Fluid & blood

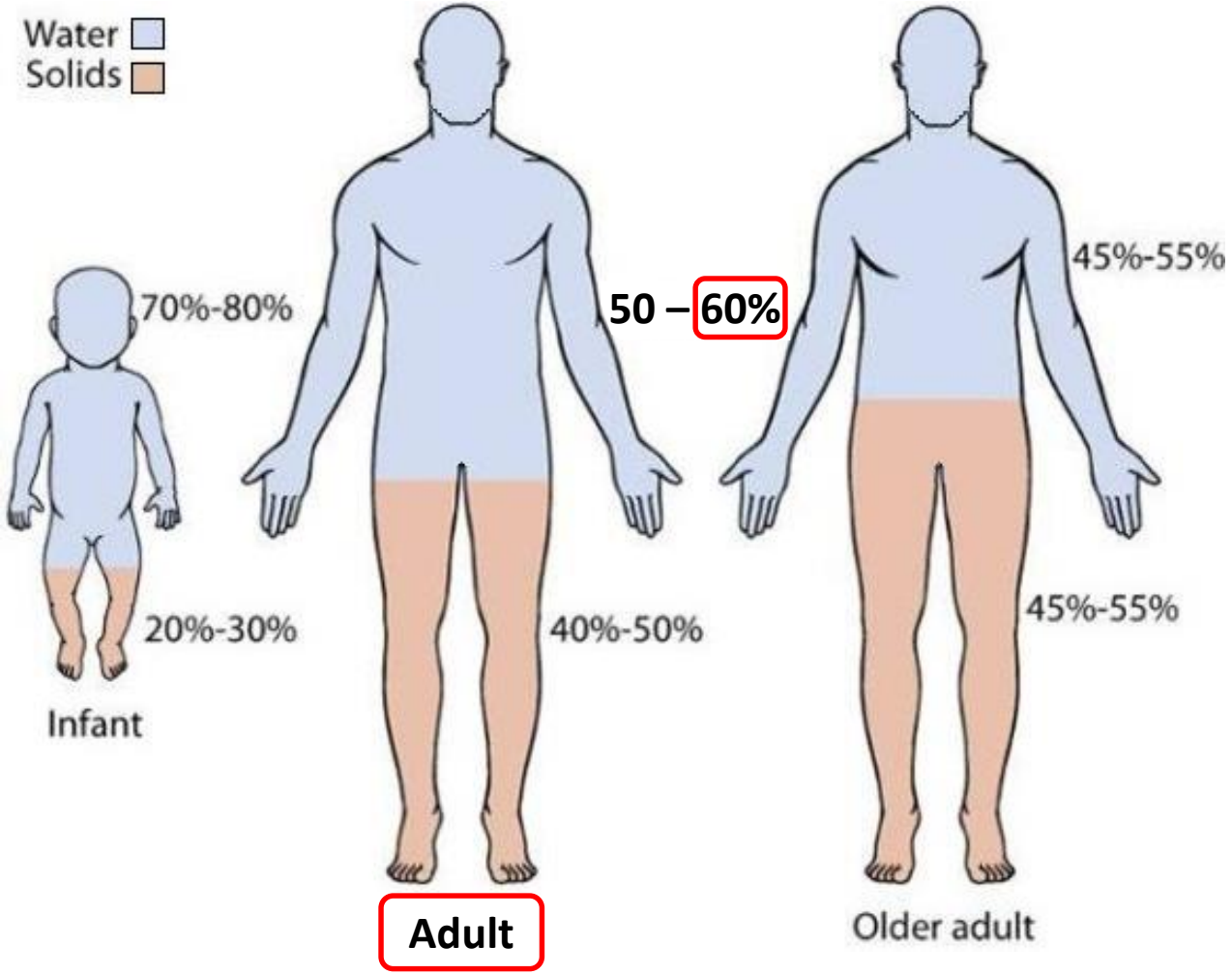
Dr. Philip Hung

Outline

- body fluid
  - body composition
  - difference of body composition in gender, age, and body size
  - body fluid compartment
  - chemical composition of body fluid
  - different solution for fluid imbalance

- blood
  - function
  - physical characteristics
  - RBC
  - WBC

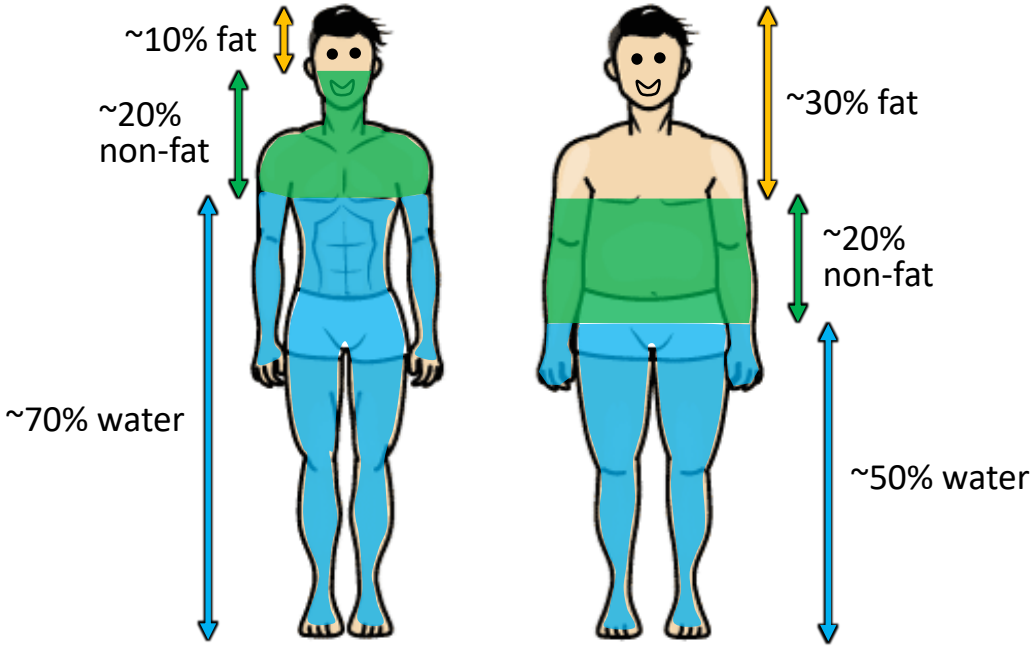
Body composition

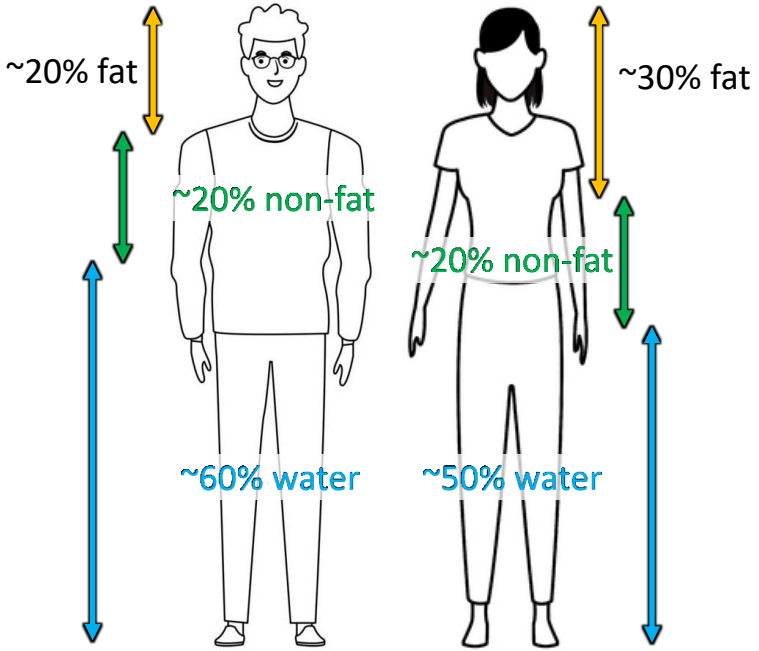


- during aging, there is a decrease in lean body mass in favor of fat.
- **elderly** therefore have **less body water** than the young one

A fat man contains less water (%) than a thin man.

Women contains less water (%) than men.

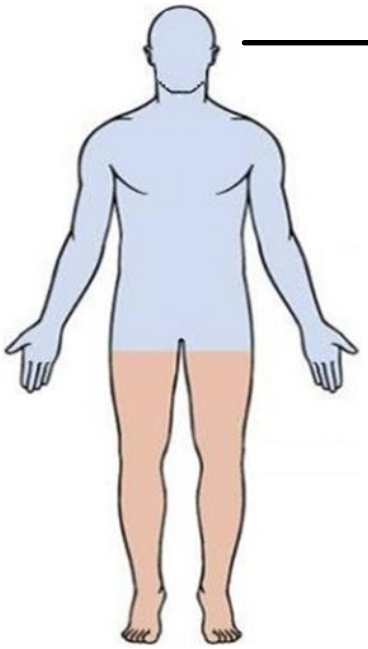




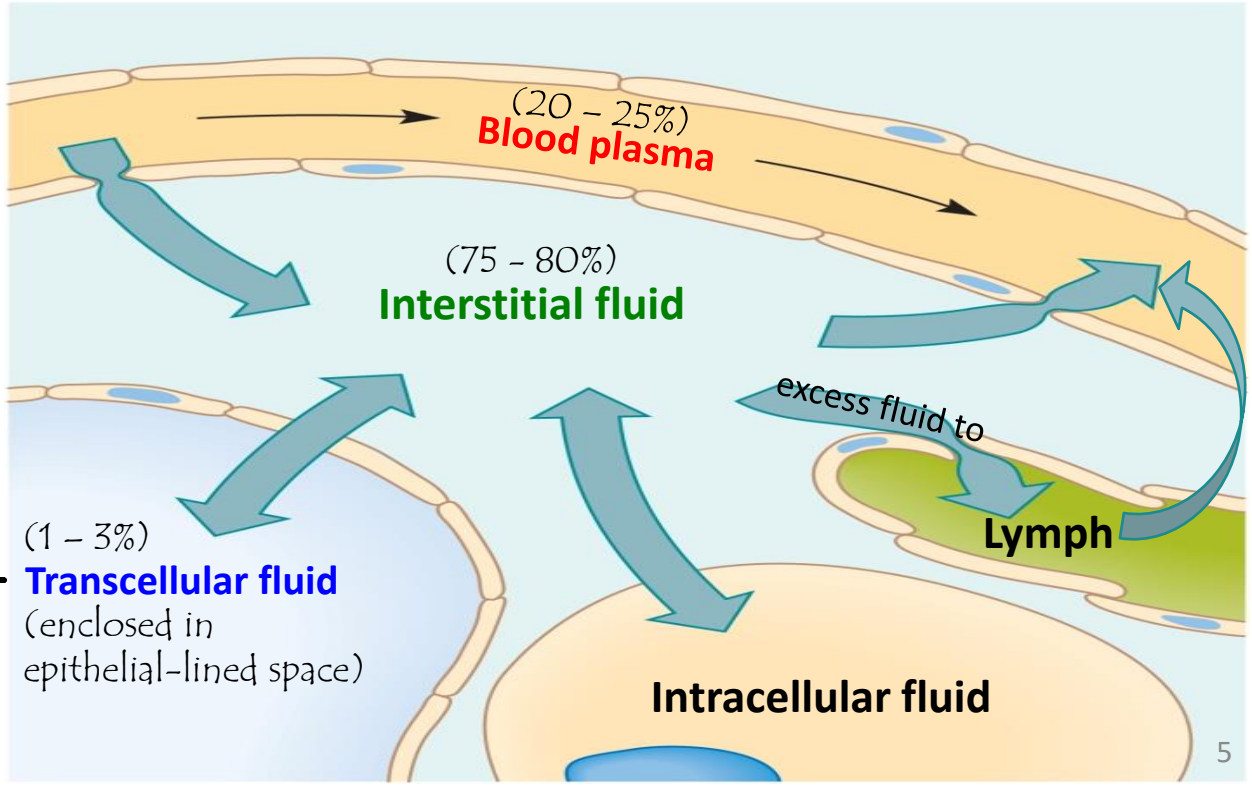
Body fluid: different compartments

Total body fluid
(~60% body weight)

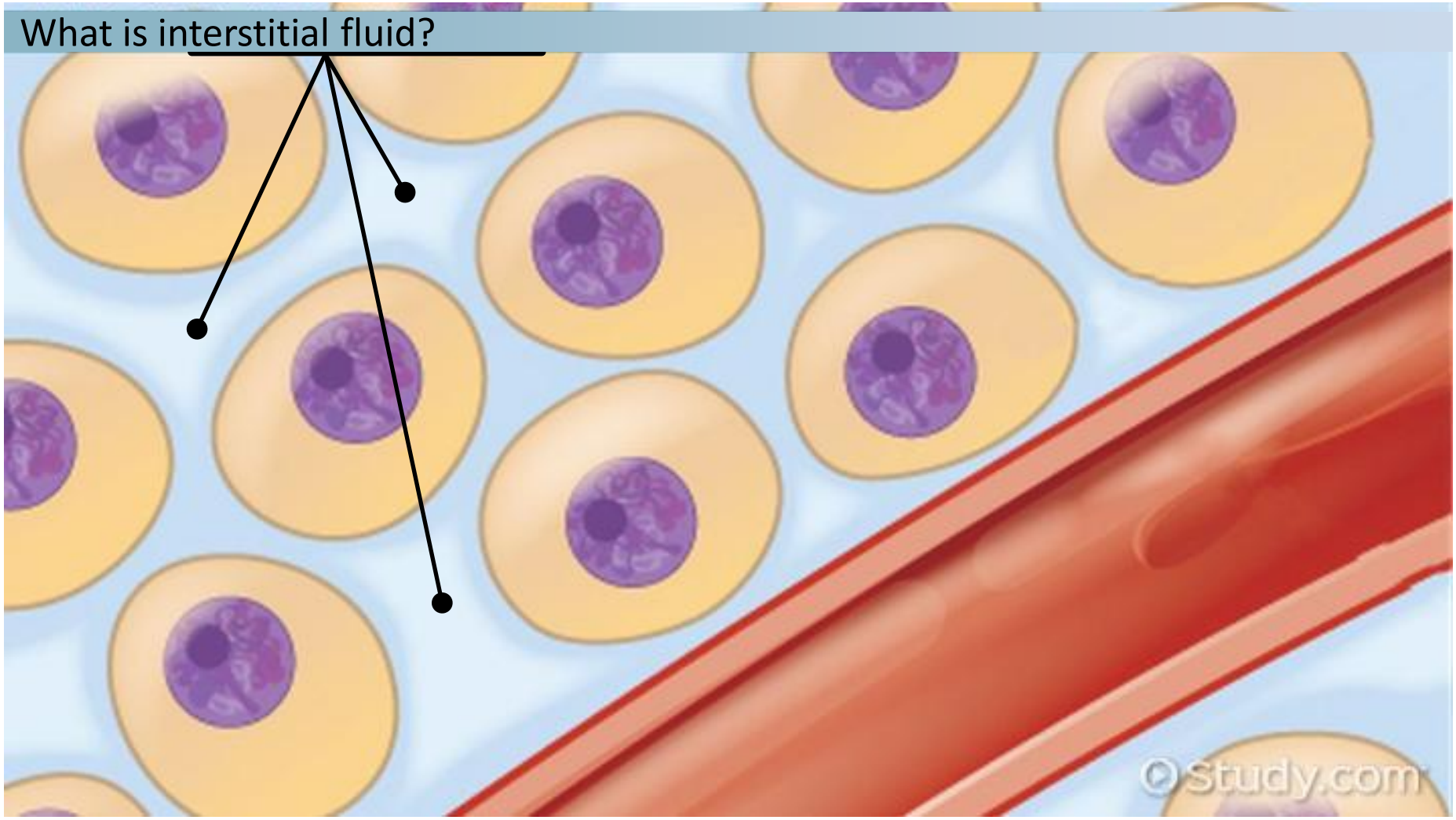
- **intracellular fluid** ($\frac{2}{3}$ **of total body fluid**)
- **extracellular fluid** ($\frac{1}{3}$)
  - **intravascular fluid** (20–25%) — **blood**, **lymph**
  - **interstitial fluid** (75–80%)
  - **transcellular fluid** (1–3%)



Additional info:
e.g. synovial fluid,
peritoneal fluid
cerebrospinal fluid
gastrointestinal fluid
urine



What is interstitial fluid?

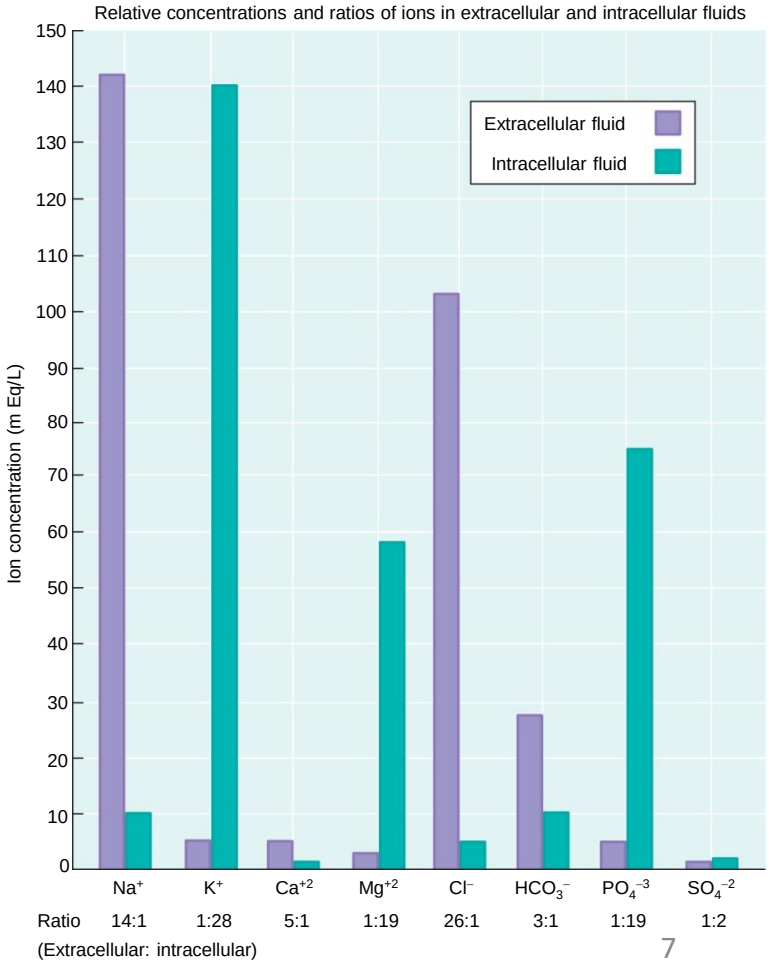


Na, Latin *natrium*
K, Neo-Latin kalium

Body fluid: chemical composition

- **extracellular** fluid: relatively high in
  - **sodium ions**, Na^+
  - **calcium ions**, Ca^{2+}
  - **chloride ions**, Cl^-
  - **bicarbonate ions**, HCO_3^-

- **intracellular** fluid: relatively high in
  - **potassium ions**, K^+
  - magnesium ions, Mg^{2+}
  - **phosphate ions**, PO_4^{3-}
  - sulfate ions, SO_4^{2-}



Infusion solutions used for fluid imbalance

- **Isotonic**
  - if solution has the osmolarity the same as that inside the cell & **blood**

- **Hypertonic**
  - if solution has the osmolarity higher than that inside the cell & **blood** *[more concentrated]*

- **Hypotonic**
  - if solution has the osmolarity lower than that inside the cell & **blood** *[less concentrated]*

Questions…

Which of the solutions is preferred in the following situations?

- hyponatremia (blood sodium lower than normal range)
  [hypo– = "lower" ; natr– = "sodium" ; –emia = "in blood"]

- hypernatremia

- bleeding

Way of thinking:

- water follows s _ _ _ or s _ _ _ _ _

Osmolarity OR osmolality

Both indicate total concentration of all solutes…but…

- osmolarity
  = number of all solute particles **per unit volume** (Osm/L)
  [Note: volume changes with environmental temperature] 😢

- osmolality
  = number of all solute particles **per unit weight** (Osm/kg)
  [Note: weight does not change with environmental temperature] 😊

So which unit is preferred to use clinically?

Crystalloid VS colloid infusion solution

Crystalloid:

- **has solutes which can pass through cell membrane, so fluid (solute+water) can translocate among blood, ISF and even** intracellular fluid (**ICF**)
- **e.g. isotonic crystalloid solution** (**0.9% saline**, **5% dextrose**[glucose])

Colloid:

- **has solutes which are too big to pass through cell membrane, so fluid stay in blood**
- **is also called as volume or plasma expander**
- **e.g. albumin** (hypertonic [20%] or isotonic [4%]) **for hypoalbuminemia or hypovolemia**

Blood

- River of life that surges within each of us
- Blood is life-sustaining transport vehicle of cardiovascular system

Transport

- oxygen, minerals, nutrients
- metabolic wastes
- hormones

Regulation

- maintains body temperature

Protection

- protects from blood loss
- prevents infections

Blood: physical characteristics

- sticky, opaque (non-transparent)
- ~8% of body weight
- male: 5 – 6 L ; female: 4 – 5 L
  - e.g. 70 kg man, his blood: ~ 5.6 L
- color depends on O_2 content
  - **high O_2 level: scarlet red**
  - **low O_2 level: dark red**
- pH: **7.4** (7.35 – 7.45), i.e.
  - **slightly alkaline**

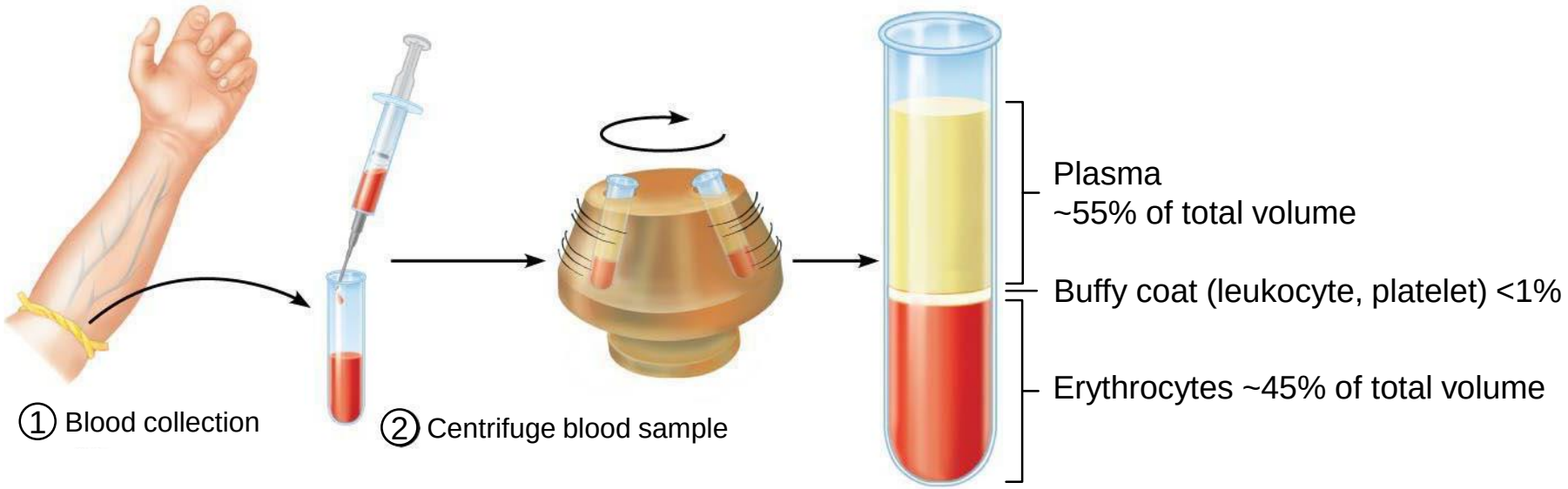
Blood: composition

Other than lymph, blood is only fluid tissue

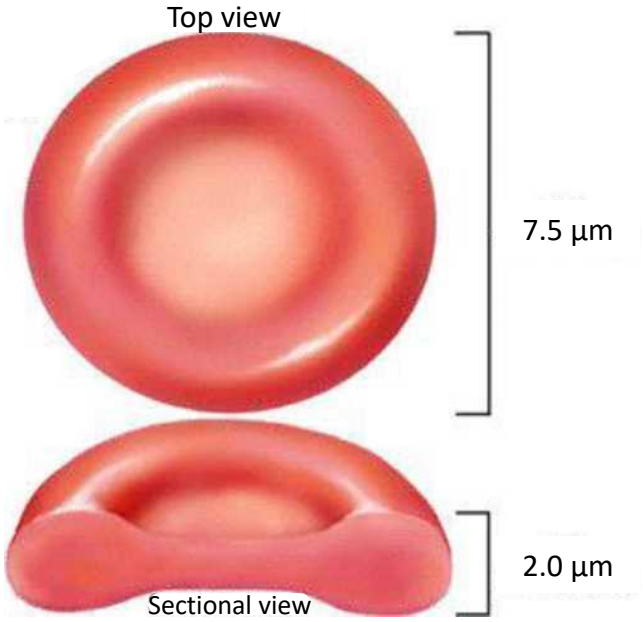
- **matrix**, i.e. **fluid component / plasma**

- **formed elements**, i.e. **blood cells**
  - **red blood cells** (erythrocytes)
  - **white blood cells** (leukocytes)
  - **platelets** (thrombocytes) for **blood coagulation**

Blood: composition



RBC/erythrocyte

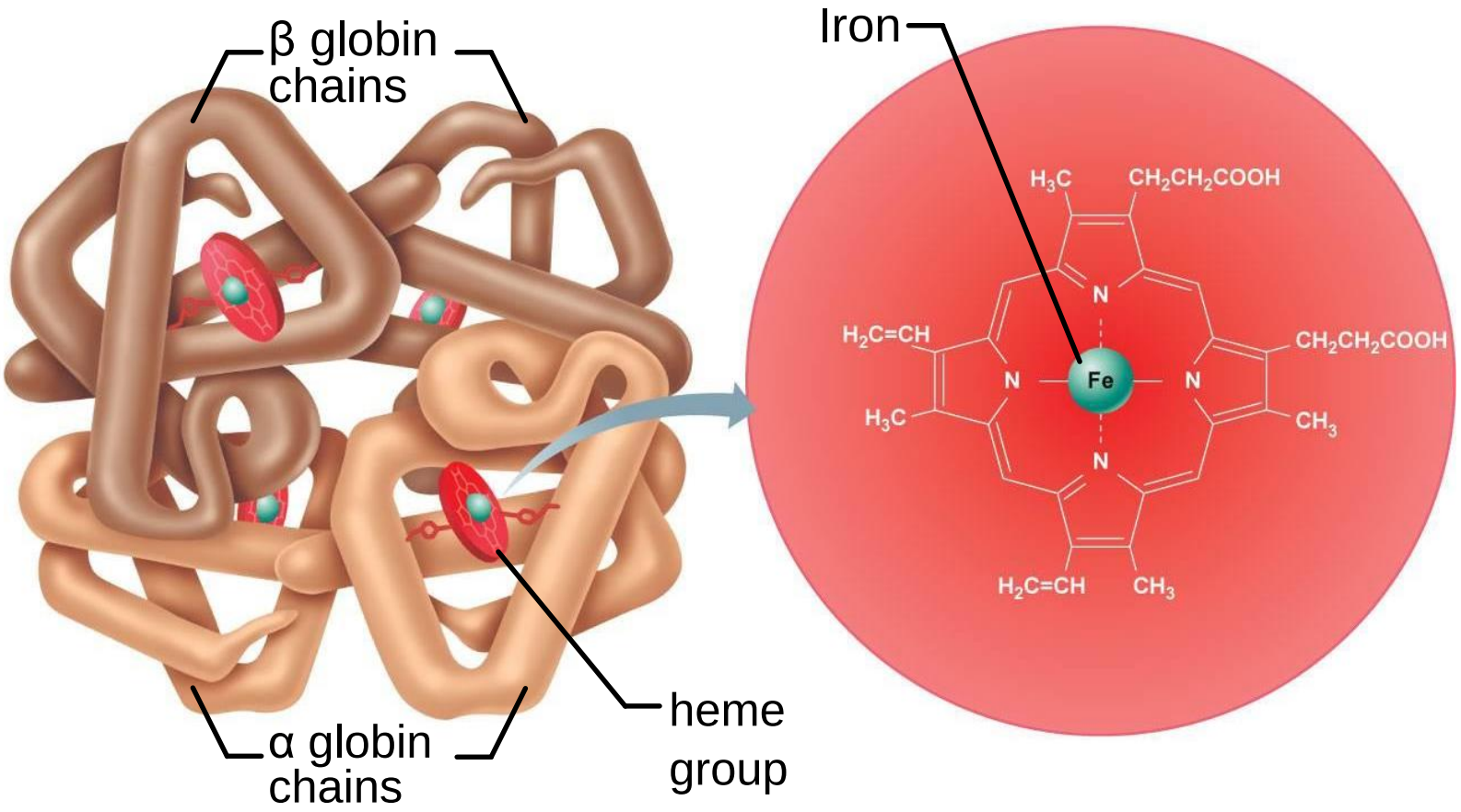


Structural characteristics

- to facilitate efficient gas transport:
  - **is biconcave**
    - **so more surface area for gas exchange**
  - **has no nucleus & no organelles**
    - **so more hemoglobin** is packed inside cell
  - **has no mitochondria,**
    - **so does not consume O_2**

- **is flexible** / change shape **when passing through capillaries**

Hemoglobin



- **consists of four subunits** /polypeptide chains (two alpha & two beta) **& four heme groups**
  - **each heme binds to _ _ _ oxygen molecule**

Leukocytes

- responsible for inflammation, phagocytosis, fever & adaptive immunity

- from most abundant to least abundant
  - **N**ever **Neutrophil**
  - **L**et **Lymphocyte, e.g. B cell, T cell**
  - **M**onkeys **Monocytes/macrophage**
  - **E**at **Eosinophil**
  - **B**ananas **Basophil**

Additional info: other leukocyte: mast cell & natural killer cell

Neutrophil

- **most abundant leukocyte** in blood
- "**bacterial slayer**"
- **phagocytic**

Neutrophil (60 – 70%)
- multilobed nucleus,
- pale red & blue cytoplasmic granules

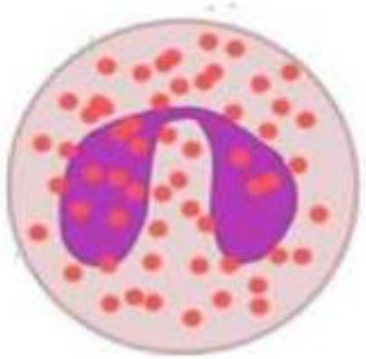
Monocytes/macrophage

- **largest** of all leukocytes
- **various cellular targets**
- when entering tissue,
  - differentiate into **macrophage**
    - **chief phagocytic**
    - **prefer to reside in tissue**

Monocyte (3 – 8%)
- kidney-shaped nucleus
- pale blue cytoplasm

Eosinophil

- **phagocytic**
- **target parasitic worms**
- **induce allergies and asthma by stimulating basophils**



Eosinophil (2 – 4%)
- bilobed nucleus
- red cytoplasmic granules

Basophil

- **phagocytic**
- **release heparin to counteract blood clotting**
- **release histamine** (inflammatory chemicals) to
  - **induce vasodilation**
  - **attract leukocytes to inflamed sites**

Basophil (0.5 – 1%)
- bilobed nucleus
- purplish-black cytoplasmic granules

Lymphocytes

- **non-phagocytic**
- crucial to **adaptive immunity**, e.g. T cell & B cell
- rather **found in lymphoid tissues** than blood circulation

Lymphocyte (20 – 25%)
- large spherical nucleus,
- thin rim of pale blue cytoplasm

Additional info:
- natural killer cell,
  - lymphocyte, but rather important in innate immunity
  - kill cancer cell or virus-infected cell by inducing apoptosis (programmed cell death)

Additional info: lymphoid tissues