

Body Fluids

Red: very important.

Green: only found in males' slides.

Purple: only found in females' slides.

Gray: notes.

Physiology Team 436 – Foundation block lecture 3

Objectives

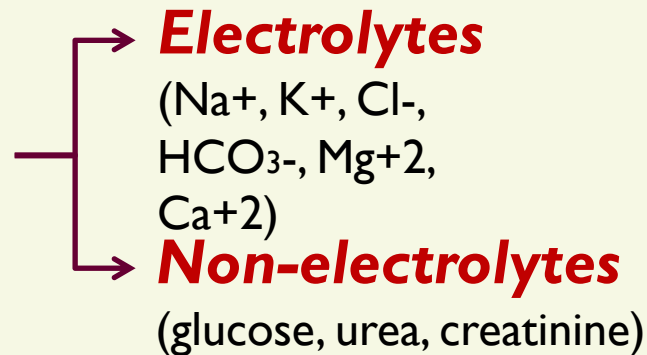
- ▶ State the water content of the body.
- ▶ Describe the physiologic factors that determine the body's water content.
- ▶ Discuss water balance in the body with regards to intake and output.
- ▶ Describe the physiologic mechanisms involved in water balance (the role of ADH hormone and thirst mechanism).
- ▶ Enumerate the different body fluid compartments and state their normal volume.
- ▶ Describe the composition of the different body fluid compartments.
- ▶ Define osmolarity and state the normal osmolarity of body fluids.
- ▶ Explain the effects of placing a cell in solutions with varying tonicity on the cell volume.
- ▶ Enumerate fluids used in clinical practice and state their tonicity compared to that of normal body fluids.
- ▶ Describe the effects of infusing IV fluids with different tonicities on the volume of the different body compartments.

Body Fluid Content

▶ Total body fluids \approx 60% (50-70%) of total body weight (TBW).

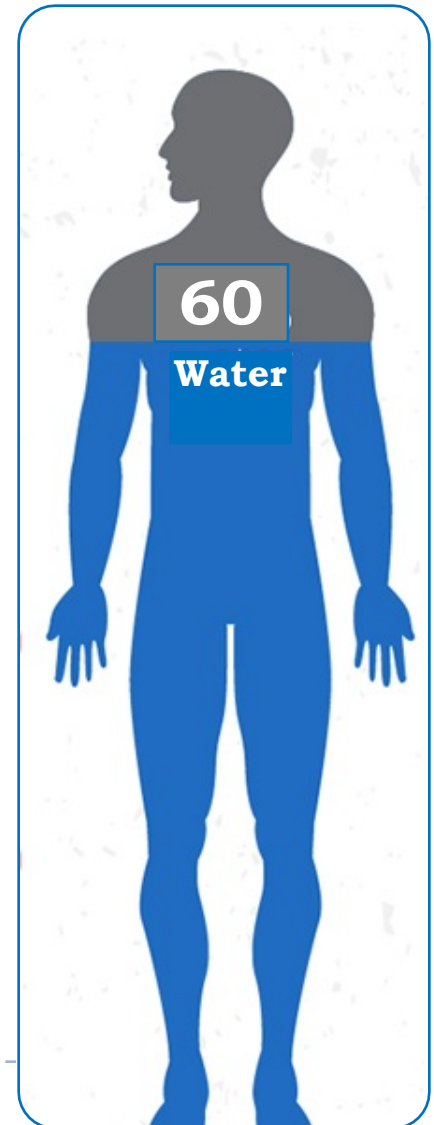
▶ Body fluids = water + dissolved solutes.

■ Solutes



▶ Total body water \approx 60% of TBW.

▶ **Kg of water = L of Water**

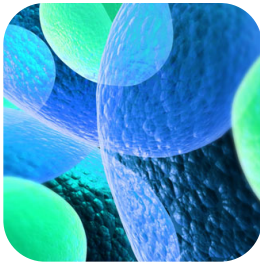


Factors Affecting (TBW)



Physiological:

- Age
- Sex
- Body Fat



Pathological:

- Vomiting
- Diarrhea
- Diseases With Excessive loss of water (DM = Diabetes Mellitus , excessive Sweating ...)
- Blood loss
- Burns



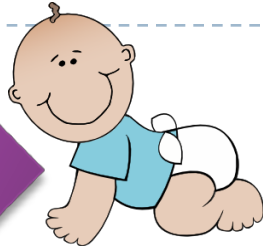
Other:

- Climate
- Habits
- Physical Activity

disturbances
in fluid
balance

Body Fluid Content

Low body fat
Low bone mass
73% or more water



Higher body fat
Smaller amount of
skeletal muscles
40-50% water



60% of body weight
is water

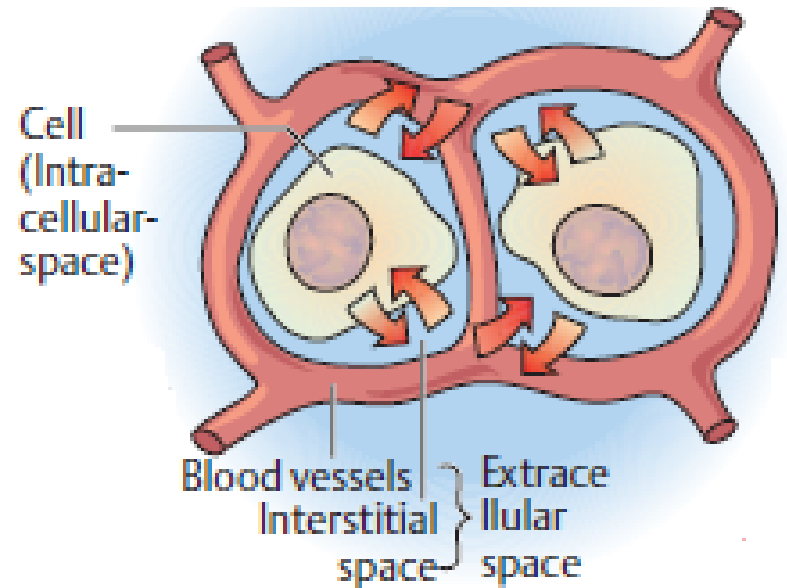


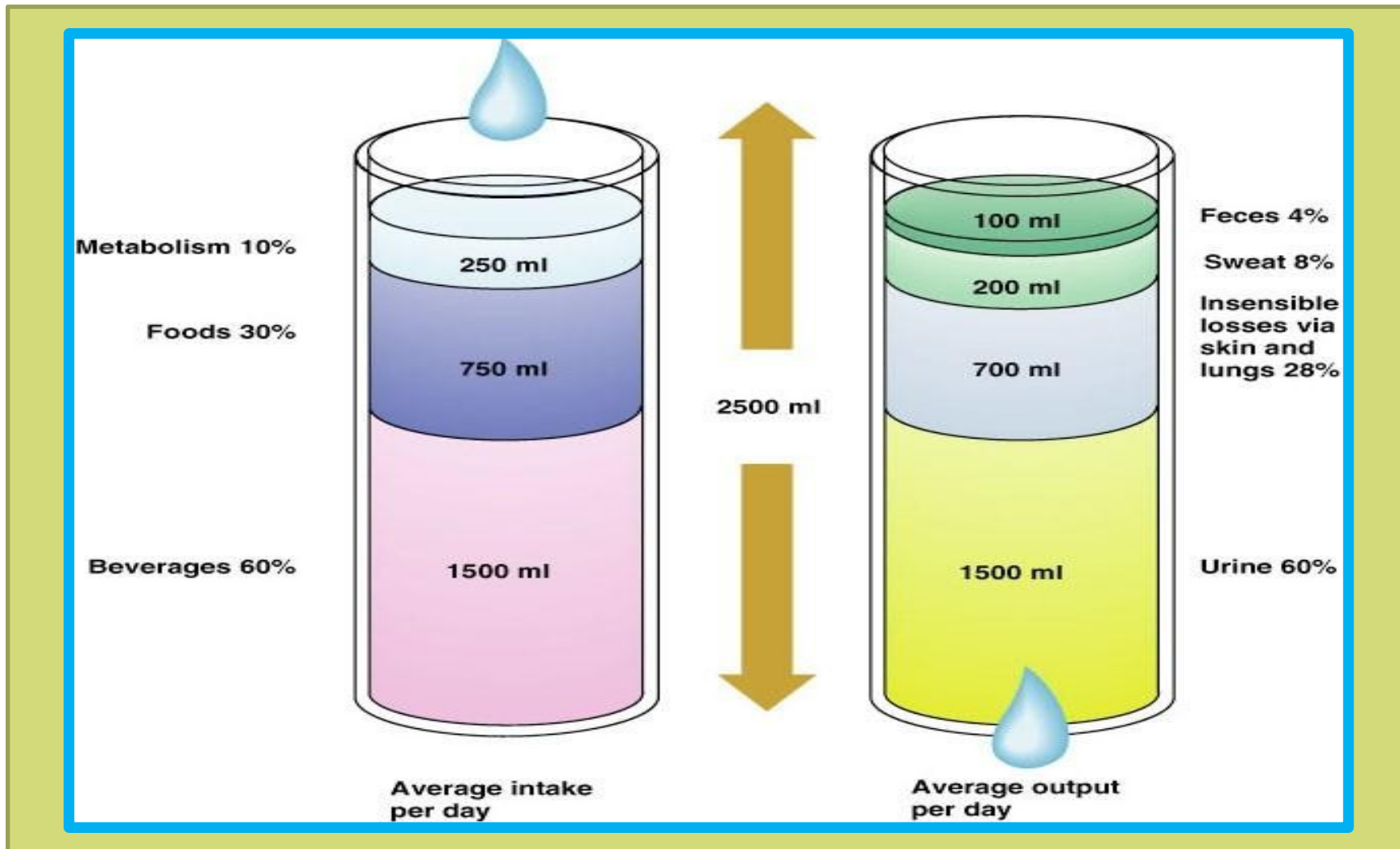
Only about 45% of
body weight is
water



Water Balance

- ▶ Cells are largely made of water and are surrounded by a “sea” of water.
- ▶ Water is constantly being exchanged between the cells and surrounding environment.
- ▶ Keeping a constant volume of water is essential for homeostasis.





Fluid Intake = Fluid output

the body modifies intake by thirst and output by kidney excretion



Fluid intake:

60% from
beverages
(major intake)
30% from food
10% from
metabolism

Fluid output:

60% from urine
(major output)
28% insensible
through skin
and lungs
8% sweat
4% feces

Definition of insensible through skin and lungs:

الموية الي تطلع من الجسم بدون ما تحس فيها. مثال:
رطوبة الجلد
الموية (بخار الماء) الي يطلع مع التنفس

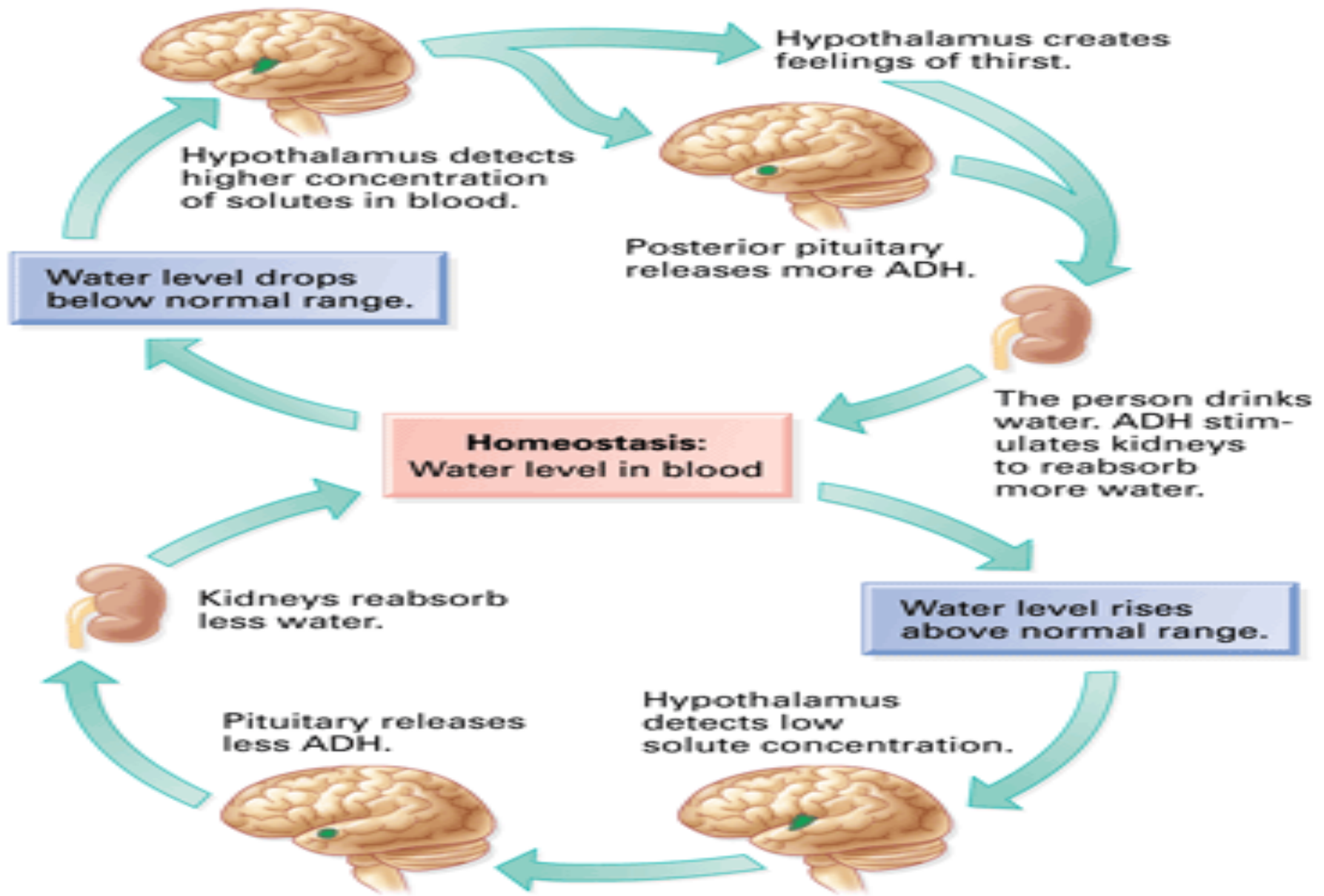
Regulation of Fluid Balance

• Water deficit

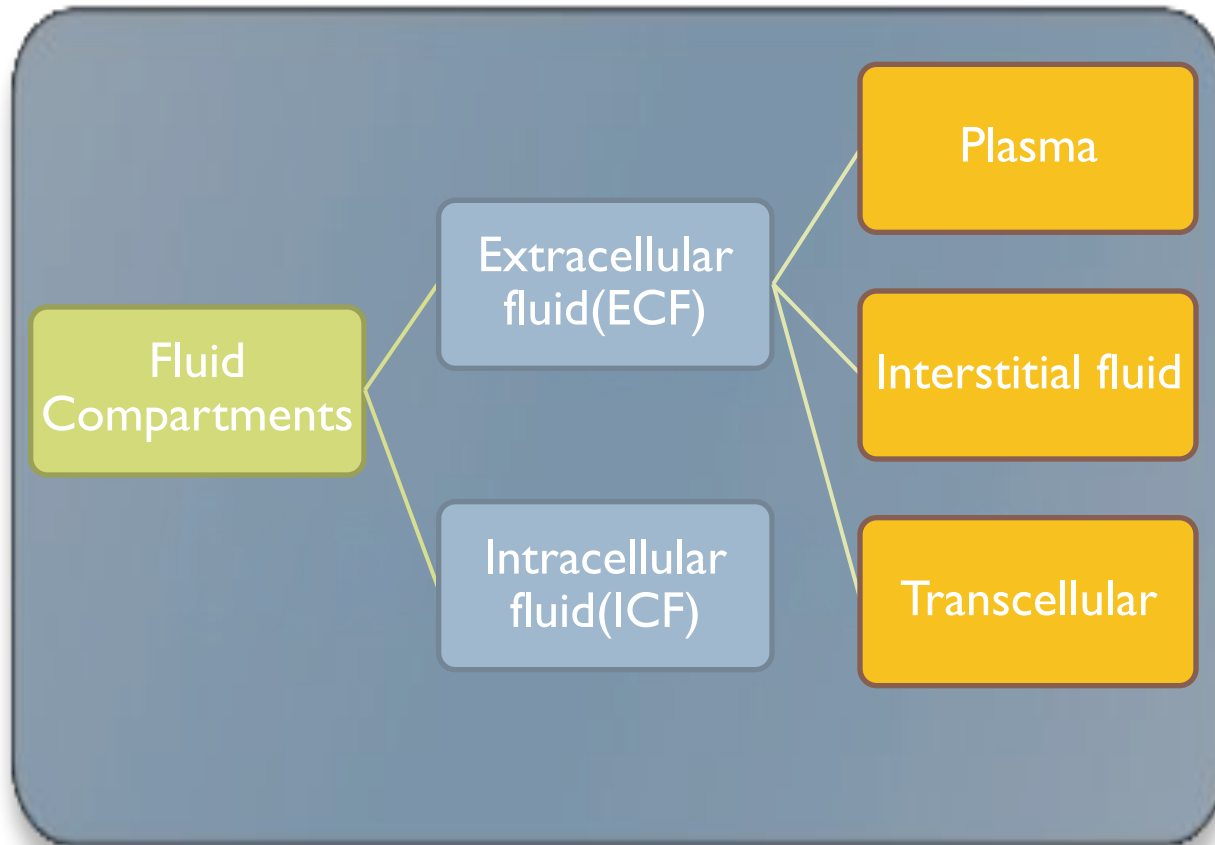
- ▶ Input < output.
- ▶ Leads to:
 - ▶ Hypovolemia
 - ▶ Dehydration
- ▶ **Physiologic regulation:**
 1. **Activates hypothalamic thirst centre → ↑ fluid intake**
 - ▶ The hypothalamic thirst centre is activated by:
 - ▶ ↓ ECF volume (10-15%)
 - ▶ ↑ ECF osmolarity (1-2%)
 2. **↑ ADH secretion by posterior pituitary → ↑ water reabsorption by the kidney.**

• Water excess

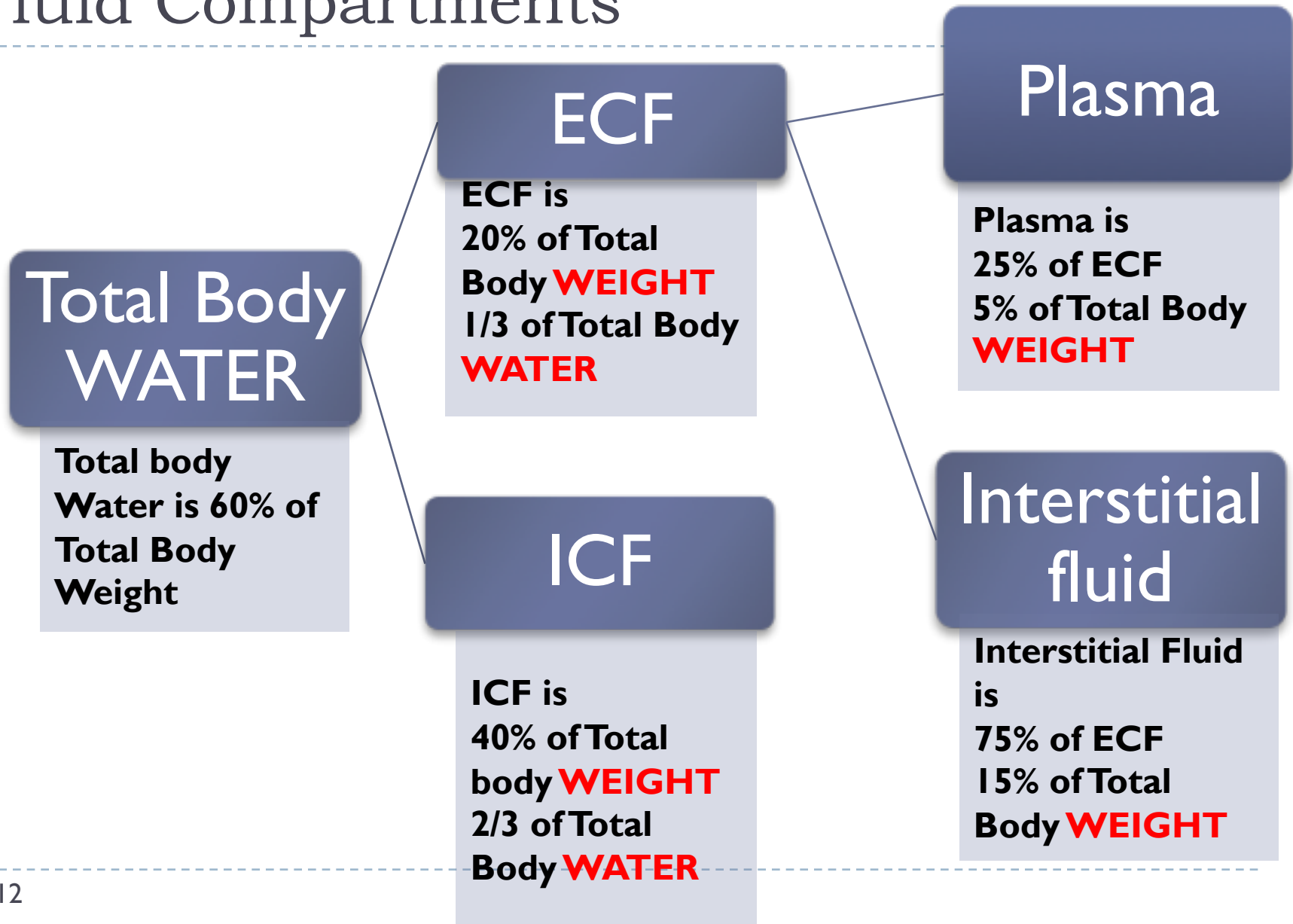
- ▶ Input > output
- ▶ Leads to:
 - ▶ Hypervolemia.
 - ▶ Edema.
- ▶ **Physiologic regulation:**
 - ▶ **↓ ADH secretion →**
 - ↓ water reabsorption →**
 - ↑ water excretion by kidney.**
 - Decrease thirst**



Fluid Compartments



Fluid Compartments



Fluid Compartments

Total body water = 60% TBW

***2/3 (40% of TBW)
Intracellular**

**1/3 (20% of
TBW)
Extracellular**

Transcellular fluid (specialised type of ECF e.g. synovial, CSF, ocular, pericardial, pleural, peritoneal fluids) = 1-2L

**3/4 (15%)
Interstitial
Fluid**

**1/4
(5%)
Plasma**

N. B. the fractions refer to its relation with the preceding compartment. While the percentage refers to its relation to Total body **WEIGHT)**

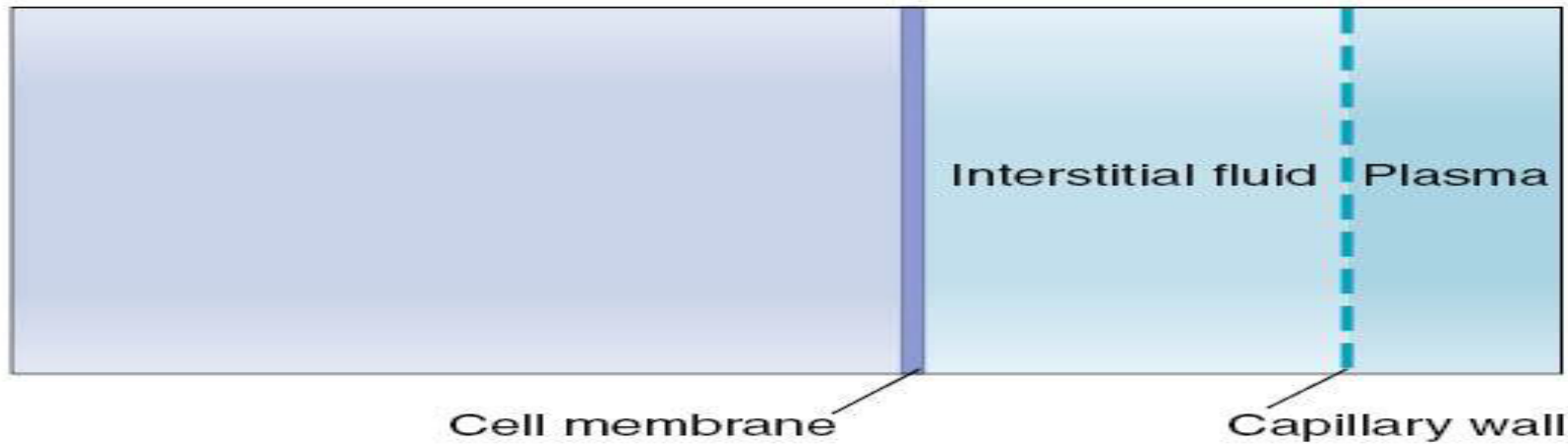
NOTE

- ▶ Plasma is not a set number nor range for all individuals. It is **5% of total body WEIGHT**.
- ▶ If calculated through **total body WATER**, we must calculate **the percentage of ECF** first.

TOTAL BODY WATER

Intracellular fluid

Extracellular fluid



Total body water
(60% body weight)

Intracellular fluid
(40% body weight)

Extracellular fluid
(20% body weight)

Interstitial fluid

Plasma

Extracellular Fluid

Extracellular fluid forms 1/3 of TBW and consists of:

Interstitial fluid:

Fluid bathing the cell .

75% of ECF

15% of total body weight

Ultra filtration of plasma .

contained in a gel-like extracellular matrix .

surrounds all cells except blood cells

The main difference between plasma and interstitial fluids is the presence of protein in large quantities

Plasma :

- Fluid circulating in the blood vessels.
- 25 % of ECF
- 5% of total body weight
- There is High Protein in Plasma.

Transcellular fluid:

small amount.

Examples:
digestive secretions and
CBS (cerebrospinal fluid)

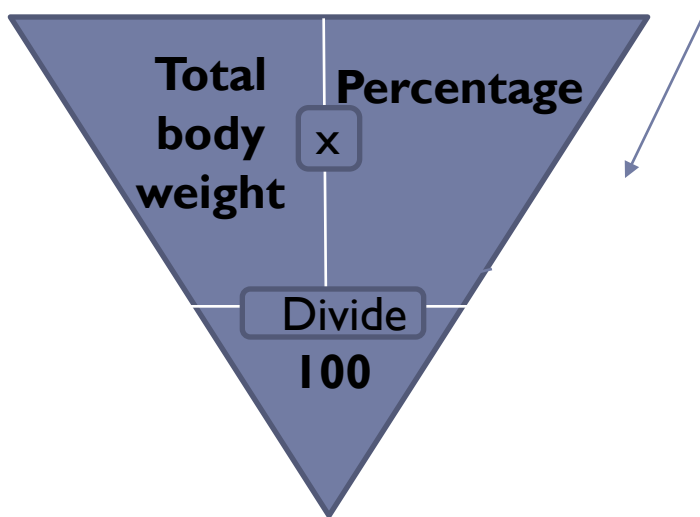
Intracellular Fluid (ICF)

Intracellular fluid forms 2/3 of TBW

- High Concentration of protein
- Inside The cell

How to Calculate Body Fluid Content

Ex. Calculate the total body water content of a 30-year-old 70 kg man?



Solution:
 $70 \times 60 / 100 = 42 \text{ L}$

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Continue..

- ▶ How many liters in ICF?
- ▶ $42 \text{ L} \times 2/3 = 28 \text{ L}$
- ▶ Or
- ▶ $70 \text{ Kg} \times 40/100 = 28 \text{ L}$
- ▶ -----
- ▶ How many Liters in ECF?
- ▶ $42 \text{ L} \times 1/3 = 14 \text{ L}$
- ▶ Or
- ▶ $70 \text{ Kg} \times 20/100 = 14 \text{ L}$



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How many liters in Interstitial fluid?

▶ $14 \text{ L} \times 75/100 = 10.5 \text{ L}$

Or

▶ $70 \text{ Kg} \times 15/100 = 10.5 \text{ L}$

How many liters in plasma?

▶ $14 \text{ L} \times 25/100 = 3.5 \text{ L}$

Or

▶ $70 \text{ Kg} \times 5/100 = 3.5 \text{ L}$

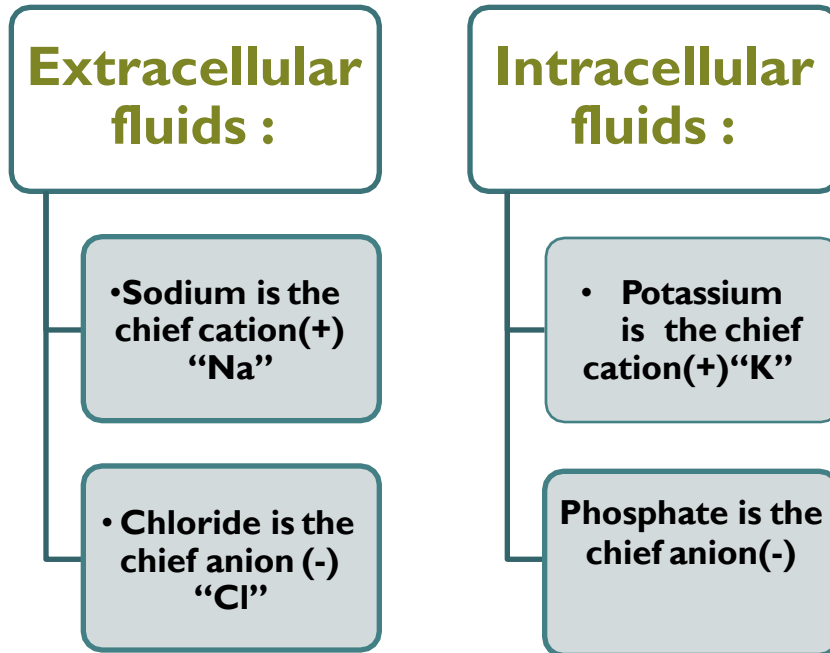


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Remember

- ▶ Transcellular Fluid is very little
- ▶ **DON'T CONFUSE TOTAL BODY WATER WITH TOTAL BODY WEIGHT.**

Composition Of Body Fluids



Electro-neutrality :

- Each compartment must Have almost the same concentration of positive charge (cations) as of negative charge (anion)

	Extracellular fluid	Intracellular fluid
Na ⁺	142 mEq/L	10 mEq/L
K ⁺	4 mEq/L	140 mEq/L
Ca ⁺⁺	2.4 mEq/L	0.0001 mEq/L
Mg ⁺⁺	1.2 mEq/L	58 mEq/L
Cl ⁻	103 mEq/L	4 mEq/L
HCO ₃ ⁻	28 mEq/L	10 mEq/L
Phosphates	4 mEq/L	75 mEq/L
SO ₄ ⁻	1 mEq/L	2 mEq/L
Glucose	90 mg/dl	0 to 20 mg/dl
Amino acids	30 mg/dl	200 mg/dl ?
Cholesterol	0.5 gm/dl	2 to 95 gm/dl
Phospholipids		
Neutral fat		
PO ₂	35 mm Hg	20 mm Hg ?
PCO ₂	46 mm Hg	50 mm Hg ?
pH	7.4	7.0
Proteins	2 gm/dl (5 mEq/L)	16 gm/dl (40 mEq/L)

❖ Calcium , chloride , sodium , protein , phosphate , potassium , glucose
“IMPORTANT”

Protein is highly concentrated in intracellular fluids and plasma

Electrolyte Concentrations

- ▶ Memorize concentration level averages here rather than ranges: (as averages vary from book to book but the value in the exam will be very close to the average here.)

هنا بس طلعو المتوسط و احفظوه ما يحتاج تحفظون الفترات، لانها مختلفة من كتاب لكتاب لكن خليك على قيمة المتوسط و في الاختبار راح يجيبون قيم ممكن ما تكون بالضبط نفس المتوسط لكن بيكون جداً قريب

Concentrations of Extracellular and Intracellular Electrolytes in Adults		
Electrolyte	Extracellular Concentration*	Intracellular Concentration*
Sodium	135–148 mEq/L	10–14 mEq/L
Potassium	3.5–5.0 mEq/L	140–150 mEq/L
Chloride	98–106 mEq/L	3–4 mEq/L
Bicarbonate	24–31 mEq/L	7–10 mEq/L
Calcium	8.5–10.5 mg/dl	< 1 mEq/L
Phosphate/ phosphorus	2.5–4.5 mg/dl	4 mEq/kg [†]
Magnesium	1.8–2.7 mg/dl	40 mEq/kg [†]

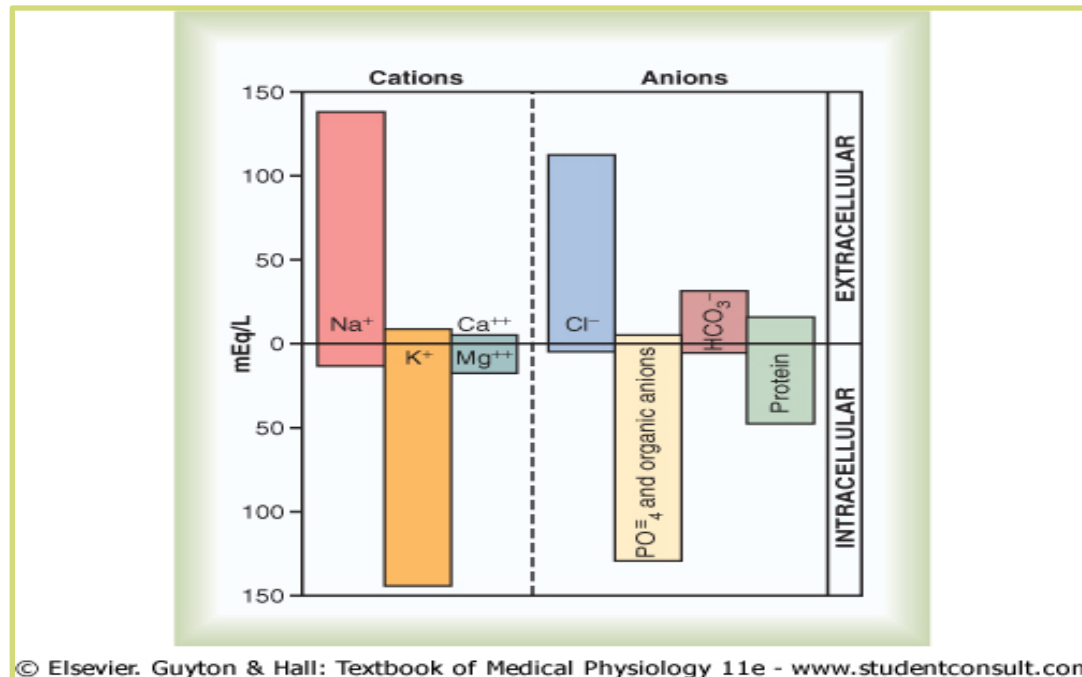
*Values may vary among laboratories, depending on the method of analysis used.
†Values vary among various tissues and with nutritional status.

Normal Ranges cont.

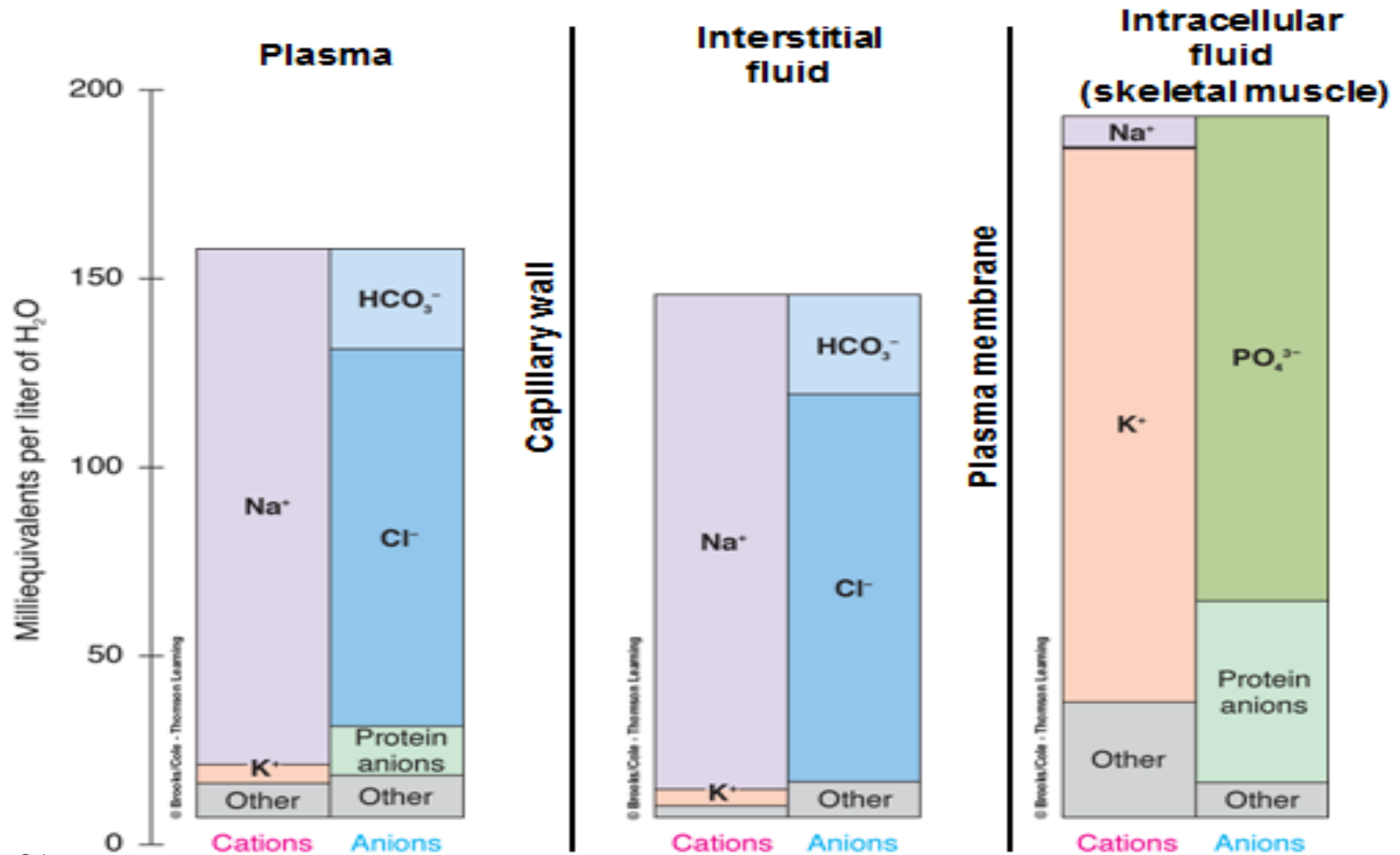
- ▶ Sodium (Na) : 135 – 145 mEq/L
- ▶ Chloride (Cl) : 98 – 107 mEq/L
- ▶ Potassium (K) : 3.5 – 5.1 mEq/L

Solute Overview: Intracellular vs. Extracellular

- ▶ Ionic composition very different
- ▶ Total ionic concentration very similar
- ▶ Total osmotic concentrations virtually identical



Does the composition of the compartments differ? (yes)



[Figure 15-2; Sherwood]

How is it related to patient care?

Abnormalities in electrolytes can change the osmolarity of ECF and can affect the cells.

- a. **Hypernatremia** (↑ Na conc. In ECF)
- b. **Hyponatremia** (↓ Na conc. In ECF)
- c. **Hyperkalemia** (↑ K conc. In ECF) (K is 60 – 100% above normal)
- d. **Hypokalemia**(↓ K conc. In ECF) (1-2 mEq/L)

Osmolarity

- ▶ A unit of concentration.
- ▶ describes the concentration of **one** solution.
- ▶ It measures how concentrated or diluted a solution is.
- ▶ Defined as = the number of osmoles of a solute per litre of solution.
- ▶ The normal osmolarity of body fluids is $\approx 300 \text{ mOsm/L}$

Terms of Concentration

Osmolarity : Osm / L

Osmolality Osm / Kg

Molarity M/L

In biological solutions

Millimoles per liter (mM / L)

Milliosmoles per liter (mOsm / L)

$\text{m} = 1 / 1000$

What is Tonicity?

- ▶ **'reminder' Osmolarity** describes the concentration of **one** solution.
- ▶ **Tonicity** is used to compare between the osmolarities of **two or more** solutions separated by a semi-permeable membrane

why it is important ?

The difference in tonicity between two different solutions separated by a semi-permeable membrane determines the movement of water.

Tonicity of Solutions: how does it apply to physiology ?

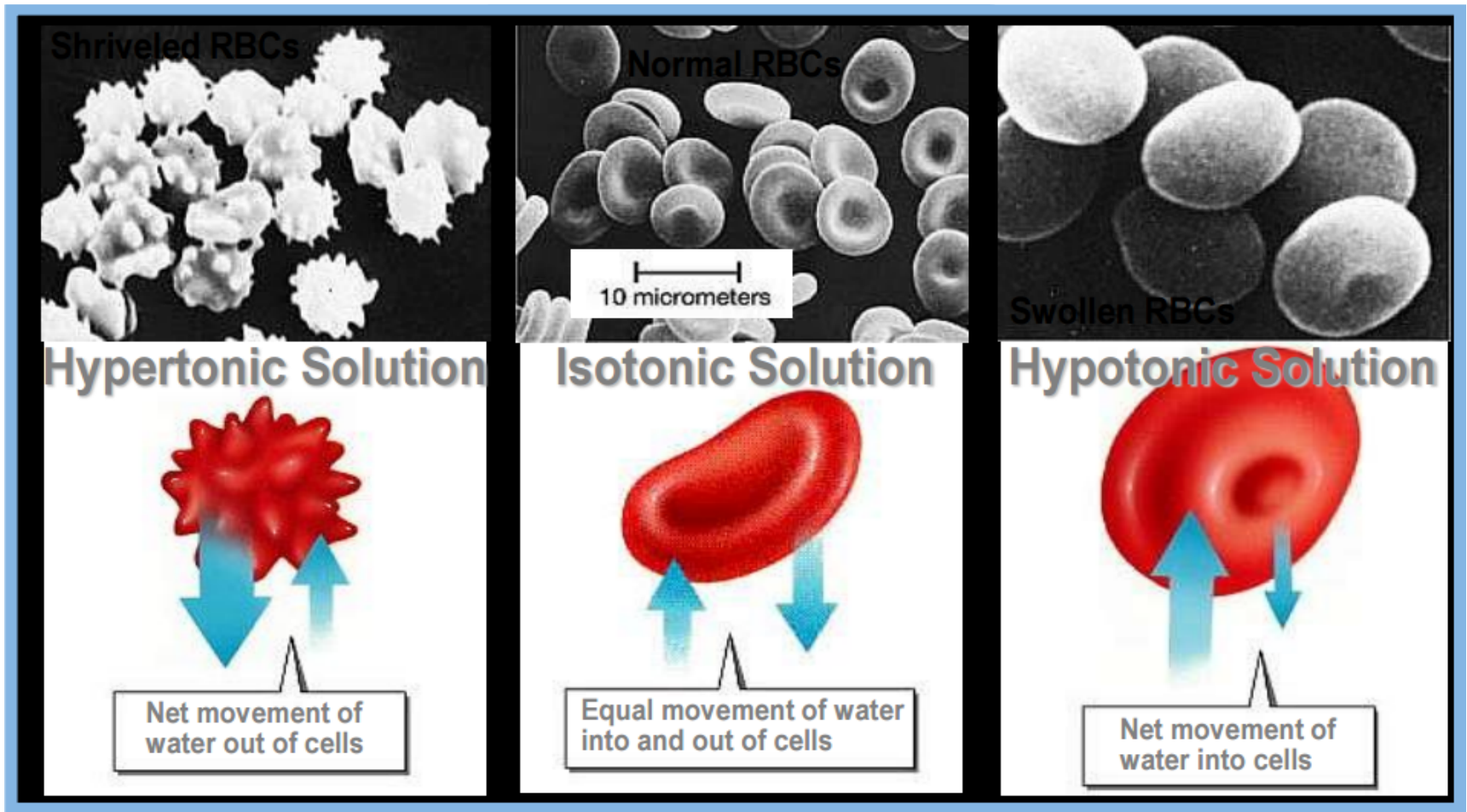
- ▶ Isotonic solution : - (no swells or shrinking) - 0.9% solution of sodium chloride - same in and out.
- ▶ Hypotonic solution : - (swelling) 0.9% - inside the cell is higher than outside the cell.
- ▶ Hypertonic solution : - (shrinking) 0.9% - outside the cell is higher than inside the cell.

Remember: the cell membrane functions as semi-permeable membrane

Osmosis

- ▶ Definition :
- ▶ It is the movement of **water(not solutes)** across a semi-permeable membrane from a region of low solute concentration to a region of high solute concentration.
- ▶ The net diffusion of water from a region of high water conc. to low water conc.
- ▶ Osmotic equilibrium is maintain between ECF and ICF .
- ▶ Small changes in conc. In ECF can cause huge change in cell volume
- ▶ Intracellular Osmolarity = Extracellular Osmolarity = 300 mOsm/L

Movement of Water

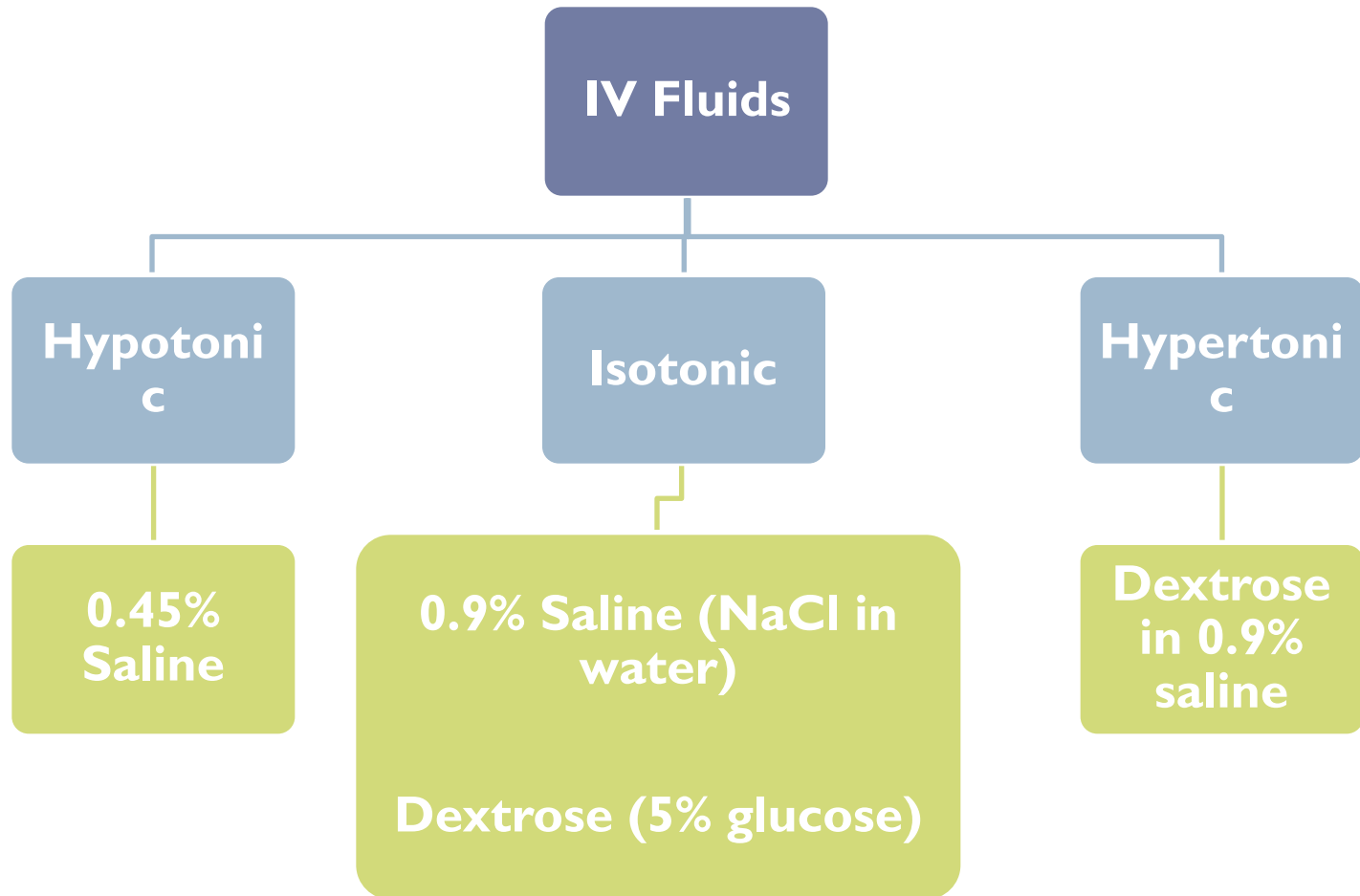


Intravenous (IV) Fluids

IV Fluids Administration

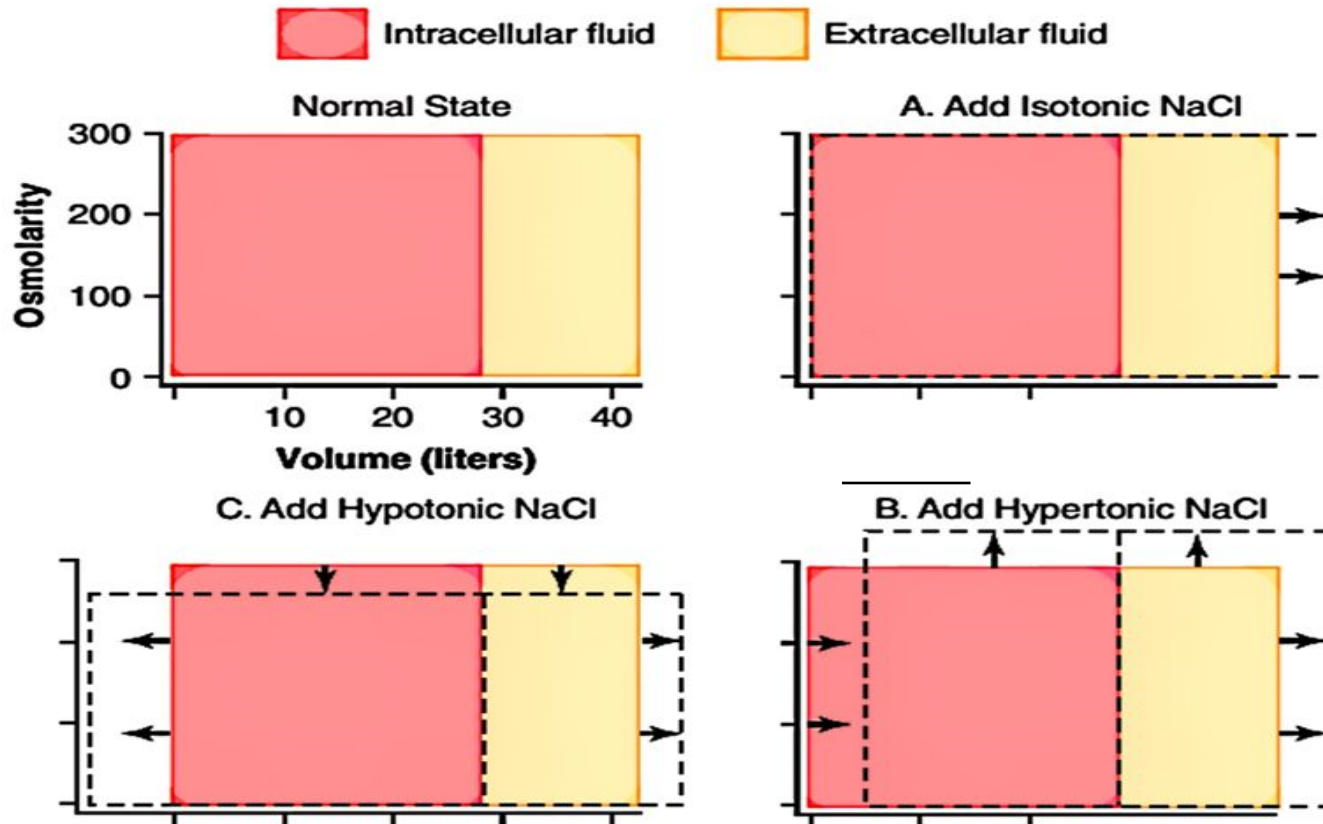
- ▶ Glucose and other solutions are administered for nutritive purposes
- ▶ For people who can not take adequate amount of food.
- ▶ It is administered slowly into the blood stream.
- ▶ It is prepared in isotonic solution.
- ▶ Water is excreted in the process.

Types of Intravenous (IV) Fluids



What happens to the different compartments with the administration of IV fluids?

Effect of adding isotonic, hypertonic, and hypotonic solutions to the extracellular fluid after osmotic equilibrium. The normal state is indicated by the solid lines, and the shifts from normal are shown by the shaded areas.



Explanation of Previous Figure:

When Isotonic NaCl is added:

- Water volume increases
- No change in osmolarity because it's isotonic

When Hypotonic NaCl is added:

- volume in ECF increases
- Osmolarity in ECF decreases

- Volume in ICF increases
- Osmolairity in ICF decreases

When hypertonic NaCl is added:

- Osmolarity in ECF will increase
- Volume in ECF will increase

- Osmolarity in ICF will increase
- Volume in ICF will decrease

Thank you!

اعمل لترسم بسمة، اعمل لتمسح دمة، اعمل و أنت تعلم أن الله لا يضيع أجر من أحسن عملا.

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