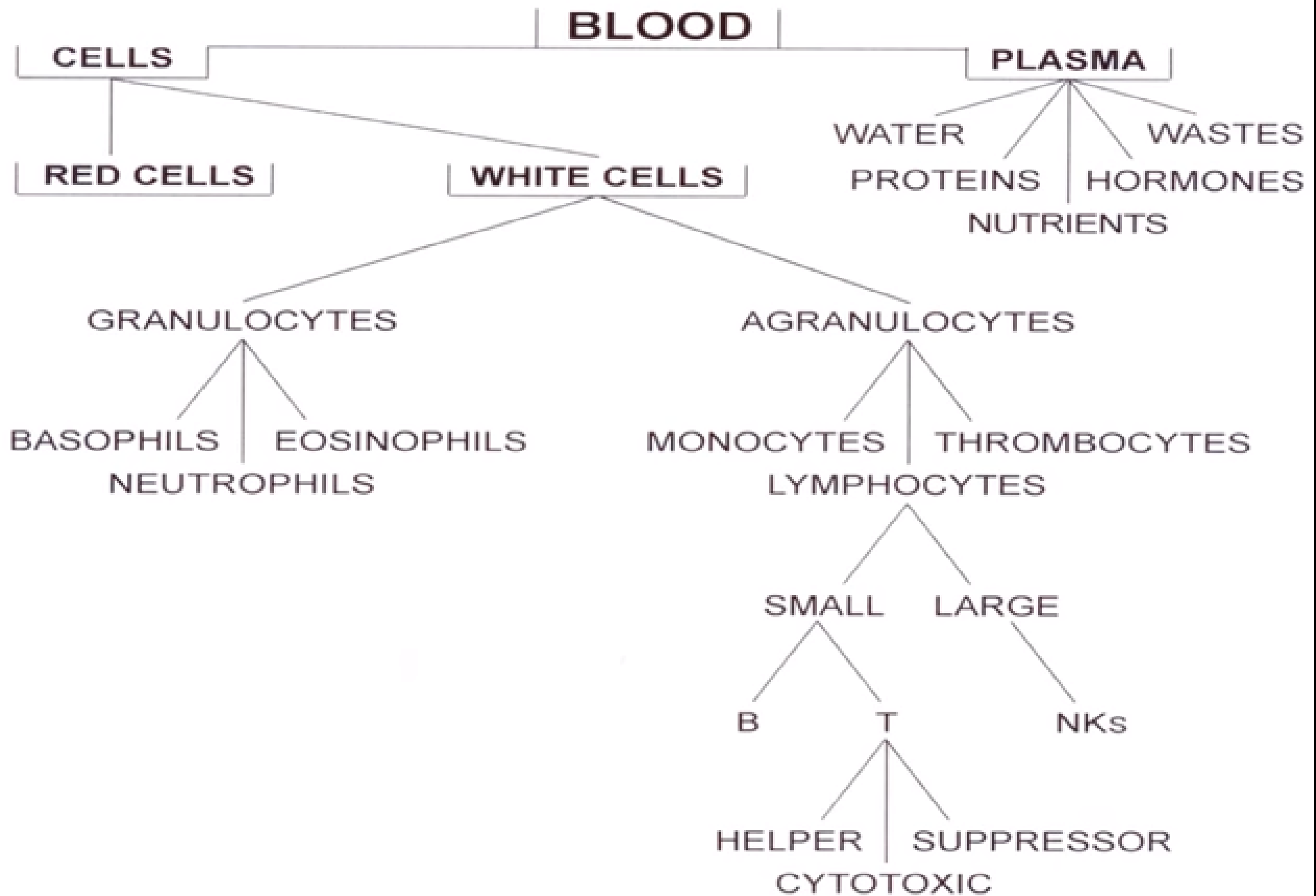


- **Blood is a specialized connective tissue in which cells are suspended in fluid extracellular material called plasma.** Propelled mainly by rhythmic contractions of the heart, about five liters of blood in an average adult moves unidirectionally within the closed circulatory system. The so-called formed elements circulating in the plasma are erythrocytes (red blood cells), leukocytes (white blood cells) and platelets. When blood leaves the circulatory system, either in a test tube or in the ECM surrounding blood vessels, plasma proteins react with one another to produce a clot, which includes formed elements and a yellowish liquid called serum. Serum contains growth factors and other proteins released from platelets during clot formation, which confer biological properties very different from those of plasma. Collected blood in which clotting is prevented by the addition of anticoagulants (eg, heparin, citrate) can be separated by centrifugation into layers that reflect its heterogeneity. Erythrocytes make up the bottom layer and their volume, normally about 45% of the total blood volume in healthy adults, is called the hematocrit.

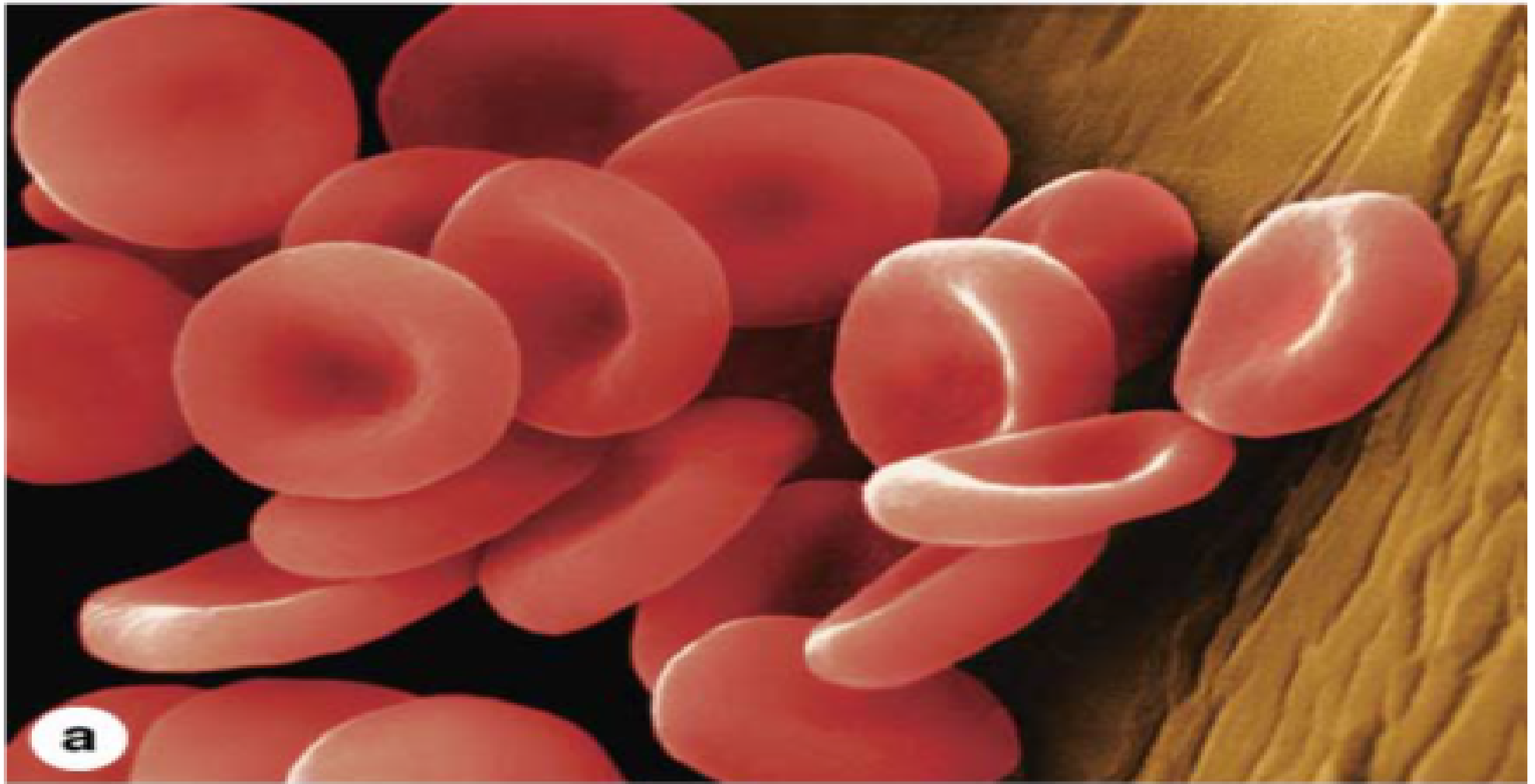


functions of blood

- Blood is a distributing vehicle, **transporting O₂ -CO₂, metabolites, hormones, and other substances to cells throughout the body.** O₂ is bound mainly to hemoglobin in erythrocytes, while CO₂ is carried in solution as CO₂ or HCO₃⁻, in addition to being hemoglobin bound. **Nutrients are distributed from their sites of synthesis or absorption in the gut** and metabolic residues are collected from all cells and removed from the blood by the excretory organs. **Hormone distribution** in blood permits the exchange of chemical messages between distant organs for normal cellular function. Blood further participates in heat distribution, the **regulation of body temperature, and the maintenance of acid-base and osmotic balance.**

Erythrocytes

- Erythrocytes are normally quite flexible, which permits them to adapt to the irregular bends and small diameters of capillaries. Observations in vivo show that when traversing the angles of capillary bifurcations, erythrocytes with normal adult hemoglobin (HbA) are easily deformed and frequently assume a cuplike shape. Erythrocyte cytoplasm is densely filled with hemoglobin, the tetrameric O₂-carrying protein that accounts for the cells' uniform acidophilia. When combined with O₂ or CO₂, hemoglobin forms oxyhemoglobin or carbaminohemoglobin, respectively. The reversibility of these combinations is the basis for the gas-transporting capability of hemoglobin



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leukocytes

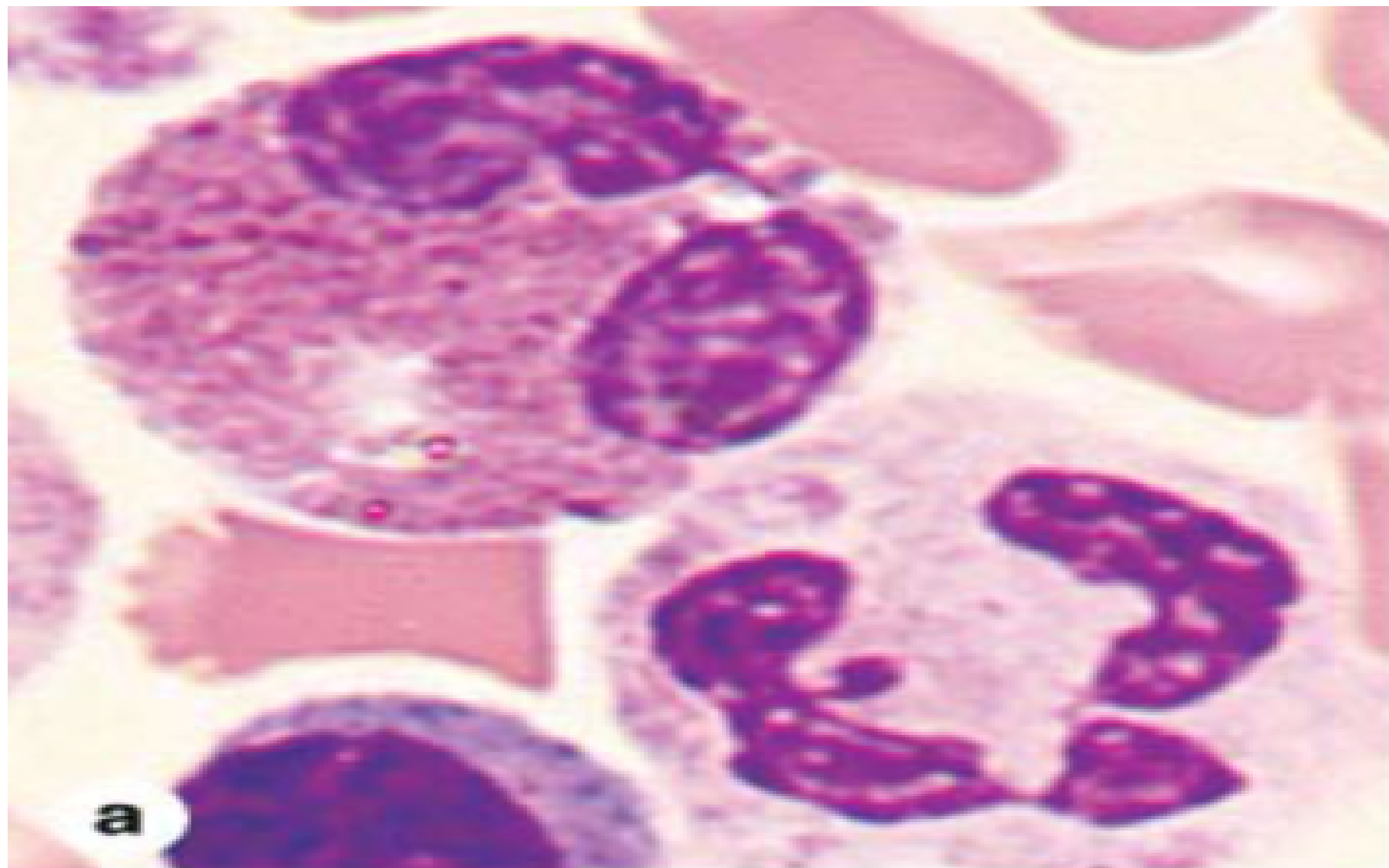
- Five types of human leukocytes. :Neutrophils, eosinophils, and basophils have granules that stain specifically with certain dyes and are called granulocytes. Lymphocytes and monocytes are considered agranulocytes, even though they may show azurophilic granules (lysosomes), which are also present in other leukocytes.

Eosinophils

- Eosinophils are far less numerous than neutrophils, constituting only 2–4% of leukocytes in normal blood. In blood smears, this cell is about the same size as a neutrophil, but with a characteristic bilobed nucleus . The main identifying characteristic is the abundance of large, red specific granules (about 200 per cell) that are stained by eosin.
- Ultrastructurally the eosinophilic specific granules are seen to be oval in shape, with many having a flattened crystalline core containing major basic protein, an arginine-rich factor accounting for the granule's intense acidophilia. This protein constitutes 50% of the total granule protein. ***The major basic protein, along with eosinophilic peroxidase, other enzymes and toxins, have cytotoxic effects on parasites such as helminthic worms and protozoa. Eosinophils also phagocytose antigen-antibody complexes and modulate inflammatory responses in many ways.*** They are an important source of the factors mediating allergic reactions and asthma.

Neutrophils

- Neutrophils constitute 60–70% of circulating leukocytes. They are 12–15 μ m in diameter in blood smears, with nuclei having two to five lobes linked by thin nuclear extensions. In females, the inactive X chromosome may appear as a drumstick-like appendage on one of the lobes of the nucleus although this characteristic is not obvious in every neutrophil. Neutrophils are inactive and spherical while circulating but become actively amoeboid during diapedesis and upon adhering to solid substrates such as collagen in the ECM.



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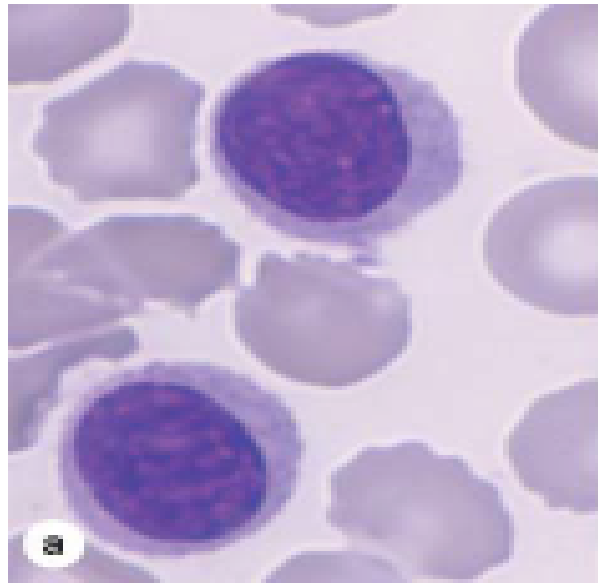
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Basophils

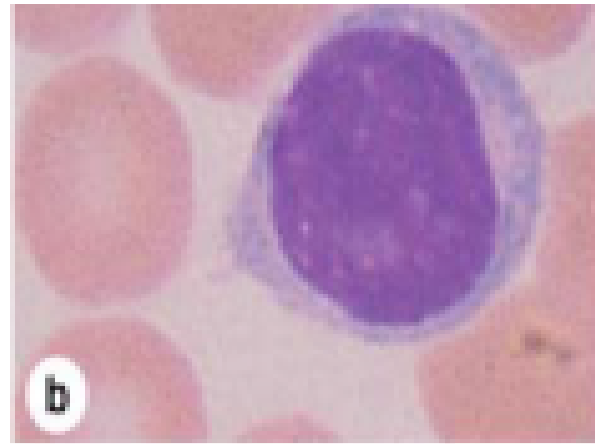
- Basophils are also about 12–15 μ m in diameter, but make up less than 1% of blood leukocytes and are therefore difficult to find in smears of normal blood. The nucleus is divided into two or more irregular lobes, but the large specific granules overlying the nucleus usually obscure its shape. The azurophilic specific granules (0.5 μ m in diameter) stain dark blue or metachromatically with the basic dye of blood smear stains and are fewer and more irregular in size and shape than the granules of the other granulocytes. The metachromasia is due to the presence of heparin and other sulfated glycosaminoglycans (GAGs) in the granules. Basophilic specific granules also contain much histamine and various mediators of inflammation, including platelet activating factor, eosinophil chemotactic factor, and phospholipase A which produces low molecular weight factors called leukotrienes. By migrating into connective tissues, basophils may supplement the functions of mast cells, with which they share a common progenitor cell origin. Both basophils and mast cells have metachromatic granules containing heparin and histamine, have IgE bound to surface receptors, and secrete their granular components in response to certain antigens.

Lymphocytes

- Lymphocytes constitute a family of leukocytes with spherical nuclei . They can be subdivided into functional groups according to distinctive surface molecules (markers) that can best be distinguished immunocytochemically, notably T lymphocytes, B lymphocytes, and natural killer (NK) cells. ***Lymphocytes have diverse functional roles related to immune defense against invading microorganisms, foreign or abnormal antigens, and cancer cells.*** Most lymphocytes in the blood are small with diameters of 6–8 μ m; medium and large lymphocytes range in size from 9 to 18 μ m in diameter. Some larger lymphocytes may be cells that have been activated by specific antigens. The small lymphocytes that predominate in the blood are characterized by spherical nuclei, sometimes indented, and condensed, very basophilic chromatin, making them easily distinguishable from granulocytes.

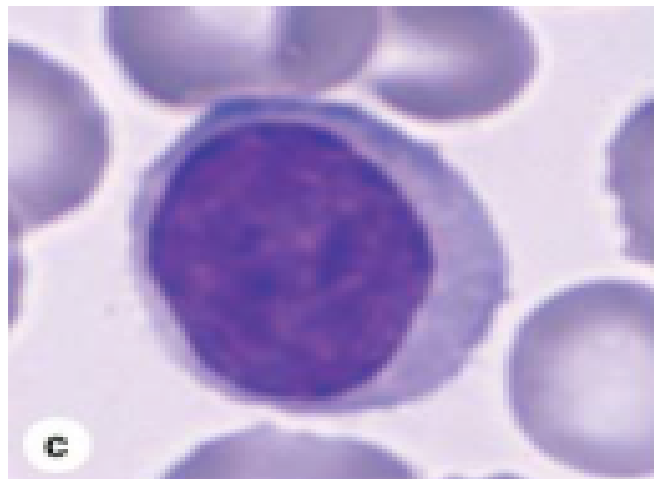


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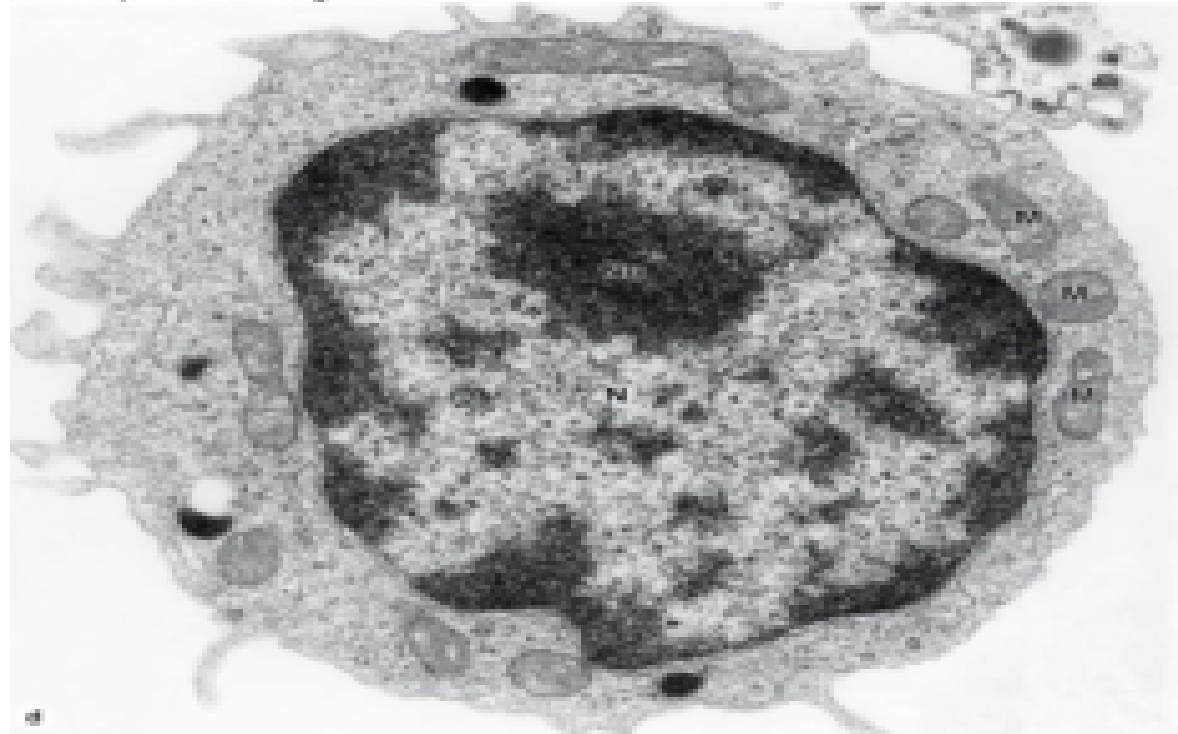
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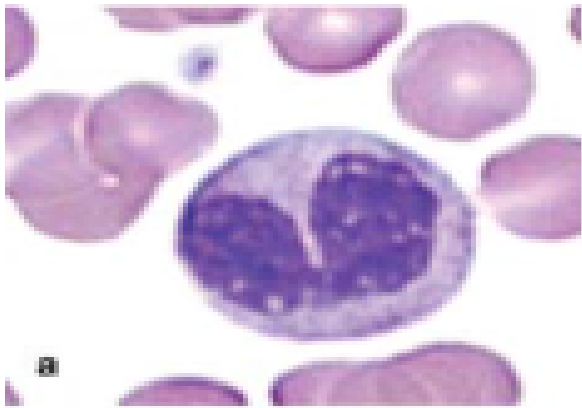
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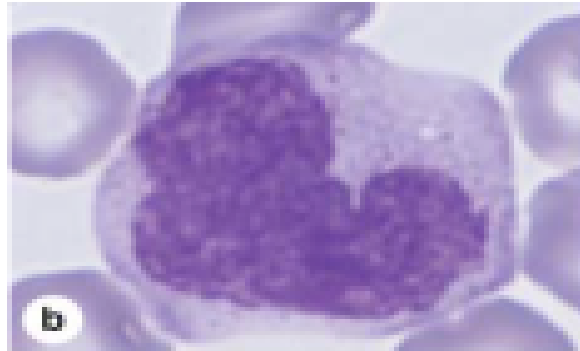
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Monocytes

- Monocytes are bone marrow–derived agranulocytes with diameters varying from 12 to 20 μm . The nucleus is large, off-center, and may be oval, kidney-shaped, or distinctly U-shaped. The chromatin is less condensed than in lymphocytes and stains lighter than that of large lymphocytes. The cytoplasm of the monocyte is basophilic and contains very small azurophilic granules (lysosomes), some of which are at the limit of the light microscope's resolution.



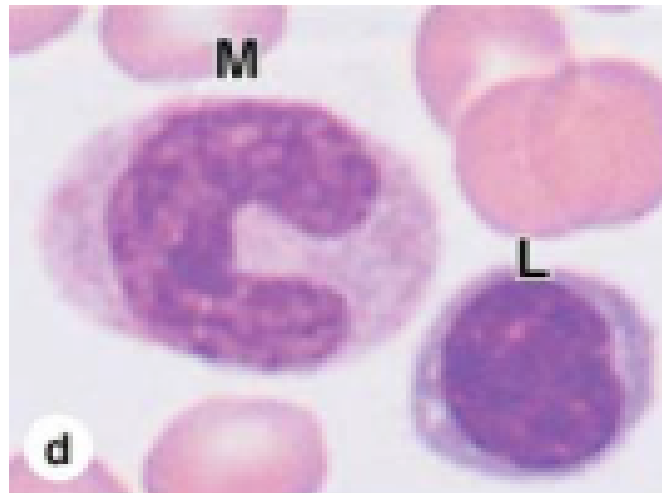
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