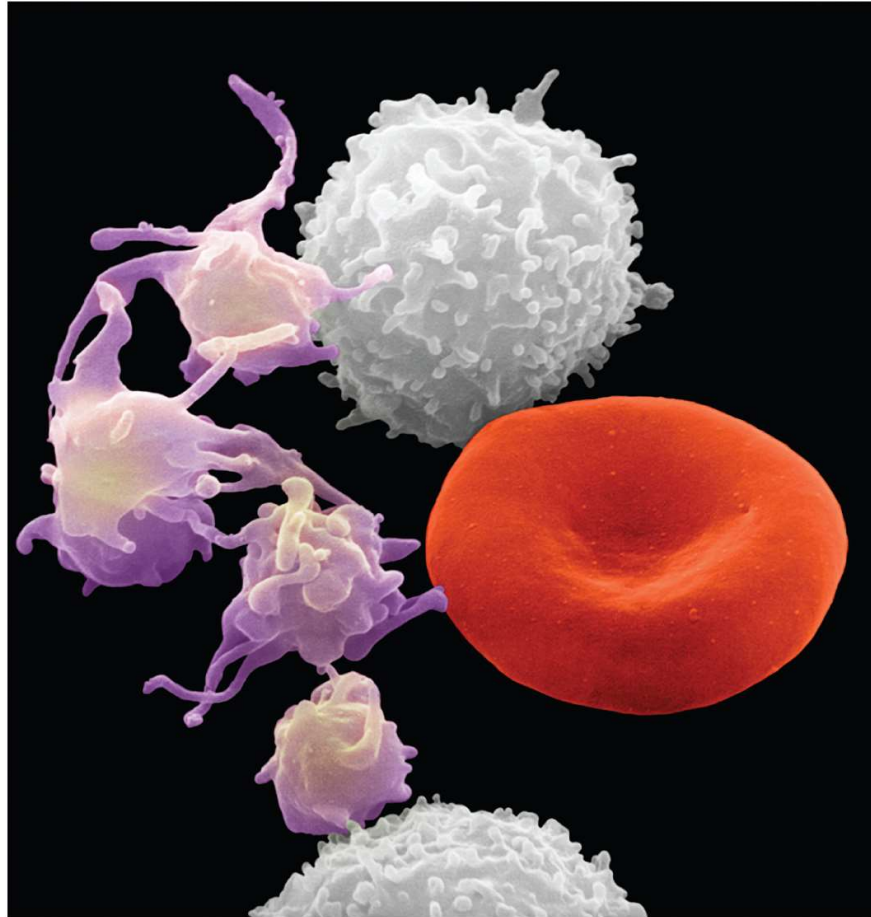


Chapter 19(1)

An Introduction to the Circulatory System and Blood



Circulatory System VS Cardiovascular System

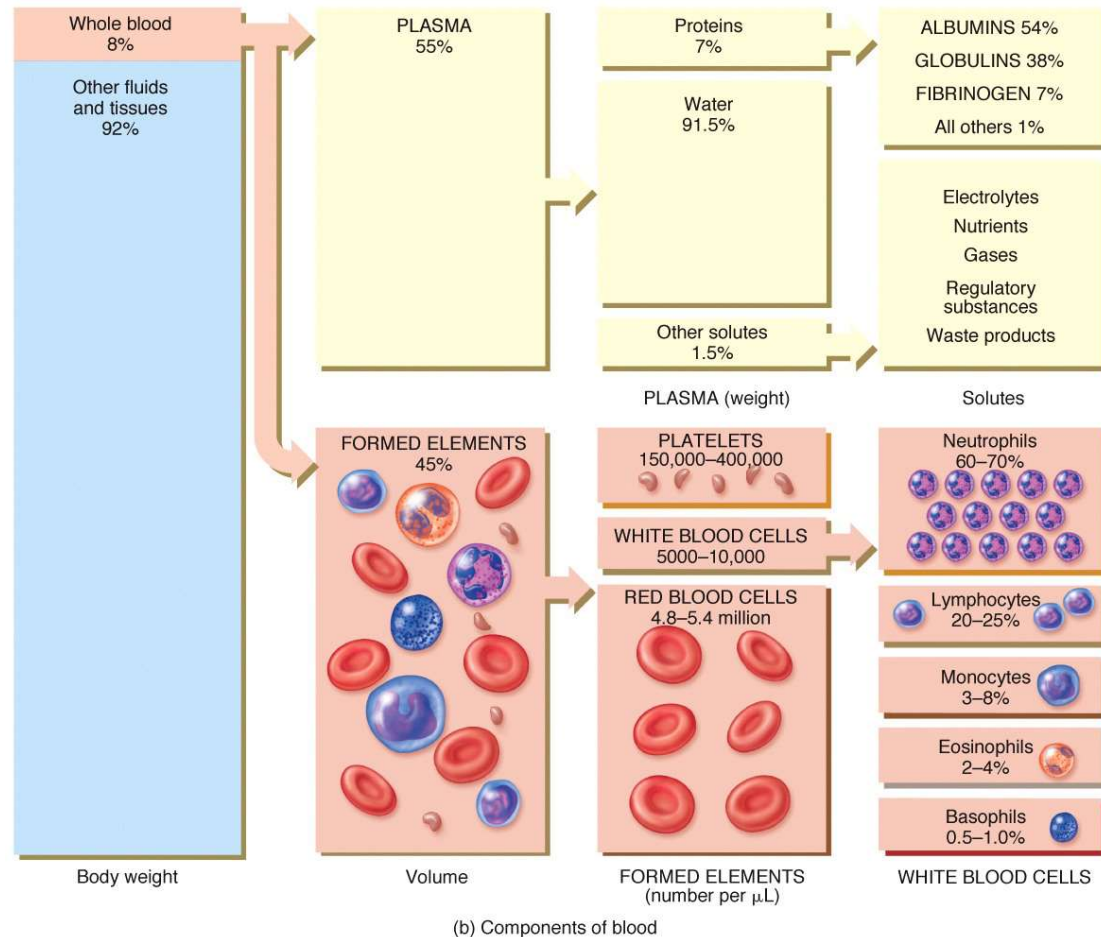
- **circulatory system** = heart, blood vessels and blood
- **cardiovascular system** = heart and blood vessels
- **hematology** = the study of blood

Functions of Circulatory System

- **Transport** // O₂, CO₂, nutrients, wastes, hormones, and stem cells
- **Protection** // inflammation, limit spread of infection, destroy microorganisms and cancer cells, neutralize toxins, and initiates clotting
- **Regulation** // fluid balance, stabilizes pH of ECF, and temperature control

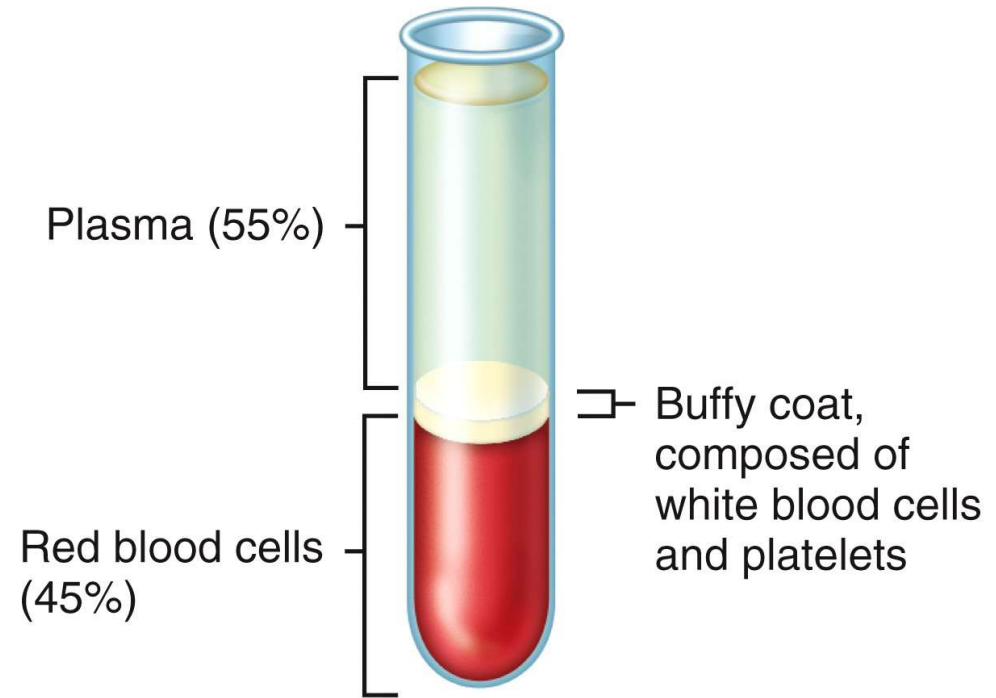
General Properties of Blood

- Blood volume = Adults 4-6 L
- **Test benchmark = 5L**
- Blood = connective tissue
- Connective tissue defined by
 - Cells = the formed elements // low volume
 - Matrix = plasma = extra-cellular material // high volume



General Properties of Blood

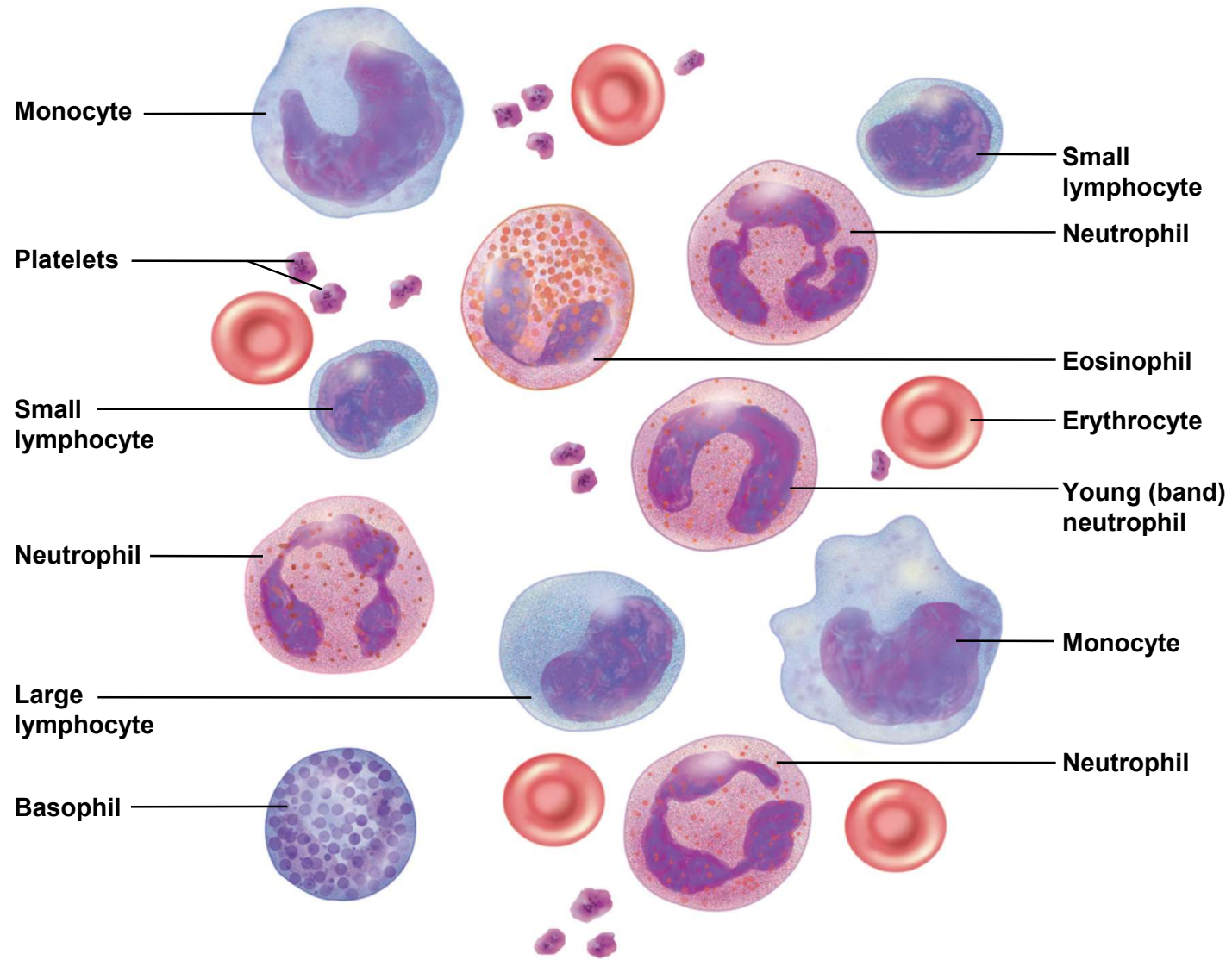
- Plasma = matrix = extra cellular material
 - A translucent, light colored to slightly yellow fluid
 - Consist of several different types of proteins
 - Serum = plasma minus the fibrinogen
 - Fibrinogen is one of the clotting protein
 - Fibrinogen is converted into fibrin by the enzyme thrombin // this turns soluble proteins into insoluble protein



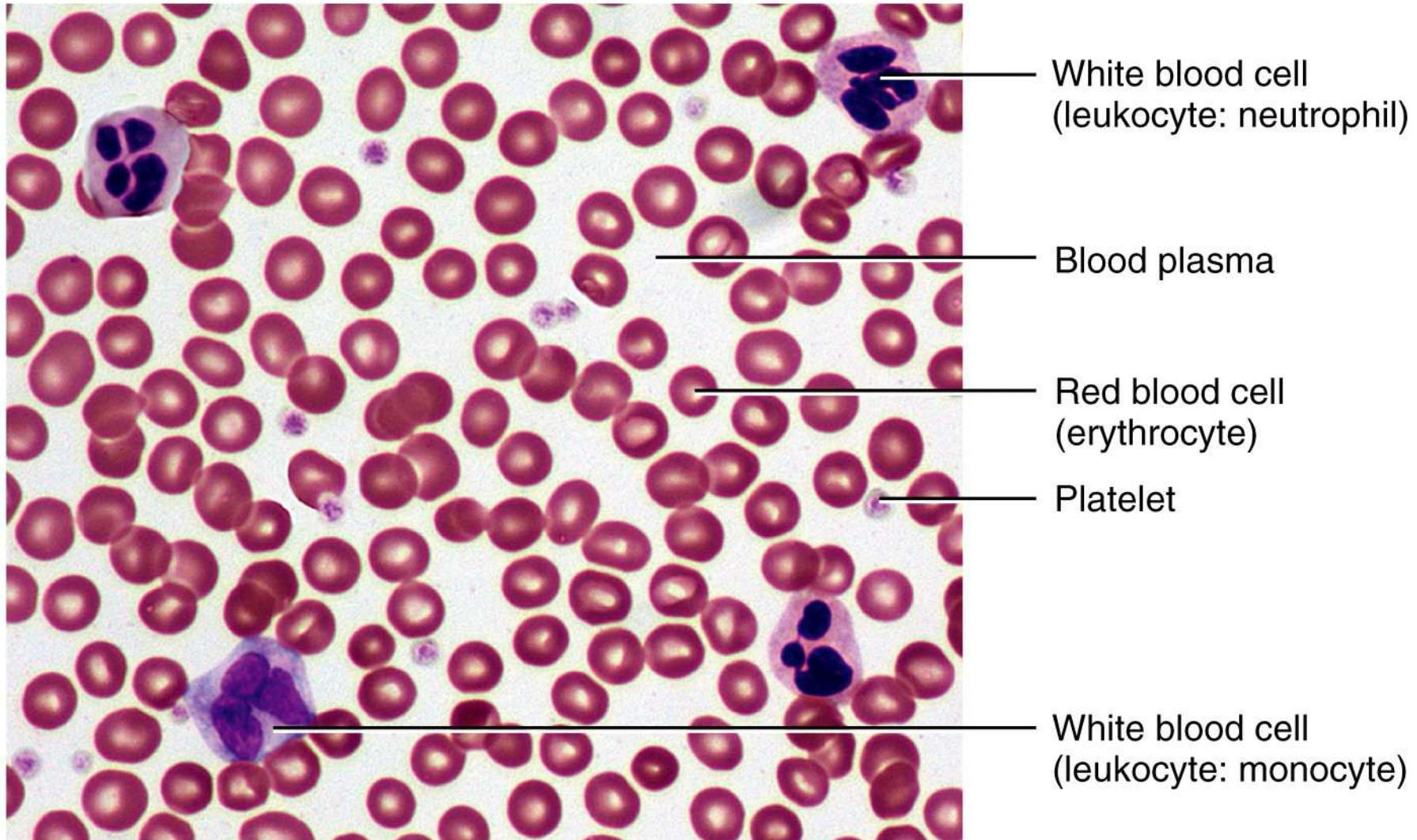
(a) Appearance of centrifuged blood

Formed elements = blood cells and cell fragments

Formed Elements of Blood



Blood Smear Viewed with Light Microscope



Mark Nielsen

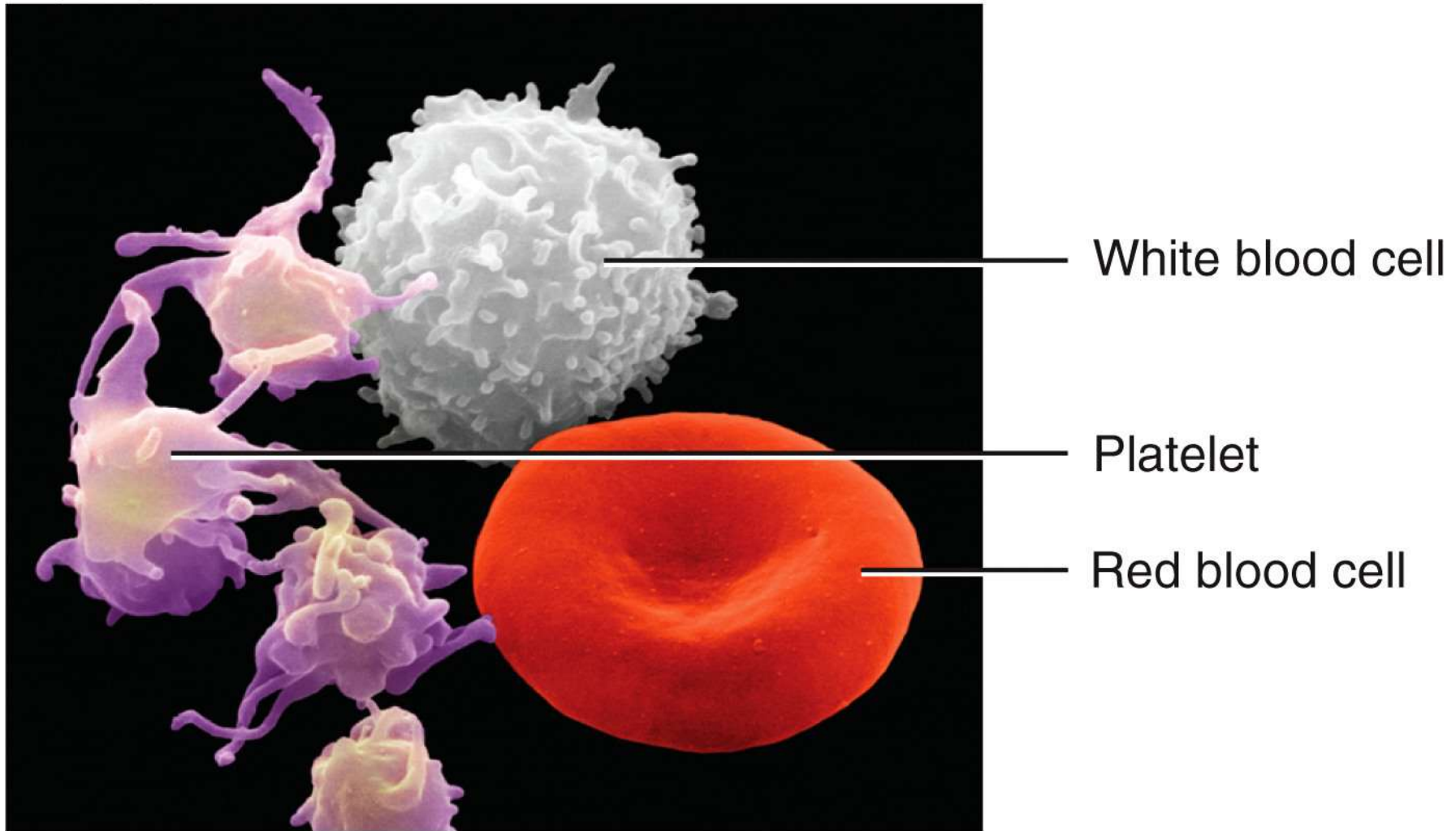
LM

400x

(b) Blood smear (thin film of blood spread on a glass slide)

Formed Elements of Blood

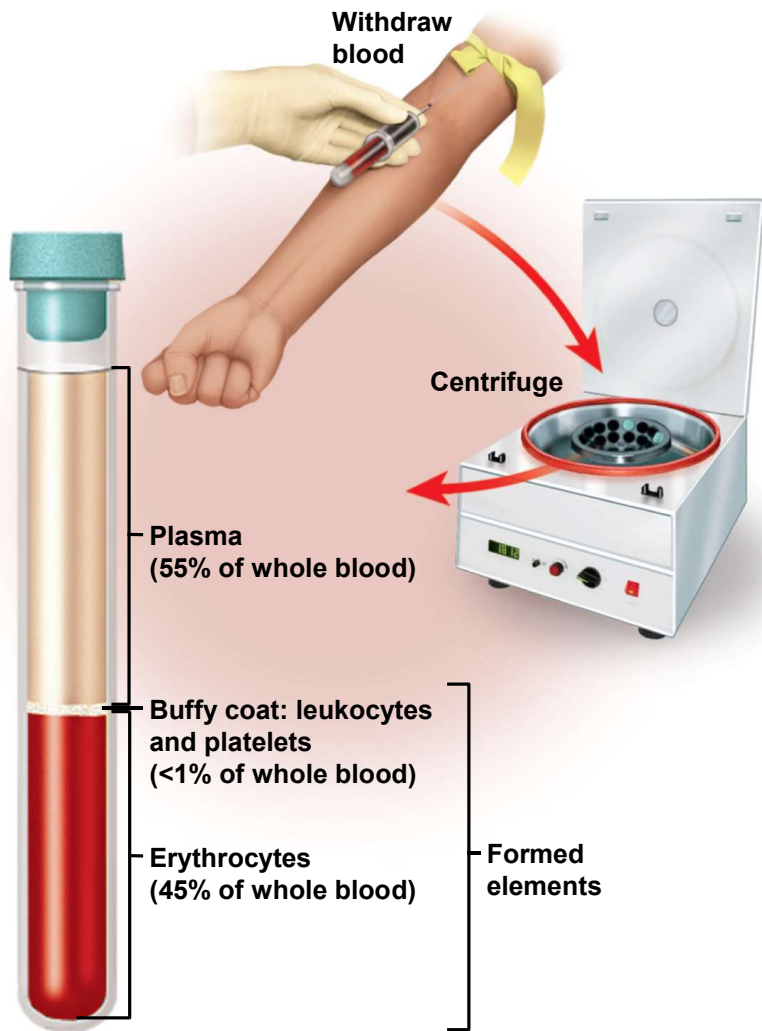
Juergen Berger/Photo Researchers, Inc.



SEM 3500x

(a) Scanning electron micrograph

Centrifuge Used to Separate Plasma From Formed Elements of Blood

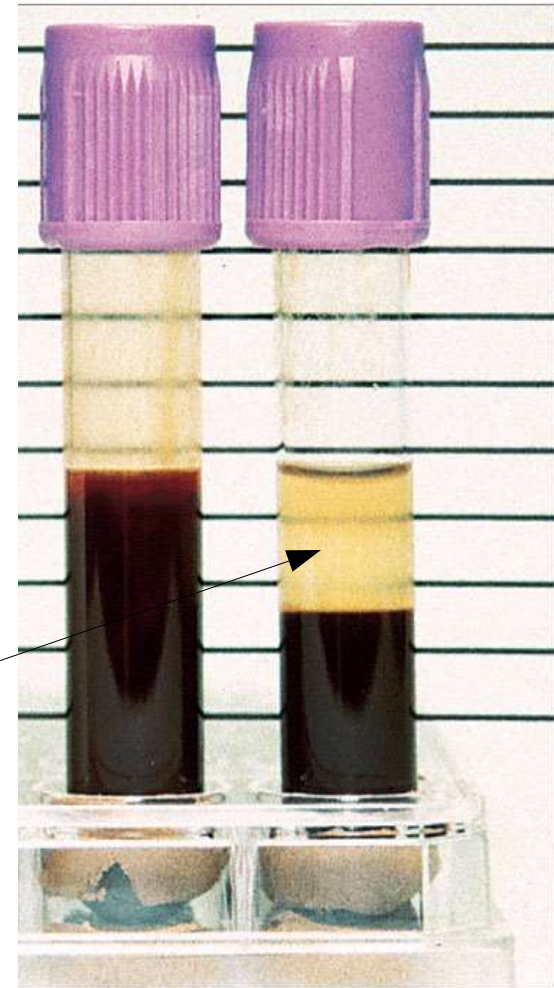


- The Hematocrit Number = RBC volume (mostly!)
 - determined by centrifuging whole blood to separate components
 - Plasma the lightest // on top
 - RBC (erythrocytes) are heaviest // on the bottom
 - RBC = range 37% to 52% total volume (test benchmark = 45%)
 - Buffy coat = between RBC and plasma /// white blood cells and platelets = less than 1% total volume

Plasma, Serum, and Plasma Proteins

- **Plasma** = liquid portion of blood // complex mixture of water, proteins, nutrients, electrolytes, nitrogenous wastes, hormones, and gases
- **Serum** = what remains after formed elements and fibrinogen removed

Plasma



Plasma, Serum, and Plasma Proteins

- Plasma proteins_
 - Most plasma proteins formed by liver
 - Globulin proteins (also called immunoglobulins) are the exception /// these are the antibodies produced by activated B cells called plasma cells)
 - Poor nutrition and liver diseases reduces liver's ability to make proteins

Plasma Proteins

- Three major categories of plasma proteins
 - **albumins**
 - smallest molecules of plasma proteins
 - most abundant
 - contributes to viscosity and osmolarity
 - influences blood pressure, flow and fluid balance
 - **globulins (immunoglobins or antibodies)**
 - provide immune system functions
 - Egs. = alpha, beta and gamma globulins
 - **fibrinogen** /// precursor to fibrin /// thread like protein that help form blood clots

Factors Changing Properties of Blood

- **Viscosity**

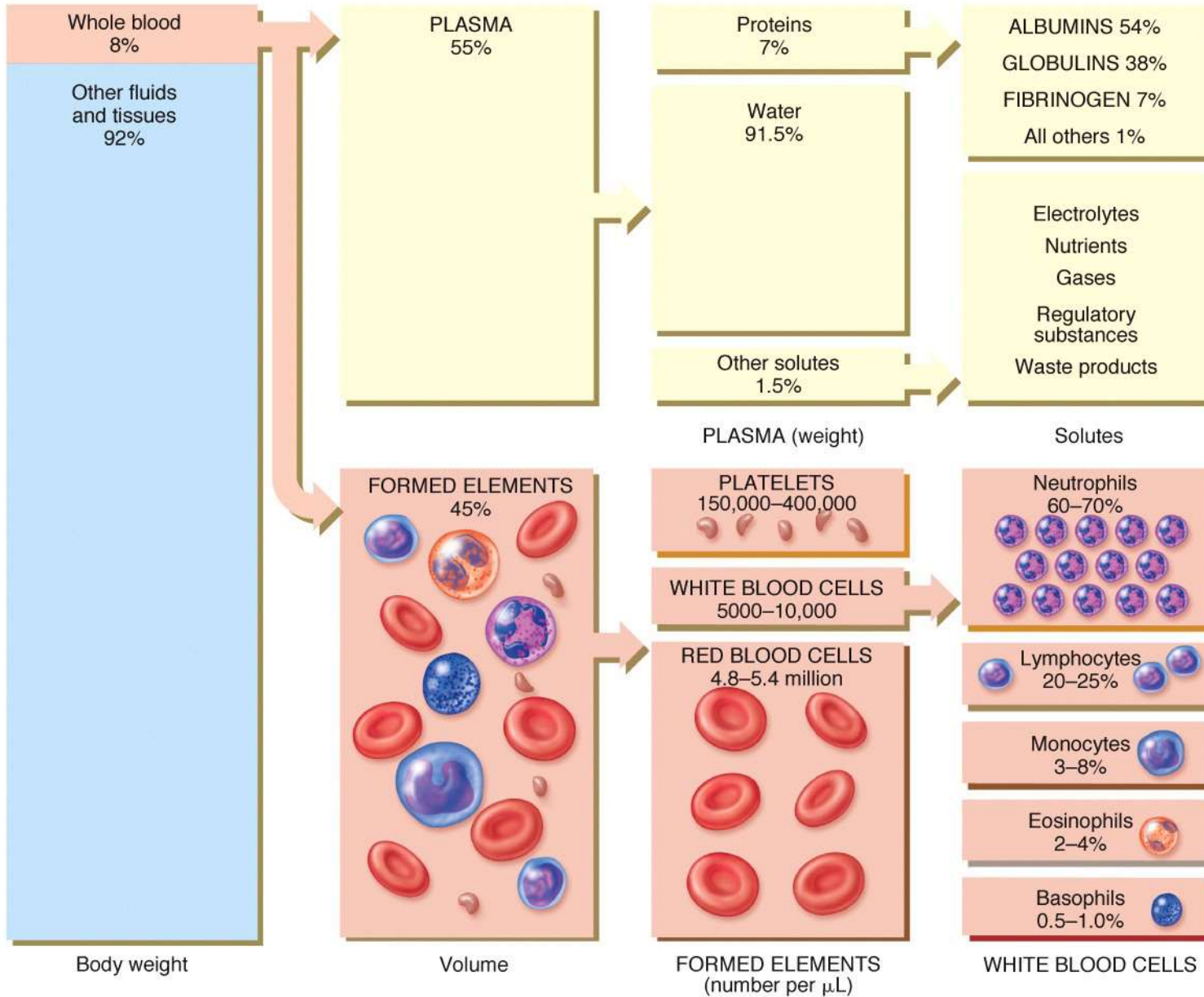
- A fluid's resistance to flow (e.g. water VS oil VS honey)
- This results from the cohesion between the particles in blood
- whole blood 4.5 - 5.5 times as viscous as water
- plasma is 2.0 times as viscous as water
- Conclusion = blood cells in general and RBC in particular are the major factor in determining the viscosity of blood
 - Therefore any conditions which increase the hematocrit will increase viscosity
 - It is harder to pump “thick liquid” through a tube /// therefore anything that makes the blood more viscous will make the heart work harder

Factors Changing Properties of Blood

- Osmolarity of blood
 - An index of all the solute in blood that can not pass through the blood vessel wall (i.e. semipermeable membrane)
 - **if too high**, blood absorbs too much water
 - increasing the blood pressure // extra stress on blood vessels and heart
 - **if too low**, too much water stays in tissue
 - blood pressure drops and edema occurs // heart will need to beat faster to maintain blood pressure and cardiac output
 - optimum osmolarity is achieved by bodies regulation of sodium ions, proteins, and red blood cells.

Nonprotein Components of Plasma

- Nitrogenous compounds
 - free amino acids // from dietary protein or tissue breakdown
 - nitrogenous wastes (urea)
 - toxic end products of catabolism
 - normally removed by the kidneys
 - If these build up in blood may cause mental confusion, heart problems, coma, death
- Nutrients // glucose, vitamins, fats, cholesterol, phospholipids, and minerals
- Gasses / dissolved O₂, CO₂, and nitrogen
- Electrolytes // many different anions and cations // Na⁺ makes up 90% of plasma cations



(b) Components of blood

Formed Elements

- Erythrocytes // red blood cells (RBCs)
- Platelets // cell fragments from special cell in bone marrow
- Leukocytes // white blood cells (WBCs)
 - two categories with subgroups
 - Granulocytes (neutrophils, esinophils, basophils)
 - Agranulocytes (lymphocytes, monocytes)

**Red Blood Cells (RBCs)
or Erythrocytes**



Granular leukocytes

Neutrophils



Eosinophils



Basophils



Agranular leukocytes

**Lymphocytes (T cells, B cells,
and natural killer cells)**



Monocytes

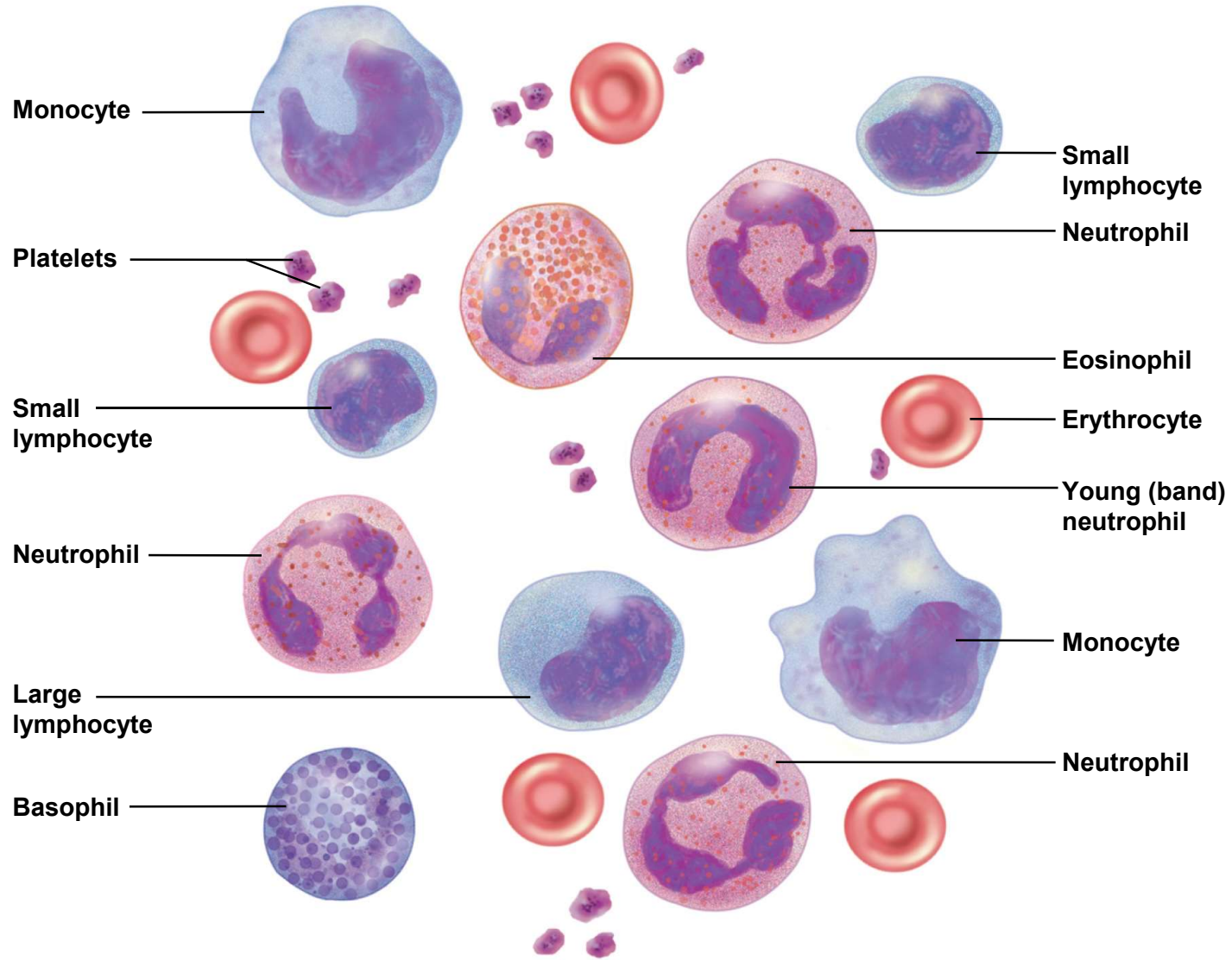


Platelets



Formed Elements of Blood

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Leucocytes (WBC) Divided Into Two Groups

– Granulocytes (with visible granules)

- » Neutrophils
- » Eosinophils
- » Basophils (“mature” into mast cells // located avascular)

– Agranulocytes (without visible granules)

- » Lymphocytes (T cells / B cells / NK cells)
- » Monocytes (“matrue” into macrophage // located avascular)

– Notes:

- » a complete review of these WBC and their functions will follow
- » all of these cells have the ability to emigrate from the blood into the tissue spaces /// where they spend most of their time
- » memorize ranking concentrations with this saying / high to low / “Never let monkeys eat bananas”

Starvation and Plasma Proteins

- Hypoproteinemia
 - deficiency of plasma proteins
 - Causes // extreme starvation / liver or kidney disease / severe burns
- Kwashiorkor
 - children with severe protein deficiency
 - fed on cereals once weaned from protein rich breast milk
 - thin arms and legs
 - swollen abdomen



Lack of dietary protein results in deficiency of blood proteins which allows fluid to move from blood into abdomen. (Kwashiorkor)

Lack of both dietary protein and carbohydrate results in catabolism of muscle to make glucose. (true starvation)

