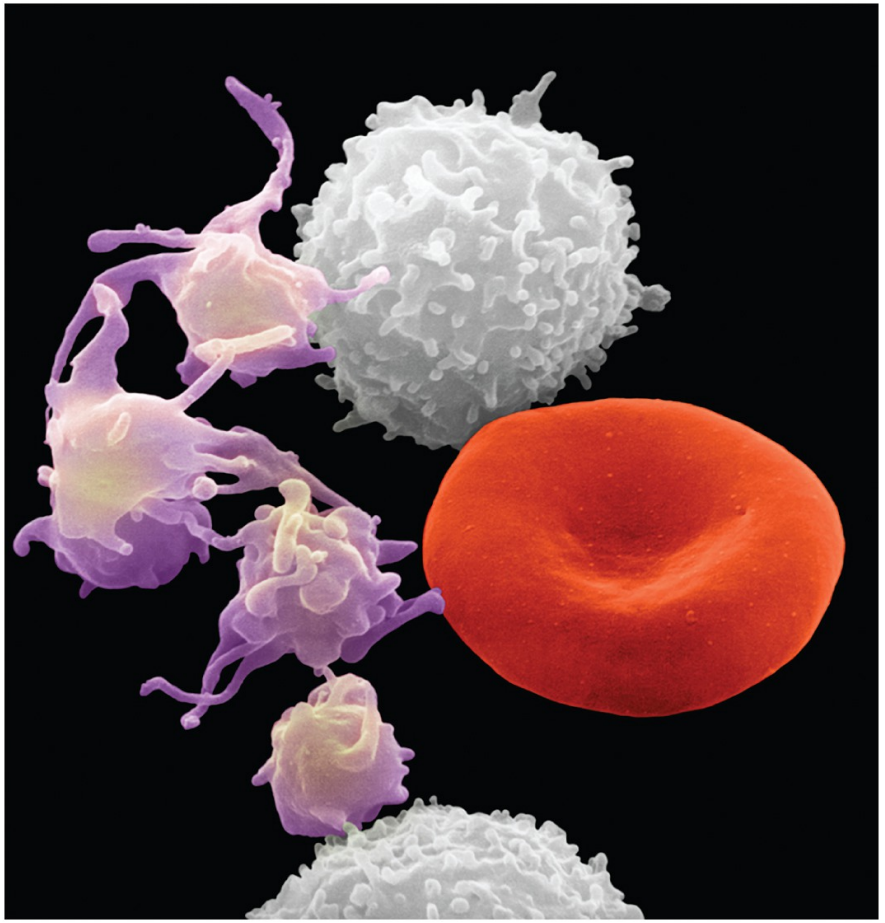
Chapter 18.1

An Introduction to the Circulatory System and Blood



Circulatory System VS Cardiovascular System

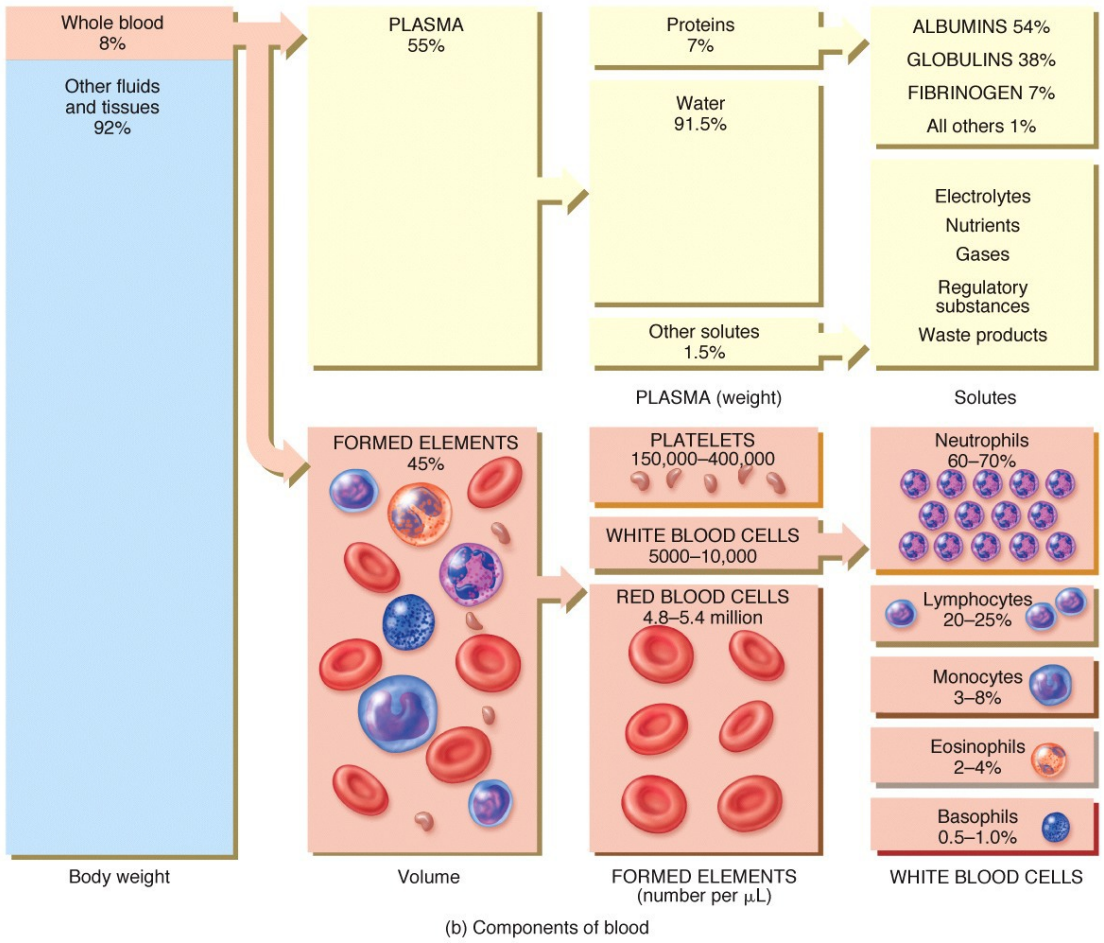
- **circulatory system** = heart, blood vessels and blood
- **cardiovascular system** **=** heart and blood vessels
- **hematology** = the study of blood

Functions of Circulatory System

- Transport // O_2, CO_2, 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

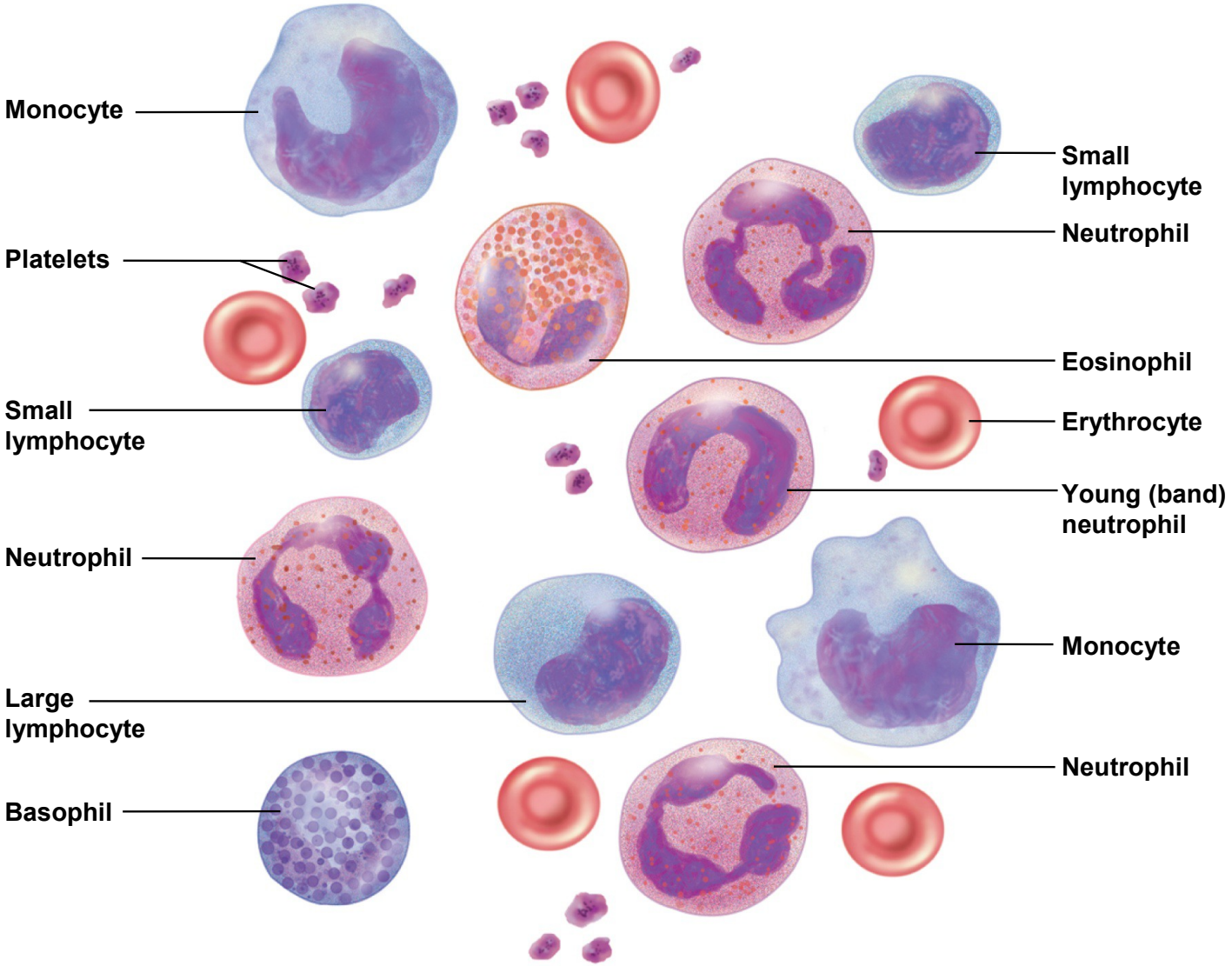
General Properties of Blood

- Blood volume = Adults 4-6 L
- **Test benchmark = 5.25 L**
- Blood = connective tissue
- Connective tissue defined by
  - Cells = many type of formed elements // low volume
  - Matrix = plasma = the extra-cellular material // high volume

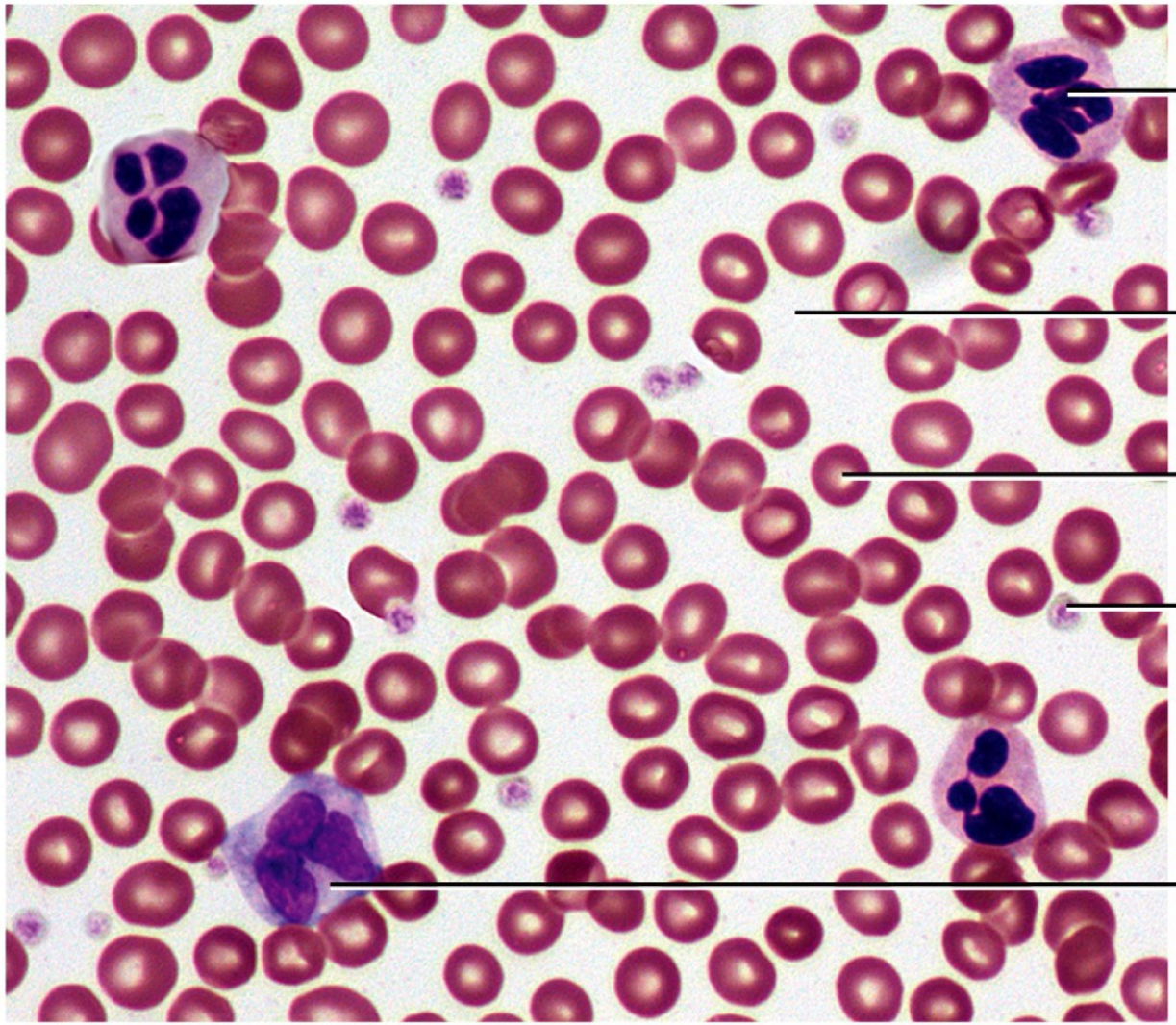


(b) Components of blood

Formed Elements of Blood



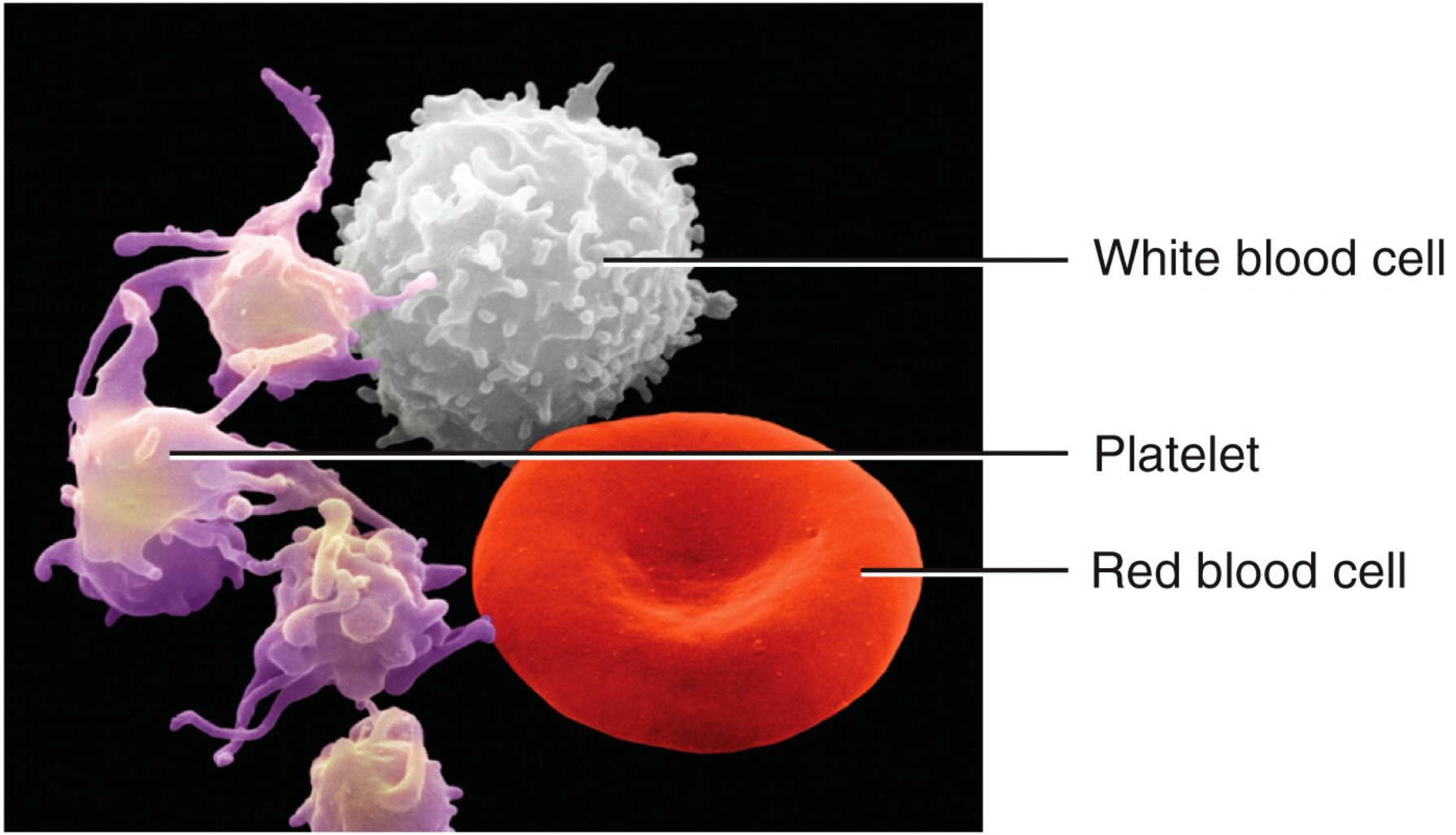
Blood Smear Viewed with Light Microscope



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

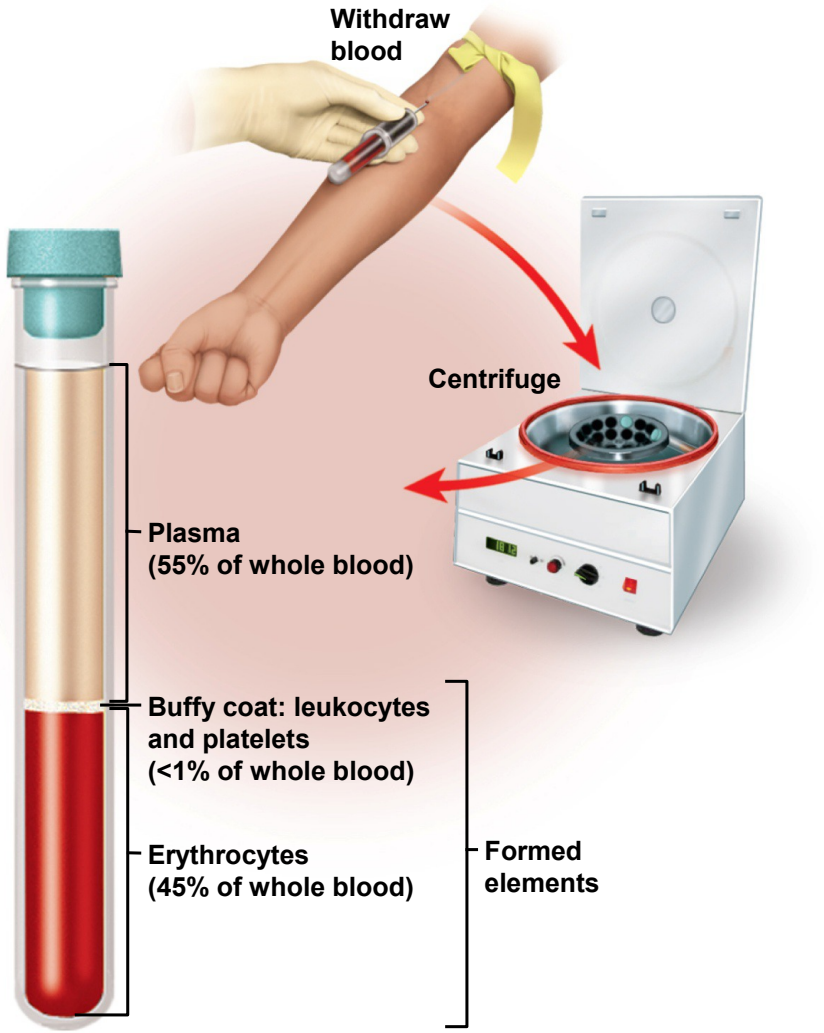
Formed Elements of Blood

Juergen Berger/Photo Researchers, Inc.



(a) Scanning electron micrograph

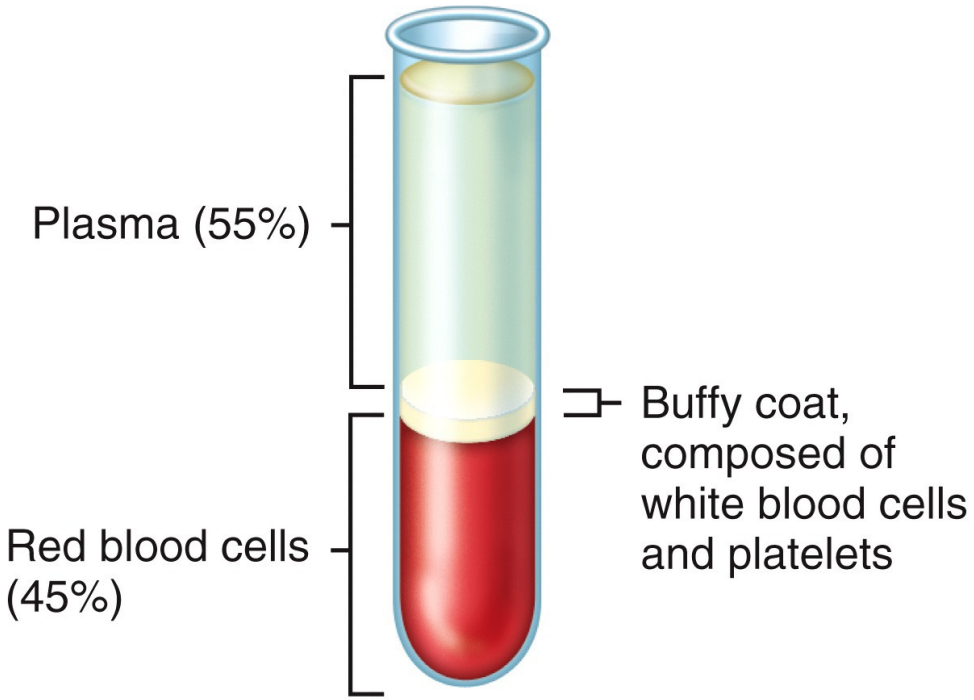
Centrifuge Used to Separate Plasma From Formed Elements of Blood



- 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 between 37% to 52% total volume (test benchmark = 45%)
  - Buffy Coat = WBC between RBC and plasma /// less than 1% total 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 the precusor for fibrin /// "the key 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

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

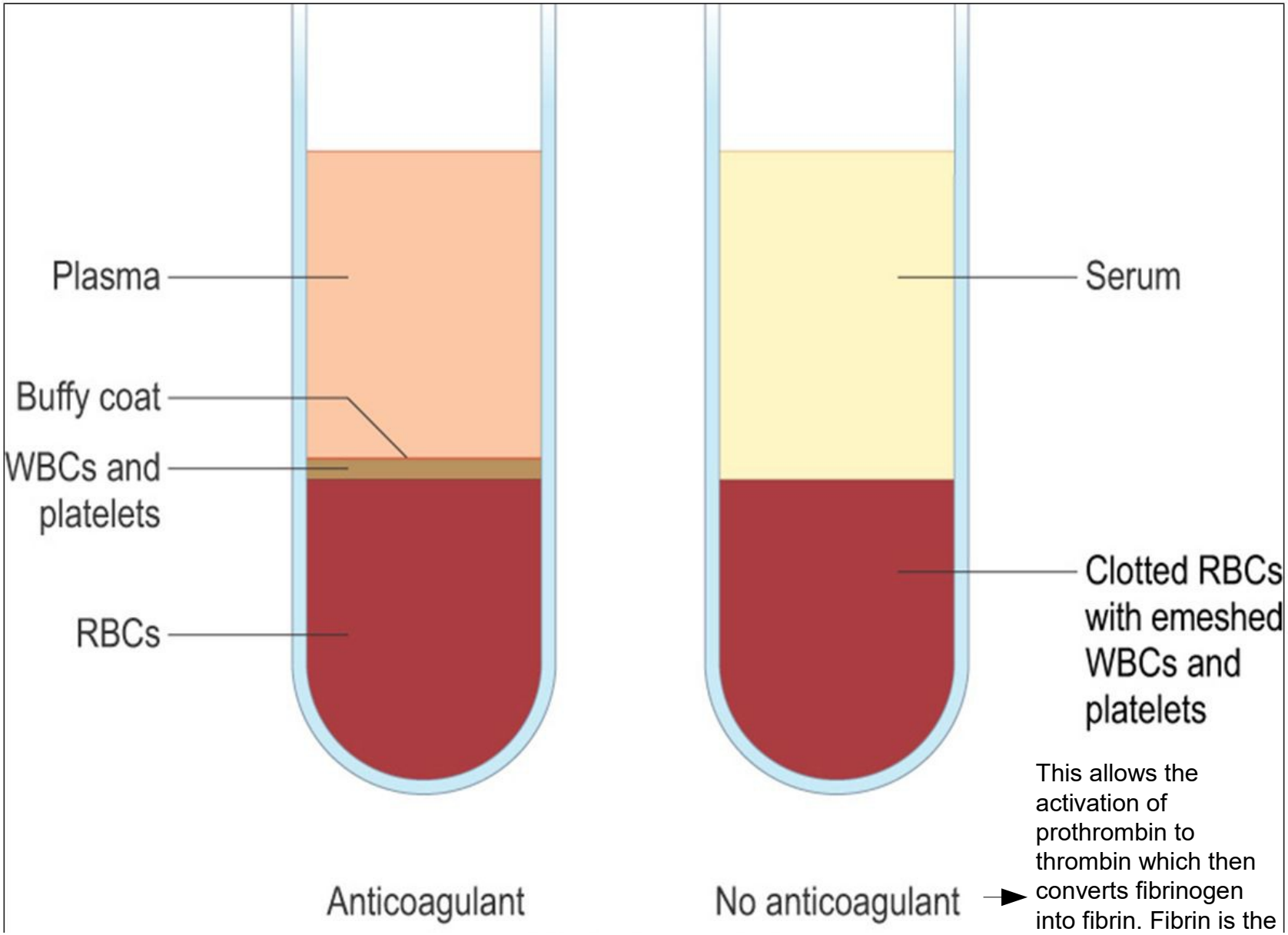
Tube volume in tube A and B // left test tube above line is blood residue

If you remove fibrinogen from tube B then the plasma changes to serum and it will not form a blood clot. The color would not change.

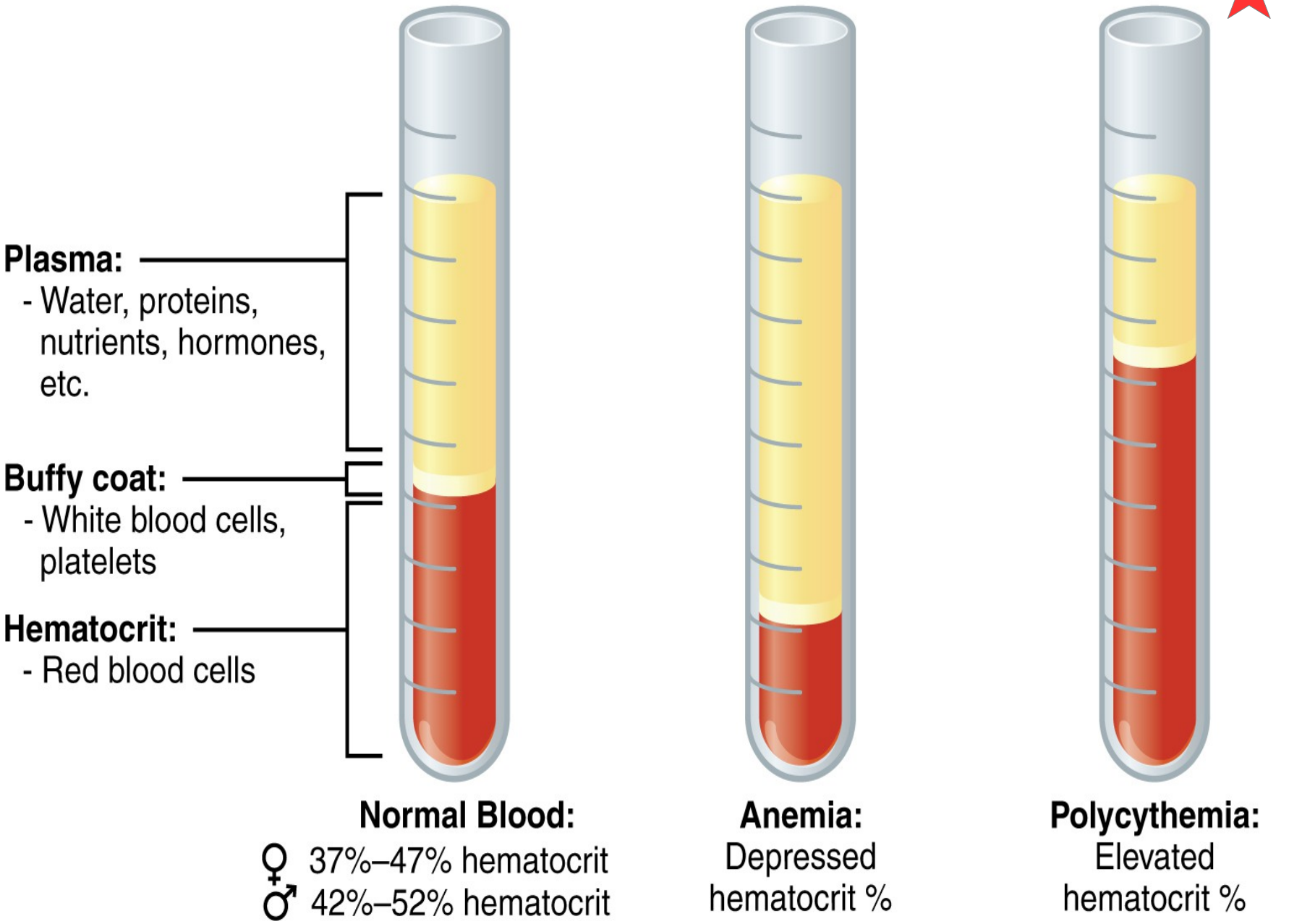
Plasma

Formed Elements

See next slide



This allows the activation of prothrombin to thrombin which then converts fibrinogen into fibrin. Fibrin is the fibrous mesh which traps platlets and other formed elements into clotted blood


Plasma:
- Water, proteins, nutrients, hormones, etc.
Buffy coat:
- White blood cells, platelets
Hematocrit:
- Red blood cells
Normal Blood:
♀ 37%–47% hematocrit
♂ 42%–52% hematocrit
Anemia:
Depressed hematocrit %
Polycythemia:
Elevated hematocrit %

Plasma Proteins

- Most plasma proteins formed by liver
  - Poor nutrition or liver diseases reduces liver's ability to make proteins
- Globulin proteins (also called immunoglobulins = antibodies) /// formed by “activated B cells” called plasma cells

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
  - **fibrinogen** /// precursor to fibrin /// thread like protein that help form blood clots
  - **globulins** (immunoglobins or antibodies) /// provide immune system functions (Egs. = alpha, beta and gamma globulins)

Blood Viscosity

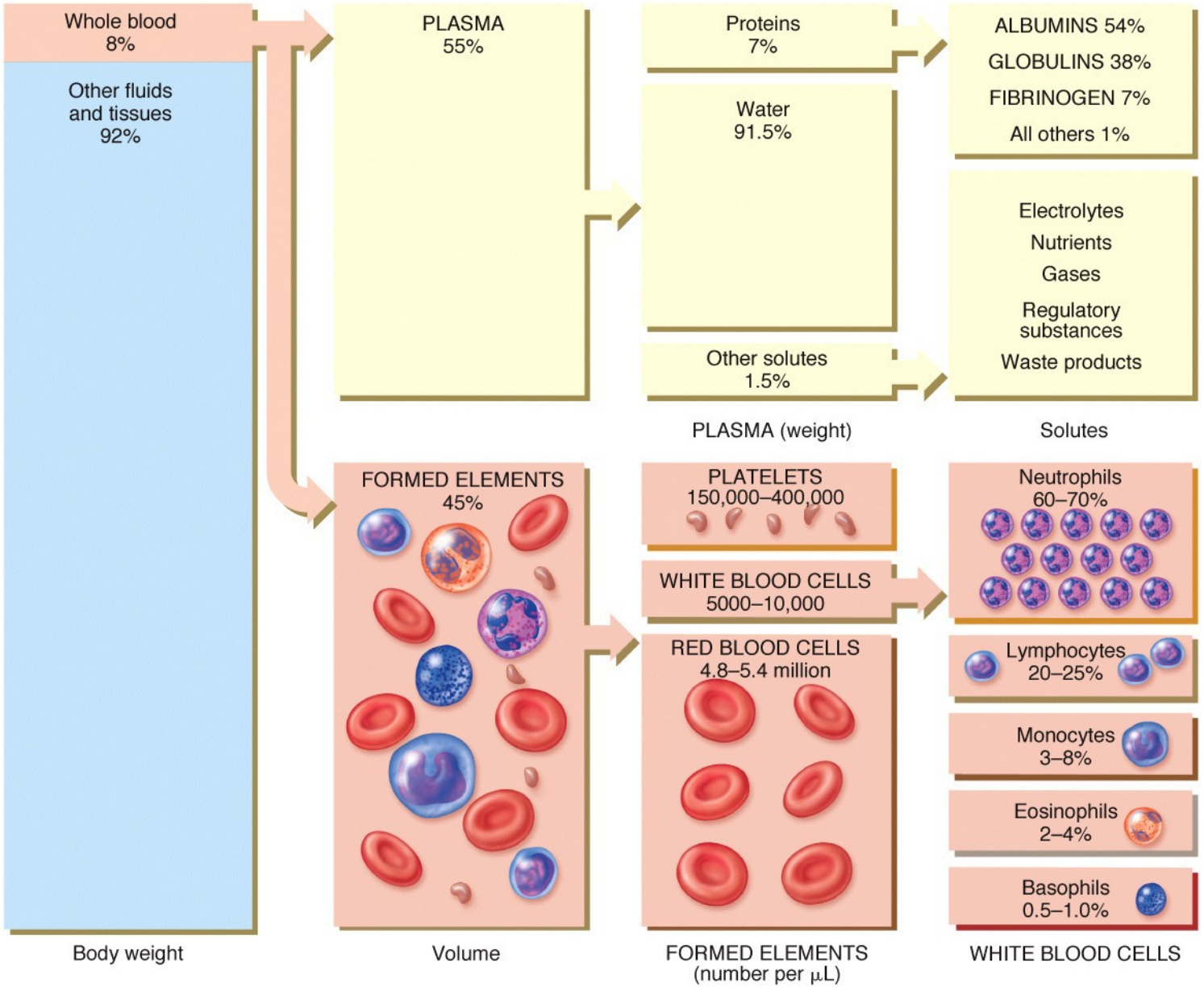
- **Viscosity ///** a fluid's resistance to flow (e.g. water VS oil VS honey)
  - this results from the cohesion between the particles in blood
  - whole blood 4.5 - 5.5 times as viscous as water
  - plasma is 2.0 times as viscous as water
  - conclusion = RBC are the major factor that determine the viscosity of blood
    - any conditions which increase the hematocrit will increase viscosity
    - key idea = it is harder to pump "thick liquid" through a tube /// anything that makes the blood more viscous will make the heart work harder

Blood Osmolarity

- Osmolarity /// indicates the number of solutes in blood
- Those solutes not able to cross semipermeable membrane are most significant /// can not pass through the capillary or plasma membranes /// protein
  - 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 (test number = 300 mosm) /// osmolarity is regulated by nuclei in the hypothalamus

Non-protein 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 O_2, CO_2, 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 // megakaryocyte fragments released into blood from red bone marrow
- Leukocytes // white blood cells (WBCs)
  - Two subgroups
    - Granulocytes (neutrophils, esinophils, basophils)
    - Agranulocytes (lymphocytes, monocytes)

Leucocytes (WBC) Divided Into Two Groups

- Granulocytes (with visible granules)
  - » Neutrophils
  - » Eosinophils
  - » Basophils (“mature” into mast cells // basophils in blood then emigrate into interstitial space to become mast cells)
- Agranulocytes (without visible granules)
  - » Lymphocytes (T cells / B cells / NK cells)
  - » Monocytes (monocytes in blood then become macrophage after they emigrate into interstitial space)
- 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 /// WBC spend most of their time in tissue spaces not blood
  - » memorize WBC order with this saying / high to low / “Never let monkeys eat bananas”

Red Blood Cells (RBCs)
or Erythrocytes

Granular leukocytes

Neutrophils

Eosinophils

Basophils

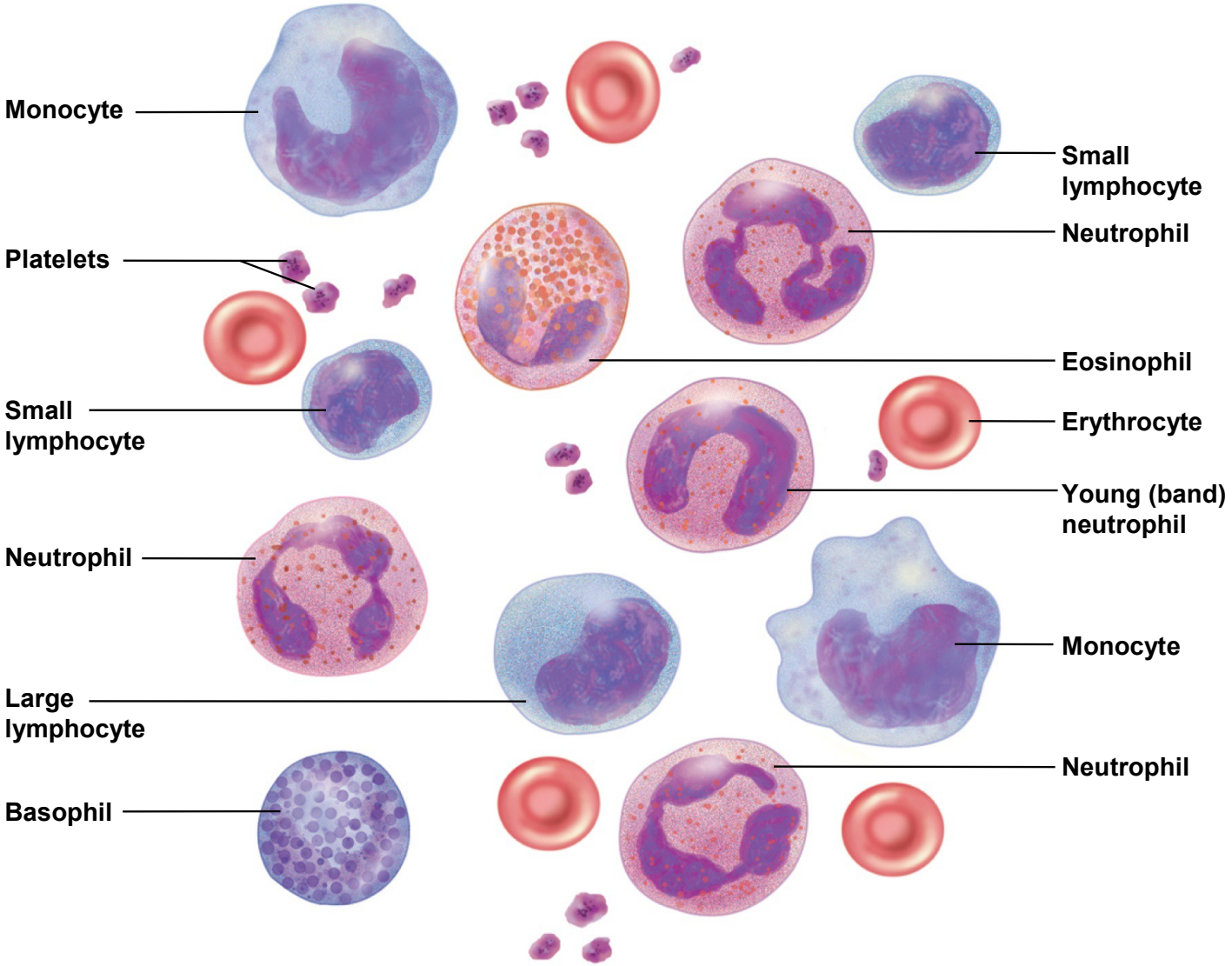
Agranular leukocytes

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

Monocytes

Platelets

Formed Elements of Blood



Protein Deficiency VS Starvation

- Hypoproteinemia
  - deficiency of plasma proteins
  - caused by starvation, liver disease, kidney disease and/or severe burns

- Kwashiorkor
  - children with severe protein deficiency – no protein in diet
  - carbohydrates rich diet // available to make ATP
  - after mother's protein rich milk diet changed to carbohydrate rich diet
  - thin arms and legs // swollen abdomen
  - immune system compromised // increase diseases

- Marasmus = true starvation
  - lack dietary protein
  - lack dietary carbohydrate
  - results in catabolism of muscle mass to make glucose.
  - immune system compromised // increase diseases

Kwashiorkor = Lack of dietary protein /// but diet of carbohydrate /// results in deficiency of blood proteins which allows fluid to move from blood into abdomen.

Marasmus = Starvation = Lack of both dietary protein and carbohydrate /// results in catabolism of muscle to make glucose.