The Immune System Defends the Body Against Infection

- The immune system protects the body against infection through a graded series of responses that attack foreign molecules and organisms

- **Pathogens**
  - Disease-causing agents such as viruses, bacteria, fungi, and parasites

### Bacterial Pathogens

- [Image of bacterial pathogens]

### Viral Pathogens

- [Image of viral pathogens: Ebola virus, HIV (AIDS virus)]
ABO Blood Types

- **Compatible Blood Types (no clumping):**
  - Donor: O
    - Recipient: A, B, AB
  - Donor: A
    - Recipient: B, O, AB
  - Donor: B
    - Recipient: A, O
  - Donor: AB
    - Recipient: B
  - Donor: AB
    - Recipient: O

- **Incompatible Blood Types (clumping):**
  - Donor: A
    - Recipient: B, O
  - Donor: B
    - Recipient: A, O
  - Donor: AB
    - Recipient: A, B, O

Rh Incompatibility

Diseases Associated with HLA Alleles

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
<th>Relative Risk for Certain HLA Type*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narcolepsy</td>
<td>Suddenly falling asleep</td>
<td>264</td>
</tr>
<tr>
<td>Ankylosing spondylitis</td>
<td>Inflamed and deformed vertebrae</td>
<td>77</td>
</tr>
<tr>
<td>Reiter's disease</td>
<td>Inflamed joints, eyes, and urinary tract</td>
<td>37</td>
</tr>
<tr>
<td>Dermatitis herpetiformia</td>
<td>Burning, itchy skin lesions</td>
<td>16</td>
</tr>
<tr>
<td>Psoriasis</td>
<td>Scaly skin lesions</td>
<td>8</td>
</tr>
<tr>
<td>Autoimmune hepatitis</td>
<td>Inflamed liver</td>
<td>7.4</td>
</tr>
<tr>
<td>Type 1 diabetes</td>
<td>Insulin resistance</td>
<td>5–7</td>
</tr>
<tr>
<td>Graves disease</td>
<td>Malfunction of thyroid gland</td>
<td>5.5</td>
</tr>
<tr>
<td>Celiac disease</td>
<td>Severe diarrhea</td>
<td>5.1</td>
</tr>
<tr>
<td>Myasthenia gravis</td>
<td>Fluctuating weakness of voluntary muscles</td>
<td>4.2</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>Severely inflamed joints</td>
<td>3–6</td>
</tr>
<tr>
<td>Multiple sclerosis</td>
<td>Degeneration of brain and spinal cord, producing weakness and poor coordination</td>
<td>2.7</td>
</tr>
<tr>
<td>Systemic lupus erythematosus</td>
<td>Facial rash, high persistent fever, destruction of heart, brain, kidneys</td>
<td>2</td>
</tr>
</tbody>
</table>

*Recall from chapter 1 that a relative risk of greater than 1 indicates a greater risk than that of the general population.

Levels of Immune Protection

- **Physical barriers:**
  - Skin
  - Mucous membranes
  - Infection-fighting chemicals
  - Antibody production
- **Innate immunity:**
  - Phagocytosis
  - Antimicrobial proteins
  - Inflammatory response
- **Adaptive immunity:**
  - Macrophages present antigens
  - T cells
  - Cytokines
  - B cells
  - Memory B cells
  - Humoral response
  - Cytotoxic T cells
  - Plasma cells
  - Antibodies
Phagocytes (Neutrophils, macrophages), engulf invaders. Macrophage secretions directly kill invaders, call for fever and for T and B cell proliferation.

Mast cells in tissue release histamine: blood vessels dilate and become leaky.

Fluid and plasma proteins leak out of capillaries; localized edema (tissue swelling) and pain result.

Complement proteins attack bacteria.

Phagocytes (Neutrophils, macrophages), engulf invaders. Macrophage secretions directly kill invaders, call for fever and for T and B cell proliferation.

Complement proteins attack bacteria.

1. Bacteria invade a tissue.
2. Fluid and plasma proteins leak out of capillaries; localized edema (tissue swelling) and pain result.
5. Phagocytes (Neutrophils, macrophages), engulf invaders. Macrophage secretions directly kill invaders, call for fever and for T and B cell proliferation.

**Inflammatory Response**

**Nonspecific Innate Defense**

- Phagocytosis
- Antimicrobial proteins
  - Complement system
  - Cytokines
  - Interferon
  - Interleukins
  - Tumor necrosis factor (cytokine)
- Inflammatory response
- Fever

**The Human Immune System**

Different Antibody Proteins Recognize and Bind to Different Features of Foreign Cells
**Humoral Immune Response:**

**Antigens Activate B cells**

- **Figure 17.9** Antibody Structure

**Types of Antibodies or Immunoglobins (Ig)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Location</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>IgA</td>
<td>Milk, saliva, urine, and tears; respiratory and digestive secretions</td>
<td>Protects against pathogens at points of entry into body</td>
</tr>
<tr>
<td>IgD</td>
<td>On B cells in blood</td>
<td>Stimulates B cells to make other types of antibodies, particularly in infants</td>
</tr>
<tr>
<td>IgE</td>
<td>In secretions with IgA and in mast cells in tissues</td>
<td>Acts as receptor for antigens that cause mast cells to secrete allergy mediators</td>
</tr>
<tr>
<td>IgG</td>
<td>Blood plasma and tissue fluid; passes to fetus</td>
<td>Protects against bacteria, viruses, and toxins, especially in secondary immune response</td>
</tr>
<tr>
<td>IgM</td>
<td>Blood plasma</td>
<td>Fights bacteria in primary immune response; includes anti-A and anti-B antibodies of ABO blood groups</td>
</tr>
</tbody>
</table>

*The letters A, D, E, G, and M refer to the specific conformation of heavy chains characteristic of each class of antibody.*

**The Human Immune System**

- **Figure 17.11**
The Immune system

**Antigen-Presenting Cells**

- Cells that bind antigens with HLA glycoproteins
- Two types of antigen-presenting cells are: Macrophages, Lymphocytes

**Cytotoxic T cells Can Destroy Cancer Cells**

- Cytotoxic T cell binds to cancer cell.
- Perform destroys cancer cell.
- T cell has lysed cancer cell.

**Types of Immune Cells**

<table>
<thead>
<tr>
<th>Cell Type</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macrophage</td>
<td>Presents antigens, performs phagocytosis</td>
</tr>
<tr>
<td>Mast cell</td>
<td>Releases histamine in inflammation, releases allergy mediators</td>
</tr>
<tr>
<td>B cell</td>
<td>Matures into antibody-producing plasma cell or into memory cell</td>
</tr>
<tr>
<td>T cells</td>
<td>Helper recognizes nonself antigens presented on macrophages, stimulates B cells to produce antibodies, secretes cytokines, activates cytotoxic T cells</td>
</tr>
<tr>
<td>Cytotoxic</td>
<td>Attacks cancer cells and cells infected with viruses upon recognizing antigens</td>
</tr>
<tr>
<td>Natural killer</td>
<td>Attacks cancer cells and cells infected with viruses without recognizing antigens, activates other white blood cells</td>
</tr>
<tr>
<td>Suppressor</td>
<td>Inhibits antibody production</td>
</tr>
</tbody>
</table>
**SCID: Severe Combined Immune Deficiency**

- The boy in the bubble, died at age 12

David Vetter 1971-1984

**Inherited Immune Deficiencies**

<table>
<thead>
<tr>
<th>Disease</th>
<th>OMIM</th>
<th>Inheritance*</th>
<th>Defect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic granulomatous disease</td>
<td>304600</td>
<td>ar, AD, xfr</td>
<td>Abnormal phagocytes can’t kill engulfed bacteria</td>
</tr>
<tr>
<td>Immune defect due absence of thymus</td>
<td>242700</td>
<td>ar</td>
<td>No thymus, no T cells</td>
</tr>
<tr>
<td>Neutrophil immuno-deficiency syndrome SCID</td>
<td>608203</td>
<td>ar</td>
<td>Deficiencies of T cells, B cells, and neutrophils</td>
</tr>
<tr>
<td>Adenosine deaminase deficiency</td>
<td>102700</td>
<td>ar</td>
<td>No T or B cells</td>
</tr>
<tr>
<td>Adenosine deaminase deficiency with sensitivity to ionizing radiation</td>
<td>602450</td>
<td>ar</td>
<td>No T, B, or natural killer cells</td>
</tr>
<tr>
<td>IL-2 receptor mutation</td>
<td>300400</td>
<td>xfr</td>
<td>No T, B, or natural killer cells</td>
</tr>
</tbody>
</table>

*ar = autosomal recessive
AD = autosomal dominant
xfr = X-linked recessive

**HIV / AIDS**

1. Virus binds receptor on plasma membrane and enter cell. Enzyme removes proteins around viral RNA.
2. RT synthesizes formation of DNA complementary to viral RNA.
3. New DNA strand serves as a template for complementary DNA strand.
4. Double-stranded DNA is incorporated into host cell’s genome.
5. Viral gene transcribed into mRNA.
6. mRNA translated into HIV proteins in cytoplasm.
7. Capsids surround new viral RNA genomes.
8. New viruses bud from host cell.

**Allergy**

1. Allergen (pollen grain) enters blood stream.
2. B cells make antibodies.
3. Antibodies attach to mast cell.
4. Mast cell.
5. Allergen binds to antibodies on mast cell.
6. Histamine is released, causing allergy symptoms.

Sensitization: Initial exposure to allergen
Later exposure to same allergen
Vaccination, Edward Jenner 1796

Monoclonal Antibody Technology

Transplant Types

Xenografts
pigs and baboons have been tissue and organ donors for human transplants
Transgenic Pig with human HLAs

Parkinson Patient treated with fetal pig neural cells