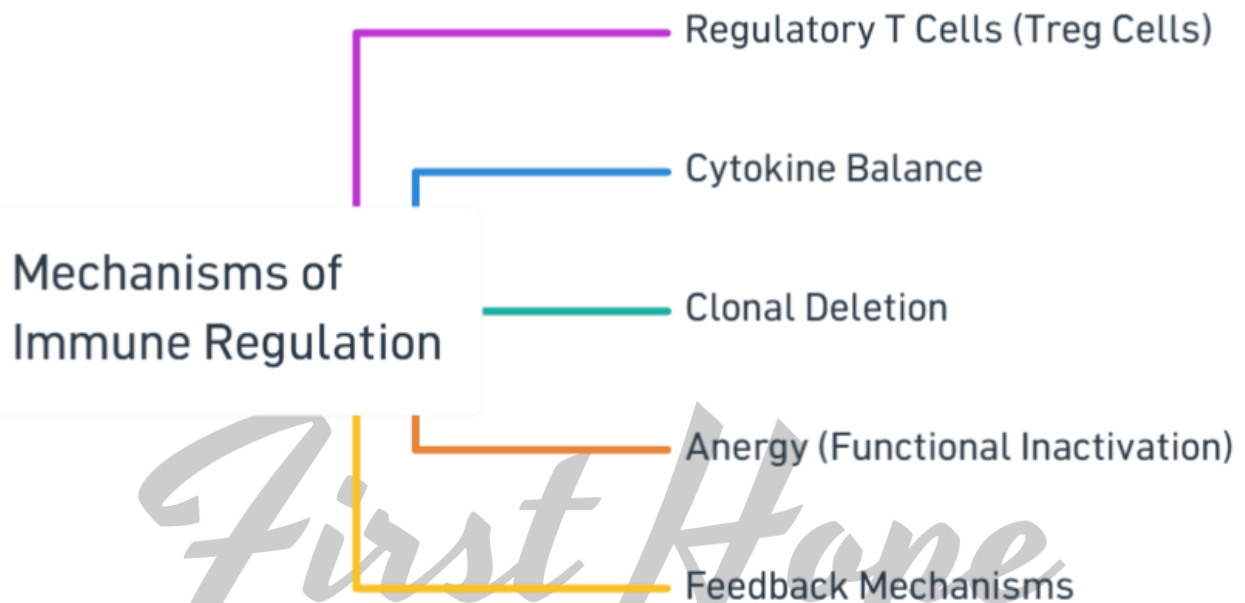


Immune Regulation and Tolerance

Immune Regulation (Overview)

- Immune regulation refers to the mechanisms that **control and balance the immune response**.
- It ensures that the immune system responds effectively to pathogens but does not damage the body's own tissues.

Mechanisms of Immune Regulation



A. Regulatory T Cells (Treg Cells)

- Specialized T cells that suppress immune responses.
- Maintain **self-tolerance** and prevent autoimmune diseases.
- Secrete inhibitory cytokines like **IL-10** and **TGF- β** .

B. Cytokine Balance

- Cytokines can either stimulate or suppress immune responses.
- Proper balance is necessary to avoid excessive inflammation.

C. Clonal Deletion

- Self-reactive lymphocytes are destroyed during development (in thymus and bone marrow).

D. Anergy (Functional Inactivation)

- Lymphocytes become inactive when antigen is recognized without proper co-stimulation.

E. Feedback Mechanisms

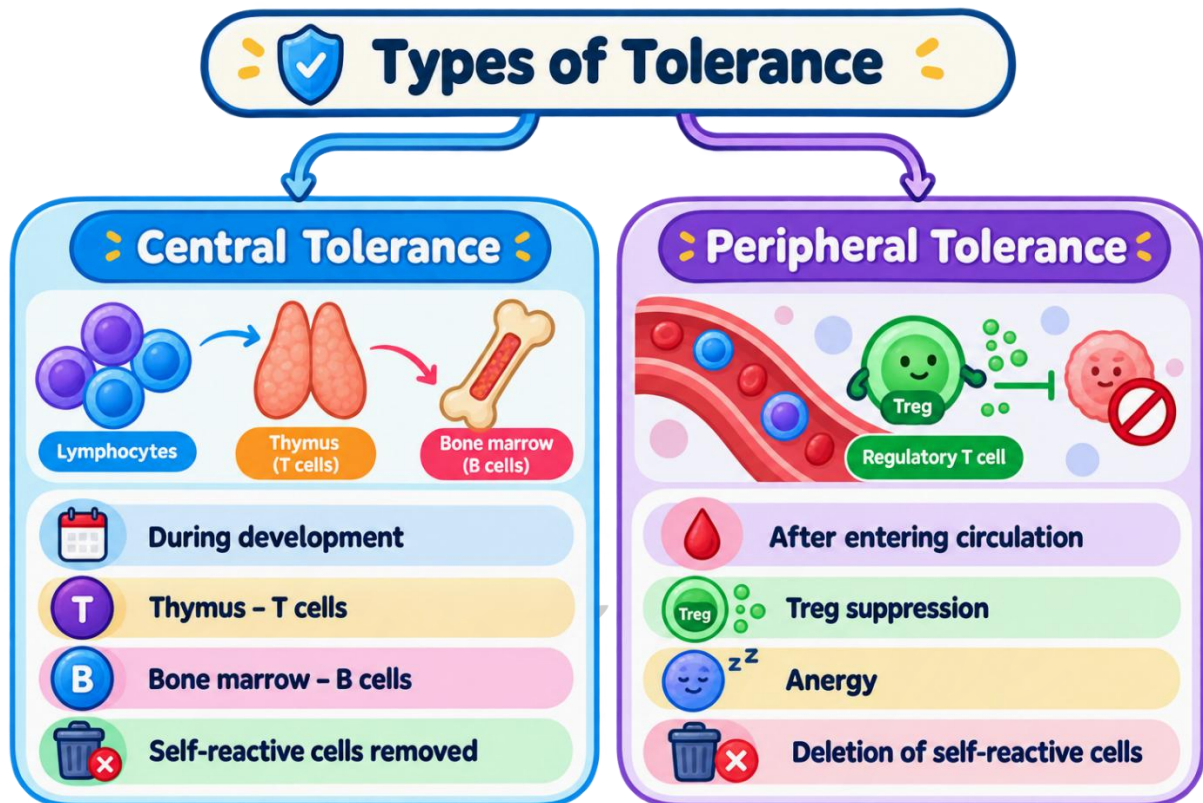
- Activated immune cells can produce signals that limit further activation.

Immunological Tolerance

Definition

- The ability of the immune system to **not respond to self-antigens**.
- Prevents autoimmune diseases.

Types of Tolerance



1. Central Tolerance

- Occurs during development of lymphocytes in:
 - Thymus (T cells)
 - Bone marrow (B cells)
- Self-reactive cells are eliminated.

2. Peripheral Tolerance

- Occurs after lymphocytes enter circulation.
- **Mechanisms:**
 - Suppression by Treg cells
 - Anergy
 - Deletion of self-reactive cells

Breakdown of Tolerance

- Failure of tolerance leads to **autoimmune diseases**.

- Example: rheumatoid arthritis, type 1 diabetes.

Importance of Tolerance

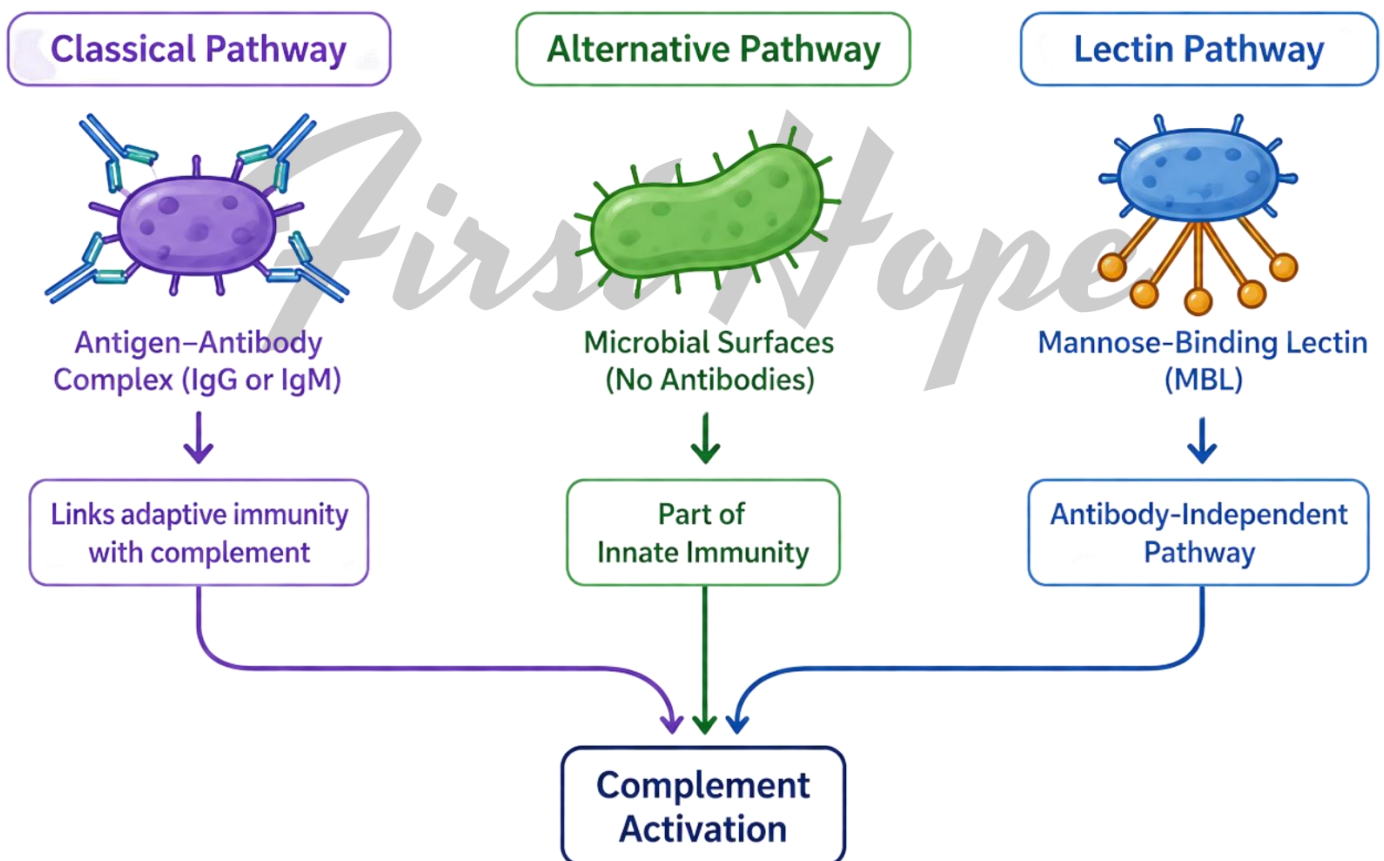
- Prevents autoimmune diseases
- Maintains immune system balance
- Ensures proper immune functioning

Complement System

Definition

- A group of **plasma proteins** that enhance (complement) immune responses.
- Part of **innate immunity** but also supports adaptive immunity.

Types (Pathways) of Complement Activation



1. Classical Pathway

- Triggered by antigen-antibody complexes (IgG or IgM).
- Links adaptive immunity with complement system.

2. Alternative Pathway

- Activated directly by microbial surfaces.
- Does not require antibodies.

- Part of innate immunity.

3. Lectin Pathway

- Initiated by binding of **mannose-binding lectin (MBL)** to pathogens.
- Antibody-independent pathway.

Common Outcome of All Pathways

- Formation of Membrane Attack Complex (MAC).
- Leads to lysis (destruction) of pathogens.

Biological Functions of Complement System

A. Opsonization

- C3b coats pathogens, making them easier to phagocytose.

B. Cell Lysis

- Formation of **Membrane Attack Complex (MAC)** destroys pathogens.

C. Inflammation

- C3a and C5a act as inflammatory mediators.
- Attract immune cells (chemotaxis).

D. Immune Complex Clearance

- Helps remove antigen-antibody complexes from circulation.

E. Chemotaxis

- Attracts phagocytes to site of infection.

Cytokines

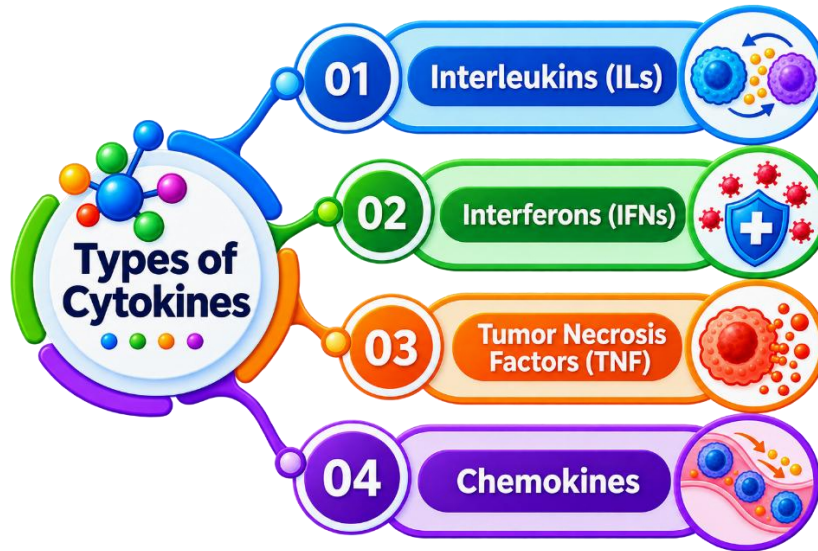
Definition

- Cytokines are small **signaling proteins** released by immune cells.
- They regulate the intensity and duration of immune responses.

Characteristics of Cytokines

- Act in very small amounts
- Bind to specific receptors
- Can have multiple effects (pleiotropy)
- Act on nearby or distant cells

Types of Cytokines



1. Interleukins (ILs)

- Communication between leukocytes.
- Example: IL-2 stimulates T cell growth.

2. Interferons (IFNs)

- Protect against viral infections.
- Example: IFN- α , IFN- β inhibit viral replication.

3. Tumor Necrosis Factors (TNF)

- Involved in inflammation and cell death.
- Example: TNF- α .

4. Chemokines

- Induce movement of immune cells towards infection site.

Role of Cytokines in Immune Response

A. Cell Activation and Proliferation

- Stimulate growth and differentiation of immune cells.

B. Regulation of Immune Response

- Can enhance or suppress immune activity.

C. Inflammation

- Promote inflammatory responses.

D. Antiviral Defense

- Interferons inhibit viral replication.

E. Cell Communication

- Coordinate interaction between different immune cells.

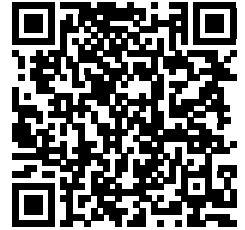


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