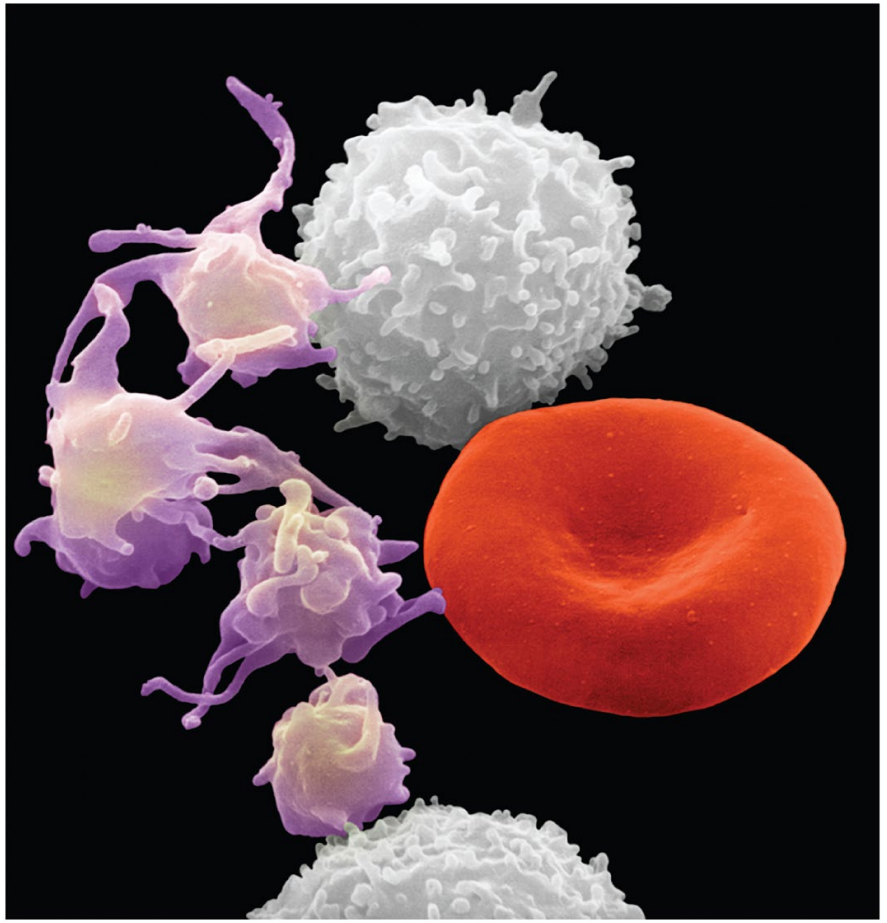
Chapter 18.1

# An Introduction to the Circulatory System and Blood

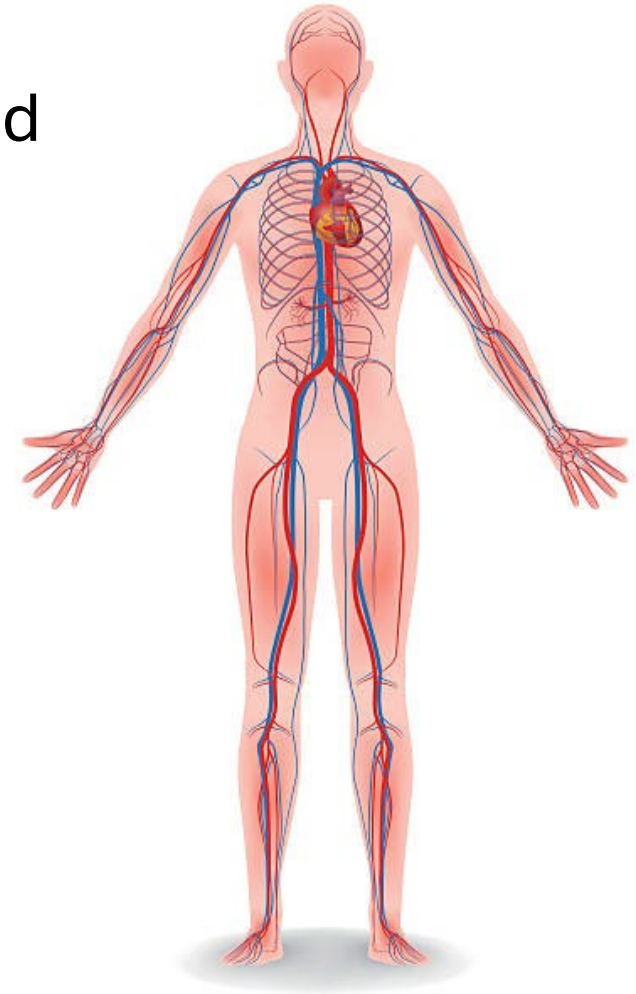


# Circulatory System VS Cardiovascular System

Circulatory system = heart, blood vessels and blood

Cardiovascular system = heart and blood vessels

What is hematology? the study of blood



# Functions of Circulatory System

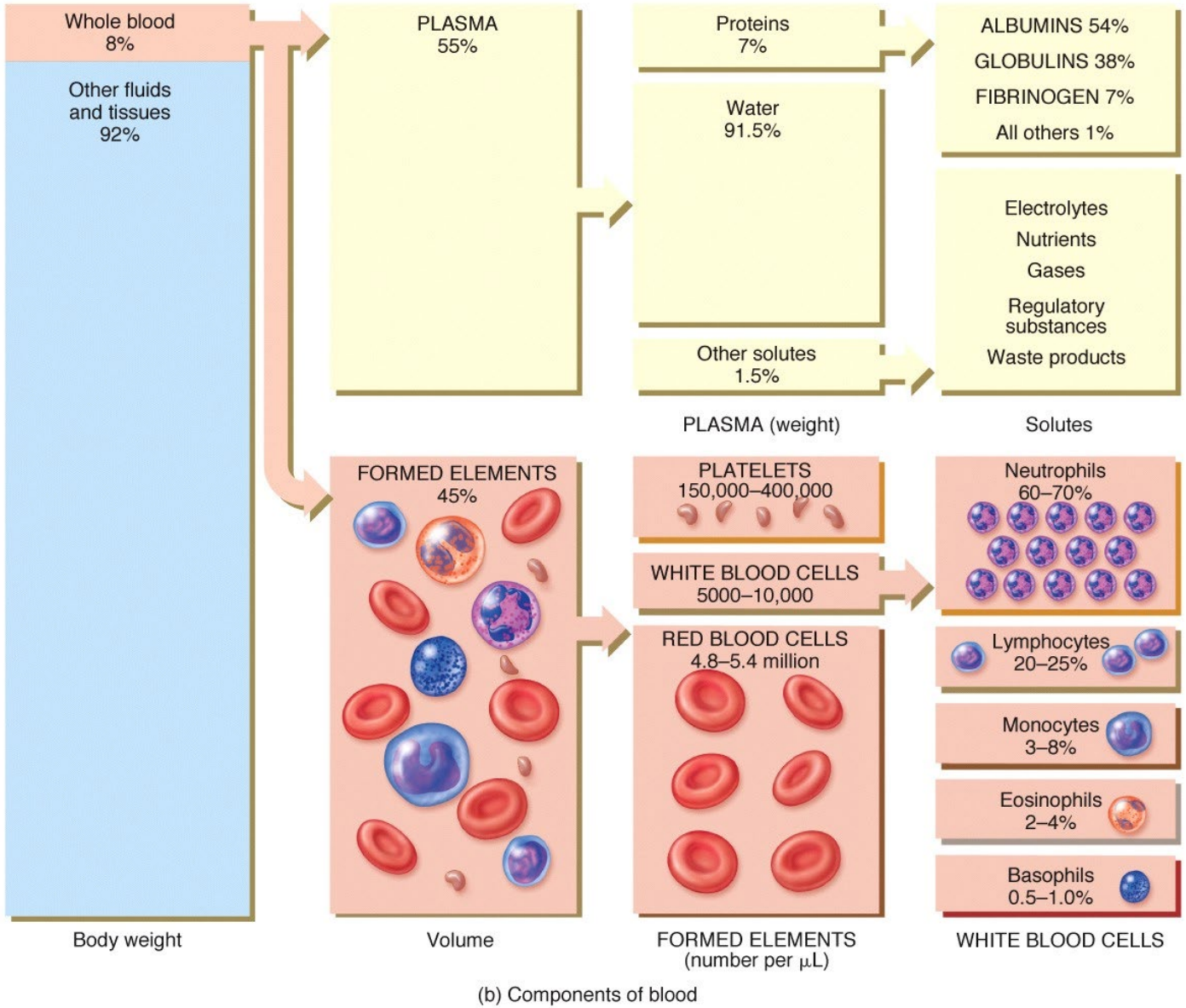
Transport // $O_2$, $CO_2$, nutrients, wastes, hormones, and stem cells

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

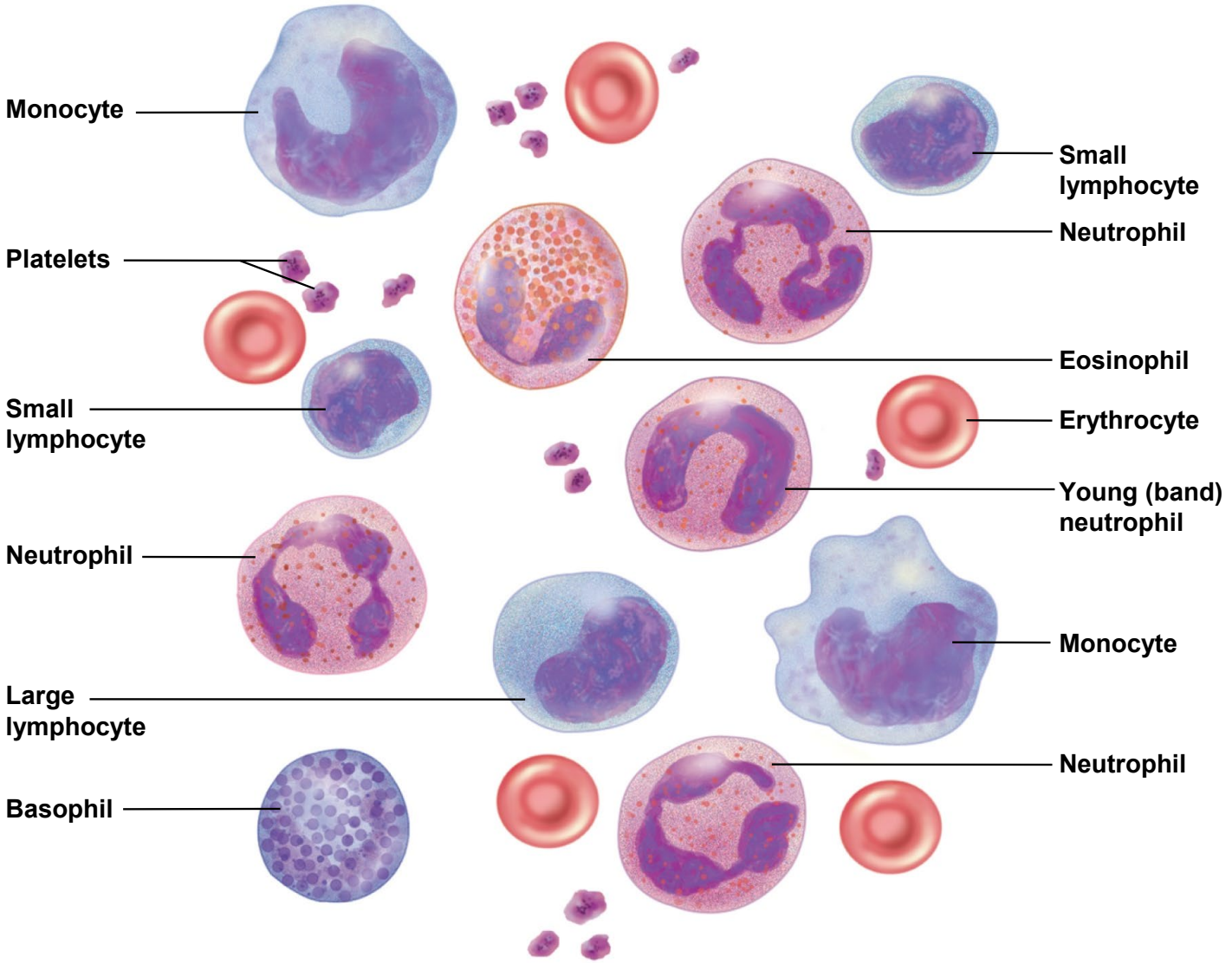
# General Properties of Blood

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

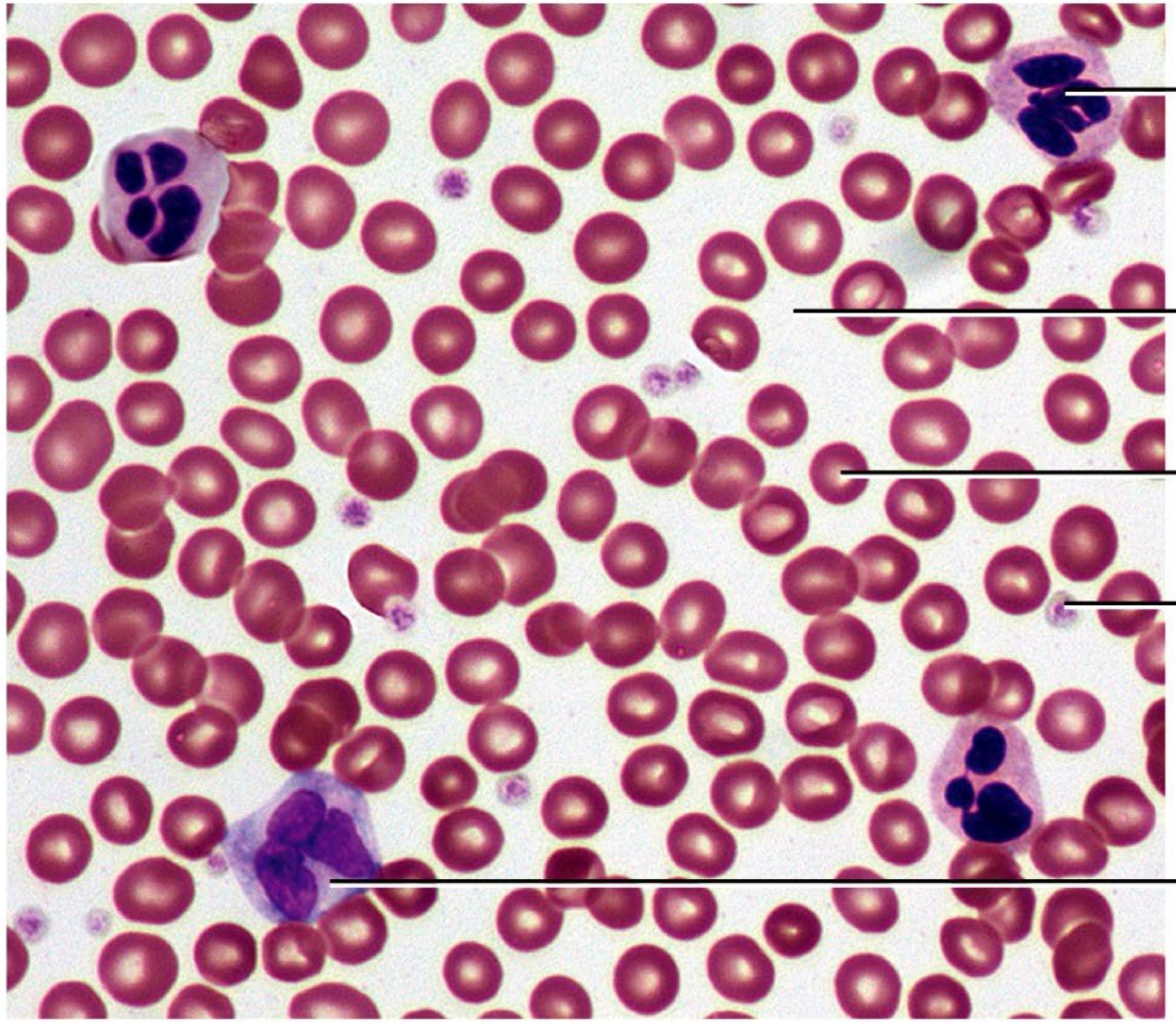


(b) Components of blood

# Formed Elements of Blood



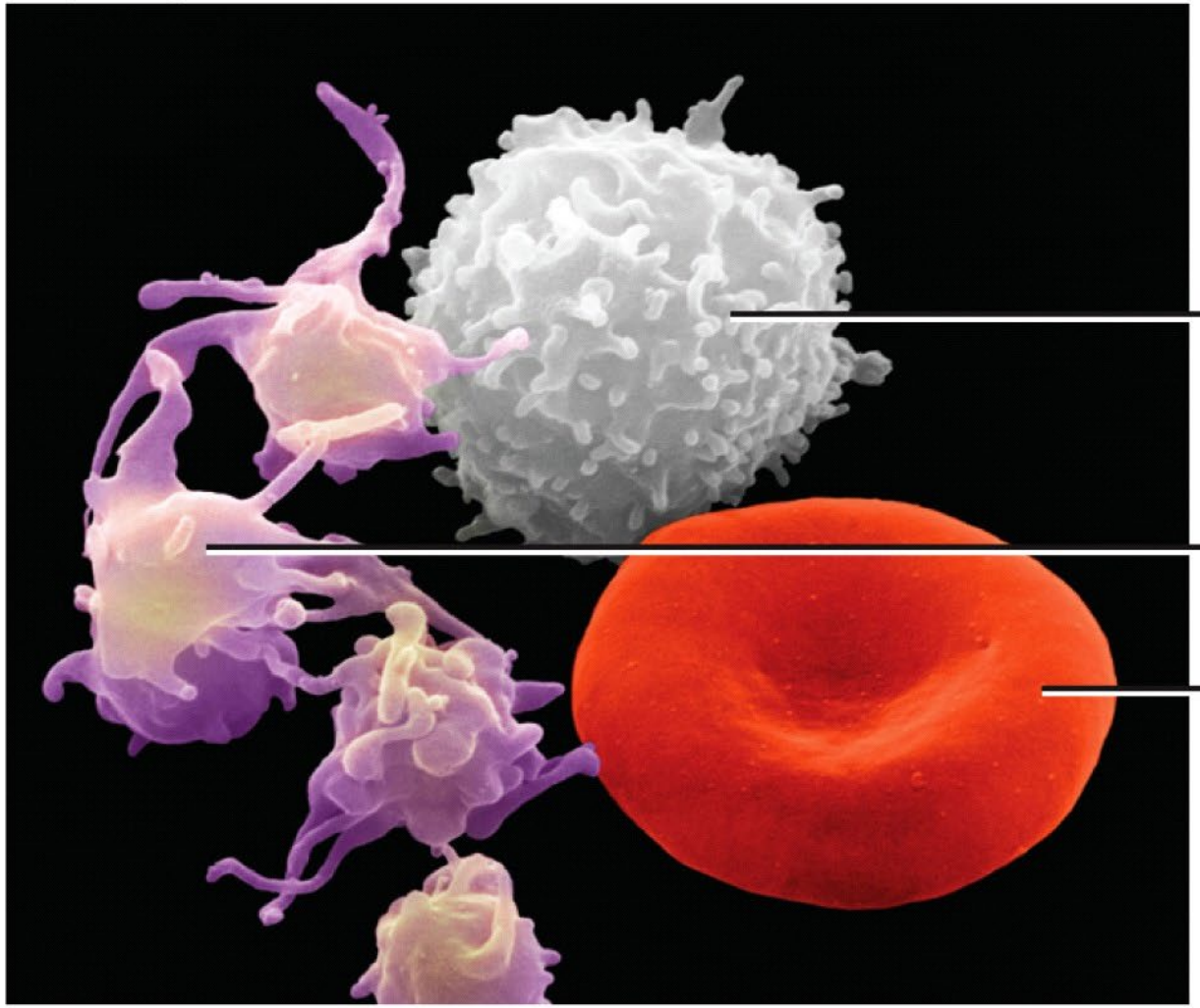
# Blood Smear Viewed with Light Microscope




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

# Formed Elements of Blood

Juergen Berger/Photo Researchers, Inc.




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

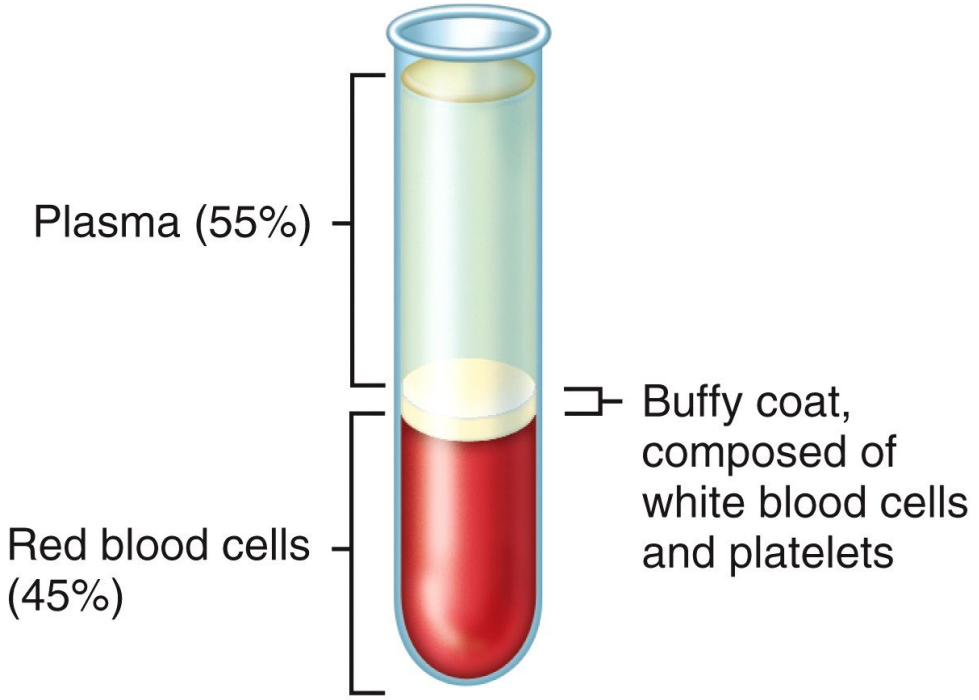
Matrix is the plasma = different types of proteins

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 a "fibrin clump"




(a) Appearance of centrifuged blood

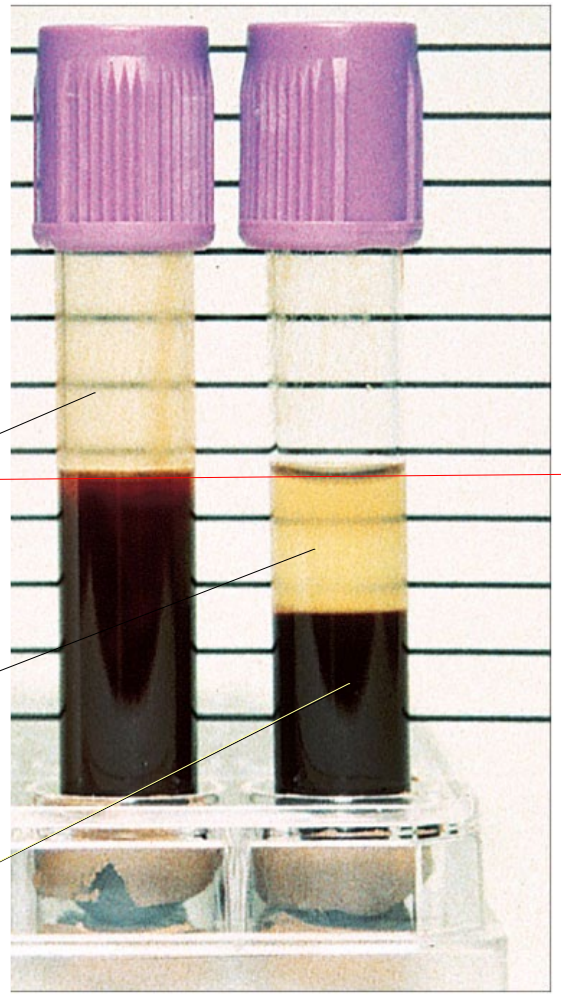
Formed elements = all blood cells and cell fragments

# 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

A B



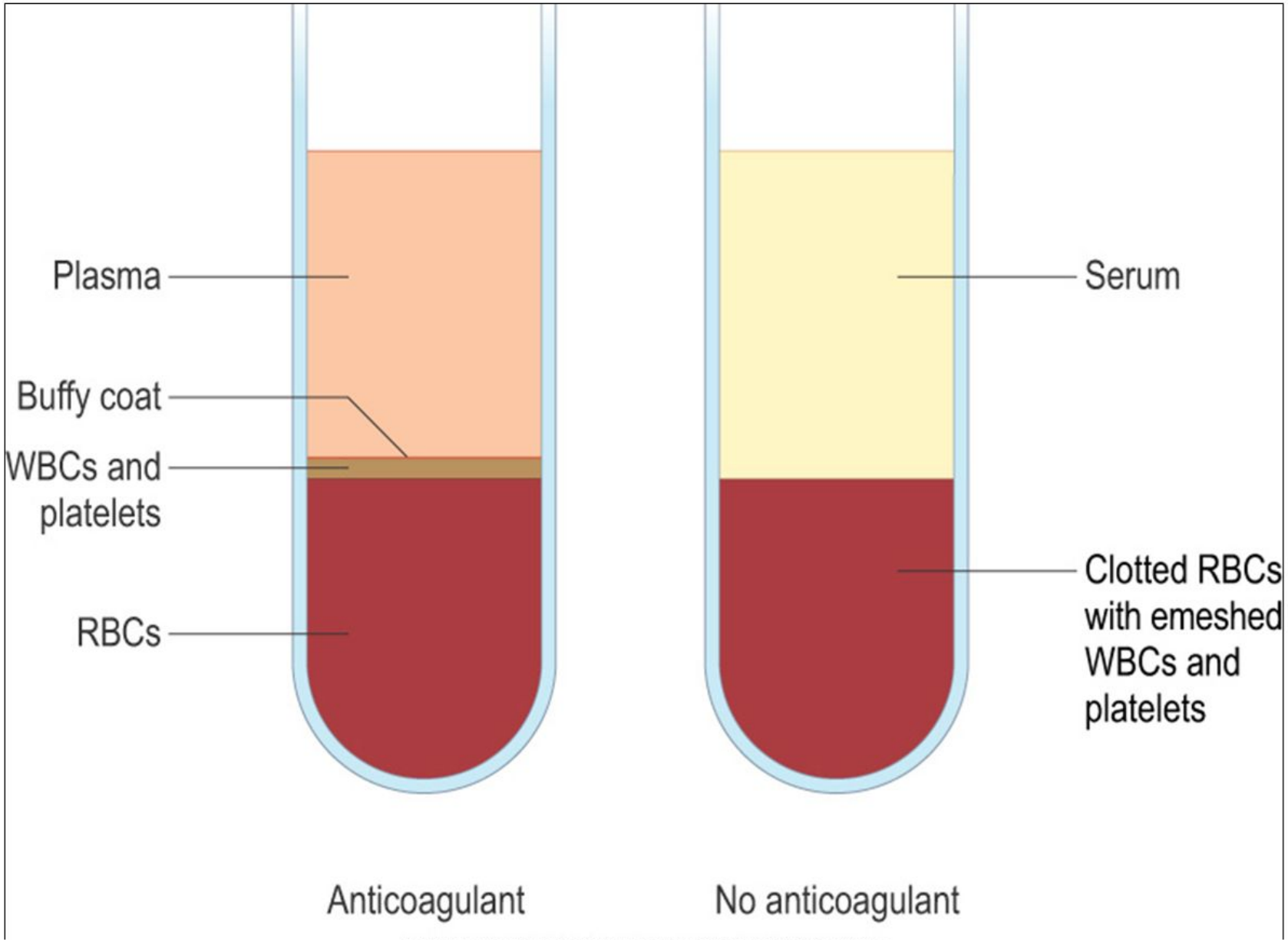
Left test tube above red line is blood residue On the inner surface of the test tube

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

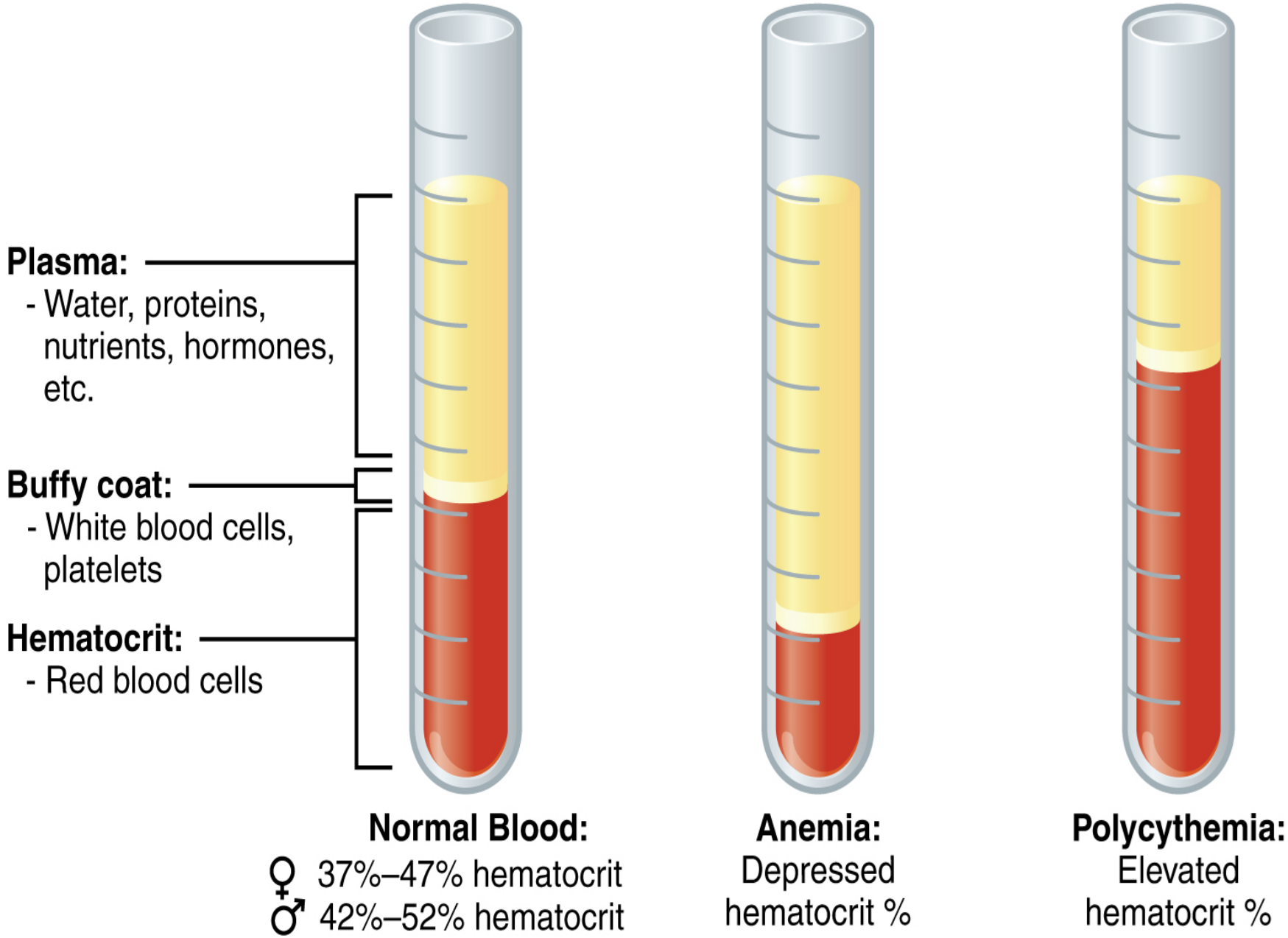
Formed Elements

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.

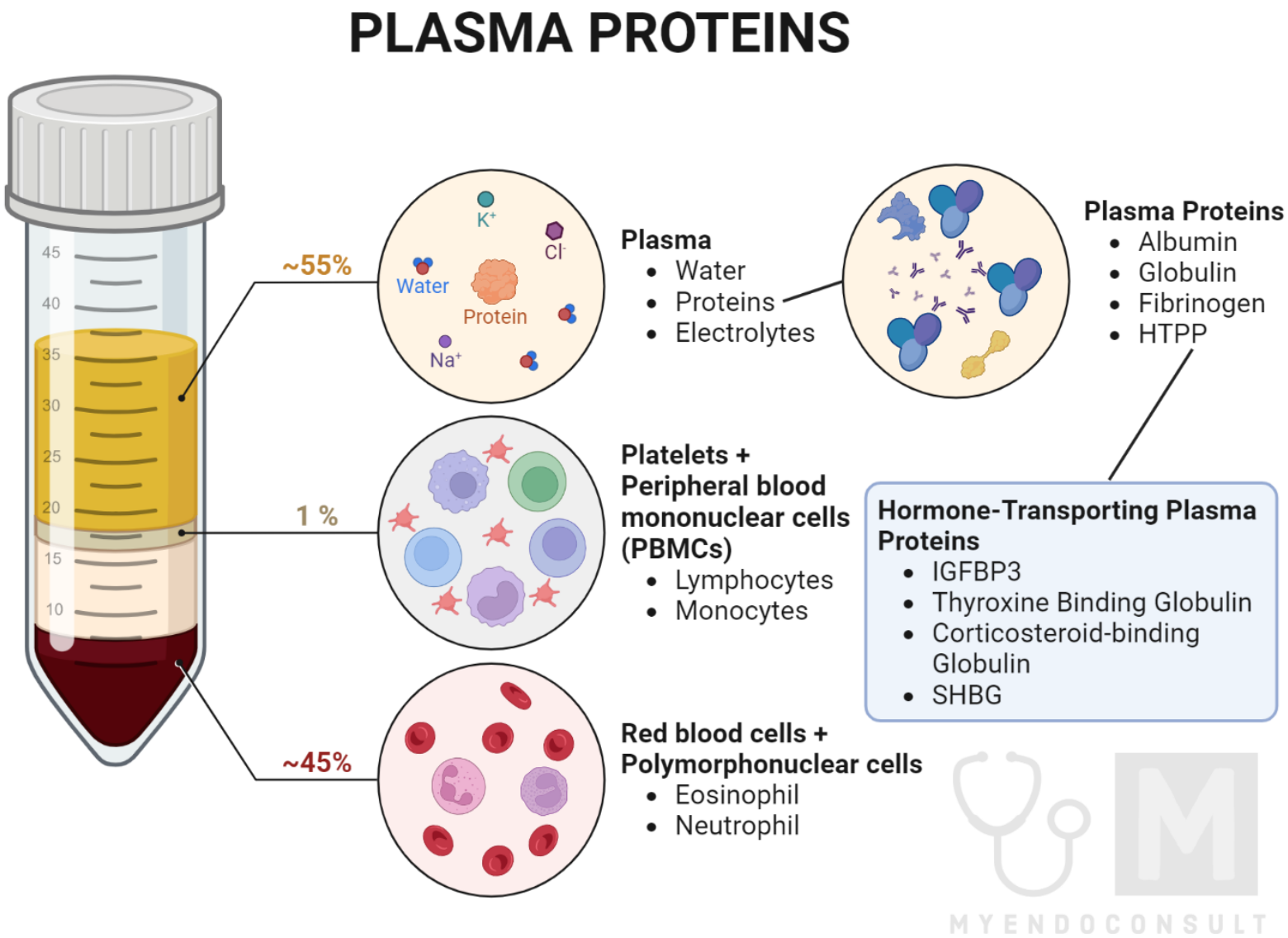

Plasma:
- Water, proteins, nutrients, hormones, etc.
Buffy coat:
- White blood cells, platelets
Hematocrit:
- Red blood cells
Normal Blood:
♀ 37%–47% hematocrit
♂ 42%–52% hematocrit
Anemia:
Depressed hematocrit %
Polycythemia:
Elevated hematocrit %

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) make up part of the plasma proteins but these proteins are formed by plasma cells.

Plasma cells are a formed element that start as a B cells and after proper stimulation become a plasma cell.



# 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)

# Viscosity

Viscosity is a measure of a fluid's resistance to flow.

**Water**
Lower Viscosity
1.0 centipoise

**Honey**
Higher Viscosity
12,200.0 centipoise

sciencenotes.org

# 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

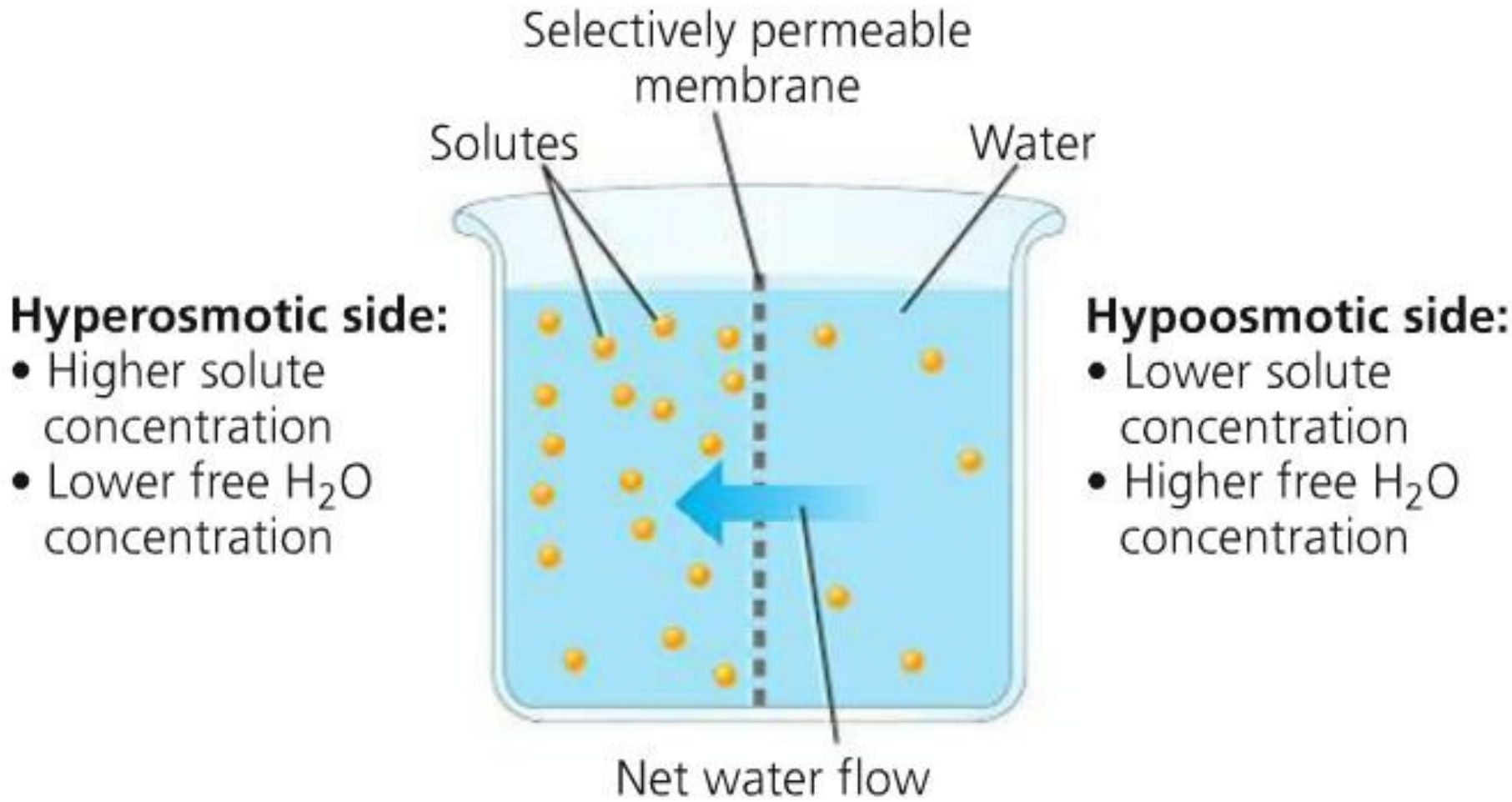
Osmosis requires a semipermeable membrane to restrict the movement of solute across the membrane /// capillaries and plasma membranes are semipermeable membranes

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


Selectively permeable membrane
Solutes
Water
Hyperosmotic side:
• Higher solute concentration
• Lower free $H_2O$ concentration
Hypoosmotic side:
• Lower solute concentration
• Higher free $H_2O$ concentration
Net water flow

# Non-Protein Components of the Plasma

Nitrogenous compounds

Free amino acids // from dietary protein or tissue breakdown

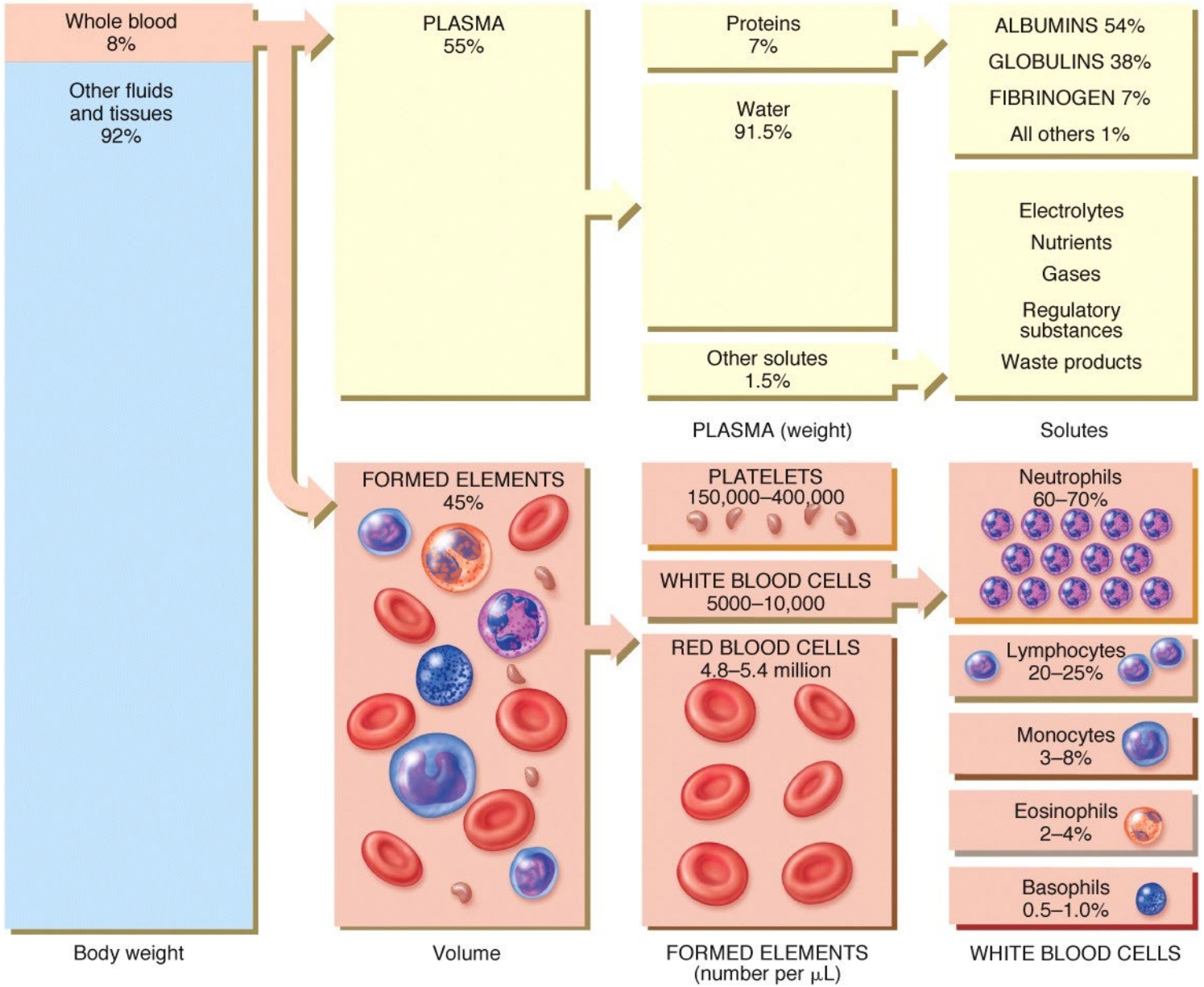
Nitrogenous wastes (urea)

- 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 $O_2$, $CO_2$, 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

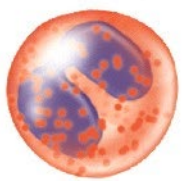
» memorize WBC order with this saying / high to low / “Never let monkeys eat bananas”

Red Blood Cells (RBCs)
or Erythrocytes

**Granular leukocytes**

Neutrophils

Eosinophils



Basophils

**Agranular leukocytes**

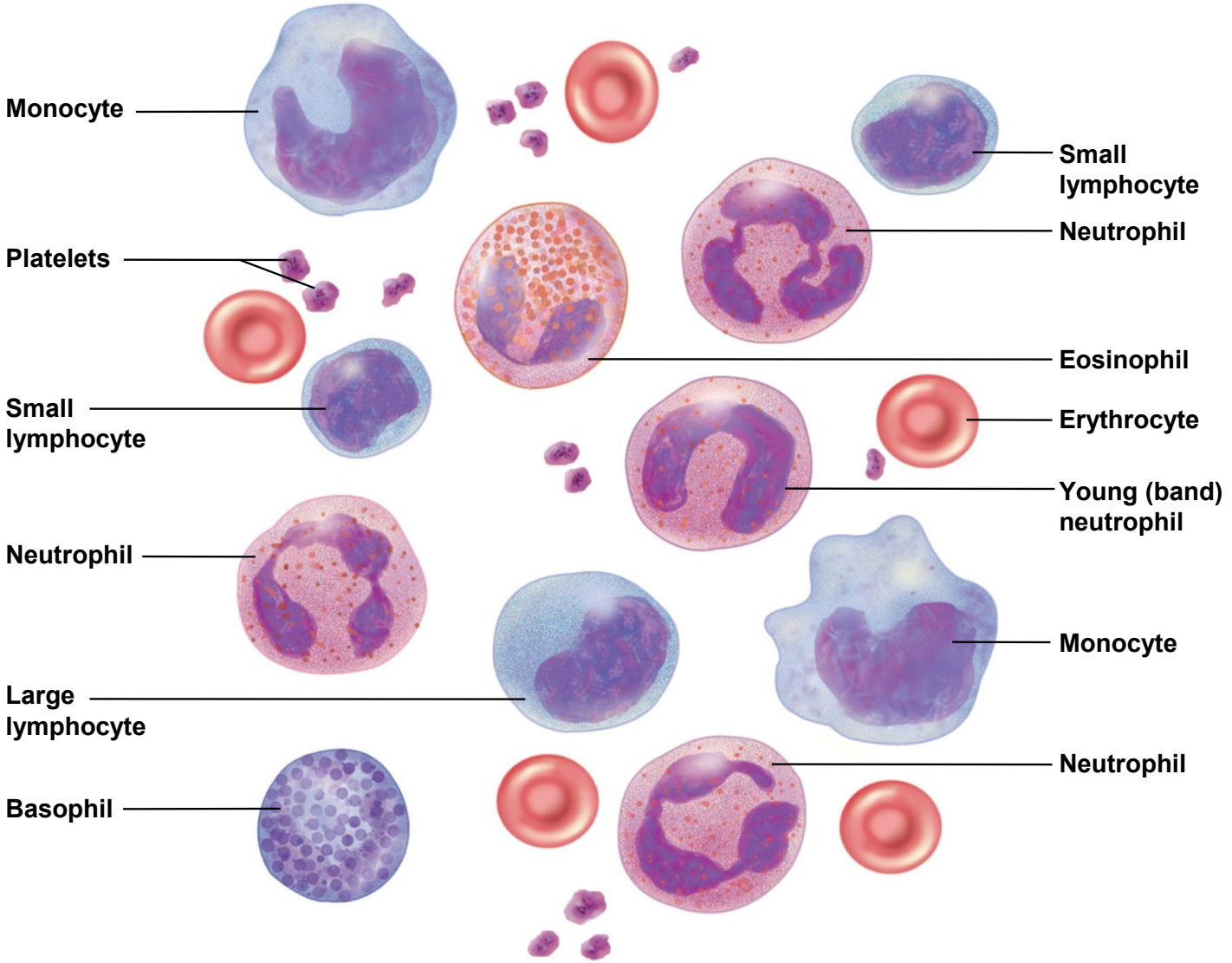
Lymphocytes (T cells, B cells,
and natural killer cells)

Monocytes

Platelets

# Formed Elements of Blood





# 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

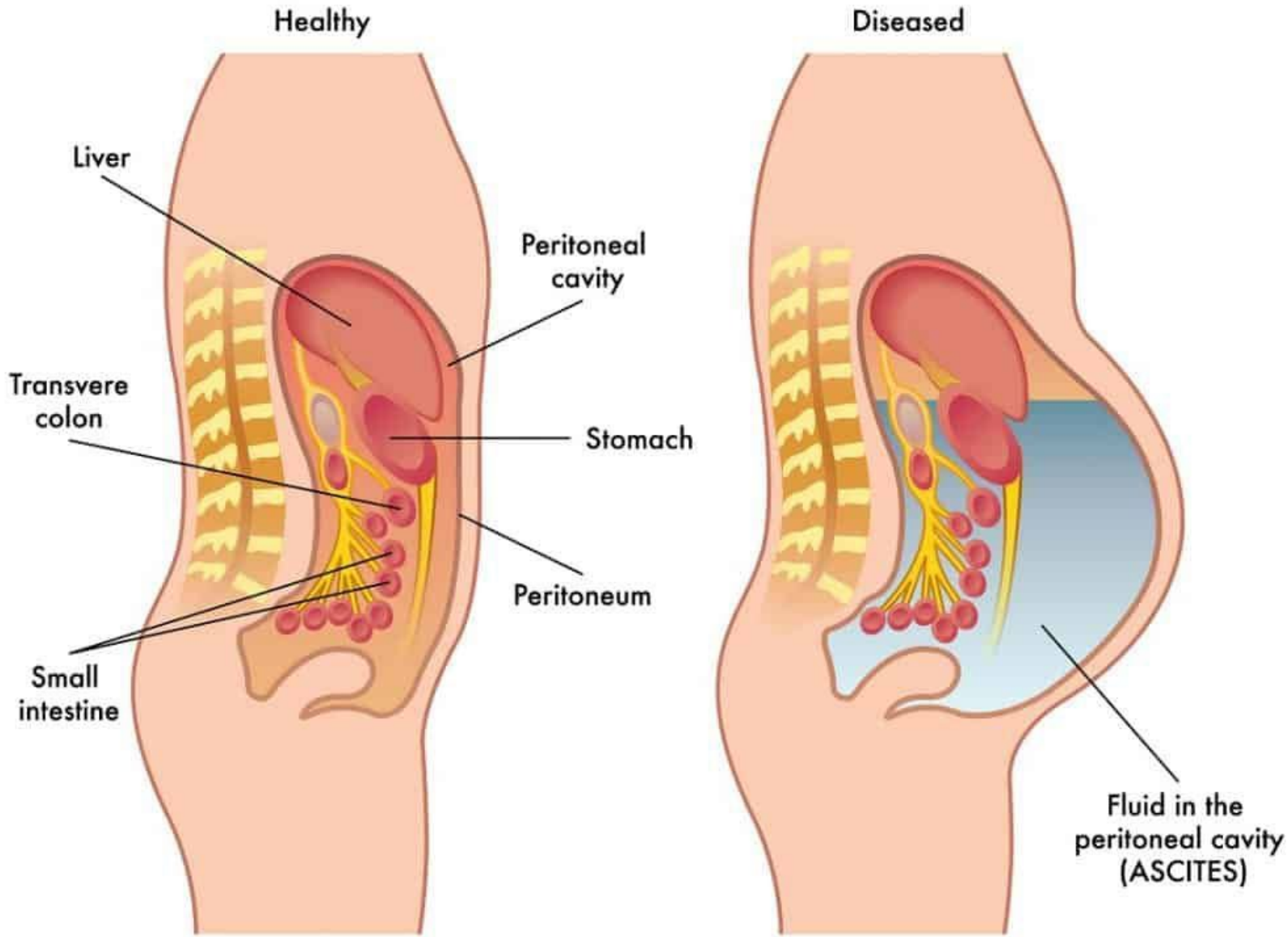
–lack dietary carbohydrate

–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.
See next slide

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


Healthy
Diseased
Liver
Peritoneal cavity
Transvere colon
Stomach
Peritoneum
Small intestine
Fluid in the peritoneal cavity (ASCITES)