Outline

I. Nonspecific Defenses
   A. Barrier
   B. Protective proteins
   C. Phagocytes
   D. Natural killer cells
   E. Inflammatory reaction

II. Specific Defenses
   A. B cells – Antibody mediated response
   B. T cells – Cell mediated response

Immune System Function

- Immune response
  - Recognizing foreign or dangerous macromolecules
  - Responding to eliminate them

Terminology

- Immunology - Study of internal defensive responses
- Pathogen – organisms that cause disease
  - Include viruses, bacteria, fungi, protists, worms
- Antigen – any object or substance that is perceived as foreign and therefore elicits an immune response.

Two Types of Immune Defense

1. Innate Immunity - Nonspecific defenses
   - Immune system parts that attack any antigen

2. Adaptive Immunity -Specific defenses
   - Other immune cells will only respond to one particular antigen
   - Leads to an immunity that is a long lasting protection from that particular antigen

Innate Immunity = Non Specific

- All animals have innate immunity, a defense active immediately upon infection
- Innate immunity is present before any exposure to pathogens and is effective from the time of birth
- Innate immunity consists of external barriers plus internal cellular and chemical defenses
Adaptive Immunity = Specific

- Vertebrates also have adaptive immunity
- Adaptive immunity, or acquired immunity, develops after exposure to agents such as microbes, toxins, or other foreign substances
- It involves a very specific response to pathogens

Innate - Nonspecific Defenses

- Five types:
  1. Barrier
  2. Protective proteins
  3. Phagocytes
  4. Natural killer cells
  5. Inflammatory reaction

1. Barriers to Entry

1. Skin, cuticle, shell, chitin, wax: barriers to keep many things out of the body
2. Tears and saliva have lysozmes - Enzymes that can kill bacteria.
3. The lungs have ciliated cells and mucus that help to transport foreign things out of the respiratory system
4. The stomach has acids that help kill bacteria

2. Non-specific proteins

- Cytokines
- Complement proteins

Non-specific proteins - Cytokines

- Cytokines – proteins and peptides that are signaling molecules and have regulatory functions for both the specific and nonspecific immune responses.
  - Interferons
  - Interleukins
  - Chemokines
  - Tumor necrosis factors

Non-specific – Complement Proteins

1. Lyse viruses and bacteria
2. Coat invading cells to make them easier to engulf
3. Attract white blood cells to site of infection
4. Attach to immune system cells to increase their activity
3. Phagocytes

- Phagocytes are non specific scavenger cells that engulf foreign invaders and damaged cells
  - Macrophages
  - Neutrophils
  - Eosinophils

Phagocytes

- Macrophages are large phagocytes that can engulf large objects. They also can become “antigen-presenting cells” (APCs).
  - And there are two smaller (microphages):
    - Neutrophils – consume bacteria
    - Eosinophils – engulf antigen and destroy them, also destroy parasitic worms by releasing enzymes (don’t engulf worms)

4. Natural Killer Cells

- Natural Killer Cells are a type of lymphocyte
  - Attacks virus infected cells and tumor cells
  - These cells are both a part of the non-specific defenses
  - They kill any cell they don’t recognize as a normal cells
5. Inflammatory Response

- First on the scene are **mast cells** - release histamines and other compounds
- **Histamines** cause blood vessels to dilate and make the vessels more permeable
- Mast cells send signals to attract other cells – increasing phagocytosis

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- When blood vessels are wider, more blood flows here and brings more defense cells and proteins to the injury.
- Also, the blood vessels are more permeable so the defense cells and proteins can pass out of the vessels to the site of injury.
- Other defense cells can now get to the injury, including phagocytes (neutrophils and macrophages) and dendritic cells.

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**These phagocytes attack parasitic worms**

1. Natural Killer cells
2. Macrophages
3. Neutrophils
4. Eosinophils

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**These non specific lymphocyte attack virus infected cells and tumor cells**

1. Natural Killer cells
2. Macrophages
3. Neutrophils
4. Eosinophils
Adaptive Immunity - Specific Defenses

- Specific defenses are “acquired immunity”

- If our body come in contact with an antigen, it “remembers” that antigen so the next time it comes in contact with it, the body can quickly mount a defense.

How do we acquire immunity?

- In the specific defenses there are two ways we fight invaders:
  - Antibody-mediated immunity - B cells
  - Cell-mediated immunity - T cells

Terminology

- **Antibodies** – specific proteins produced by the B cells in response to an antigen.

Lymphocytes

- There are two types of specific defense lymphocytes:
  - B Cells
  - T Cells

- Lymphocytes, and all other white blood cells, are produced in bone marrow by stem cells

Lymphocytes

- Immature T cells leave the bone marrow and travel to the thymus (endocrine gland) where they develop into T Cells.

- Immature B cells stay in the bone marrow and develop into B Cells

- Both types of cells (B cells and T cells) will go to the lymphatic system when they are mature
**Antibody Mediated Immunity**

- **Antibodies** are proteins that circulate through the body and bind onto a particular antigen (foreign object) and mark it as foreign.

- Antibodies start out as receptors on the surface of B cells. The antibody is specific – it only binds with one type of antigen.

- Antibodies are released from B cells and are circulate throughout the body.

**Antibodies**

- An Antibody is specific to a particular antigen – How can we have so many different types of receptors (antibodies) on our B cells?

- The B cells have DNA sequences that are constantly being “shuffled” to create new B cells with new types of receptors.

**Roll of B cells**

- So we get a great diversity in B cells, but each B cell only has one type of receptor.

- When a B cell receptor comes into contact with the antigen it is specific for, the B cell starts to make identical copies of itself through mitosis – these copies are called clones = clonal selection.

- So now there are lots of the B cells with receptors that are specific to the antigen.

- Remember that these receptors are antibodies that will be released from the B cell to circulate freely

- Some of the B cell clones will shed their receptors (antibodies) and keep producing and shedding more antibodies. These are plasma cells.

- Other B cell clones will keep their receptors/antibodies and will remain in the body, ready to defend against the antigen in the future = memory cells.
How do antibodies defend against antigens

- The antibodies that are free floating in your body will bind to the antigen
  1. mark the antigen, stimulating the nonspecific defenses to destroy the antigen.
  2. make it easier for the nonspecific defenses to destroy the antigen
  3. inactivate pathogens and toxins

How antibodies work

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Cell Mediated Immunity

- Remember that some lymphocytes go to the thymus to develop into T cells.

- There are two types of T cells
  - Helper (CD4) T cells = target of HIV
  - Cytotoxic T cells

Antigen-presenting cells

- Macrophages can also be Antigen presenting cells (APCs) which pick up antigens (foreign material) and they bring them to the lymph nodes and the spleen.

- The lymph nodes and spleen store huge numbers of immune system cells.

- One type of cell they meet there are Helper T cells

T cells

- When a helper T cell meets a APC cell it becomes activated – meaning it starts to make copies or clones of itself. These T cells leave the lymphatic system and circulate throughout the body.

- The helper T cells also activate cytotoxic T cells to also start making clones, and the helper T cells activate B cells

- The cytotoxic T cells kill the invading antigens
These B cells shed their receptors, making antibodies

1. Memory cells
2. Plasma cells

T cells mature in the

1. Bone
2. Thymus
3. Thyroid
4. Spleen

B cells mature in the

1. Bone
2. Thymus
3. Thyroid
4. Spleen

T cells are produced in the

1. Bone
2. Thymus
3. Thyroid
4. Spleen

Major Histocompatibility Complex

- Major histocompatibility complex – genes that vary greatly between individuals
- The proteins these genes code for help identify "self" from foreign antigens

Autoimmune Disorders

- Remember that I said an antigen is something the immune system recognizes as foreign.
- Sometimes the body recognizes parts of the body as foreign or harmless foreign objects as harmful.
  - Rheumatoid arthritis
  - Multiple sclerosis
  - Myasthenia gravis
The target of HIV is

1. Cytotoxic T cells
2. Helper T cells
3. B cells
4. Natural Killer cells

Important Concepts

- Function of the immune system
- Know the vocabulary in this lecture
- Nonspecific defenses vs Specific defenses
- Know the types of nonspecific defenses and specific defenses
- Three types of lymphocytes
- Examples of Barrier defenses
- Know the types of nonspecific proteins, know what complement proteins do
- How the body mounts an inflammatory response

Important Concepts

- What are Natural Killer cells, what do they do
- The three types of phagocytes, what are they, what do they do
- T cells and B cells – where are they produced, what cells produce them, what they do, where do they mature and where are they found when mature, are they part of the cell mediate or antibody mediated defenses
- Know cell mediated and antibody mediated defenses

Important Concepts

- What are antibodies, how are they produced, how do they work. What are memory cells, plasma cells, and how does clonal selection work.
- What are “antigen-presenting cells” (APCs)
- What are Major histocompatibility complexes
- What is the target of HIV
- What are examples of autoimmune diseases
- Know all the immune system cells discussed in lecture, know what do they do