Lecture Notes

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PHYSIOLOGY

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019

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Leukocytes/White Blood Cells (WBCs)

WBCs count ranges between 4000 and 11000

- Leukopenia: low WBCs count, below 3000 but it depends on the normal WBCs count in each person
- Leukocytosis: high WBCs count

There is no difference between males and females in the number of the WBCs, but even in the same person the count changes from time to time, e.g.:

- WBCs count is high in the evening and low in the morning.
- WBCs count increases after exercises, meals and during pregnancy

WBCs count is less than that of RBCs as well as their half-lives; their lives range from hours to days and months (such as monocytes)

WBCs are larger than RBCs, they have a nucleus and can move easily through blood vessels and they leave blood vessels into the tissues

Types of leukocytes:

1. Granular leukocytes: neutrophils, eosinophils, and basophils
2. Agranular (non-granular) leukocytes: lymphocytes and monocytes

All WBCs have enzymes to kill foreign bodies. Basophils have extra chemicals such as: Heparin, Histamine and Serotonin.

TABLE 19.3

Summary of Formed Elements in Blood

NAME AND APPEARANCE	NUMBER	CHARACTERISTICS*	FUNCTIONS
RED BLOOD CELLS (RBCS) OR ERYTHROCYTES 	4.8 million/μL in females; 5.4 million/μL in males.	7–8 μm diameter, biconcave discs, without nuclei; live for about 120 days.	Hemoglobin within RBCs transports most oxygen and part of carbon dioxide in blood.
WHITE BLOOD CELLS (WBCS) OR LEUKOCYTES	5000–10,000/μL.	Most live for a few hours to a few days.†	Combat pathogens and other foreign substances that enter body.
Granular leukocytes			
Neutrophils 	60–70% of all WBCs.	10–12 μm diameter; nucleus has 2–5 lobes connected by thin strands of chromatin; cytoplasm has very fine, pale lilac granules.	Phagocytosis. Destruction of bacteria with lysozyme, defensins, and strong oxidants, such as superoxide anion, hydrogen peroxide, and hypochlorite anion.
Eosinophils 	2–4% of all WBCs.	10–12 μm diameter; nucleus usually has 2 lobes connected by thick strand of chromatin; large, red-orange granules fill cytoplasm.	Combat effects of histamine in allergic reactions, phagocytize antigen–antibody complexes, and destroy certain parasitic worms.
Basophils 	0.5–1% of all WBCs.	8–10 μm diameter; nucleus has 2 lobes; large cytoplasmic granules appear deep blue-purple.	Liberate heparin, histamine, and serotonin in allergic reactions that intensify overall inflammatory response.
Agranular leukocytes			
Lymphocytes (T cells, B cells, and natural killer cells) 	20–25% of all WBCs.	Small lymphocytes are 6–9 μm in diameter; large lymphocytes are 10–14 μm in diameter; nucleus is round or slightly indented; cytoplasm forms rim around nucleus that looks sky blue; the larger the cell, the more cytoplasm is visible.	Mediate immune responses, including antigen–antibody reactions. B cells develop into plasma cells, which secrete antibodies. T cells attack invading viruses, cancer cells, and transplanted tissue cells. Natural killer cells attack wide variety of infectious microbes and certain spontaneously arising tumor cells.
Monocytes 	3–8% of all WBCs.	12–20 μm diameter; nucleus is kidney- or horseshoe-shaped; cytoplasm is blue-gray and appears foamy.	Phagocytosis (after transforming into fixed or wandering macrophages).
PLATELETS 	150,000–400,000/μL.	2–4 μm diameter cell fragments that live for 5–9 days; contain many vesicles but no nucleus.	Form platelet plug in hemostasis; release chemicals that promote vascular spasm and blood clotting.

*Colors are those seen when using Wright's stain.
†Some lymphocytes, called T and B memory cells, can live for many years once they are established.

The leukocytes count (4000-11000) in blood is only 50% of the total number of leukocytes in the body (50% of WBCs are in the circulation). The rest of the WBCs (50%) adhere to the inner surfaces of the blood vessels. These adhering leukocytes are called the marginal WBCs pool and these cells are released in conditions like hemorrhage or hemolysis of WBCs

TABLE 32–1 Normal values for the cellular elements in human blood.

Cell	Cells/μL (average)	Approximate Normal Range	Percentage of Total White Cells
Total white blood cells	9000	4000–11,000	...
Granulocytes			
Neutrophils	5400	3000–6000	50–70
Eosinophils	275	150–300	1–4
Basophils	35	0–100	0.4
Lymphocytes	2750	1500–4000	20–40
Monocytes	540	300–600	2–8

60% 0f WBCs are neutrophiles

About 4% eosinophils

About 1% basophils

30% lymphocytes

5% monocytes

The duration of erythropoiesis (the production of RBCs) is about 6 days. Also, the duration of the production of the WBCs (leukopoiesis) is 6 days, but the produced WBCs remain in the bone marrow extra 6 days to mature and to be computerized to function when they are released into the circulation

All the WBCs are produced in the bone marrow, but lymphocytes have another extra source; they are produced in the lymphoid tissue. Therefore, when there is a problem in the bone marrow, all the other four types of the WBCs decrease dramatically while the lymphocytes they don't decrease as much as the other types of the WBCs.

Normally 75% of the bone marrow cells are WBC-producing myeloid series and only 25% are maturing red cells even though there are over 500 times as many red cells in the circulation as there are white cells. The difference in the marrow reflects the fact that the average life span of WBCs is short, whereas that of RBCs is long.

Leukopoiesis: the production of WBCs
It's the most complicated process in the body because:

- There are **many factors** involved in the process
- Each factor involved is produced by **many sources**
- There's an **overlap** in the action and effect of these factors; one factor affects more than one type of cells: G-CSF (granulocyte colony stimulating factor) affects the production of neutrophils and affects other cells
- There are **many stages** and steps (like in the production of RBCs). In each stage, **many** types of cells are produces

When the colony stimulating factors are added to a single stem cell in the lab, it produces many cells (these factors cause a single stem cell to proliferate forming colonies in culture medium). therefore, these factors are called **colony stimulating factors (CSFs)**

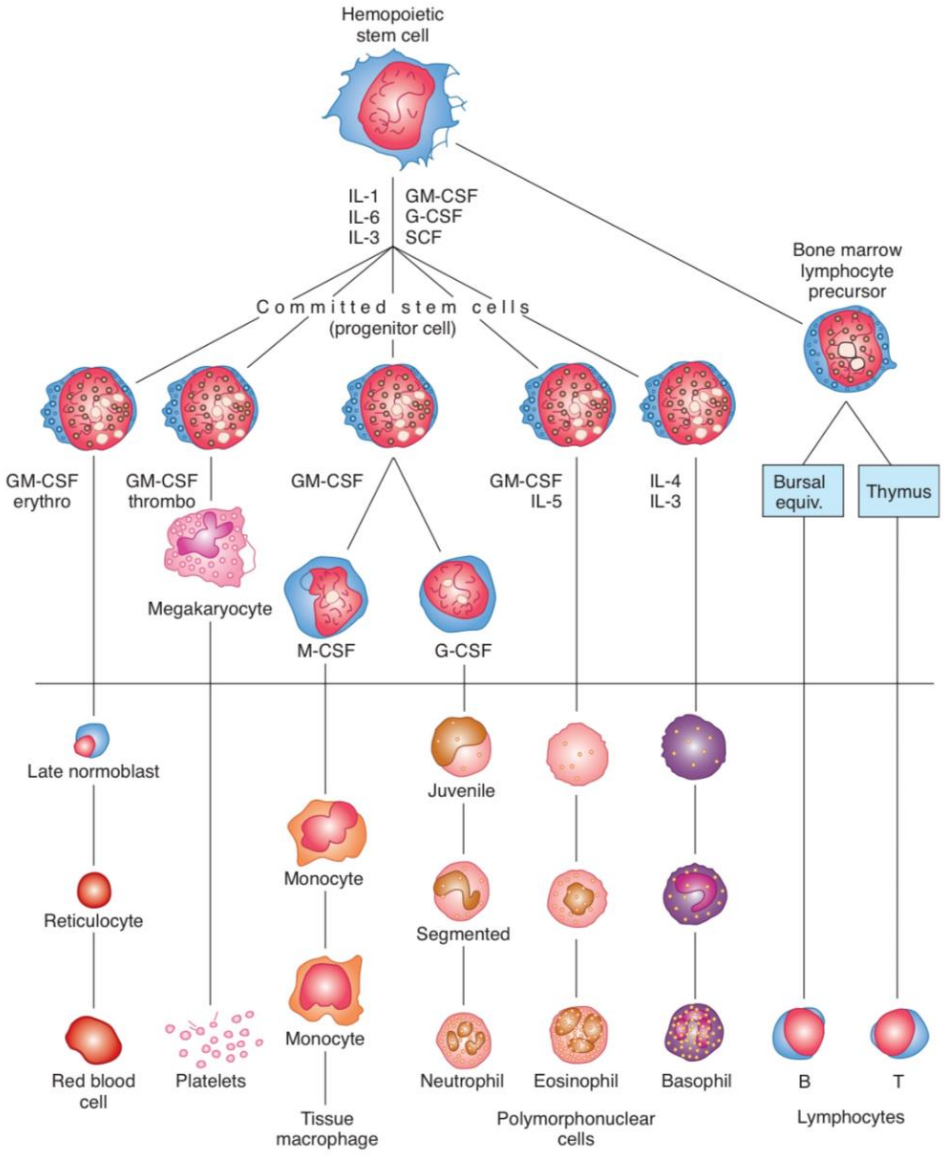

FIGURE 32–3 **Development of various formed elements of the blood from bone marrow cells.** Cells below the horizontal line are found in normal peripheral blood. The principal sites of action of erythropoietin (erythro) and the various colony-stimulating factors (CSF) that stimulate the differentiation of the components are indicated. G, granulocyte; M, macrophage; IL, interleukin; thrombo, thrombopoietin; SCF, stem cell factor.

Interleukins IL-1 and IL-6 followed by IL-3 act in sequence to convert pluripotential uncommitted stem cells to committed progenitor cells. The factors stimulating the production of committed stem cells include: GM-CSF, G-CSF & M-CSF

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