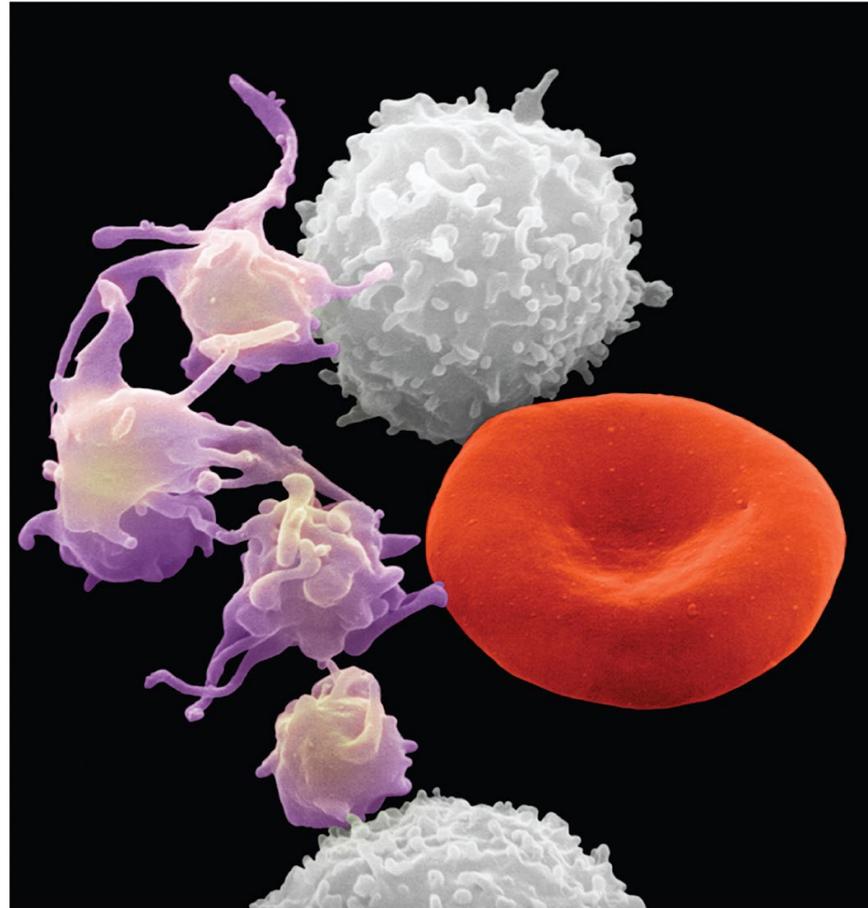


Chapter 18.1

An Introduction to the Circulatory System and Blood

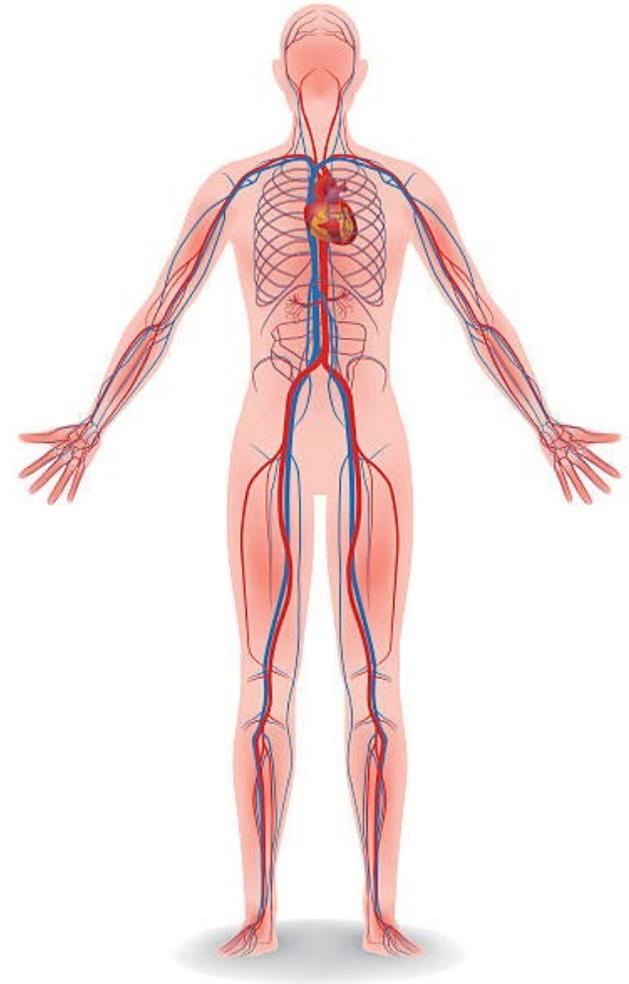


Circulatory System VS Cardiovascular System

Circulatory system = heart, blood vessels and blood

Cardiovascular system = heart and blood vessels

What is hematology? the study of blood



Functions of Circulatory System

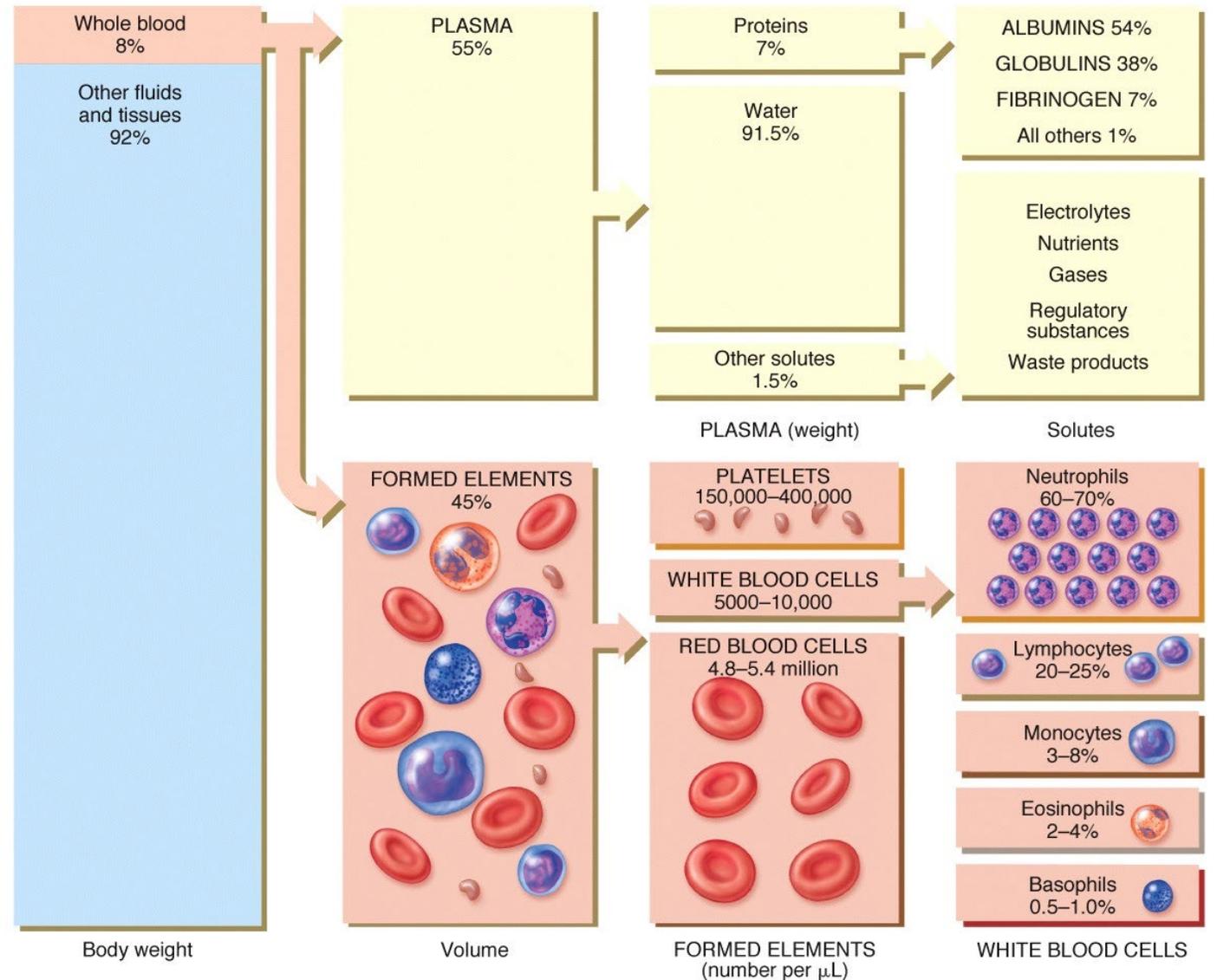
Transport // O₂, CO₂, nutrients, wastes, hormones, and stem cells

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

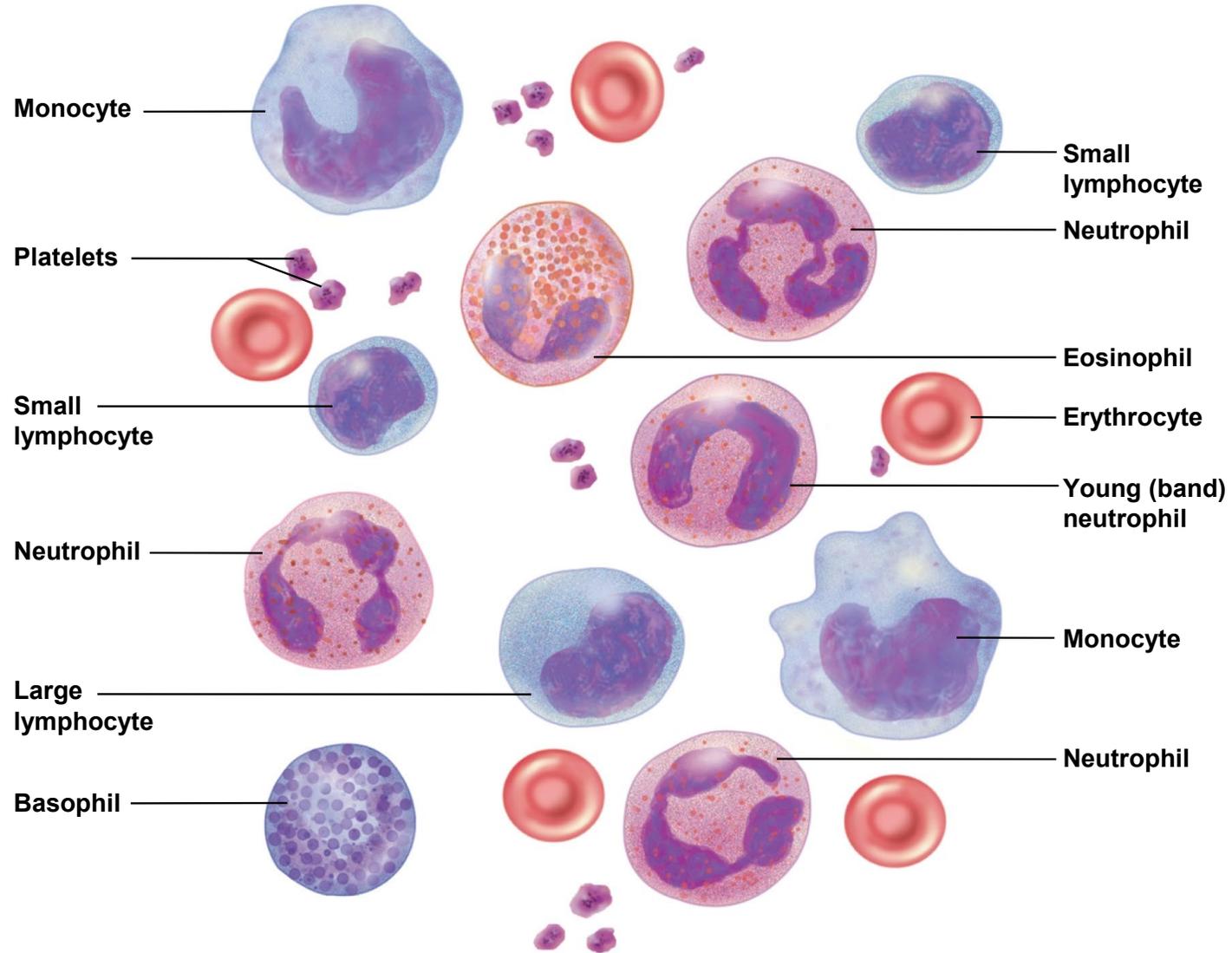
General Properties of Blood

- Blood volume = Adults 4-6 L
- Test benchmark = 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

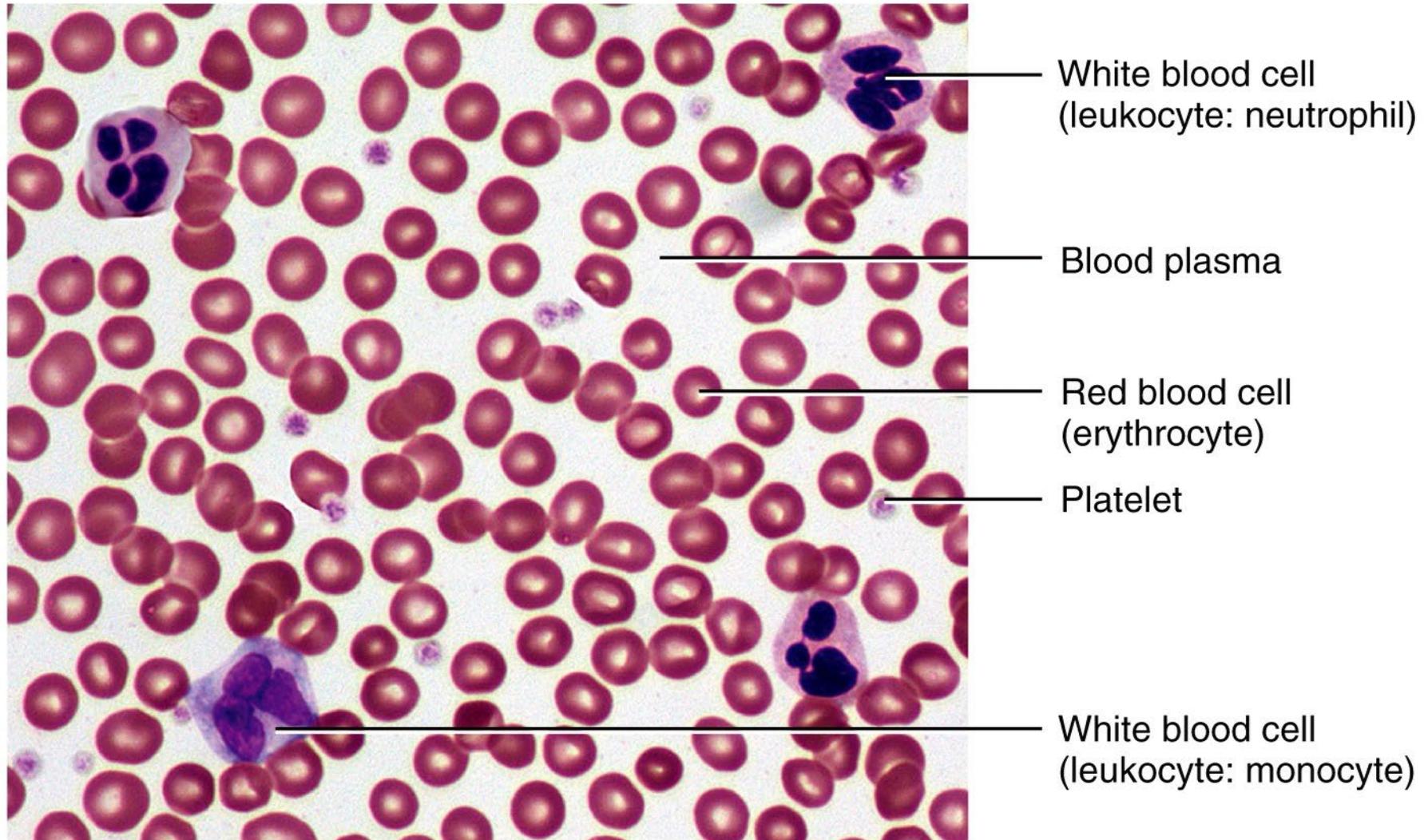


(b) Components of blood

Formed Elements of Blood



Blood Smear Viewed with Light Microscope



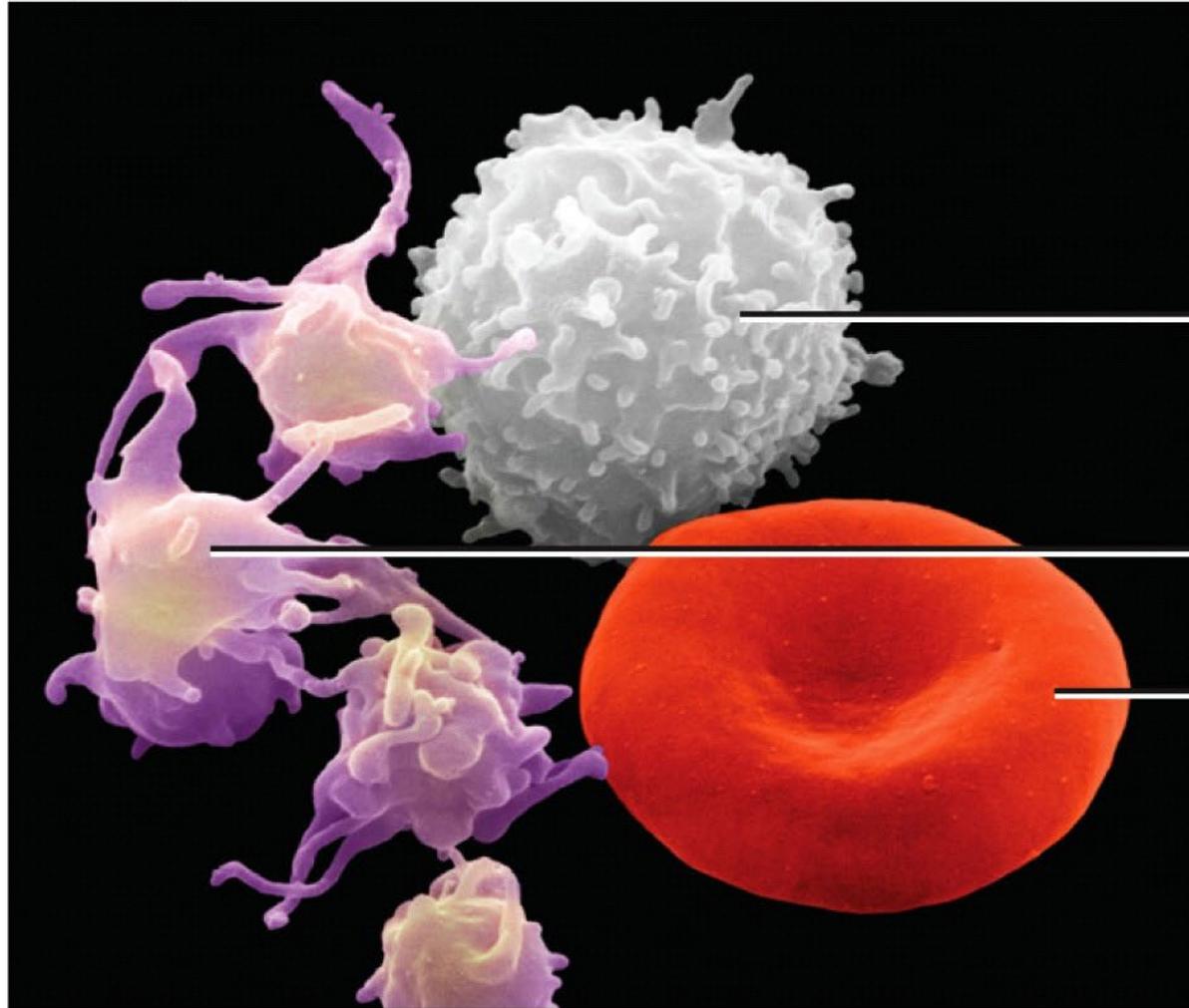
Mark Nielsen

LM 400x

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

Formed Elements of Blood

Juergen Berger/Photo Researchers, Inc.



White blood cell

Platelet

Red blood cell

SEM is only in gray tones. Color added.

SEM 3500x

(a) Scanning electron micrograph

General Properties of Blood

Plasma = matrix = extra cellular material

A translucent /// light colored to slightly yellow fluid

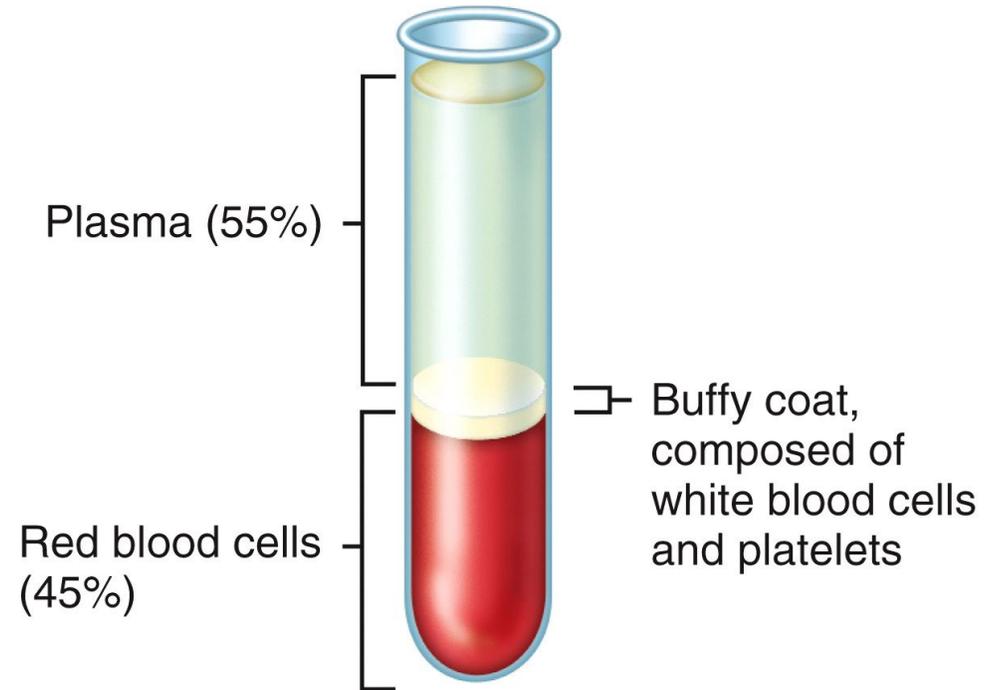
Matrix = different types of proteins

Serum = plasma minus fibrinogen

Fibrinogen is the precursor for fibrin /// “the key clotting protein”

Fibrinogen is converted into fibrin by the enzyme **thrombin** // this turns soluble fibrinogen into insoluble fibrin

Fibrin fibers stick to each other to form “fibrin clot”



(a) Appearance of centrifuged blood

Formed elements = all blood cells and cell fragments

Plasma VS Serum

Plasma = liquid portion of blood // complex mixture of water, proteins, nutrients, electrolytes, nitrogenous wastes, hormones, and gases

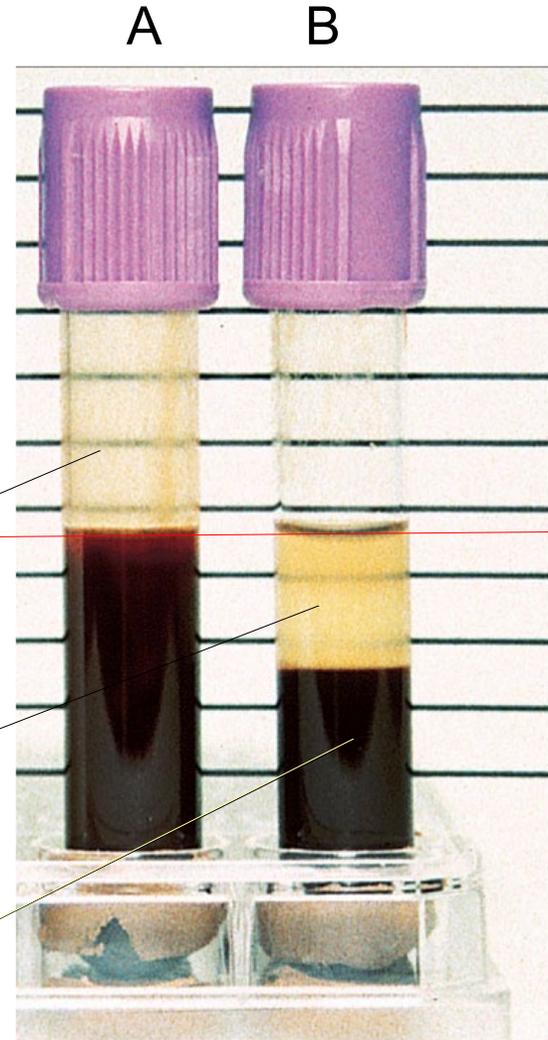
Serum = what remains after formed elements and fibrinogen removed

Left test tube above red line is blood residue

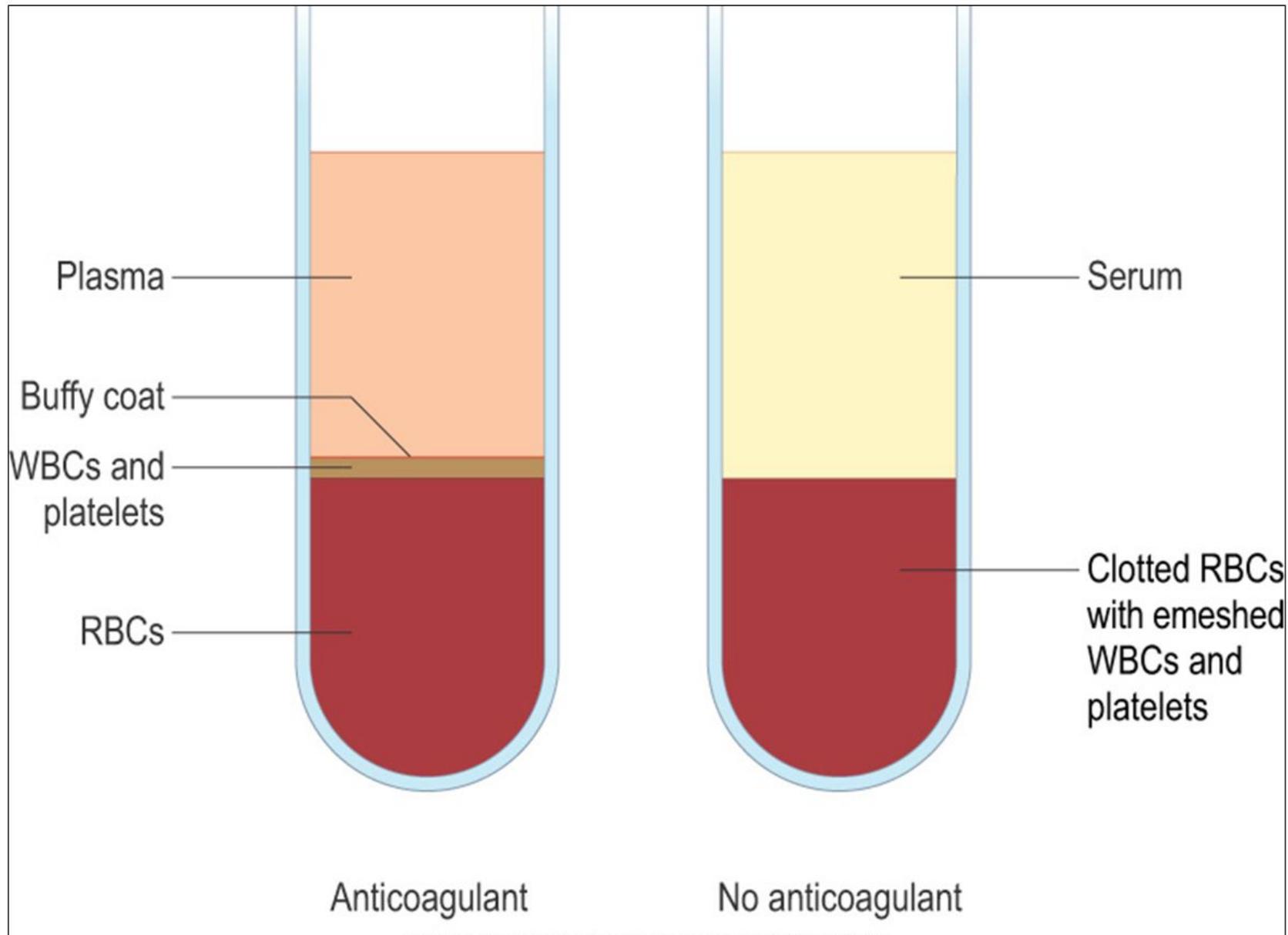
If you remove fibrinogen from tube B then the plasma changes to serum and it will not form a blood clot. The color would not change.

Plasma

Formed Elements

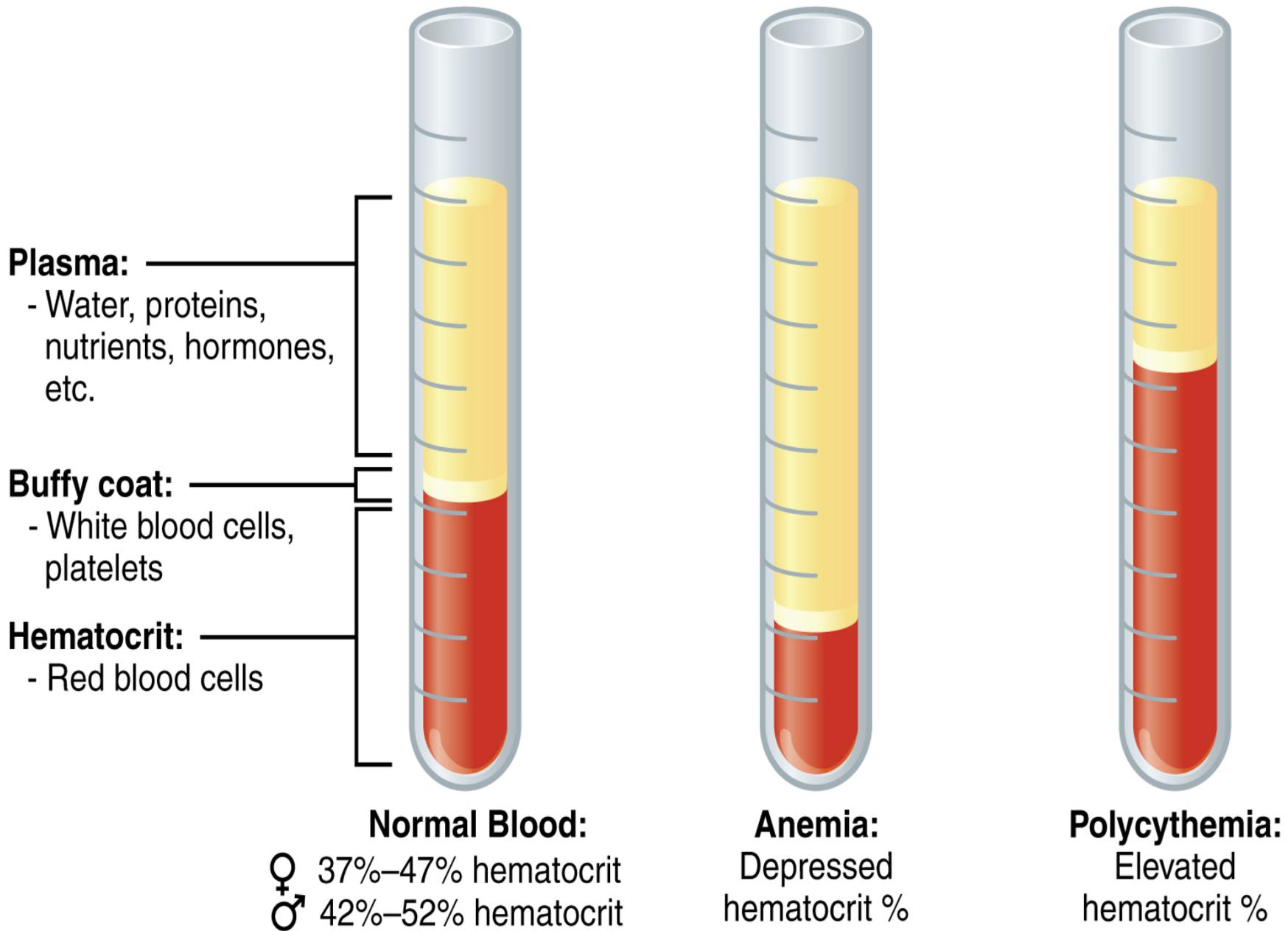


See next slide



Without the anticoagulant, now an inactive enzyme, prothrombin will be activated to thrombin. This enzyme then converts fibrinogen into fibrin. Fibrinogen is soluble but fibrin is insoluble and adheres to other fibrin proteins.

Fibrin forms the fibrous mesh which traps platelets and other formed elements to form the blood clot.



Plasma Proteins

Majority of plasma proteins are formed by liver

Poor nutrition or liver diseases reduces liver's ability to make proteins

Globulin proteins (also called immunoglobulins = antibodies) are also plasma proteins but these proteins are formed by plasma cells. Plasma cells are a type of formed element that morph from “activated B 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 (also called 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 /// measures the number of solutes in blood

Osmosis requires a semipermeable membrane to restrict the movement of solute across the membrane /// capillaries and plasma membranes are semipermeable membranes

Proteins in blood are restricted from passing through the blood vessel's semipermeable membranes (capillaries)

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) /// blood osmolarity is **regulated by nuclei in the hypothalamus**

Non-Protein Components of the Plasma

Nitrogenous compounds

Free amino acids // from dietary protein or tissue breakdown

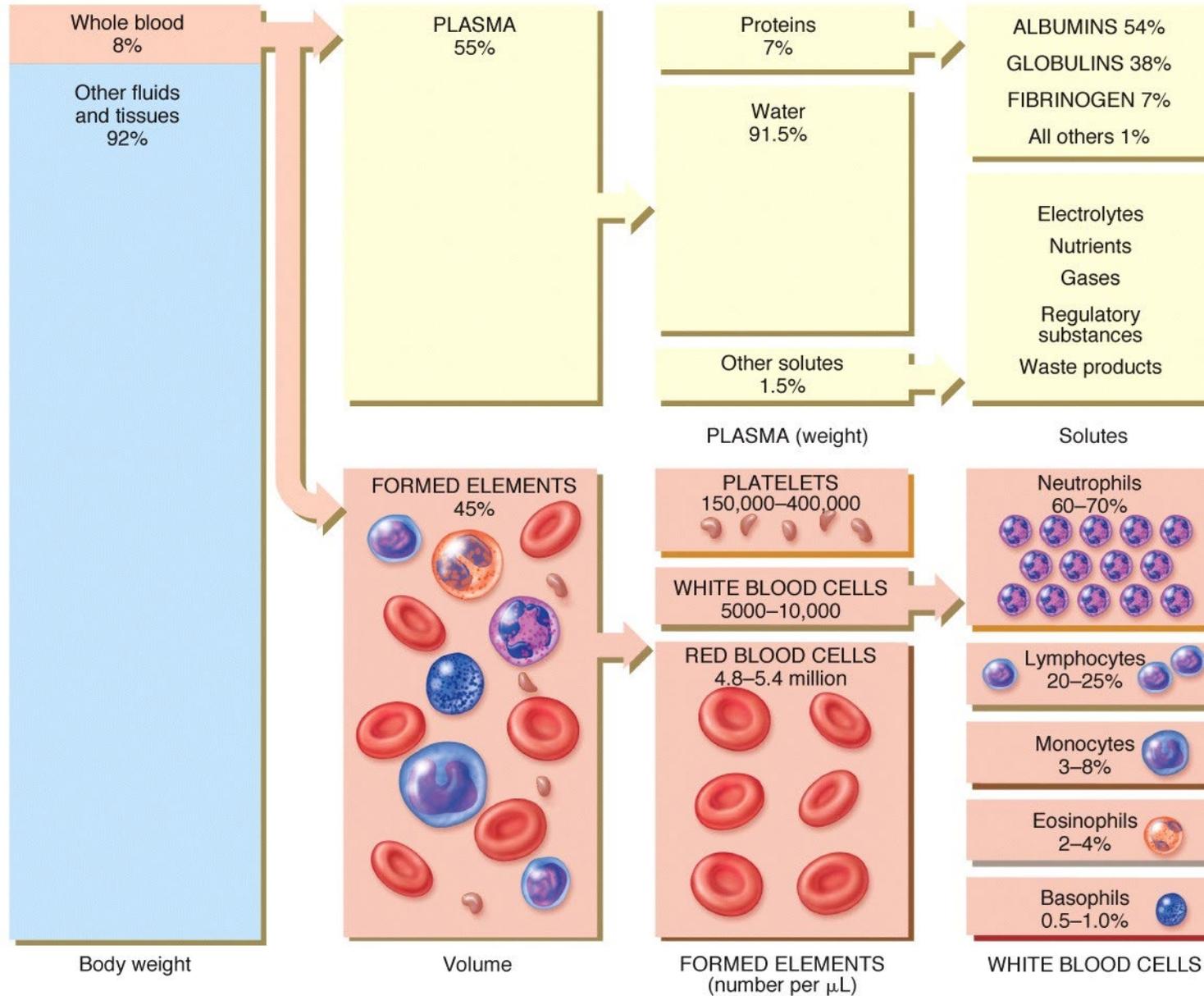
Nitrogenous wastes (urea)

- toxic end products of catabolism
- normally removed by the kidneys
- but may build up in blood to 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

The Formed Elements

Erythrocytes // red blood cells (RBCs)

Platelets // megakaryocyte fragments released into blood from red bone marrow

Leukocytes // white blood cells (WBCs)

Two subgroups of WBC

- **Granulocytes** (neutrophils, esinophils, basophils)
- **Agranulocytes** (lymphocytes, monocytes)

Leucocytes Two Groups

Granulocytes (with visible granules)

- » Neutrophils
- » Eosinophils
- » Basophils (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

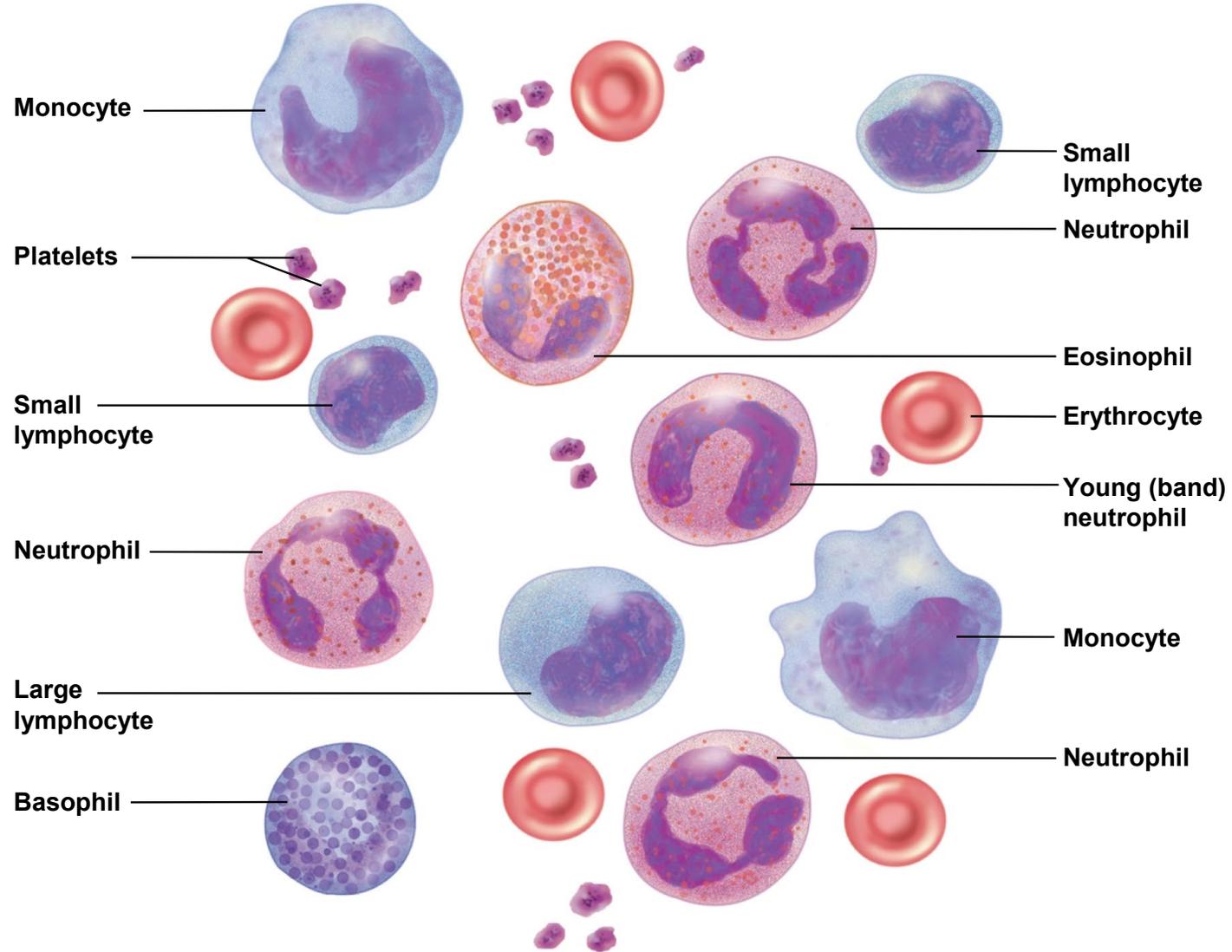


Platelets



Formed Elements of Blood

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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.

