

White Blood Cells (WBCs) or Leukocytes

Although **leukocytes** are far less numerous than red blood cells, they are important to body defense against disease. On average, there are 4000 to 11.000 WBCs/mm³, and they account for less than 1 percent of total blood volume. White blood cells are the only complete cells in blood; that is; they contain nuclei and the usual organelles.

Leukocytes form a protective, movable army that helps defend the body against damage by bacteria, viruses, parasites, and tumor cells. As such they have some very special characteristics. Red blood cells are confined to the bloodstream and functions in the blood. White blood cells, by contrast, are able to slip into and out of the blood vessels (by process called *diapedesis*). The circulatory system is simply their means of transportation to areas of the body where their services are needed for inflammatory or immune responses.

In addition, WBCs can locate areas of tissue damage and infection in the body by responding to certain chemicals that diffuse from the damaged cells. This capability is called *positive chemotaxis*. Once they have "caught the scent," the WBCs move through the tissue spaces by *ameboid motion* (forming of cytoplasmic extensions that help move along). By following the diffusion gradient, they pinpoint areas of tissue damage and rally round in large numbers to destroy microorganisms or dead cells.

Whenever WBCs mobilize for action, the body speeds up their production, and as many as twice the normal number of WBCs may appear in the blood within a few hours.

Types of WBCs:

WBCs are classified into two major groups, depending on whether or not they contain visible granules in their cytoplasm. Microscopic views can be seen in Figure (10).

Granulocytes are granule-containing WBCs. They have lobed nuclei, which typically consist of several rounded nuclear areas connected by thin strands of nuclear material. The granules in their cytoplasm stain specifically with Wright's stain. The granulocytes include the neutrophils, eosinophils and basophils.

1. Neutrophils have a multilobed nucleus (3-5lobes) and very fine

granules that respond to both acid and basic stains. Consequently, the cytoplasm as a whole stains pink. Neutrophils are avid phagocytes at sites of acute infection.

- 2. Eosinophils** have a bilobed blue-red nucleus that resembles an old-fashioned telephone receiver and large red cytoplasmic granules. Their number increases rapidly during allergies and infections by parasitic worms (flat-worms, tapeworms, etc.).
- 3. Basophils**, the rarest of the WBCs, have S shaped nucleus contain large histamine-containing granules that stain dark blue. **Histamine** is an inflammatory chemical that makes blood vessels leaky and attracts other WBCs to the inflammatory site.

Agranulocytes lack visible cytoplasmic granules. Their nuclei are spherical oval or kidney-shaped. The agranulocytes include lymphocytes and monocytes

- 1. Lymphocytes** have a large dark purple nucleus that occupies most of the cell volume. Only slightly larger than RBCs, lymphocytes reside in lymphatic tissues, where they play an important role in the immune response.

There are two types of lymphocytes:

- * T lymphocytes: provide cell mediated immunity.
- * B lymphocytes: provide humoral immunity.

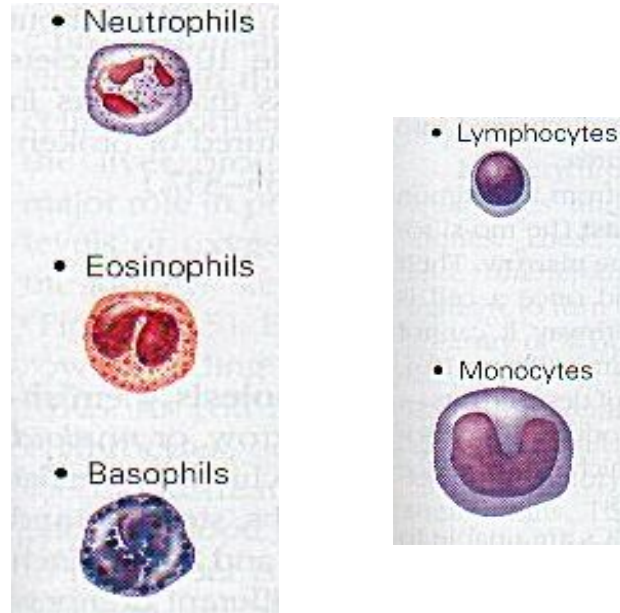
- 2. Monocytes** are the largest of the WBCs. Except for their more abundant cytoplasm and indented (kidney like) nucleus, they resemble large lymphocytes. When they migrate into the tissues, they change into macrophages. Macrophages are very important in fighting chronic infections, such as tuberculosis.

The granulocytes and the monocytes protect the body against invading organisms by ingesting them by the process of *phagocytosis*. The lymphocytes function mainly in connection with the immune system. However, a function of certain lymphocytes is to attach themselves to specific invading organisms and destroy them, an action similar to those of the granulocytes and monocytes.

Concentrations of the Different White Blood Cells in the Blood:

The adult human being has approximately 11000 WBCs/mm³ of blood. The normal percentages of the different types of white blood cells are approximately the following:

Neutrophils	62.0%
Eosinophils	2.3%
Basophils	0.4%
Monocytes	5.3%
Lymphocytes	30.3%



Granulocytes
Fig. (10): Types of WBCs

A granulocytes

Genesis of the Leukocytes

Aside from those cells committed to the formation of red blood cells, two major lineages of *white blood cells* are also formed, the myelocytic and the lymphocytic lineages. The *lymphocytic lineage* beginning with the *lymphoblast*; that produce lymphocytes, and the *myelocytic lineage* beginning with the *myeloblast*; which produce other WBCs.

The granulocytes and monocytes are formed only in the bone marrow. Lymphocytes are produced mainly in the various lymphogenous organs, including the lymph glands, the spleen, the thymus, the tonsils, and various lymphoid rests in the bone marrow, gut, and elsewhere.

Like erythrocyte production, the formation of leukocytes and platelets is stimulated by hormones. These *colony stimulating factors (CSFs)* and *interleukins* not only prompt red bone marrow to turn out leukocytes, but enhancing the ability of mature leukocytes to protect the body. Apparently, they are released in response to specific chemical signals in the environment such as inflammatory chemicals and certain bacteria or their toxins.

The white blood cells formed in the bone marrow, especially the granulocytes, are stored within the marrow until they are needed in the circulatory system.

Normally, about three times as many granulocytes are stored in the marrow as circulate in the entire blood.

Life Span of the White Blood Cells

The life of the granulocytes once released from the bone marrow is normally 4 to 8 hours circulating in the blood and another 4 to 5 days in the tissues. In times of serious tissue infection, this total life span is often shortened to only a few hours because the granulocytes then proceed rapidly to the infected area, perform their functions, and in the process are themselves destroyed.

The monocytes also have a short transit time, 10 to 20 hours, in the blood before wandering through the capillary membranes into the tissues. However, once in the tissues they swell to much larger sizes to become tissue *macrophages* and in this form can live for months or even years unless destroyed by performing phagocytic function. These tissue macrophages form the basis of the tissue macrophage system that provides a continuing defense in the tissues against infection.

Lymphocytes enter the circulatory system continually along with the drainage of lymph from the lymph nodes. Then, after a few hours, they pass back into the tissues by diapedesis, then re-enter the lymph and return to the blood again and again; thus, there is continual circulation of the lymphocytes through the tissues. The lymphocytes have life spans of months or even years, but this depends on the body's need for these cells.

Leukocytosis and Leukopenia

A total WBC count above 11,000 cells/mm³ is referred to as **leukocytosis**. Leukocytosis generally indicates that a bacterial or viral infection is stewing in the body.

The opposite condition, **leukopenia**, is an abnormally low WBC count. It is commonly caused by certain drugs, such as corticosteroids and anticancer agents.

Leukemia

Leukocytosis is a normal and desirable response to infectious threats to the body. By contrast, the excessive production of abnormal WBCs that occurs in infectious mononucleosis and leukemia is distinctly pathological. In leukemia, the bone marrow becomes cancerous, and huge numbers of WBCs are turned out rapidly. Although this might not appear to present a problem, the "newborn" WBCs or leukemic cells,

especially the very undifferentiated cells, are usually nonfunctional, so that they cannot provide the usual protection against infection associated with white blood cells.