Acquired Immunity

Chapter 16

3 Lines of Defense

Specific Immunity

- Defense against distinct invaders
  - Memory develops
  - Acquired
  - Triggered by antigens
- Major players: B and T lymphocytes
Antigens

- **Examples**
  - Bacterial components – cell walls, capsules, pili, fimbriae, flagella
  - Viruses – proteins & glycoproteins
  - Fungi, protozoans – cell walls, proteins, etc.
  - Food, dust, pollen

- **Routes of Entry**
  - Ingestion
  - Inhalation
  - Breaks in skin and mucous membranes
  - Direct injection
  - Organ transplants and skin grafts

3 Types of Antigens

Lymphatic System

- Screens body tissues for foreign antigens
- Lymphatic vessels
  - Lymphatic cells
- Lymphatic vessels
  - Transport lymph
Lymphoid Cells
- Develop from stem cells in bone marrow
- Include B-lymphocytes and T-lymphocytes

Lymph Nodes
- Contain leukocytes
- Receive lymph -- afferent vessels
- Drain lymph -- efferent vessels

Other Lymphoid Tissues & Organs
- Spleen
- Tonsils and mucosa-associated lymphoid tissue (MALT)
  - "Crypts"
  - MALT
    - Appendix, lymphoid tissue of the respiratory tract, and Peyer's patches
B-lymphocytes

- Spleen, lymph nodes, red bone marrow, and Peyer’s patches
- Small % circulate in the blood
- Major function → secretion of antibodies
- Antibody-mediated (humoral) response

Antibodies

- Immunoglobulins (Ig)
- Soluble proteins that bind antigens
- Secreted by plasma cells

Functions of Antibodies

- Complementary to Ag
- Results:
  - Activation of complement
  - Stimulation of inflammation
  - Killing by oxidation
  - Agglutination
  - Neutralization
  - Opsonization
Functions of Antibodies

- Agglutination
- Neutralization
- Opsonization

5 Classes of Antibodies

- Light chain
- Heavy chain
- Carbohydrates
- J Chain
- Alpha heavy chain

<table>
<thead>
<tr>
<th>Class</th>
<th>Characteristics of the Five Classes of Immunoglobulins</th>
</tr>
</thead>
<tbody>
<tr>
<td>IgM</td>
<td>Agglutination and neutralization, low affinity, Thy. Membrane secretion, circulating in 40-50% of serum</td>
</tr>
<tr>
<td>IgG</td>
<td>High affinity, binds to Fc receptor, phagocytosis, complements activation</td>
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<tr>
<td>IgA</td>
<td>Secretory, binds to Fc receptor, attaches to gut and respiratory tract</td>
</tr>
<tr>
<td>IgE</td>
<td>High affinity, binds to mast cell, basophil, and eosinophil</td>
</tr>
<tr>
<td>IgD</td>
<td>Low affinity, binds to B lymphocytes, Reticular, monocytes, and macrophages</td>
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</tbody>
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B-cell Receptor (BCR)
- B-cell surface
  - Multiple copies of a single type of BCR
  - Randomly generated variable region
  - $10^{11}$ different B-lymphocytes

T-lymphocytes
- Circulate in the lymph and blood
- Cell-mediated immune response against:
  - Endogenous antigens
  - Intracellular pathogens
  - Abnormal body cells such as cancer cells
  - Cytotoxic and Helper T-cells

T-cell Receptor (TCR)
- Antigen binding site on T-cells
- Randomly generated
- $10^{11}$ different T-lymphocytes
Cytotoxic T-cells
- CD8 glycoprotein
- Directly kill certain cells
  - Cells infected with intracellular pathogens
  - Cancer cells

Helper T-cells
- CD4 glycoprotein
- Regulate the activities of B cells and cytotoxic T cells
- Secrete cytokines
  - Determine which immune response will be activated

2 Types of Helper T-cells
- Type 1 helper T-cell (T<sub>H</sub>1)
  - Assist cytotoxic T cells
  - Express CD26 and a cytokine receptor named CCR5
- Type 2 helper T-cell (T<sub>H</sub>2)
  - Assist B cells
  - Have cytokine receptors CCR3 and CCR4
- Helper T-cell Activation
  - Antigen presentation
  - Cytokines
Regulatory T-cells
- CD4 glycoprotein
- CD25
- Regulate immune response

Cytokines
- Interleukins (ILs)
- Interferons (IFNs)
- Growth factors
- Tumor necrosis factors (TNFs)
- Chemokines

Cytokine Network
Lymphocyte Editing

- Membrane glycoproteins
- Function: present antigens to T-cell
- First identified in transplant patients
  - Self vs. foreign

Major Histocompatibility Complex (MHC)

- Membrane glycoproteins
- Function: present antigens to T-cell
- First identified in transplant patients
  - Self vs. foreign

MHC Proteins

- MHC 1
  - All nucleated cells
- MHC 2
  - Only B-cells and antigen-presenting cells
Antigen Processing

- T-independent
- T-dependent
  - Endogenous vs. Exogenous

T-independent Antigen

- Large antigen molecules
  - readily accessible, repeating antigenic determinants
- B cells bind directly
- Stimulates B cells to differentiate into a plasma cell
  - Produce antibodies
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T-dependent Antigens

- Smaller antigens, less accessible determinants
- Helper T cells needed
- APC process the antigen
  - makes antigenic determinants more accessible
  - Exogenous vs. endogenous antigens
**Exogenous vs. Endogenous Processing**

**Exogenous**
- Extracellular bacteria
- Extracellular viruses
- Phagocytized by macrophage
- Digested in phagolysosome
- Presented on MHC II

**Endogenous**
- Intracellular bacteria, viral and cancer proteins
- Processed in endoplasmic reticulum
- Presented on MHC I

**Antibody-mediated Response**
- Against exogenous pathogens
- Components:
  - B cell activation and clonal selection
  - Memory B cells
B-cell Activation

B-cell activation takes TIME . . .

Plasma Cells
- Majority of cells produced during B cell proliferation
- Secrete antibody molecules specific for the antigen
- Short-lived cells
  - Die within a few days of activation
  - Antibodies can persist
Memory B-cells

- Do not secrete antibodies
- BCRs specific for antigen that triggered their production
- Long-lived cells
  - Persist in the lymphoid tissue
  - Available to initiate antibody production if the same antigen is encountered again

Cell-mediated Immune Response

- Responds to intracellular pathogens and abnormal body cells
- Intracellular pathogens
  - viruses
  - intracellular bacteria
- Triggered when antigens are displayed on the host cell’s surface
Tc Cell Activation

Memory T-cells
- TCRs specific for antigen that triggered their production
- Long-lived cells
  - Persist in the lymphatic system
- Secondary immune response if exposed to same antigen again
Enzymes
Complement
Interferons
Defensins
Leukocytes

Pathway A
Non-Specific
Natural Immunity
(reacts in hours)

Pathway B
Specific
Immunity
(reacts in days)

Initial Infection

Enzymes
Complement
Interferons
Defensins

Leukocytes

Pathogen is destroyed by non-specific action

Specific
Immunity

T-Cells
B-Cells

Specific
Features:
- T-Cell mediated production
- Antibody production