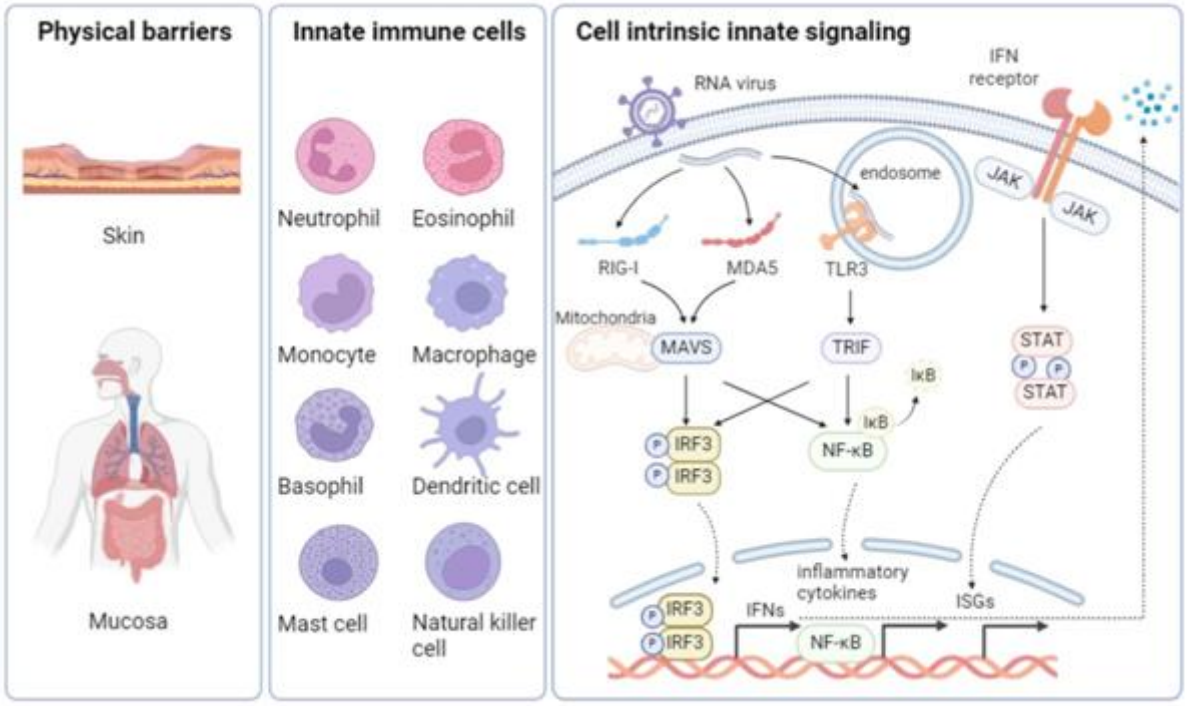

Figure 8: Mechanism of Innate Immunity

Cellular Factors in Innate Immunity

Phagocytic cells (Macrophages, neutrophils etc) play a crucial role in the body's natural defence against microorganisms and foreign particles. These cells are ingested and destroy pathogens. Macrophages include histiocytes**,** which are wandering ameboid cells found in tissues, as well as fixed reticuloendothelial cells, which reside in specific tissues. Additionally, monocytes circulate in the blood and differentiate into macrophages when they migrate into tissues.

Adaptive Immunity

The immunity acquired through out lifetime after exposure of pathogen is known as adaptive immunity. The adaptive immune system works by exploiting an incredible diversity of molecules to carry out its functions.

Acquired immunity can be generating from;

a) Pathogen or antigen exposure
b) Vaccine

The function of the acquired immunity is to protect us from the infection or disease in future. This immune system recognise antigen which is encountered

in the past. It is caused when individuals come in contact with antigen our body fight against the antigen or pathogen by producing antibodies. Whenever body encounters first time is called “primary response” and produce antibodies against them. When it gets used to these antigens and ready for it is called acquire immunity.

Types of Acquired Immunity

Acquired immunity is of two types

- Active immunity
- Passive immunity

Active Immunity

It is the resistance developed in an individual by direct contact with an antigen, vaccination or natural infection. Direct contact with antigenic particles stimulates immune cells to form antibodies. Active immunity evolves after a latent period which is required for immune system to act but once it evolved, it becomes long lasting. Active immunity further divided into “natural” or “artificial” immunity.

Natural Active Immunity: When our body encounters an antigen, our immune system or cells activate and fight against the specific antigen by producing antibodies against them. Active immunity plays a crucial role because it is a long-lasting immunity and produces a memory cell with antibodies against the specific antigen. Memory cells are active after encountering specific antigens in the future. This immunity is developed by naturally and is known as natural active immunity.

Artificial Active Immunity: This type of Immunity produced by vaccination. Vaccines are made up of attenuated microbes or immunogenic substances (Ag or toxoids). Toxoids themselves are immunogenic but not toxigenic.

Passive Immunity

Passive immunity is developed in host by introducing antibodies (antiserum) against infectious particle. Passive immunity is not long lasting, it provides short term immunity because immune system does not produce antibodies or memory cells to recognise antigen for further encounter. It is useful if it is needed immediately. Passive immunity is also two types- “natural” and “artificial” passive immunity.

Natural Passive Immunity: The best example of natural passive immunity is maternal antibodies. Maternal antibodies provide immunity in two ways:

- By across the placenta.
- By breast-feeding.

When a pregnant women's blood circulates through the body it across the placenta and give nourishment to the foetus, at that time antibodies of the immune cells also travel and across the placenta. In this way the foetus receives the ready-made antibodies through its mother.

Breast-feeding babies also receive the antibodies is good example of natural passive immunity. Breast milk is protein rich milk which is served after the delivery for first few days to foetus. This milk is called “colostrum”. These antibodies are transfer from mother to child and protect them against the pathogen for few times of period while its immune system can generate its own protection.

Artificial Passive Immunity

When man-made or synthesized antibodies are given to the body, this is called artificial passive immunity.

The example of artificial passive immunity is ‘antivenom’. When an individual is bitten by snake the man-made ready-made antibodies are given to the person.

Cell Response in Acquired Immunity: In acquired immunity, there are two types of cell responses:

B Cells: B-cells produces in bone marrow. These cells differentiated into plasma cells and produces antibodies during encountering antigen. B cells produce specific antibodies against the specific type of antigen. This type of immunity is called “Humoral immunity”.

T Cells: T-cell are produces from the bone marrow and mature in thymus. T-cells are two types of cells, T helper cells (Th) and T cytotoxic cells (Tc).These cells are activated after the encounter of pathogen or antigen. Helper T cells release a chemical called cytokines which is act as messengers. These messengers activate the B- cells to plasma cells and antibodies are produced against the antigen. Cytotoxic T cells kill the infected cells or cancer cells this is called cellular or cell-mediated immunity.

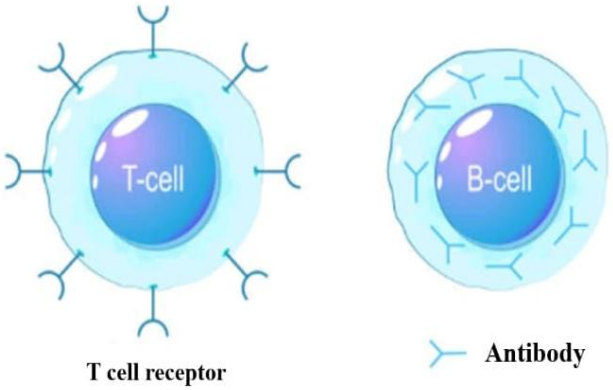

Figure 9: B Cell and T Cell

III. CONCLUSION

Immunity is a sophisticated system that protects the body from infection and disease. It involves both innate (non-specific) and adaptive (specific) immune responses. Innate immune system provides immediate, general defense while adaptive immunity creates long-lasting protection and memory. However, Malfunctioning or hyperactivity of immune system results allergies & autoimmune abnormal conditions. Understanding immunity is essential for improving health outcomes, especially through vaccination programs and treatments for immune-related disorders.

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