Key Concepts:

1. Vertebrates have physical, chemical, and cellular defenses against pathogenic organisms, tumors, and other agents
2. In the early stages of invasion and damage, white blood cells escape from capillaries and execute a counter attack
3. Some white blood cells make immune responses
Key Concepts:

4. The antigen triggers an immune response
5. One type of immune response involves the production of antibodies
6. Another type of immune response involves whole cell responses

Three Lines of Defense

- Pathogens
  - Viruses, bacteria, fungi, protozoa, parasitic worms

- Nonspecific Defenses – First Line
  1. Skin: a. cells – Prevent entry of pathogens
     b. glands (oil and sweat pH 3-5, discourages microbial growth)
     c. earwax – trap microorganisms
  2. Mucous membranes - trap pathogens
  3. Hair & hair-like structures (cilia)
     filter air (nasal hairs)
     transport mucus
  4. Acid: a. stomach
     b. vagina (limits growth of fungi and bacteria)
  5. Saliva, tears with lysozyme (enzyme attacks the cell walls of many bacteria)
  6. “harmless bacteria” - suppress pathogenic bacterial growth
Nonspecific Internal Defenses

1. Phagocytic cells
   a. Neutrophils and macrophages (developed from monocytes) engulf and digest foreign cells. Eosinophils bombard large parasites

2. Natural killer cells (NK) – release chemical that break down their targets’ cell membrane (attack tumor cells, cells infected by viruses).

The Roles of Phagocytes

Macrophages - Engulf and digest all foreign objects
The Roles of Killer Cells

The larval form of filaria, a parasitic worm, being attacked by white blood cells

Nonspecific Internal Defenses

3. Inflammation – literally means “to set a fire”
Injured tissues release chemicals. These chemicals stimulate mast cells, which are connective tissue cells specialized to release histamine. Histamine promotes vasodilation.
Redness - Vasodilation
Warmth - Increase blood flow and phagocytes
Swelling - Increase capillary permeability
- Attracts phagocytic white blood cells
Pain
Nonspecific Internal Defenses

4. Fever—an attempt to inhibit bacterial growth
   White blood cells release pyrogens (hormone)
   1) Raise body temperature set point
   2) Increase the body’s temperature
   3) Decrease iron and zinc concentration in the bloodstream (to slow down bacterial reproduction)

5. Proteins that kill invading microbes
   Complement system – complex composed of about 30 circulating proteins (each protein can activate many others)
   attack bacteria, fungi on cell wall (form pores)
   attract phagocytes
   stimulate phagocytosis
   stimulate inflammation

6. Interferons
   A chemical messenger produced by virus infected body cells and capable of stimulating resistance in uninfected cells by synthesis of anti-viral enzymes.

Specific responses – Immune System

1. Components of Immune system
   a. Lymph nodes and spleen: WBCs maturation sites
   b. Thymus glands: T-cell lymphocytes maturation
   c. Bone marrow: stem cells produce blood cells: B-cell lymphocytes maturation site
   d. Blood cells – WBCs
      Phagocytes (macrophage), B-cells and T-cells
   e. Antibodies

2. Immune responses
Specific responses – Immune System

White Blood Cells

1. Macrophages – big eater.
   WBCs that both destroy invading microbes and help alert other immune cells by secrete interleukin-1 (chemical regulator).

2. B cells – Lymphocytes that produce antibodies; when stimulated, certain of their daughter cells (plasma cells) secrete large quantities of antibodies into the bloodstream.
   - Memory B cells – long-lived, provide future immunity.
   - Plasma cells – secrete antibodies – circulate (2,000 – 30,000 AB/cell/second); 5-17 days delay.

White Blood Cells

3. T cells – A set of lymphocytes that regulate the immune response or kill certain types of cells.
   - Cytotoxic T cells – destroy foreign cells, infected own body cells, or cancerous body cells; attack foreign antigen displayed with MHC-1.
   - Rejection of tissue and organ transplant
   - Helper T cells – stimulate immune responses (secrete interleukin-2) by both B cells and killer T cells.
   - Suppressor T cells – turn off immune response.
   - Memory T cells – long-lived, provide future immunity.
A WBC squeezing out of a blood capillary

A macrophage about to engulf a yeast cell

A cytotoxic T cell has lysed a cancer cell

**Antibodies**

Antigens = something that elicits a specific response from a lymphocyte.

Antibody (Immunoglobulin) = an antigen binding protein associated with B-cells.

Y-shaped protein; four polypeptides and each has constant region and variable region; genetic rearrangements during B cell maturation; bind to antigen (neutralization, promotion of phagocytosis).
Antibodies (rearrangement)

Antibodies bind to a hormone secreted by newly pregnant woman

Memory

First and secondary response to the same antigen

Memory cells
The Immune Response

1. Recognition
   - Recognition of foreign antigens, not “self”
   - Antigen presentation through membrane antigen-MHC protein complex
     (Major Histocompatibility Complex I or II = MHC-I and MHC-II)

2. Attack
   a. Humoral immunity
   b. Cell-mediated defense

3. Memory
   a. B and T memory cells survive many years
   b. Memory cells activate a quicker second defense against the same invader

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The Recognition

- Antigen-presenting cell (an infected cell)
  - Class I MHC molecule
  - Antigen fragment
  - T-cell receptor
  - Cytotoxic T cell (T_c)

- Antigen-presenting cell (a macrophage)
  - Class II MHC molecule
  - Antigen fragment
  - T-cell receptor
  - Helper T cell (T_h)

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Co-stimulation

- Class II MHC molecule
- T-cell receptor
- Antigen fragment
- Bacterium
- CD4
- Intercostin-1 activates T_c cells.
- Intercostin-2 and other cytokines activate T_h cells, B cells, and T_c cells.
- APC (macrophage)
- T_h cell
- T_c cell
- Cell-mediated immunity (attack on infected cells)
- Humoral immunity (secretion of antibodies by plasma cells)

APC – antigen presenting cell
CD4 = co-receptor (surface protein of Helper T cells)
The Immune Response

Destruction of infected cell

CD8 = co-receptor (surface protein of killer T cells)
Humoral (antibody-mediated) immune response

B cell

Plasma cells

Cell-mediated immune response

Stimulates

Gives rise to

Memory B cells

Antigen (1st exposure)

Engulfed by Antigen-presenting cell

Memory Helper T cells

Helper T cell Cytotoxic T cell

Memory Cytotoxic T cells

Defenses Enhanced

Defenses Enhanced

(Vaccines and allergies)

Immunizations

Vaccines – like antigens but not pathogenic

Vaccination – injection of weakened or killed microbes stimulate development of memory cells

Allergens

Pollen, foods, dust, spores

Allergies – inappropriate immune response (to some generally harmless substance)
**Hepatitis B**

**Hepatitis B booster**

**Hepatitis B assessment**

**DTP (Diphtheria; Tetanus; and Pertussis, or whooping cough)**

**DTP booster**

**DT booster**

**HIB (Hemophilus influenzae)**

**HiB booster**

**Polio**

**Polio booster**

**Polio booster**

**MMR (Measles, Mumps, Rubella)**

**MMR booster**

**MMR assessment**

**Varicella**

**Varicella assessment**

**Birth–2 months**

**1–4 months**

**6–18 months**

**11–12 years**

**2, 4, and 6 months**

**16–24 months**

**4–6 years**

**4–6 years**

**11–12 years**

**11–12 years**

**12–15 months**

**2 and 4 months**

**6–18 months**

**4–6 years**

**11–12 years**

**AIDS: Acquired Immune Deficiency Syndrome**

**Symptoms**

- Flu-like
- Weight loss, fever, night sweats
- Enlarged lymph nodes

1. Caused by RNA viruses
2. Destroy helper-T cells (CD4+ T cells)
3. Helper T cells make more viruses
4. Infect more helper T cells
5. Immune system → quit work

**AIDS: Acquired Immune Deficiency Syndrome (1997)**

**RECOMMENDED VACCINES**

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AIDS: Acquired Immune Deficiency Syndrome

Phagocytosis  Cytotoxic T cells (T_c)
Macrophages  Helper T cells (T_H)
Eosinophils  Humoral immunity
Natural killer cells  Cell-mediated immunity
Inflammation  Immunization
Histamine  Vaccination
B lymphocytes  AIDS
T lymphocytes  Interferon
Antigens  Interleukin-1
Antibodies  Interleukin-2
Memory cells  Major Histocompatibility Complex
Plasma cells

Key Terms

AIDS posters

Antigens

Interleukin-1

Plasma cells

Histamine

B lymphocytes

Cytotoxic T cells (T_c)

Phagocytosis

Humoral immunity

Vaccination

Helper T cells (T_H)

AIDS

T lymphocytes

Major Histocompatibility Complex

CD4

CD8

Natural killer cells

Cell-mediated immunity

Macrophages

CD4
In Conclusion

1. Skin and mucous membranes lining body surfaces are physical barriers to infection.

2. Immune responses show specificity, memory, and normally don’t fight one’s own self-marker proteins.
   - Lymphocytes have receptors that bind to antigen-MHC complexes.

3. After recognition of antigen, repeated cell division form clones of B and T cells.

4. T cells arise in bone marrow but continue to develop in the thymus and B cells arise and mature in bone marrow.

5. Antibodies are protein molecules with binding sites for one kind of antigen.

6. Allergic reactions are immune responses to some generally harmless substance.