Body fluids

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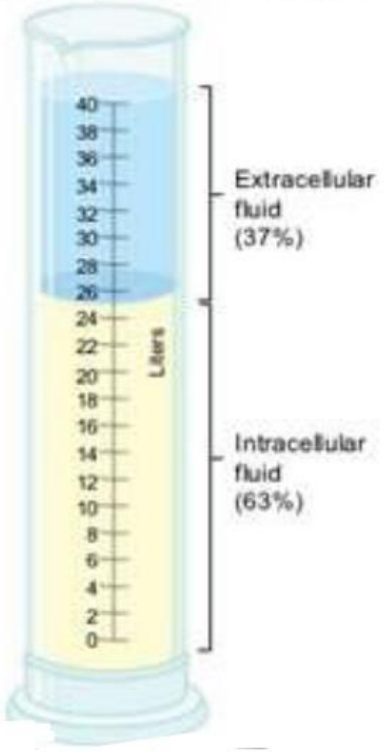
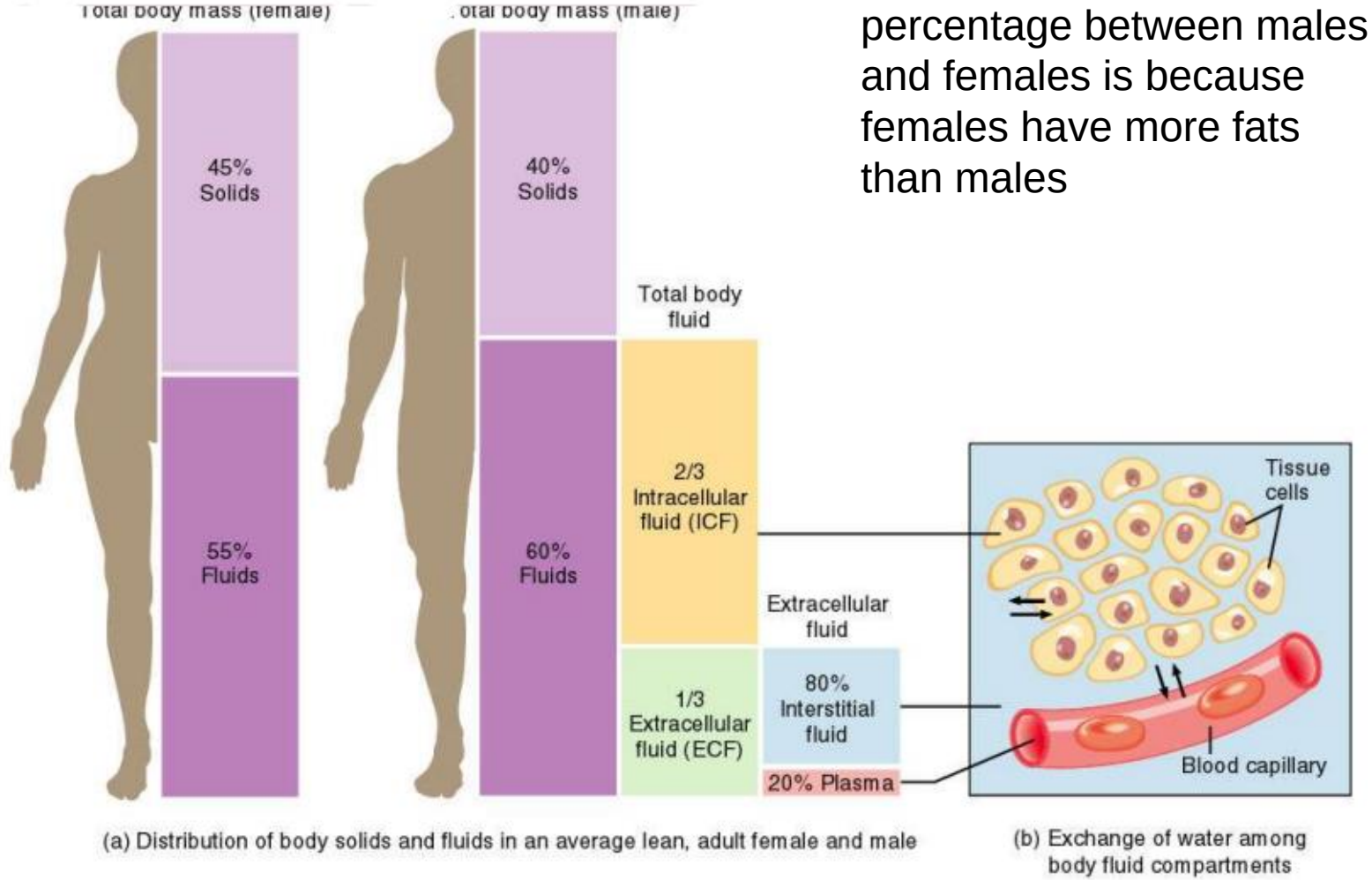
Topics discussed

- 1- Composition of body fluids
- 2- Water Balance
- 3- Water and Electrolytes Homeostasis
- 4- Regulation of Na+ and Water
- 5- Measurements of Body Fluids

1- Composition of body fluids



→ the difference in percentage between males and females is because females have more fats than males



1- Composition of body fluids

- Water is forming around 60% of the total body mass in males and around 55% of the total body mass in females (the difference in percentage is because females have more fats than males).
- These fluids are distributed inside cells and outside cells forming 2 compartments:
  1) 2/3 of these fluids are found inside cells forming intracellular fluid compartment.
  2) 1/3 of these fluids are distributed outside cells forming extracellular fluid compartment (ECF):
  A- 80% of (ECF) are found between cells forming interstitial fluid.
  B- around 20% of (ECF) are found inside vessels forming plasma (which is around the red blood cells and the blood cells inside vessels).
  C- There are fluids in the lymphatic vessels & trans-cellulary
- Types of transcellular fluids: Synovial • Pericardial • Pleural • Peritoneal • Ocular • Cerebrospinal

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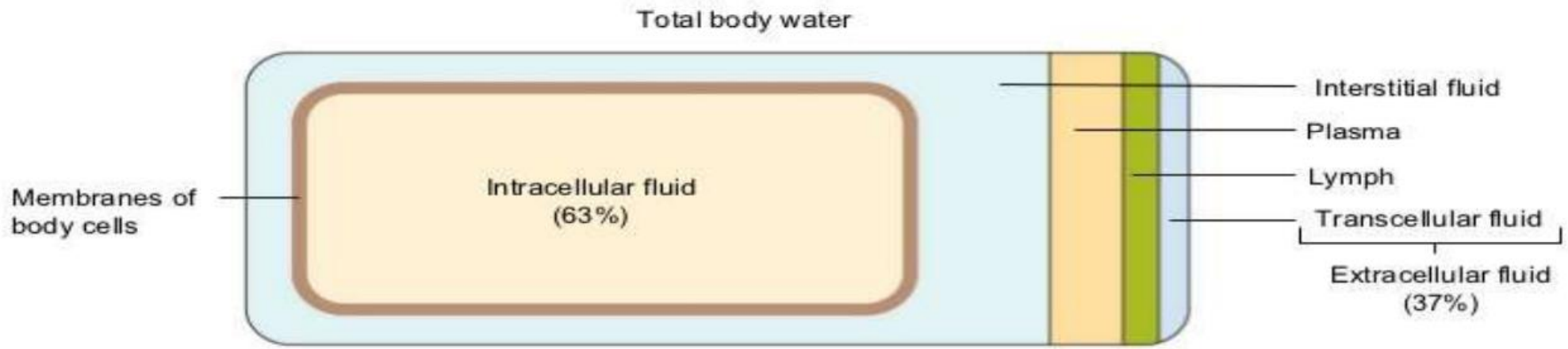
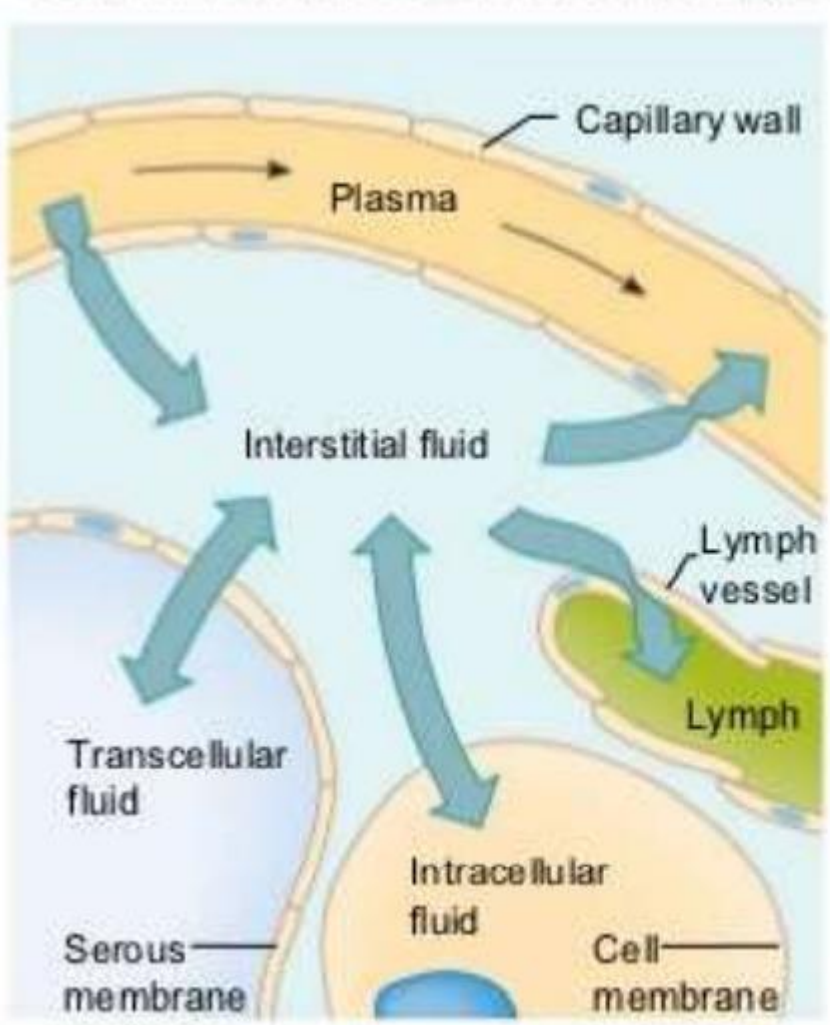
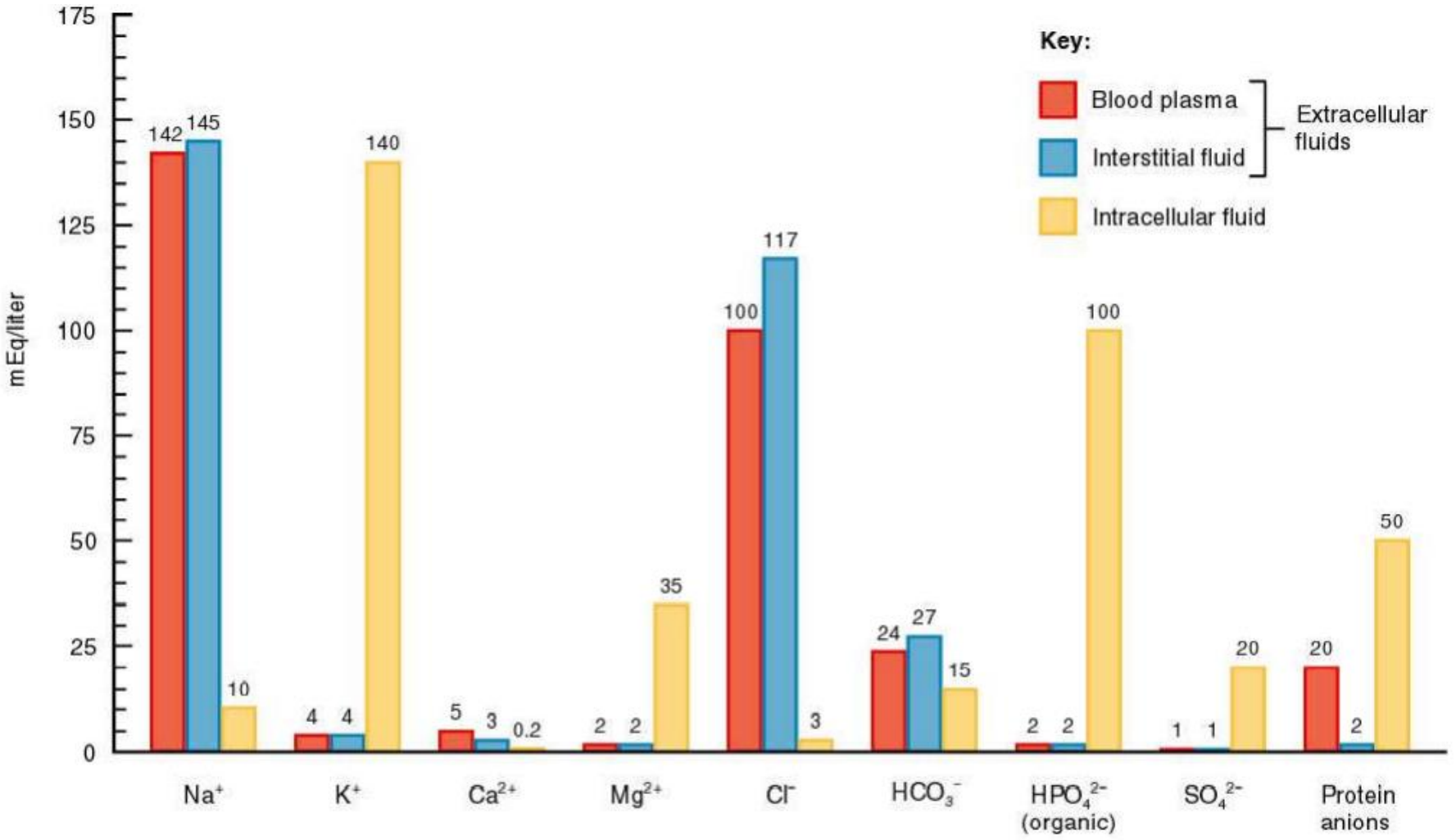


1- Composition of body fluids

- Major factors that regulate movements:
  - Osmotic pressure:
  - Hydrostatic pressure (pressure applied by the fluid in the wall of vascular system to the interstitial fluid)
- Note: the doctor didn't focus on the directions in the picture below, but he mentioned the movement of water particles between domains in general and the sites that water is found in



1- Composition of body fluids

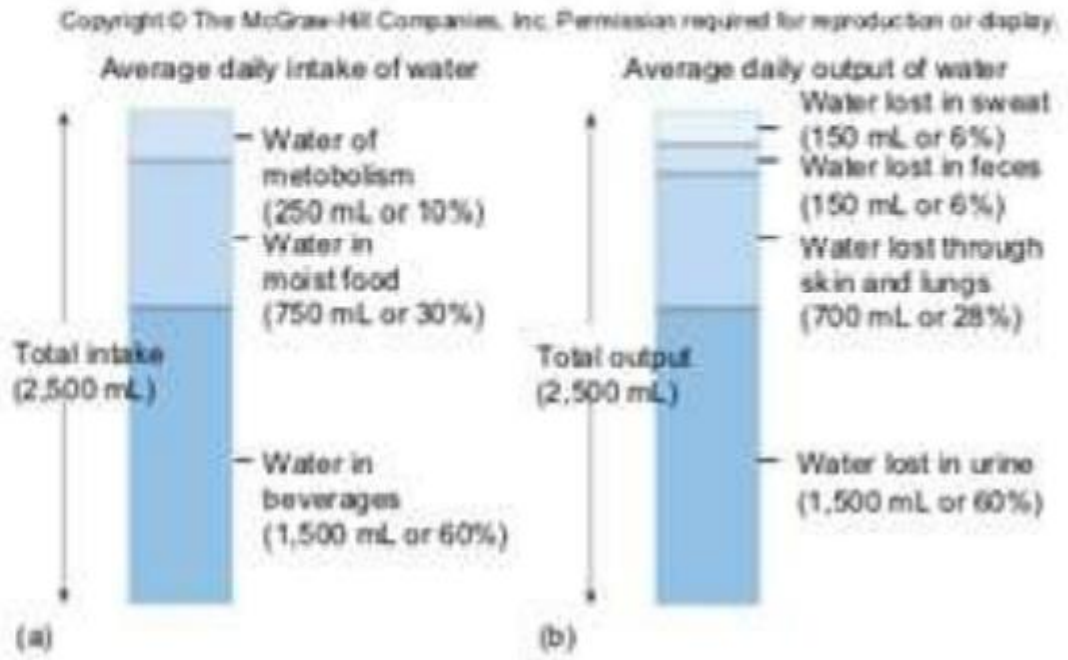


→ water moves between these compartments according to the pressure we are having in these compartments; the composition of these fluid may vary according to compartments (example: Na+ in extracellular compartment is high while K+ in intracellular fluid is high and we have low K+ in ECF)

→ There are also differences between sub compartments (example: higher amount of protein in plasma than in interstitial fluid both belong to ECF)

2- Water Balance

- Water Balance: Water input = Water output
- a) Water input:
  - The volume of water gained each day varies among individuals averaging about 2,500 milliliters daily for an adult:
    - 60% from drinking
    - 30% from moist foods
    - 10% as a bi-product of oxidative metabolism of nutrients called water of metabolism

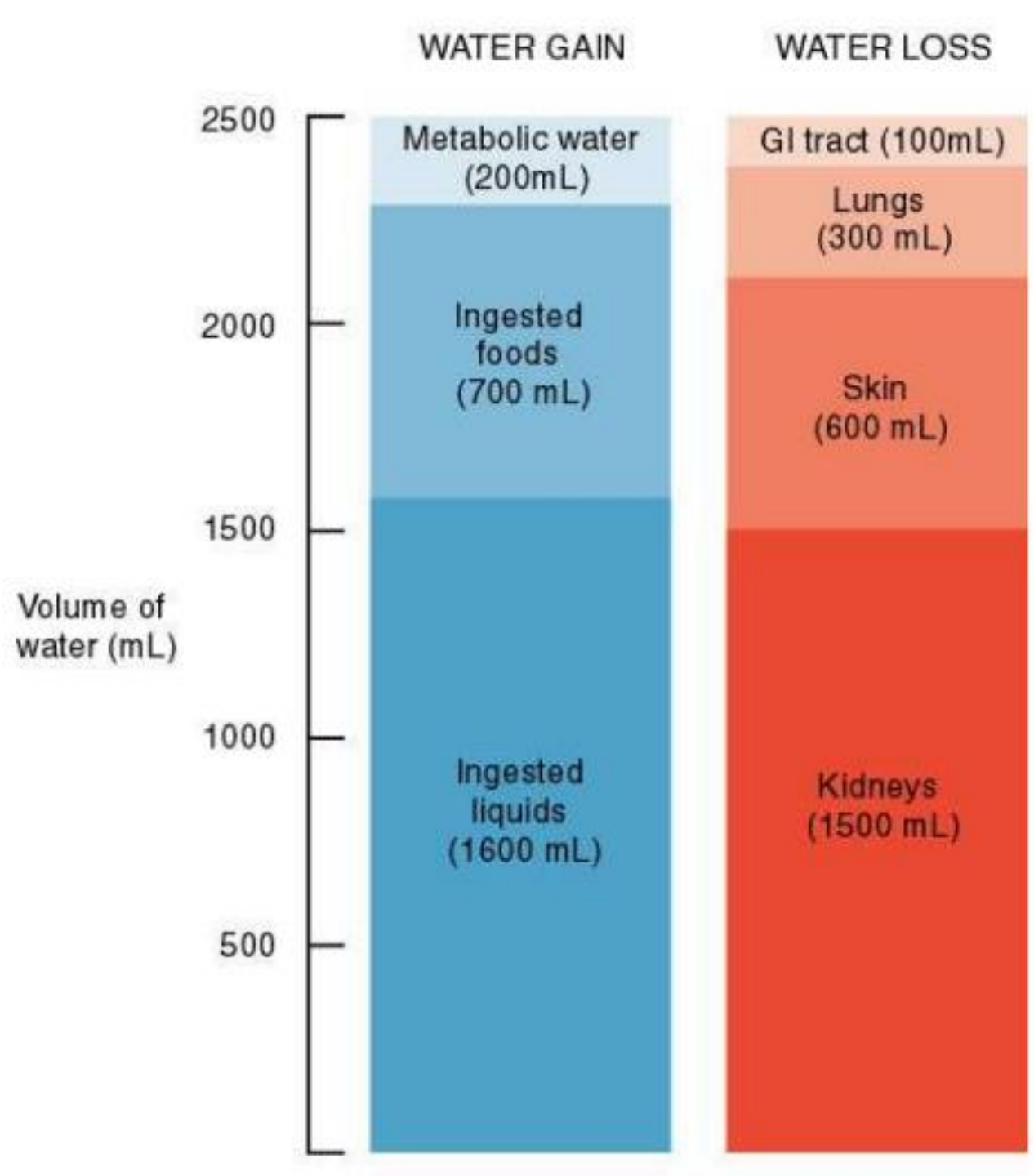


2- Water Balance

- Water Balance: Water input = Water output
- b) Water output:

- Water normally enters the body only through the mouth, but it can be lost by a variety of routes including:
  - Urine (60% loss)
  - Feces (6% loss)
  - Sweat (sensible perspiration) (6% loss)
  - Evaporation from the skin (insensible perspiration)
  - The lungs during breathing

  (Evaporation from the skin and the lungs is a 28% loss)


WATER GAIN
WATER LOSS
2500
2000
1500
1000
500
Volume of water (mL)
Metabolic water (200mL)
Ingested foods (700 mL)
Ingested liquids (1600 mL)
GI tract (100mL)
Lungs (300 mL)
Skin (600 mL)
Kidneys (1500 mL)

3- Water and Electrolytes Homeostasis

- How can we keep the balance between water intake and loss, and keep the volume of water roughly fixed in our bodies??
- By asking this question, we should conclude that water balance is highly regulated in our bodies. There are many systems that are involved in the regulation of water's amount in our bodies and the regulation of fluids and electrolytes, like:
  → Urinary system
  → Cardiovascular system
  → Endocrine system, through (Pituitary, parathyroid and adrenal glands)
  → Respiratory system (Lungs participate in this process of regulation)

4- Regulation of Na+ and Water

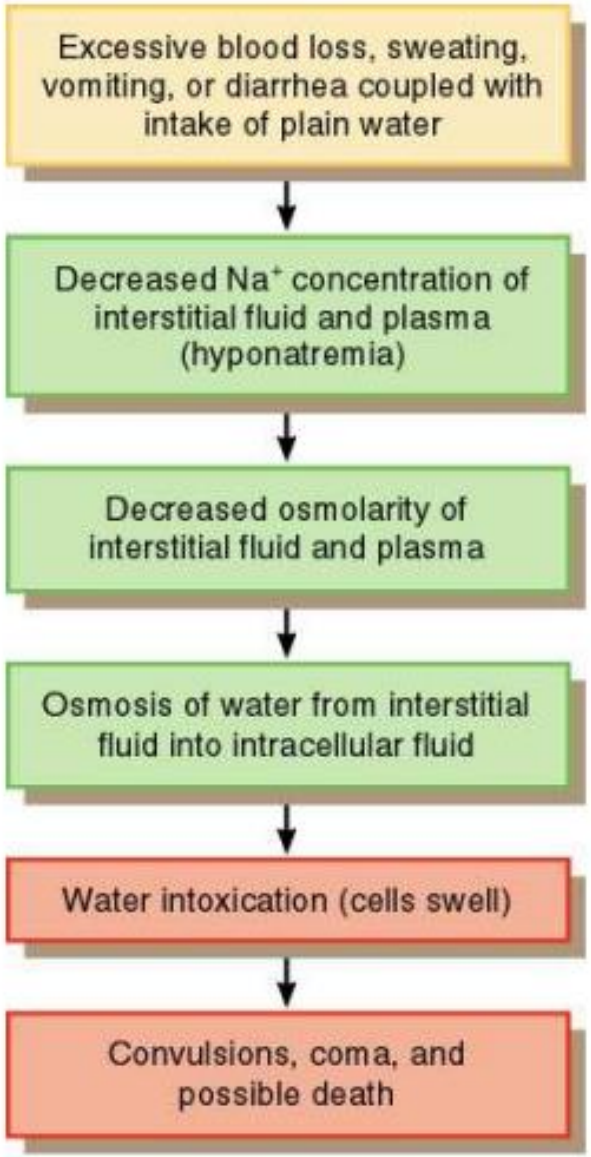
- Involves regulation of:
  - Osmolality
  - Volume of ECF (different regulations with many overlapping mechanisms.) (see picture)
- imagine that we have excessive loss of water from the body (water without Na+). In this case, ECF volume will decrease, so the osmolarity of the ECF will increase and this will cause water to move from inside the cells towards ECF and this will end with shrinkage of cells. This process is called Dehydration of cells (we are decreasing the volume of water inside the cells).
- Now, let's think of it in the opposite way. What will happen if we have excessive intake of water? Surely, you will say that ECF volume will increase and the osmolarity of ECF will decrease. As a result, water will move from ECF towards cells. This will end with swelling of cells. This is important for you as a doctor, because when this happens in some tissues and organs, it leads to edema
- You should know that neither dehydration nor swelling is healthy

(a) Consequences of dehydration. If more water than solutes is lost, cells shrink.

(b) Consequences of hypotonic hydration (water gain). If more water than solutes is gained, cells swell.

- Example of hypotonic hydration

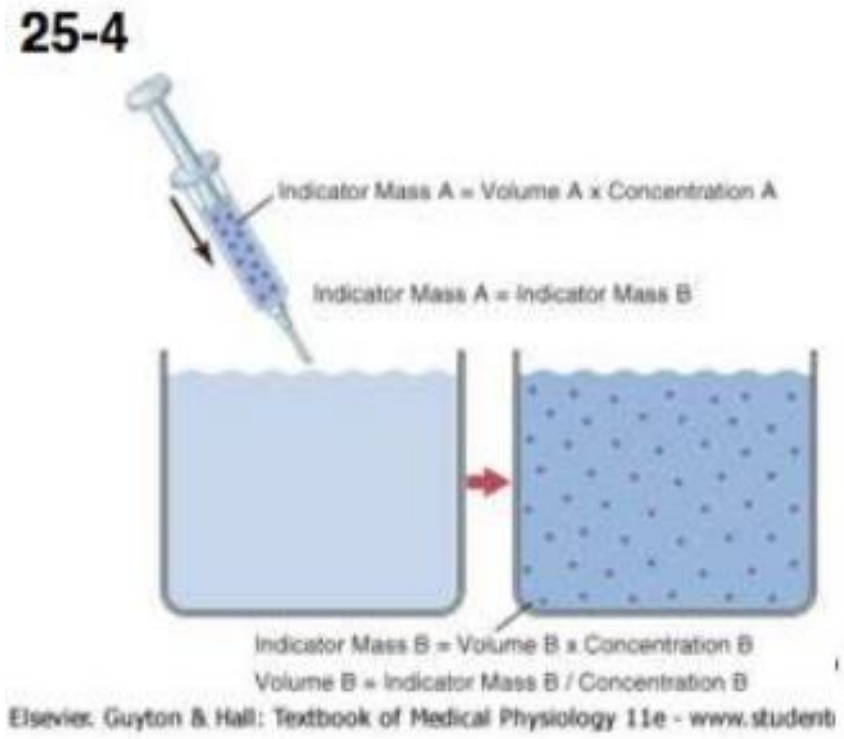
Fig. 27.05



27.05

5- Measurements of Body Fluids

- Remember:
- no. of moles in the dye before injection = no. of moles after injection
- Concentration before * Volume before = Concentration after * Volume after
- Volume after = (Concentration before * Volume before) / Concentration after
- Volume B = (Volume A * Concentration A) / Concentration B



$$\text{Volume B} = \frac{\text{Volume A} \times \text{Concentration A}}{\text{Concentration B}}$$

If 1ml of a 10mg/ml solution is injected into a fluid compartment, and the final concentration is 0.01mg/ml, the volume of the fluid compartment is,

$$\text{Volume B} = \frac{1\ \text{ml} \times 10\ \text{mg/ml}}{0.01\ \text{mg/ml}} = 1000\ \text{ml}$$

5- Measurements of Body Fluids

- Properties of an Ideal Tracer The tracer should:
  • be nontoxic
  • be rapidly and evenly distributed throughout the nominated compartment not enter any other compartment.
  • not be metabolized.
  • not be excreted (or excretion is able to be corrected for) during the equilibration period
  • be easy to measure
  • not interfere with body fluid distribution

5- Measurements of Body Fluids

- **<u>Measurement of Total Body Water, we use:</u>**
- Radioactive water (3 H_2O, T_2O, Tritium) or heavy water (2 H_2O, D_2O, Deuterium). This will mix with the total body water in just a few hours and the dilution method for calculation can be used.

  Or

- Antipyrine (Non radioactive)

5- Measurements of Body Fluids

- **Measurement of ECF volumes:** (Measured in 30-60 minutes)
- 22 Na+, (Sodium Space)
- 125 I-iothalamate
- Thiosulfate,
- Inulin (Inulin Space)

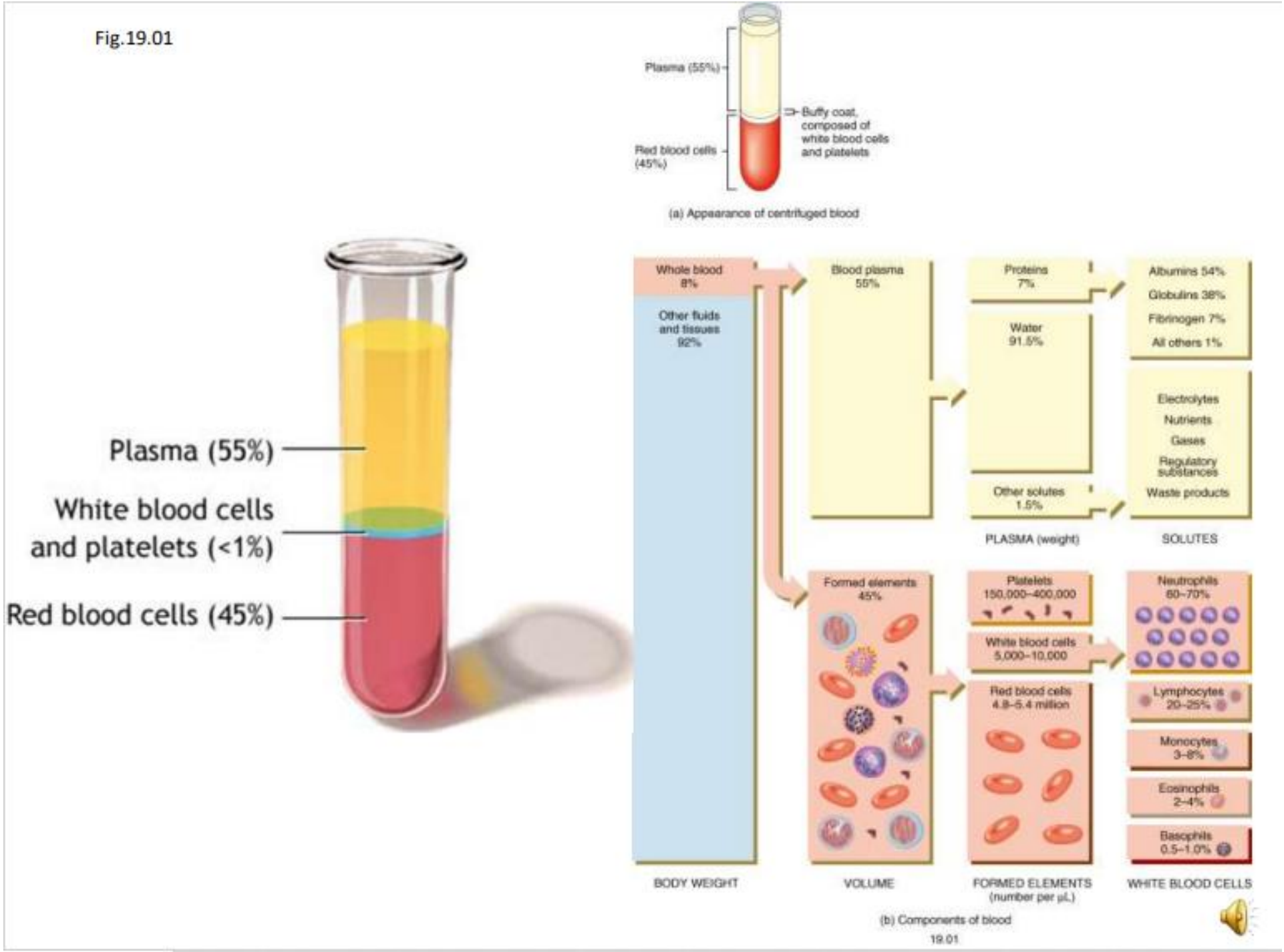
- **ICF= Total Body water - ECF**

5- Measurements of Body Fluids

- **Measurement of Plasma volumes & Total Blood Volume** (see next slide)

- Plasma Composition :
  • Water: > 90%
  • Small molecule: 2%, it is electrolytes, nutrinent, metabolic products, hormone, enzymes, etc.
  • Protein: 60-80 g/L, plasma protein include albumin (40-50 g/L)(54%), globulins (20-30 g/L, α1 -, α2 , β-, γ-) (38%)and fibrinogen (7%). Most of albumin and globulin made from liver.

Fig.19.01


Plasma (55%)
Buffy coat, composed of white blood cells and platelets
Red blood cells (45%)
(a) Appearance of centrifuged blood
Plasma (55%)
White blood cells and platelets (<1%)
Red blood cells (45%)
Whole blood 8%
Other fluids and tissues 92%
Blood plasma 55%
Proteins 7%
Water 91.5%
Other solutes 1.5%
Albumins 54%
Globulins 38%
Fibrinogen 7%
All others 1%
Electrolytes
Nutrients
Gases
Regulatory substances
Waste products
PLASMA (weight)
SOLUTES
Formed elements 45%
Platelets 150,000–400,000
White blood cells 5,000–10,000
Red blood cells 4.8–5.4 million
Neutrophils 60–70%
Lymphocytes 20–25%
Monocytes 3–8%
Eosinophils 2–4%
Basophils 0.5–1.0%
BODY WEIGHT
VOLUME
FORMED ELEMENTS (number per µL)
WHITE BLOOD CELLS
(b) Components of blood
19.01

5- Measurements of Body Fluids

Measurement of Plasma volumes	Measurement of Total Blood Volume
* ^{125}I-Albumin (RISA),	* ^{51}Cr-labeled Red Blood Cells
* Evans Blue (Dye (T1824))	***Calculated** As = Plasma Volume / 1-Hematocrit

Hematocrit : The volume percentage of RBCs in blood