

# The Immune System and its response to antigens.

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BIO 495



# What is the Immune System?

I. To understand how the Immune System works you must first consider **blood**. **Blood** is a system of circulating cells and fluids that transport nutrients and oxygen to tissues, eliminate waste products and carbon dioxide from tissues, wound repair, and protects us from infection by foreign agents.

A. Components:

-**Plasma**- the yellowish cell free fluid portion of the blood that is composed of water, proteins and salt. Plasma carries the red blood cells through the body.

-**Immune system**-cells and substances of the blood that are responsible for protection from infection.

The Immune system protects us from:

- |             |             |                             |
|-------------|-------------|-----------------------------|
| 1) viruses  | 3) protozoa | 5) multi-cellular parasites |
| 2) bacteria | 4) fungi    | 6) cancer                   |

B. Transport:

- Blood is carried through the body by 3 types of vessels that compose the circulatory system:

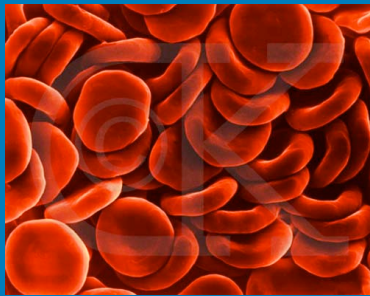
- 1) **Arteries**
- 2) **Veins**
- 3) **Capillaries**

# Cells of the Blood.

- Blood is composed of red blood cells and white blood cells.
- Red blood cells or **erythrocytes** carry oxygen to the tissues and carbon dioxide away from them
  - Erythrocytes contain a protein, *hemoglobin*, which binds to O<sub>2</sub> and CO<sub>2</sub> and carries them within itself.
  - Hemoglobin also gives red blood cells their color.
- White blood cells or **leukocytes** are divided into several types:
  1. **Megakaryocytes** are large blood cells that have budding sub-cellular fragments known as platelets which control bleeding by forming clusters to plug holes and clot formation.
  2. The cells of the **Immune System** are composed of 2 groups:
    - a. Cells that respond to a specific foreign agent or substance: **lymphocytes**
    - b. Cells that are NOT specific for the foreign agent or substance that they attack: **phagocytes, macrophages, mast cells, basophils, eosinophils and natural killer cells**
      - **Phagocytes** attack and eliminate foreign cells by engulfing or eating them. There are two types of phagocytes:
        1. **Macrophages**
        2. **Neutrophils**
      - **Mast cells, basophils, and eosinophils** attack infectious agents that are too big to be engulfed by 1 blood cell, such as protozoa, or large parasites such as worms.

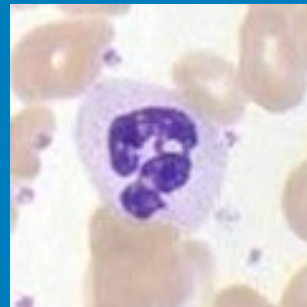
# Cells of the Blood.

## Red Blood cells



Erythrocyte

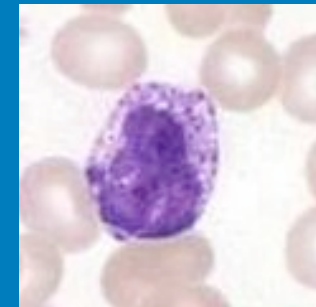
## Cells of the immune system



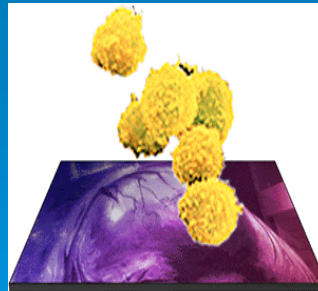
Neutrophil



Eosinophil



Basophil



White blood cell

# Cells of the Blood: Lymphocytes

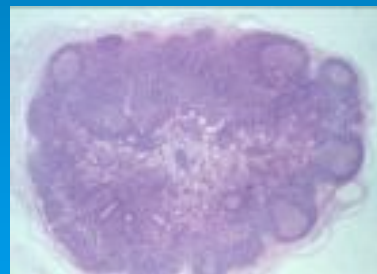
**Lymphocytes** respond specifically to particular foreign substances or antigens. Antigens are molecules/substances that are responded against such as a protein of a virus.

There are two types of Lymphocytes:

1. **B-lymphocytes** (B-cells) secrete antibodies into the circulatory system, that specifically recognize and bind to a particular agent. Once specific antibodies directly bind to and inhibit the function of foreign substances such as viruses, they are called neutralizing antibodies. B-lymphocytes are divided into two categories:

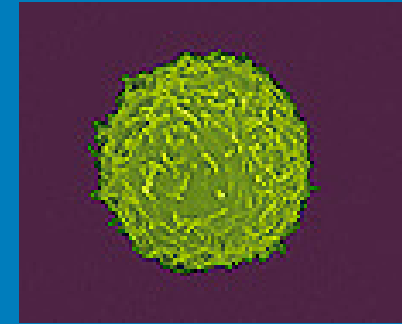
a. **Plasma cells**-produce antibodies

b. **Memory B-cells**- contain a record of specific antibody production so that if an antibody is needed again it can be made more quickly.



B-Lymphocyte

# Cells of the Blood: T-Lymphocytes



2. **T-lymphocytes** (T-cells) make proteins called receptors which are similar to antibodies in their ability to recognize antigens. Unlike antibodies which are released to bind to antigens, receptors are held on the surface of T-cells. There are 4 types of T-lymphocytes:
- a. **Suppressor T-cells**
  - b. **Killer T-cells**
  - c. **Helper T-cells**
  - d. **Memory T-cells**

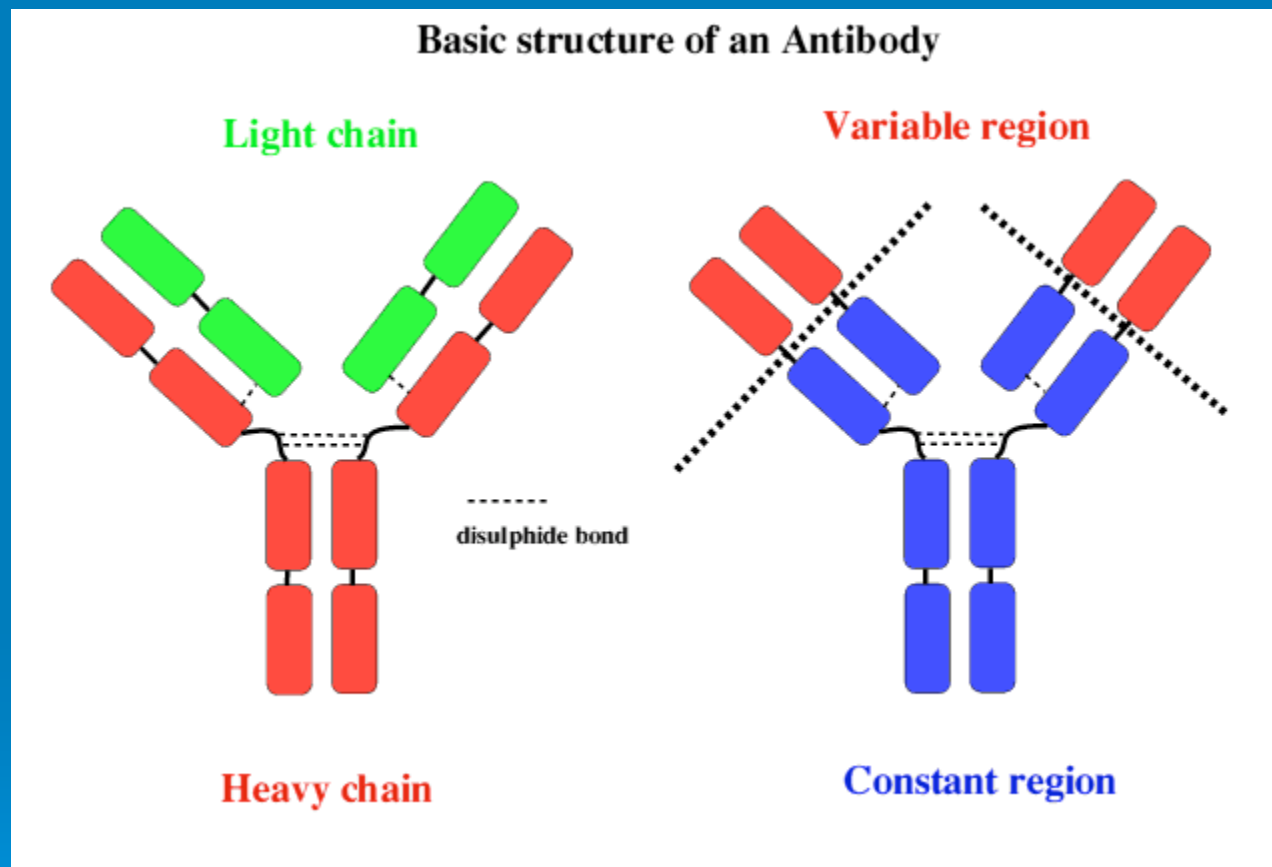
# The Immune Response

A. In order to protect us from disease our immune systems must have the ability to respond to new antigens by making new antibodies to recognize them. Because we may encounter an endless amount of antigens in our life times, it is impossible for our immune systems to produce all possible antibodies in anticipation of all of these antigens. To solve this problem the immune system employs two processes: generation of antibody gene diversity by DNA rearrangement, and clonal selection.

## 1. Generation of antibody gene diversity by DNA rearrangement:

- Our DNA contains the genetic information for antibody proteins.
- Mature B-lymphocytes can produce only one kind of antibody. For this reason, each B-lymphocytes makes 1 kind of heavy chain protein and one kind of light chain protein, which are held together by a chemical bonding on a Y-shaped molecule.
- Heavy chain proteins and light chain proteins have regions that are very similar for the different antibodies= **constant regions** (c-regions)
- Regions that are different on the light and heavy chain proteins in terms of the amino acid building-block sequence = **variable regions** (v-regions) . The protein sequences in these variable regions determine which antigen the antibody binds to.

# Heavy Chain and Light Chain proteins:



# The Immune Response.

- In **heavy chains**, the variable region is expressed from 3 sets of genes : approx. 200 V-genes, 50 D-genes, and 10 J-genes. As B-lymphocytes mature the DNA chromosomes surrounding the antibody genes is rearranged. The expression of this VDJ combination and constant region gives us a heavy chain protein.
- **Light chain proteins** result from similar DNA rearrangements but the variable region is specified by only V-genes and J-genes.
- Each B-lymphocyte has one heavy chain and one light chain protein making the number of possible antibodies, the product of possible heavy chains times the number of possible light chains.
- Maturation of B-lymphocytes can include changes or additions of individual DNA bases in the genes for variable regions. These changes alter the amino acid sequence for variable regions of both heavy and light chain proteins, increasing the number of different variable regions on antibody proteins.

# The Immune Response.

2. Clonal Selection: The second way that our immune systems create as many possible antibodies is through clonal selection.

- In a person who is uninfected, several different B-lymphocytes rearrange their antibody genes and mature. These B-lymphocytes do NOT secrete antibodies and do NOT divide, but they do express specific antibodies on their outer surfaces. When a B-lymphocyte recognizes an antigen that binds to its specific antibody, it receives a signal for activation: those that do have not bound an antigen do not receive a signal. If a second signal is received the B-lymphocyte becomes fully active
- Upon full activation, the B-lymphocyte divides to create more activated B-lymphocytes that make the same antibody and they secrete the specific antibody into an extra-cellular space such as the blood. This occurrence allows for the production of large amounts of antibody that are specific for the antigen.

## References:

- Conner, Ross F. Fan, Hung Y. Villareal, Luis P. AIDS Science and society 4<sup>th</sup> ed. "The Immune System". Jones and Bartlett (Publishers, Inc. 2004) pg 15-29
- [www.bloodcenter.org](http://www.bloodcenter.org) (7-25-05) accessed on 2-21-06
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