

Immunity – Definition

What is Immunity?

- Immunity is the body's defense mechanism against foreign harmful substances (known as antigens), such as pathogens (bacteria, viruses, fungi, parasites), toxins, or even abnormal body cells (like cancer).
- It represents the body's ability to recognize, fight, and eliminate these threats.
- In essence, immunity is a protective biological response that allows an organism to resist infection or disease.
- This involves a complex interplay between cells, molecules, and tissues that detect and neutralize harmful agents.

Immune Response Process Overview:

1. **Recognition** – Immune system detects antigens (foreign invaders).
2. **Activation** – Mobilization of immune components to respond to the threat.
3. **Effector Phase** – Destruction and elimination of the pathogen.
4. **Memory Formation** – Development of long-lasting protection (in adaptive immunity).

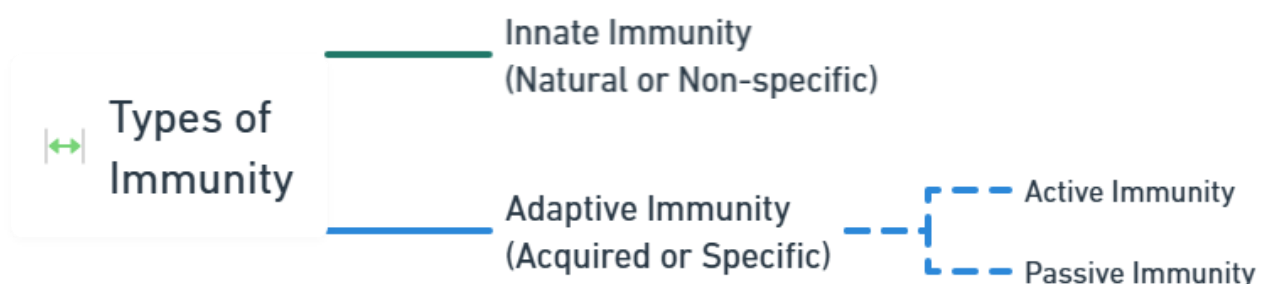
Key Components of the Immune System:

- **White blood cells (leukocytes):** Include lymphocytes (B and T cells), neutrophils, monocytes, etc.
- **Organs and tissues:** Bone marrow, thymus, spleen, lymph nodes.
- **Molecules:** Antibodies, cytokines, complement proteins.

Classification of Immunity

- Immunity is broadly classified based on its **mode of acquisition** and **response mechanism**.

The major types include:



A. Innate Immunity (Natural or Non-specific Immunity)

Characteristics:

- Present from birth.

- Provides **immediate defense**.
- **Non-specific**: Responds the same way to all pathogens.
- No immunological memory.

Main Components:

1. **Physical Barriers**: Skin, mucous membranes, cilia.
2. **Chemical Barriers**: Stomach acid, lysozyme in tears and saliva, antimicrobial peptides.
3. **Cellular Defenses**:
 - **Phagocytes**: Neutrophils and macrophages engulf pathogens.
 - **Natural Killer (NK) cells**: Destroy virus-infected and tumor cells.
4. **Soluble Factors**:
 - **Complement system**: A group of proteins that enhances pathogen destruction.
 - **Cytokines**: Small proteins that modulate immune responses.

B. Adaptive Immunity (Acquired or Specific Immunity)

Characteristics:

- Develops after exposure to specific antigens.
- **Highly specific** response to individual pathogens.
- Has **memory**: faster and stronger upon repeated exposure.
- Delayed onset (days to develop).

Subtypes:

1. Active Immunity:

- Produced when the body makes its own antibodies.
- Can be natural (after infection) or artificial (after vaccination).
- Long-lasting or permanent.

2. Passive Immunity:

- Results from the transfer of antibodies from another source.
- Can be natural (maternal antibodies via placenta or milk) or artificial (antibody injections like antivenom).
- Provides immediate but short-lived protection.

General Principles of Natural Immunity (Innate Immunity)

- Natural immunity, also called innate immunity, is the first line of defense that the body has against invading pathogens.

- It is non-specific, meaning it does not differentiate between different types of pathogens.
- It provides a general defense mechanism that works the same way each time, regardless of the pathogen involved.

Below are the general principles and components of natural immunity:

1. Anatomical (Physical) Barriers

- These are the first defenses that prevent pathogens from entering the body.
 - **Skin:** Acts as a physical barrier. The outer layer (stratum corneum) contains keratin, which is impermeable to most microbes.
 - **Mucous membranes:** Line the respiratory, gastrointestinal, and genitourinary tracts. They trap microbes in mucus.
 - **Cilia** in the respiratory tract help sweep out mucus with trapped particles.

2. Physiological and Chemical Barriers

- **pH:** The acidic environment of the stomach (pH ~2) kills many ingested microbes.
- **Lysozyme:** An enzyme present in tears, saliva, and mucus that breaks down bacterial cell walls.
- **Fatty acids and lactic acid:** Present on the skin surface; they inhibit microbial growth.

3. Cellular Components

- These include white blood cells involved in immediate defense:

A. Phagocytes:

- **Neutrophils:** First responders, short-lived, engulf pathogens.
- **Monocytes/Macrophages:** Arrive after neutrophils; live longer; process antigens for presentation.

B. Natural Killer (NK) Cells:

- Kill virus-infected and tumor cells.
- Act without prior sensitization (non-specific).

C. Dendritic Cells:

- Present in epithelial tissues.
- Capture antigens and initiate adaptive immune responses.

4. Inflammatory Response

- **Vasodilation:** Increases blood flow to the affected area.
- **Increased vascular permeability:** Allows immune cells and proteins to reach the infection site.
- **Recruitment of immune cells:** Especially neutrophils and macrophages.

- **Purpose:** To isolate and eliminate the pathogen and repair tissue.

5. Soluble Mediators

- **Complement System:** A group of plasma proteins that help in:
 - Opsonization (coating pathogens for phagocytosis),
 - Lysis of pathogens,
 - Chemotaxis (attracting immune cells).
- **Cytokines:** Small proteins (e.g., interferons, interleukins) that:
 - Modulate immune response,
 - Help communication between immune cells.

6. Genetic Factors

- Some individuals or species are naturally resistant to certain infections due to:
 - Lack of specific receptors,
 - Innate cellular resistance,
 - Host genetic variations.

Phagocytosis

- Phagocytosis is a fundamental process of the innate immune system where certain immune cells, called **phagocytes**, engulf and destroy pathogens and foreign particles.

Main Phagocytic Cells:

1. Neutrophils:

- Most abundant white blood cells.
- First responders during infection.
- Short life span.

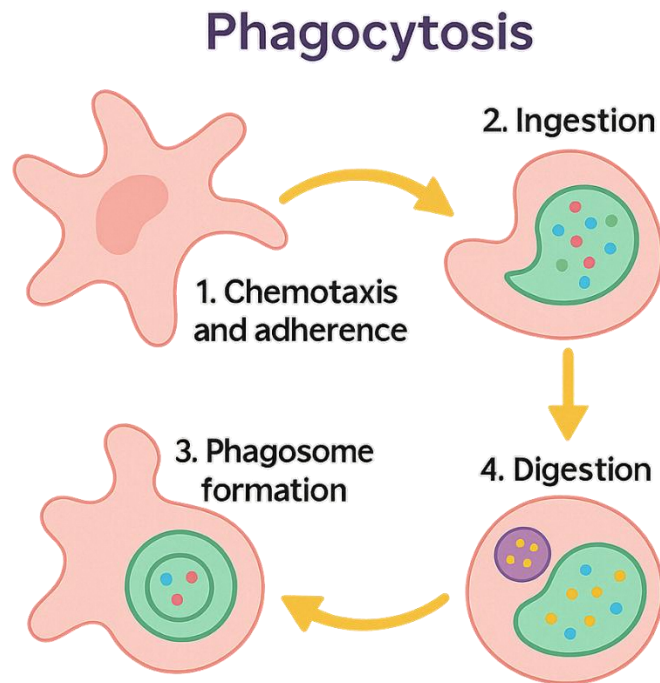
2. Monocytes/Macrophages:

- Monocytes circulate in the blood and differentiate into macrophages when they enter tissues.
- Long-lived.
- Also play a role in antigen presentation to the adaptive immune system.

3. Dendritic Cells:

- Specialized antigen-presenting cells.
- Efficient in capturing and processing antigens.

Steps of Phagocytosis:



1. Chemotaxis:

- Movement of phagocytes toward the site of infection.
- Guided by chemical signals such as cytokines or bacterial products.

2. Recognition and Attachment:

- Phagocytes recognize PAMPs (Pathogen-Associated Molecular Patterns) on microbes using PRRs (Pattern Recognition Receptors) such as Toll-like receptors (TLRs).
- Opsonins (e.g., antibodies or complement proteins like C3b) can coat pathogens to enhance recognition.
- Opsonization increases phagocytic efficiency.

3. Engulfment (Ingestion):

- The phagocyte's membrane extends around the pathogen forming a **phagosome** (a membrane-bound vesicle containing the ingested particle).

4. Phagolysosome Formation:

- The **phagosome** fuses with a **lysosome**, forming a **phagolysosome**.
- Lysosomes contain digestive enzymes and reactive oxygen/nitrogen species.

5. Killing and Digestion:

- Inside the phagolysosome, the pathogen is killed and broken down.
- Mechanisms include:
 - **Oxygen-dependent killing:** Production of reactive oxygen species (ROS) like hydrogen peroxide, superoxide.



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