Lec. 6 Immune System

The immune system is the collection of cells, tissues and molecules that protects the body from numerous pathogenic microbes and toxins in our environment. This defense against microbes has been divided into two general types of reactions: reactions of innate immunity and reactions of adaptive immunity. Thus, innate and adaptive immunity can be thought of as two equally important aspects of the immune system. As you will see, each aspect differs with respect to how quickly it responds and for how long it responds to pathogens,

- **The immune system can be classified into subsystems**

• Innate immune system

consists of cells and proteins that are always present and ready to mobilize and fight microbes at the site of infection. The main components of the innate immune system are

1) physical epithelial barrier

2) phagocytic leukocytes

3) dendritic cells

4) a special type of lymphocyte called a natural killer (NK) cell

5) circulating plasma proteins.

• Adaptive (or acquired) immunity

Adaptive (or acquired) immunity , is called into action against pathogens that are able to evade or overcome innate immune defenses. Components of the adaptive immune system are normally silent; however, when activated, these components "adapt" to the presence of infectious agents by activating, proliferating, and creating potent mechanisms for neutralizing or eliminating the microbes. There are two types of adaptive immune responses**: humoral immunity**, mediated by antibodies produced by B lymphocytes, and **cell-mediated immunity**, mediated by T lymphocytes

Adaptive (or acquired) immunity creates immunological memory after an initial response to a specific pathogen, leading to an enhanced response to subsequent encounters with that same pathogen. This process of acquired immunity is the basis of vaccination.

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Components of the immune system	
Innate immune system	**Adaptive immune system**
Response is non-specific	Pathogen and antigen specific response
Exposure leads to immediate maximal response	Lag time between exposure and maximal response
Cell-mediated and humoral components	Cell-mediated and humoral components
No immunological memory	Exposure leads to immunological memory
Found in nearly all forms of life	Found only in jawed vertebrates

- Innate immune system

Surface barriers

Several barriers protect organisms from infection, including mechanical, chemical, and biological barriers. skin are examples of mechanical barriers that are the first line of defense against infection.

However, as organisms cannot be completely sealed from their environments, other systems act to protect body openings such as the lungs, intestines, and the genitourinary tract. In the lungs, coughing and sneezing mechanically eject pathogens and other irritants from the respiratory tract. The flushing action of tears and urine also mechanically expels pathogens, while mucus secreted by the respiratory and gastrointestinal tract serves to trap and entangle microorganisms.

Chemical barriers also protect against infection. The skin and respiratory tract secrete antimicrobial peptides such as the β-defensins. Enzymes such as lysozyme and phospholipase A2 in saliva, tears, and breast milk are also antibacterials. Vaginal secretions serve as a chemical barrier following menarche, when they become slightly

acidic, while semen contains defensins and zinc to kill pathogens. In the stomach, gastric acid and proteases serve as powerful chemical defenses against ingested pathogens.

▪ Inflammation

Inflammation is one of the first responses of the immune system to infection. The symptoms of inflammation are redness, swelling, heat, and pain, which are caused by increased blood flow into tissue. Inflammation is produced by eicosanoids and cytokines, which are released by injured or infected cells. Eicosanoids include prostaglandins that produce fever and the dilation of blood vessels associated with inflammation

The complement system is a biochemical cascade that attacks the surfaces of foreign cells. It contains over 20 different proteins and is named for its ability to "complement" the killing of pathogens by antibodies. Complement is the major humoral component of the innate immune response

▪ Cellular barriers

Leukocytes (white blood cells) act like independent, single-celled organisms and are the second arm of the innate immune system. The innate leukocytes include the phagocytes (macrophages, neutrophils, and dendritic cells), mast cells, eosinophils, basophils, and natural killer cells. These cells identify and eliminate pathogens, either by attacking larger pathogens through contact or by engulfing and then killing microorganisms. Innate cells are also important mediators in the activation of the adaptive immune system.

Phagocytosis is an important feature of cellular innate immunity performed by cells called 'phagocytes' that engulf, or eat, pathogens or particles. Phagocytes generally patrol the body searching for pathogens,

Natural killer cells, or NK cells, are a component of the innate immune system which does not directly attack invading microbes. Rather, NK cells destroy compromised host cells, such as tumor cells or virus-infected cells

○ Adaptive immune system

evolved in early vertebrates and allows for a stronger immune response as well as immunological memory, where each pathogen is "remembered" by a signature antigen . The adaptive immune response is antigen-specific and requires the recognition of specific "non-self" antigens during a process called antigen presentation.

The immune system consists of cellular and molecular components that work together to destroy antigens (Ags).

- Antigen-Presenting Cells

Although some Ags can stimulate the immune response directly, T cell–dependent acquired immune responses typically require antigen-presenting cells (APCs) to present Ag-derived peptides within major histocompatibility complex (MHC) molecules.

▪ Lymphocytes

The cells of the adaptive immune system are special types of leukocytes, called lymphocytes. B cells and T cells are the major types of lymphocytes and are derived from hematopoietic stem cells in the bone marrow..

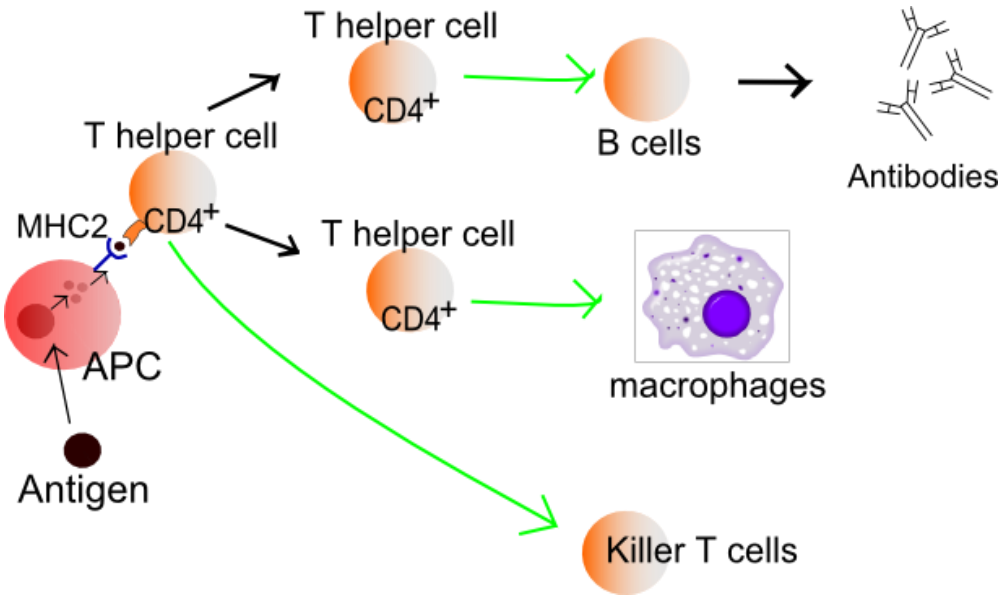
Both B cells and T cells carry receptor molecules that recognize specific targets. T cells recognize a "non-self" target, such as a pathogen, only after antigens (small fragments of the pathogen) have been processed and presented in combination with a "self" receptor called a major histocompatibility complex (MHC) molecule.

There are two major subtypes of T cells: the killer T cell and the helper T cell. In addition there are suppressor T cells which have a role in modulating immune response. Killer T cells only recognize antigens coupled to Class I MHC molecules, while helper T cells only recognize antigens coupled to Class II MHC molecules. These two mechanisms of antigen presentation reflect the different roles of the two types of T cell. A third, minor subtype are the γ δ T cells that recognize intact antigens that are not bound to MHC receptors.

In contrast, the B cell antigen-specific receptor is an antibody molecule on the B cell surface, and recognizes whole pathogens without any need for antigen processing. Each lineage of B cell expresses a different antibody, so the complete set of B cell antigen receptors represent all the antibodies that the body can manufacture.

Helper T cells regulate both the innate and adaptive immune responses and help determine which immune responses the body makes to a particular pathogen. These cells have no

cytotoxic activity and do not kill infected cells or clear pathogens directly. They instead control the immune response by directing other cells to perform these tasks.



Function of T helper cells: Antigen-presenting cells (APCs) present antigen on their Class II MHC molecules (MHC2). Helper T cells recognize these, with the help of their expression of CD4 co-receptor (CD4+). The activation of a resting helper T cell causes it to release cytokines and other stimulatory signals (green arrows) that stimulate the activity of macrophages, killer T cells and B cells, the latter producing antibodies. The stimulation of B cells and macrophages succeeds a proliferation of T helper cells.

❖ Components of the Immune System

The major components of the immune system are:

- Thymus
- Spleen
- Lymph system
- White blood cells
- Antibodies
- Complement system and Hormones

▪ Thymus

The thymus is located in your chest, between your breast bone and your heart. It is responsible for producing T-cells and is important for T cell maturation.

- **Spleen**

The spleen filters the blood looking for foreign cells. The spleen is also looking for old red blood cells that need replacement. It is an organ about the size of a fist in the upper left of the abdomen. The spleen contains two main types of tissue: red tissue that disposes of worn-out blood cells, and white tissue that contains lymphoid tissue. Different part of the the spleen specialize in different kinds of immune cells. When microorganisms get carried by the blood into the red tissue, they become trapped by the immune cells known as macrophages.

Interferon

Interferon is another type of protein produced by most cells in the body. One job of interferon is to let cells signal one another. When a cell detects interferon from other cells, it produces proteins that help prevent viral replication in the cell and also stimulates killer cells.

Interferon is the main anti-viral defense of the body. In fact Interferon was named that because it was the first compound scientists identified that "Interfered" with the virus' ability to attach to cells and cause disease. An increase in the body's production of Interferon means an increase in the body's natural defense against any viral infection.

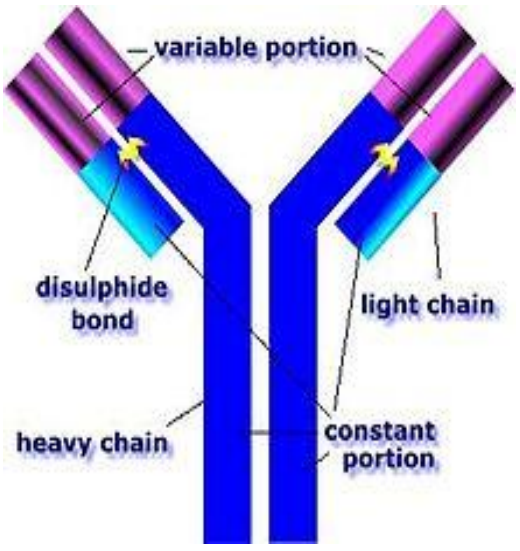
- **Antibodies**

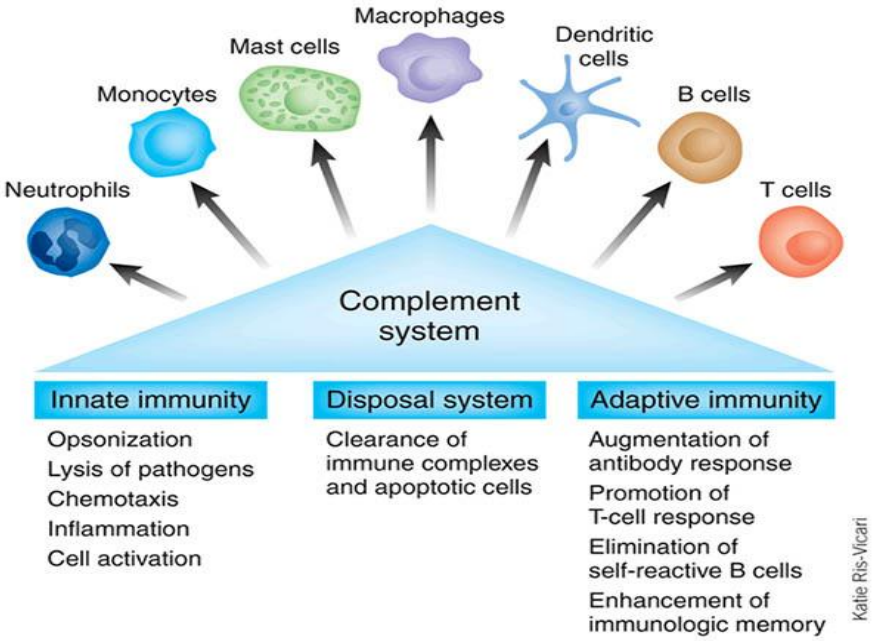
Antibodies (also referred to as immunoglobulins and gammaglobulins) are are Y-shaped proteins that respond to specific bacteria, viruses or toxins, called antigens. They are produced by white blood cells.

Antibodies can bind to toxins, disabling their chemical actions or signal that an invader needs to be removed.

These antibodies are divided into five classes. Their names are generally abbreviated. For instance, Immunoglobulin A is abbreviated IgA. Here are all of the abbreviations: IgA, IgD, IgE, IgG, i IgM.

An antibody is made up of two heavy chains and two light chains The unique variable region allows an antibody to recognize its matching antigen.



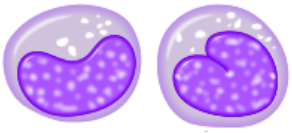


- **White blood cells**

White blood cells are a very important part of your immune system. They are actually a large collection of different cells that work together to destroy bacteria and viruses . Here are the different types, names and classifications of white blood cells

- **Neutrophils**

Neutrophils are the most abundant white blood cells, ranging between 2,000 and 7,500 per cubic mm of blood. About 55 to 75 percent of the total WBC count in the blood is made up of neutrophils. They play a crucial role in fighting infection. They have a "C" shaped, segmented nucleus . Neutrophils have a tendency to stick to the blood vessel walls and block any germs that attempt to enter the bloodstream through an infection or a wound. Mature neutrophils have a half-life of about 2 to 3 days.



- **Monocytes**

Monocytes are the biggest in size among the five types of white blood cells. Their numbers in blood fall between 200 and 800 per cubic mm of blood, accounting for about 5 to 8 percent of the total WBC count. Monocytes perform the role of tissue macrophages that eliminate foreign particles and act against the multiplication of germs that cannot be successfully combated by the neutrophils.

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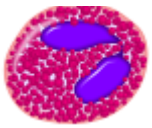
- **Lymphocytes (T cells and B cells)**

Lymphocytes produce antibodies as a part of the immune system response. The antibodies are secreted into the blood plasma to act against harmful bacteria and toxins. The antibodies induce the germs to join together in clusters, enabling the phagocytes to consume them. The limitation of lymphocytes is that they are able to identify only certain

specific antigens in the bloodstream. The number of lymphocytes ranges between 1,300 and 4,000 per cubic mm of blood, which makes them the second most largely present cells after the neutrophils.



- **Eosinophils**

Eosinophils range between 40 and 400 per cubic mm of blood, forming about 2 to 5 percent of the total blood count. The key function of eosinophils is to act against parasites and any antigen complex present in the bloodstream. These cells are also known to be the cause of many types of allergic responses within the blood

- **Basophils**

As per the Department of Immunology, functions of basophils are poorly understood. They are the least numbered white blood cells, ranging between 0 and 100 per cubic mm of blood, and constitute less than 1 percent of the total white blood count. Basophils secrete antibodies and anticoagulants. This limits any hypersensitive reactions within the blood. Basophils are commonly associated with immediate immune reaction against foreign particles in the bloodstream

- **Mast cells**

Is derived from the myeloid stem cell and a part of the immune system that contains many granules rich in histamine and heparin. . Although best known for their role in allergy and anaphylaxis, mast cells play an important protective role as well, being intimately involved in wound healing and defense against pathogens.

The mast cell is very similar in both appearance and function to the basophil, another type of white blood cell. They differ in that mast cells are tissue resident, e.g., in mucosal tissues, while basophils are found in the blood.

- **Dendritic cells**

Dendritic cells are present in the skin (as Langerhans cells), lymph nodes, and tissues throughout the body. Dendritic cells in the skin act as sentinel APCs, taking up Ag, then traveling to local lymph nodes where they can activate T cells. Their main function is to They act as messengers between the innate and the adaptive immune systems