

Lec. 1 Immunology For 3ed stage of Biology 2025/2026

Immunity

Immunity refers to the ability of an organism to resist and defend against infections and diseases caused by pathogens such as bacteria, viruses, fungi, and parasites also against cancer.

Immunology

Immunology is the branch of biomedical science that studies the immune system, its components, functions, and disorders. It encompasses the investigation of **immune responses to pathogens**, the mechanisms of immunity, the development of vaccines, and the understanding of immunological diseases such as allergies, autoimmune disorders, and immunodeficiencies.

Immune Response

The immune response is the body's defensive reaction to the presence of pathogens, foreign substances, or damaged cells.

Historical Background of Immunology

Immunology, the study of the immune system and its functions in protecting the body from pathogens, has a rich and evolving history.

Ancient Times

- **Variolation (c. 1000 AD):** In China, a practice involved the inoculation of healthy individuals with material from smallpox scabs to induce immunity, a primitive form of vaccination.

18th Century

- **Edward Jenner (1796):** Conducted the first scientific vaccination by inoculating a boy with material from cowpox lesions. This led to the development of the smallpox vaccine, demonstrating that exposure to a less virulent pathogen could confer immunity to a more dangerous one.

19th Century

- **Louis Pasteur (1880s):** Developed the germ theory of disease, establishing the link between microorganisms and diseases. He created vaccines for anthrax and rabies, further solidifying the principles of vaccination.

Early 20th Century

- **Paul Ehrlich:** Proposed the "magic bullet" concept, focusing on the role of antibodies in immune responses. He developed the first successful treatment for syphilis (salvarsan).

Immune System

The immune system is a complex network of cells, tissues, and organs that work together to defend the body against infections and diseases.

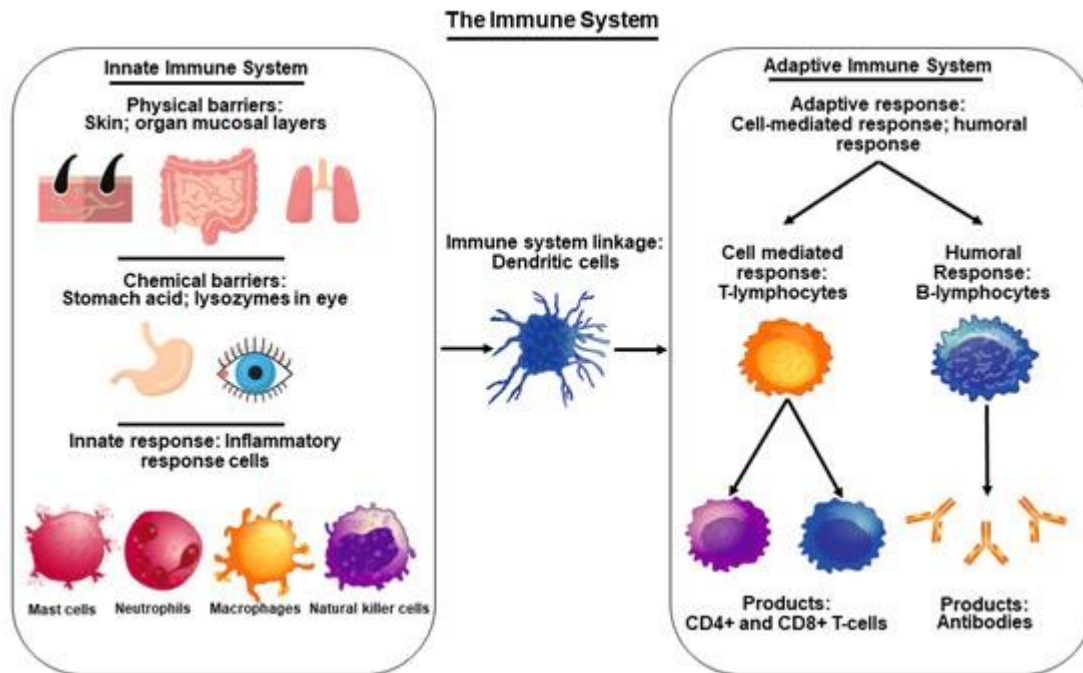
Innate Immunity

Innate immunity is the first line of defense against pathogens, characterized by its immediate and non-specific response. It includes physical, chemical, and biological barriers, as well as various immune cells (e.g., phagocytes, natural killer cells) and molecular components (e.g., cytokines, complement proteins).

Innate immunity is present from birth and provides a rapid response to a wide range of infectious agents.

Adaptive Immunity

Adaptive immunity is a specific immune response that develops over time following exposure to particular pathogens. It involves the activation and proliferation of lymphocytes, including B cells and T cells, which generate a targeted response against specific antigens. Adaptive immunity is characterized by its ability to create immunological memory, allowing for a more rapid and effective response upon subsequent exposures to the same pathogen.



Innate immunity

Importance of Innate Immunity

- **Immediate Response:** Provides rapid defense, crucial for controlling infections before adaptive immunity develops.
- **Activation of Adaptive Immunity:** Innate immunity sets the stage for adaptive responses by presenting antigens and secreting cytokines that influence the development of specific immune responses.
- **Homeostasis:** Helps maintain tissue homeostasis by clearing dead cells and resolving inflammation.

Components of Innate Immunity

1. **Physical Barriers**

Physical barriers are the first line of defense in the innate immune system, playing a crucial role in preventing pathogens from entering the body. These barriers provide a non-specific defense mechanism that is vital for maintaining health.

1. Skin

- **Structure:** The skin is the largest organ of the body, composed of multiple layers, including the epidermis and dermis. The outermost layer, the stratum

corneum, consists of dead, keratinized cells that are highly resistant to penetration by pathogens.

- **Function:**

- Acts as a robust physical barrier.
- Produces antimicrobial peptides that help inhibit pathogen growth.
- The skin's acidity (pH 4-6) and the presence of fatty acids create an environment hostile to many microbes.



2. Mucous Membranes

- **Location:** Mucous membranes line various body cavities, including the respiratory, gastrointestinal, and urogenital tracts.
- **Function:**
 - Produce mucus, which traps pathogens and debris, preventing them from entering deeper tissues.
 - Contain cilia in the respiratory tract that help propel mucus and trapped particles out of the airways.
 - Secrete antimicrobial substances, such as lysozyme and immunoglobulin A (IgA), which neutralize pathogens.

3. Secretions

- **Saliva:**
 - Contains enzymes (like lysozyme) and antibodies (IgA) that help neutralize pathogens in the oral cavity.
- **Tears:**
 - Flush out potential pathogens from the eyes and contain antimicrobial proteins.
- **Gastric Acid:**
 - The acidic environment of the stomach (pH 1.5-3.5) effectively kills many ingested pathogens.

2. Chemical barriers

Chemical barriers are crucial components of the innate immune system that provide protection against pathogens through various biochemical mechanisms. These barriers act in conjunction with physical barriers to prevent infection and maintain homeostasis.

1. Antimicrobial Peptides

- **Definition:** Small proteins that possess the ability to kill a broad spectrum of microbes, including bacteria, fungi, and viruses.
- **Examples:**

- **Defensins:** Found in skin, mucosal surfaces, and immune cells; disrupt microbial membranes.
- **Cathelicidins:** Produced by various cells, including neutrophils; exhibit broad-spectrum antimicrobial activity.

2. Enzymes

- **Lysozyme:**
 - Found in saliva, tears, and mucus; breaks down bacterial cell walls by hydrolyzing peptidoglycan, leading to cell lysis.
- **Proteases:**
 - Present in various secretions; can degrade proteins of pathogens, contributing to their inactivation.

3. Complement Proteins

- **Definition:** A series of proteins in the blood that enhance the ability of antibodies and phagocytic cells to clear pathogens.
- **Functions:**
 - **Opsonization:** Mark pathogens for destruction by phagocytes.
 - **Lysis:** Form the membrane attack complex (MAC) that creates pores in pathogen membranes, leading to cell death.
 - **Inflammation:** Promote vasodilation and recruit immune cells to sites of infection.

4. pH and Chemical Composition

- **Gastric Acid:**
 - The acidic environment (pH 1.5-3.5) of the stomach destroys many ingested pathogens.
- **Fatty Acids:**
 - Secreted by sebaceous glands; create an acidic environment on the skin surface, inhibiting pathogen growth.

3. Biological Barriers

Biological barriers in innate immunity are vital for maintaining health and preventing infections.

1. Normal Microbiota

- **Definition:** The diverse community of microorganisms (bacteria, fungi, viruses) that reside on and within the human body, primarily in the gut, skin, and mucosal surfaces.
- **Functions:**
 - **Competitive Exclusion:** Normal microbiota compete with pathogenic microorganisms for nutrients and adhesion sites, reducing the likelihood of infection.
 - **Metabolite Production:** Some beneficial bacteria produce substances (e.g., short-chain fatty acids) that have antimicrobial properties and support immune function.

2. Immune Cells

The cellular components of innate immunity consist of various immune cells that play critical roles in this type of immunity. These cells are non-specific and respond rapidly to infections.

1. Phagocytes :- Macrophages, Neutrophils

2. Natural Killer (NK) Cells

3. Dendritic Cells

4. Mast Cells

5. Eosinophils

4. Physiological Barriers

Physiological barriers in innate immunity play a crucial role in protecting the body from infections. Temperature regulation, pH levels, chemical secretions, blood flow, hormonal responses, and respiratory mechanisms all contribute to creating an environment that is hostile to pathogens and supportive of immune function.

1. Temperature

- **Fever:**
 - An increase in body temperature is a common physiological response to infection.
 - Fever can inhibit the growth of certain pathogens and enhance the activity of immune cells, promoting a more effective immune response.

2. Respiratory Mechanisms

- **Ciliary Action:**
 - The cilia lining the respiratory tract move in a coordinated manner to expel mucus and trapped pathogens, preventing their entry into the lungs.
- **Coughing and Sneezing:**
 - Reflex actions that expel pathogens and irritants from the respiratory tract.

