Two major kinds of defense:
- Innate immunity and acquired immunity

(1) Innate immunity
- Is present before any exposure to pathogens and is effective from the time of birth
- Involves nonspecific responses to pathogens

(2) Adaptive immunity
- Develops only after exposure to inducing agents such as microbes, toxins, or other foreign substances
- Very specific response to pathogens

The Immune System

External defenses
- Skin
- Mucous membranes
- Secretions

Internal defenses
- Phagocytic cells
- Antimicrobial proteins
- Inflammatory response
- Natural killer cells

Acquired immunity
- Slower responses to specific microbes

External defenses
- Skin
- Mucous membranes
- Secretions

Internal defenses
- Phagocytic cells
- Antimicrobial proteins
- Inflammatory response
- Natural killer cells

B-cells
T-cells
WBC

WBC = white blood cells
P = phagocytic cells
L = lymphocytes cells

Types of White Blood Cells (LEUKOCYTES)

White blood cells
WBCs

Lymphocytes
- Develop in the bone marrow
- Helper T-cells - help B-cells. Do not produce antibodies.
- Cytotoxic T-cells - are involved in T-cell mediated immune response. Do not produce antibodies.

Acquired immunity
- Eosinophils - fight parasitic worms, also inflammatory and allergic response
- Neutrophils - phagocytic, early stages of infection
- Basophils - release chemical in inflammatory and allergic responses
- Monocytes (Macrophages) - phagocytic, high numbers during late stage of infection

Innate immunity
- Monocytes (Macrophages) - phagocytic, high numbers during late stage of infection

Ch.18

White blood cells
WBCs

Helper T-cells
Cytotoxic T-cells
Eosinophils
Neutrophils
Basophils
Monocytes (Macrophages)
1a) The body’s first line of defenses: External

- **Skin and mucous membranes**
  - Form physical barriers that prevent the entry of microorganisms and viruses

- **Mucus**: viscous fluid that traps microbes and other particles

- **Secretions** from the skin
  - Give the skin a pH between 3 and 5, which is acidic enough to prevent colonization of many microbes
  - Also include proteins such as lysozyme, an enzyme that digests the cell walls of many bacteria (functions as an antiseptic)

1b) The body’s second line of defenses: Internal

- Depend mainly on phagocytosis (a type of endocytosis)
- **Phagocytes** are types of white blood cells that
  - Ingest invading microorganisms and
  - Initiate the inflammatory response

<table>
<thead>
<tr>
<th>White Blood Cells</th>
<th>Defensive Proteins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phagocytic cells (ingulf foreign cells or substances)</td>
<td>Interferons (protect body cells against viral infection)</td>
</tr>
<tr>
<td>Natural killer cells (destroy infected body cells and cancerous cells)</td>
<td>Complement proteins (cause invading microorganisms to lyse)</td>
</tr>
</tbody>
</table>

- Attack pathogens directly
  - Coating microbes so phagocytes can recognize them or
  - Making holes in membranes
How phagocytic cells ingest microbes…

- Phagocytes attach to their prey via surface receptors
  - And engulf them, forming a vacuole that fuses with a lysosome

1. Pseudopodia surround microbes.
2. Microbes are engulfed into cell by endocytosis.
3. Vacuole (bag) containing microbes forms.
4. Vacuole and lysosome (bag containing enzymes) fuse.
5. Toxic compounds and lysosomal enzymes destroy microbes.
6. Microbial debris is released by exocytosis.

(2) Acquired or Adaptive Immunity

- Lymphocytes (B) provide specific defenses against infection, producing antibodies, specific proteins that recognize and attack foreign particles

- **Antigens** are any foreign molecule specifically recognized by lymphocytes

**Antibody Classes**

- There are five major classes of antibodies, or immunoglobulins
- They differ in their distributions and functions within the body

- **Antibodies** are specific proteins that recognize and bind
  - To just a small, accessible portion of the antigen called an **epitope**
Humoral and Cell-mediated Immunity responses

Humoral (antibodies)  Cell mediated response

- First exposure to antigen
- Antigens engulfed and displayed by dendritic cells
- Antigens displayed by infected cells
- B cell
- Helper T cell
- Cytotoxic T cell
- Long lived cells for 2ry exposure
- "Memory" cells
- 2ry exposure has a very fast response
- Antibodies
- Plasma cells
- Memory B cells
- Active and memory helper T cells
- Memory cytotoxic T cells
- Active cytotoxic T cells
- Secrete antibodies that defend against pathogens and toxins in extracellular fluid
- Defend against infected cells, cancer cells, and transplanted tissues

Specificity of Immunological Memory

- In the secondary immune response
- Memory cells facilitate a faster, more efficient response

(1) Day 1: First exposure to antigen A
(2) Primary response to antigen A produces antibodies to A
(3) Day 28: Second exposure to antigen A; first exposure to antigen B
(4) Secondary response to antigen A produces antibodies to A; primary response to antigen B produces antibodies to B

Antibody concentration (arbitrary units)

- Antibodies to A
- Antibodies to B
- The lag phase can be as short as 2-3 days, but often is longer, sometimes as long as weeks or months
- 3 to 5 days
**Active and Passive Immunization**

- **Active immunity**
  - Develops naturally in response to an infection
  - Can also develop following immunization, also called **vaccination**
  - A nonpathogenic form of a microbe or part of a microbe elicits an immune response to an immunological memory for that microbe

- **Passive immunity**, which provides immediate, short-term protection
  - Can be conferred artificially by injecting antibodies into a nonimmune person

**Allergies**

- Allergies are exaggerated (hypersensitive) responses
  - To certain antigens called allergens

**AIDS**

- Acquired Immunodeficiency Syndrome (AIDS)
  - Because AIDS arises from the loss of helper T cells
    - Both humoral and cell-mediated immune responses are impaired
  - People with AIDS
    - Are highly susceptible to opportunistic infections and cancers that take advantage of an immune system in collapse

**Blood Groups and Transfusions**

- Certain antigens (polysaccharides) on red blood cells
  - Determine whether a person has type A, B, AB, or O blood

**ABO blood type**

<table>
<thead>
<tr>
<th>Blood Type (genotype)</th>
<th>Type A (A, AO)</th>
<th>Type B (B, BO)</th>
<th>Type AB (AB)</th>
<th>Type O (OO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Blood Cell Surface Proteins (phenotype)</td>
<td>A (A antigen only)</td>
<td>B (B antigen only)</td>
<td>A and B (A and B antigen)</td>
<td>No antigen</td>
</tr>
<tr>
<td>Plasma Antibodies (phenotype)</td>
<td>b (b antibody only)</td>
<td>a (a antibody only)</td>
<td>No antibody</td>
<td>a and b (a and b antibody)</td>
</tr>
</tbody>
</table>

Why ‘b’ antibodies if never exposed to B blood?

- Antibodies arise in response to bacteria present in the body with similar epitopes (receptors) to blood B antigens!

- Immune responses to these polysaccharides antigens **do not generate memory cells**

- **Good for pregnancy**
  - because IgM cannot cross the placenta
  - No problems of incompatibility mother-fetus
**Rh blood type**

- Rh antigens give the "+" or "-" sign to the blood type
- Rh antigens are proteins and do induce immune responses where memory cells are generated

1st pregnancy: Mother Rh- and Fetus Rh+

- If fetal blood crosses the placenta
  - Possible in late pregnancy
  - Or during birth
    - Primary immune response from the mother against the antigens Rh+ of the fetus
    - Generation of memory cells

2nd pregnancy: Mother Rh- and Fetus Rh+

- If memory cells are exposed to fetal blood
  - IgG antibodies are produced as secondary immune response
    - IgG antibodies can cross the placenta
    - And eventually destroy RBC of the fetus

**The Lymphatic System**

- Closely associated with the circulatory system and the immune system
- Lymphatic capillaries absorb **excess of fluid** in tissues and return it to the bloodstream
- Lymphatic capillaries absorb **fats** in the form of lipoproteins and deliver them to the bloodstream
- Site for **lymphocytes** production and distribution
  - B and T cells
  - Acquired immunity
- **Phagocytes** are also produced in lymphatic organs
  - Innate or non-specific immunity
Lymphatic organs

- **Red Bone Marrow**
  - Produces all type of blood cells

- **Thymus gland**
  - Hormones that help maturation of lymphocytes

- **Spleen**
  - Filters the blood
  - Macrophages engulf pathogens and debris