Outline – Immune System

I. Function of the Immune System
   • Defend the body against foreign invaders.
   • Must be able to discriminate between the body's own cells and tissues versus foreign material.

II. Barrier Defenses
   1. Skin
   2. Tears and saliva have lysozymes which are enzymes that can kill bacteria.
   3. The skin is an excellent barrier keeping many things out of the body
   4. The respiratory tract has cilia and mucus that help to transport foreign things out of the respiratory system
   5. Beneficial bacteria in the large intestine and vagina out compete harmful bacteria
   6. Acidic urine kills bacteria and washes bacteria from urethra

III. Nonspecific Defenses
   A. Immune system cells
   B. Inflammatory response
   C. Complementary proteins

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

V. Disorders of the immune system

Terminology

Antigen – any object or substance that is perceived as foreign and therefore elicits an immune response.

Antibodies – proteins produced by B cells in response to an antigen.

Pathogen – microorganisms and parasites that cause disease.

Barrier Defenses

1. Skin
2. Tears and saliva have lysozymes
3. The respiratory tract has cilia and mucus
4. The stomach has acids that help kill bacteria
5. Beneficial bacteria
6. Acidic urine

Two Types of Immune Defense

• Nonspecific defenses
  • Parts of the immune system that attack any antigen (cell or object it identifies as foreign)

• Specific defenses
  • Other immune cells will only respond to one particular antigen
  • Leads to an acquired immunity = a long lasting protection from that particular antigen
### Non Specific Defenses

1. Immune system cells
   - Neutrophils
   - Monocytes/Macrophages (APC)
   - Eosinophils
   - Natural killer cells – nonspecific lymphocyte

2. Inflammatory response

3. Proteins

### Non Specific Defenses - Cells

1. Immune system cells
   - Neutrophils
   - Monocytes/Macrophages
   - Eosinophils
   - Natural killer cells

### Inflammatory Response

- When the body is injured or damaged then the body mounts an inflammatory response.

- Mast cells in the tissue release histamines.

- Histamines cause:
  - blood vessels to dilate
  - make the vessels more permeable

### Inflammatory Response

- Now that the blood vessels are wider, more blood flows here and brings more defense cells and proteins to the injury.

- Increased blood flow causes increased temperature and redness.

### Inflammatory Response (4 signs)

- The blood vessels are more permeable so the defense cells, fluid and proteins can pass out of the vessels to the site of injury.

- This causes swelling and stimulates nerve receptors

- Proteins: including complement proteins and clotting factors

- See pages 242 – 244

### Defense Proteins - Complement proteins

- Complement proteins: Proteins that enhance the immune response.

- Effects:
  - Punch hole in invading cell
  - Attract phagocytes and coat bacteria to make it easier to phagocytize.

### Complement proteins

- [Diagram of complement proteins]
Complement proteins

Defense Proteins - Interferons

- Interferons: Cells infected with viruses secrete interferon proteins.
- Effects:
  - Attract macrophages and natural killer cells.
  - Protect other cells from viral infections.
  - Inhibit cell division in cancer cells

These phagocytes attack parasitic worms

- Natural Killer cells
- Macrophages
- Neutrophils
- Eosinophils

These non specific lymphocyte attack virus infected cells and tumor cells

- Natural Killer cells
- Macrophages
- Neutrophils
- Eosinophils

Which of the following is not a barrier defense?

- Skin
- Tears
- Antibodies
- Stomach acid

Specific Defenses

- Specific defenses are "acquired immunity"
- If our body comes 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.

Distinguishing Self from Foreign Organisms

- To defend against foreign invaders, the body needs to identify its own cells.
- All the cells in your body have proteins in their plasma membrane that identify it as part of you body.
- These proteins are major histocompatibility complex (MHC) markers
- Your MHC markers are unique to you

MHC Markers
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

Lymphocytes

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

Where are lymphocytes produced?

1. Spleen
2. Thymus
3. Lymph nodes
4. Bone

Lymphocytes - T cells

- T cells are produced in the bone marrow
- They travel to the thymus where they develop into mature T Cells.
- These cells are important in the cell-mediated part of our acquired immunity.

Lymphocytes - B cells

- B cells are produced in the bone marrow.
- They stay and mature in the bone marrow
- They are important in antibody-mediated immunity

Lymphocytes - B cells and T cells

- Both mature B cells and T cells will go to the lymphatic system and the circulatory system

An object that is perceived as foreign and illicits an immune response.

1. Pathogen
2. Antigen
3. Antibody

Antibody-Mediated Immunity

- Antibodies are proteins that circulate through the body and bind onto a particular antigen (foreign object)
- Antibodies start out as receptors on the surface of B cells. The antibody is specific – it only bind with one type of antigen.
- Antibodies are released from B cells and 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?

Antibodies

- The B cells have DNA sequences that are constantly being “shuffled” to create new B cells with new types of receptors.
- DNA is transcribed to make mRNA
- mRNA is translated to make proteins

Transcription is when:

1. DNA is copied to make RNA
2. RNA is used to make proteins

Antibodies

- DNA is transcribed to make mRNA
- mRNA is translated to make proteins

B cells are diverse, they differ in the type of receptor they have, each B cell only have 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.

Antibodies

- Some of these B cells will shed their receptors: Plasma cells
- Other B cells will keep their receptors, and will remain in the body, ready to defend against the antigen in the future: Memory cells

B Cells Produce Antibodies

- B Cells Produce Antibodies

Immune Response Steps

- Immune Response Steps

Figure 13.11 (1 of 2)

The selected B cell divides, producing a clone of cells all bearing receptors specific for that particular antigen. The antigen binds to the B cell with appropriate receptors. This B cell has receptors specific for this particular antigen. There is a tremendous variety of B cells. Each B cell has receptors for a different antigen on its surface.

Figure 13.12 (2 of 2)

Step 5: Building specific defenses
The B cell divides and forms plasma cells and memory cells.

Step 6: Defense
Plasma cells secrete antibodies specific for that antigen.

Step 7: Continued surveillance
Memory B cells remain and mount a quick response if the invader is encountered again.
How do antibodies defend against antigens?

- The antibodies that are free floating in your body will bind to the antigen.
- This has many effects on the antigen.

Effects of Antibodies Binding to Antigen

1. To mark it so the body knows to destroy it with its nonspecific defenses.
2. Attracts phagocytes to the area. The phagocytes will engulf and destroy the antigen.
3. Coats the antigen, making it easier to phagocytize.
4. Binds the antigens, causing them to clump together – this will cause them fall out of solution.
5. Neutralize toxins and viruses.
6. Activate the complement proteins which cause the bacteria to lyse open.

Cell Mediated Immunity – T Cells

- Remember that some lymphocytes go to the thymus to develop into T cells. These cells are important players in cell-mediated immunity.
- There are two types of T cells:
  - Helper (CD4) T cells
  - Killer (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 with the correct antigen, it becomes activated – meaning it starts to make copies or clones of itself.
- The helper T cells activate cytotoxic T cells to also start making clones and
  - The helper T cells activate B cells
  - The cytotoxic T cells kill the cancer cells and infected cells or organ transplant cells

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

25% 25% 25% 25%

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**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.
  - Systemic lupus erythematosus – connective tissue
  - Rheumatoid arthritis - joints
  - Multiple sclerosis – myelin sheath
  - Myasthenia gravis - acetylcholine receptors at the neuromuscular junction
  - Type 1 Diabetes Mellitus

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**Immune system disorders**

- Sometimes the body recognizes harmless foreign objects as harmful.
- See pages 253 - 254
  - Allergies, including food allergies

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**Important Concepts**

- Read Chapter 13a for next lecture
- What are the examples of barrier defenses
- What are the Nonspecific defenses and the Specific defenses, what are the differences.
- What are the functions of all the white blood cells discussed in this lecture and in the blood lecture.

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**Important Concepts**

- What are the three types of lymphocytes, which are part of the specific and which are part of the nonspecific defense system.
- How does the body mount an inflammatory response and what is the effect on the body.
- What are the functions of complement proteins and interferons.
- What is the function of major histocompatibility complex (MHC) markers

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**Important Concepts**

- T cells and B cells – where are they produced, where do they mature, where are they found once they have matured, are they part of the cell mediated or antibody mediated defenses?
- What are the types of T cells, what is the function of T cells?
- What are antibodies, how are they produced, What effect do they have. What are memory cells, plasma cells, and how does clonal selection work?

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**Definitions**

- Antigen, antibodies, immunity, pathogen, lysozymes, histamines, permeable, transcription, translation, acquired immunity

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**Please make your selection...**

1. Choice One
2. Choice Two
3. Choice Three
4. Choice Four

25% 25% 25% 25%