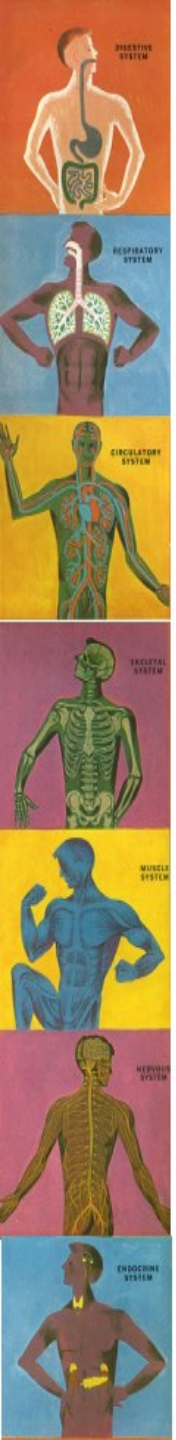

Body Fluids

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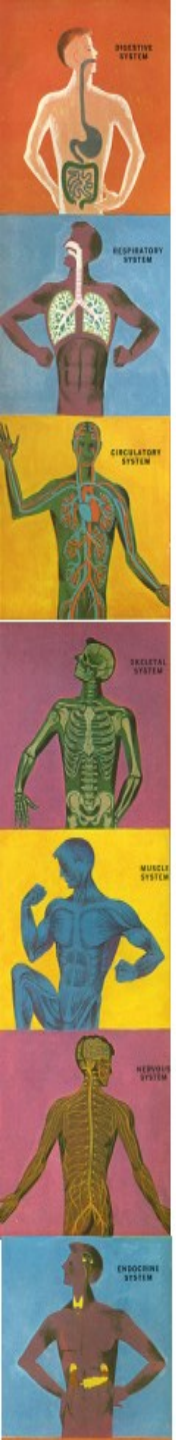
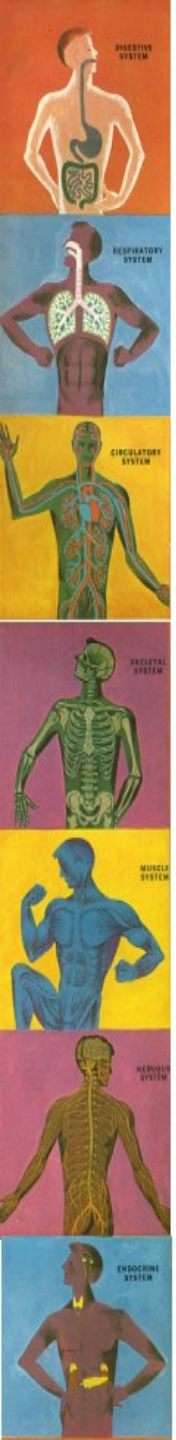


Objectives

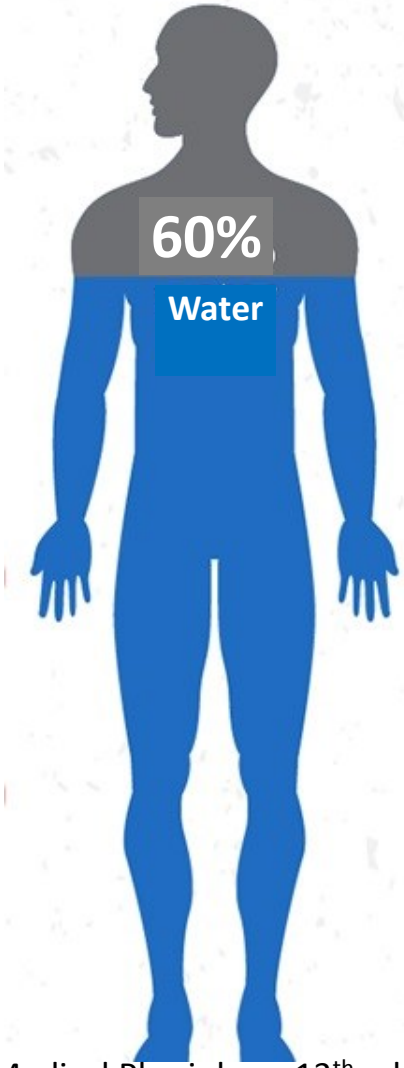
- State the water content of the body.
- Describe the physiologic factors that determine the body's water content.
- Discuss water balance in the body with regards to intake and output.
- Describe the physiologic mechanisms involved in water balance (the role of ADH hormone and thirst mechanism).
- Enumerate 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 and osmolarity of the different body compartments.

Study source for this lecture:
(Guyton & Hall Textbook of Medical Physiology, 13th ed, Chapter 25)

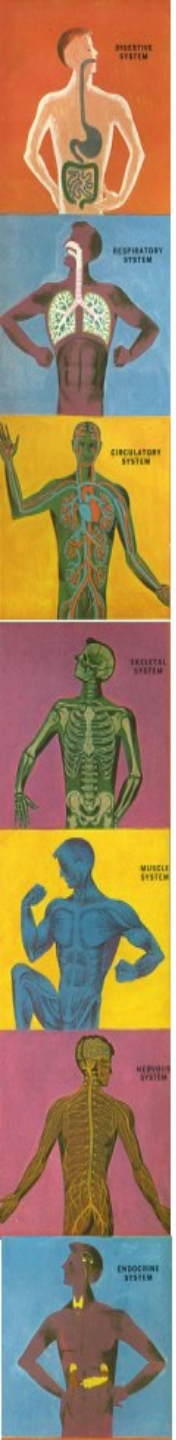


Body Fluid Content

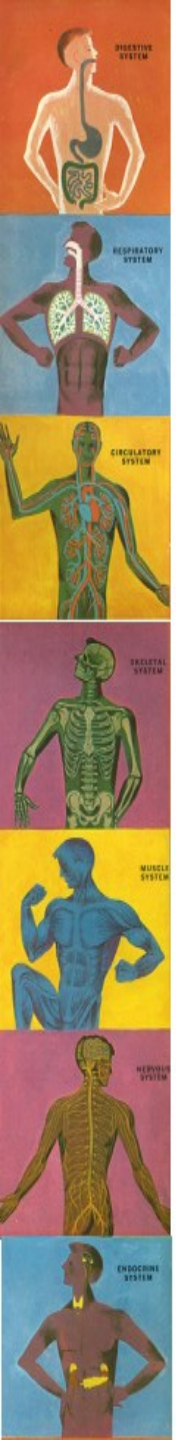
- Total body fluids ≈ 60% (50-70%) of total body weight (TBW).
- Body fluids = water + dissolved solutes.
  - Solutes
    - ***Electrolytes*** (Na+, K+, Cl-, HCO_3-, Mg+2, Ca+2)
    - ***Non-electrolytes*** (glucose, urea, creatinine)
- Total body water ≈ 60% of TBW.



(Guyton and Hall Textbook of Medical Physiology. 13th ed. Ch-25)

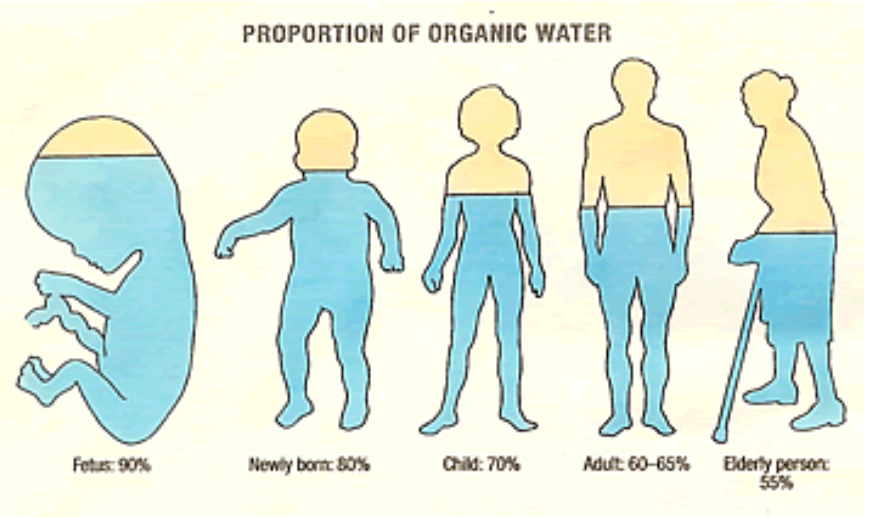


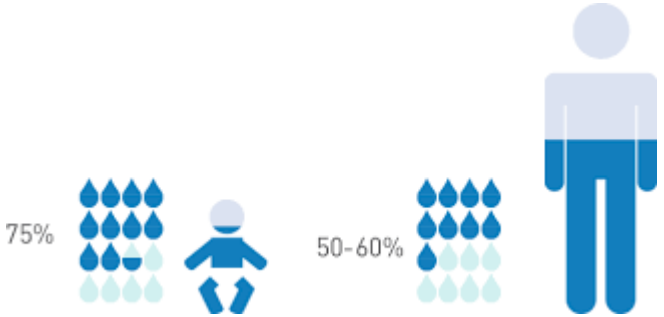
Calculate the total body water content of a 30-year-old 70kg man?



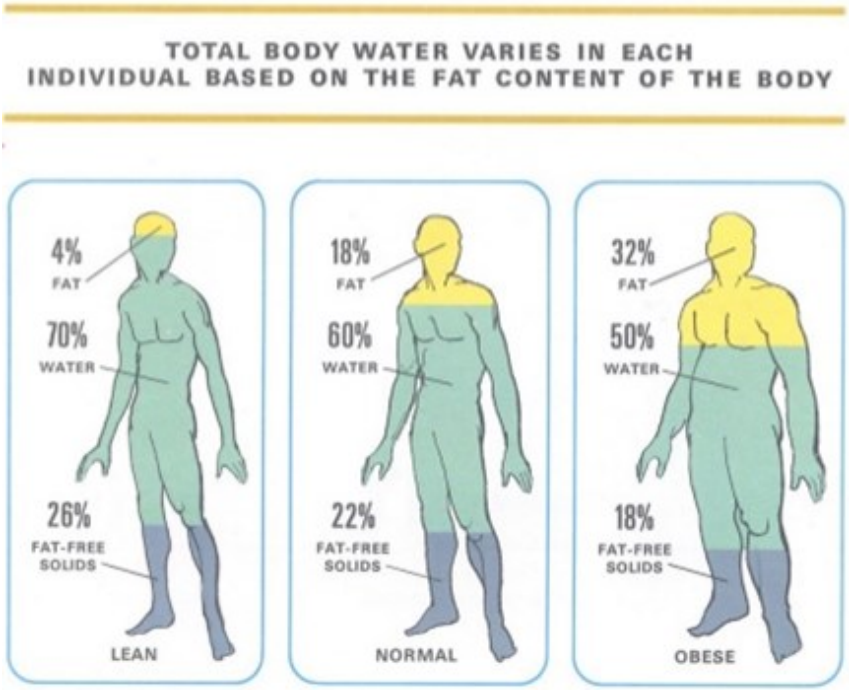
Physiologic factors affecting body water content

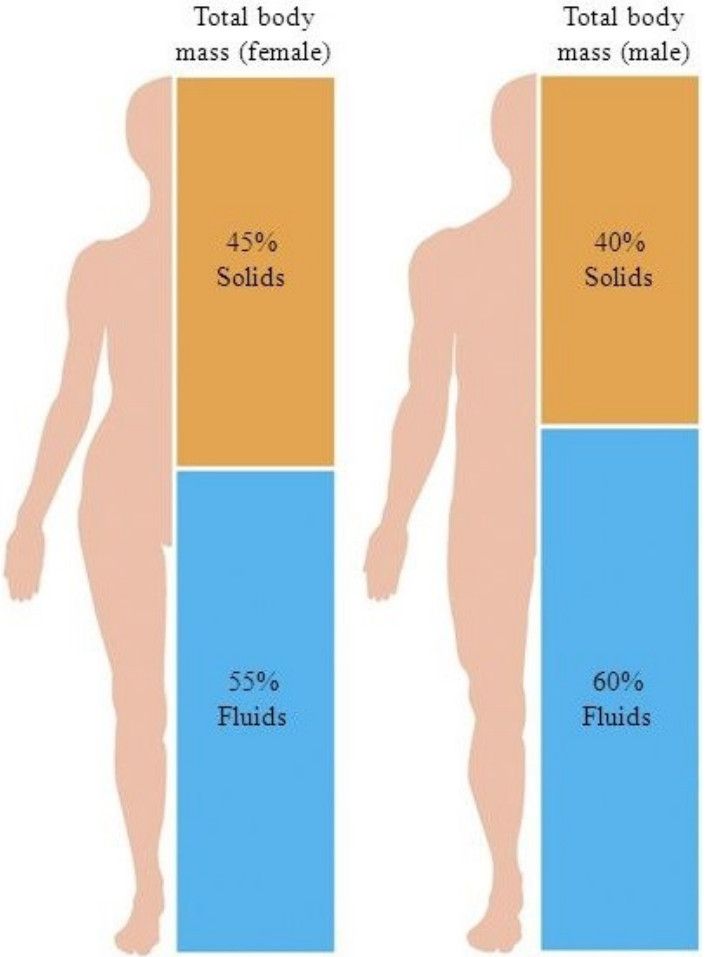
- ***Is body fluid/water content similar between;***
  - Child & adult?
  - Young & old?
  - Male & female?





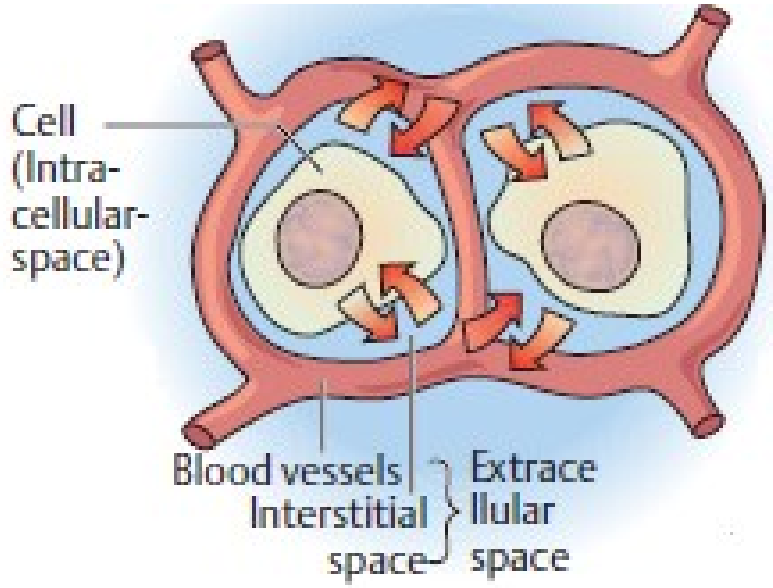
Continue.. Physiologic Factors Affecting Body Fluid Content



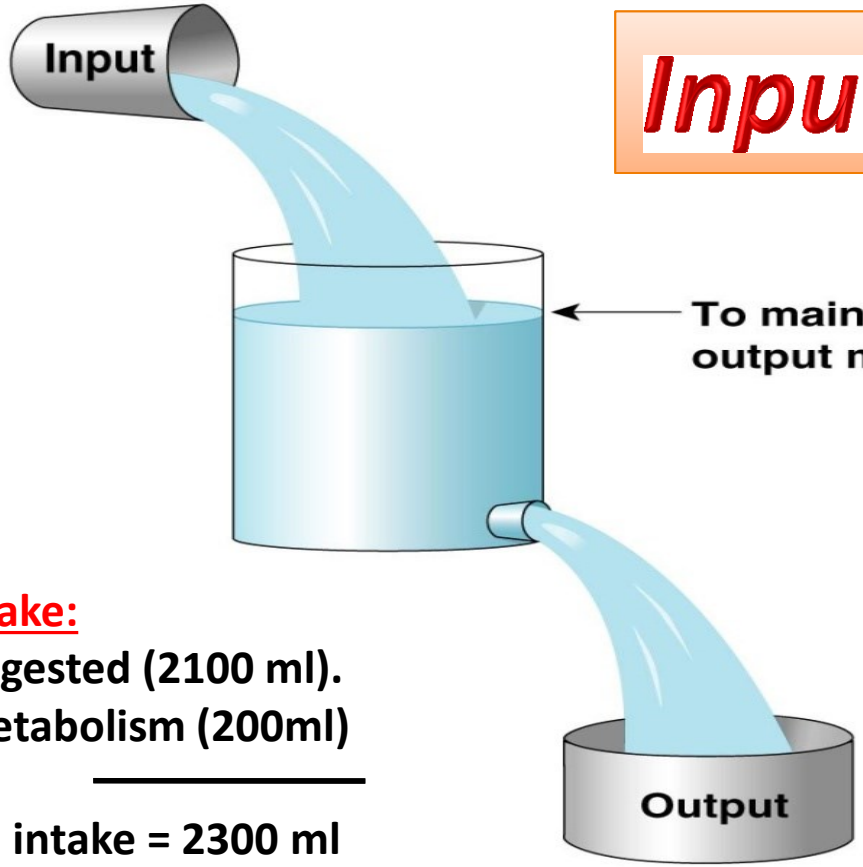


Water Balance

- 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.



Maintenance of Fluid Balance



Input = output

Water intake:

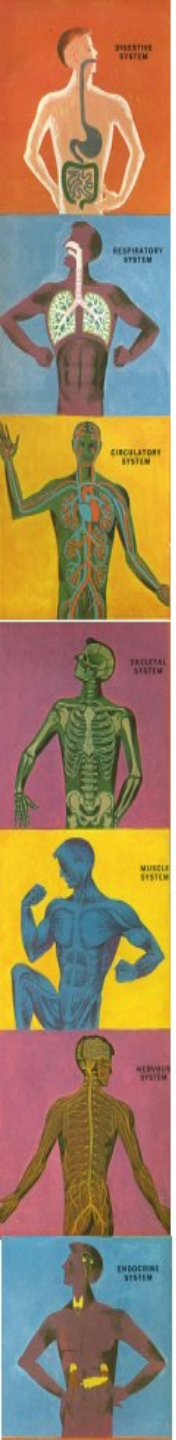
- Fluids ingested (2100 ml).
- From metabolism (200ml)

Total intake = 2300 ml

Daily loss:

- Insensible loss (700 ml).
- Sweat (100 ml).
- Feces (100 ml).
- Urine (1400 ml).

Total loss = 2300 ml



Disturbances in Fluid Balance

Water/fluid intake

- Intake is variable.
- Depends on:
  - Climate.
  - Habits.
  - Physical activity.

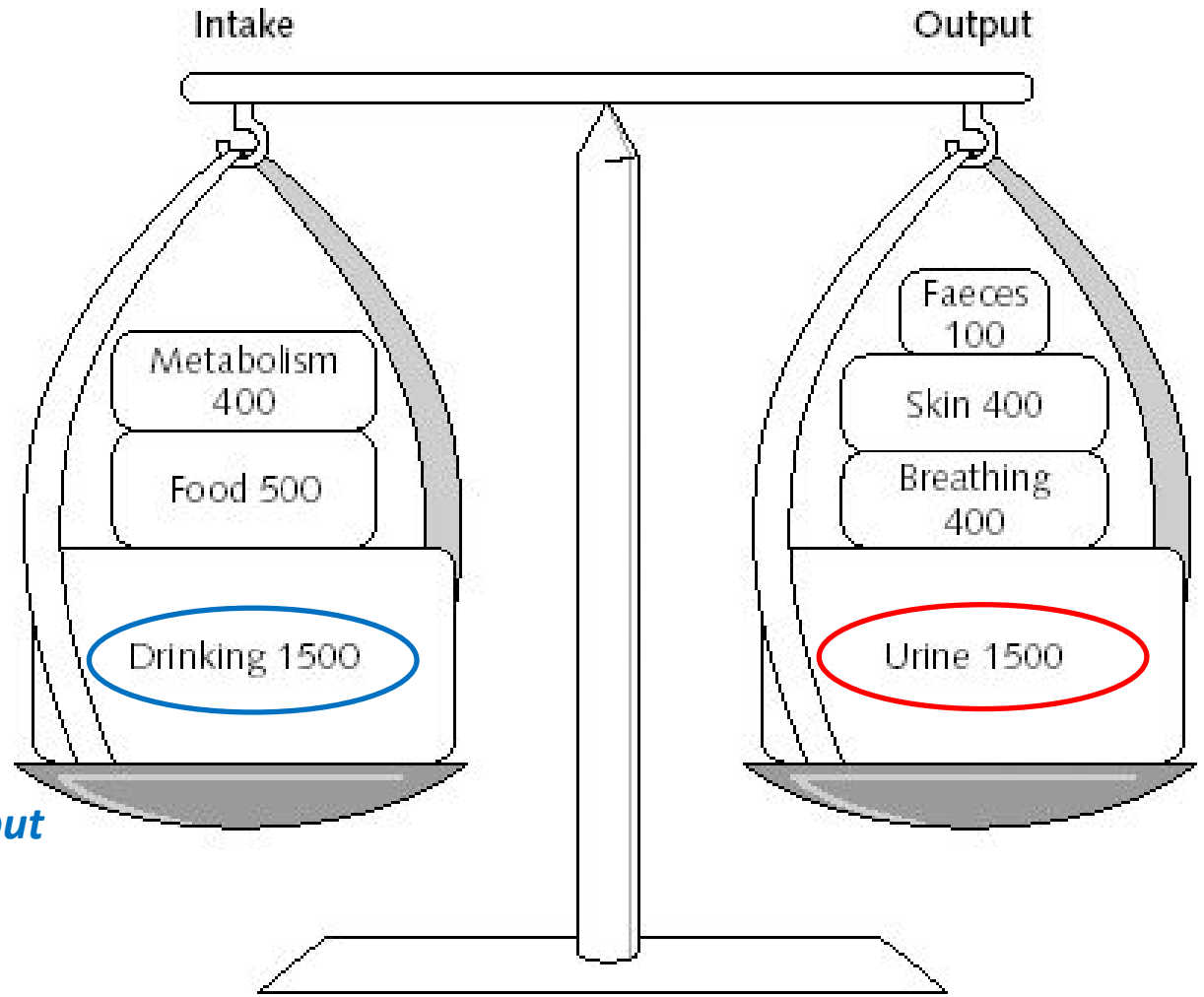
Water/fluid output

- Burns
- Exercise
- Hot weather.
- Diarrhea
- Vomiting
- Blood loss
- Diabetes

Regulation of Fluid Balance

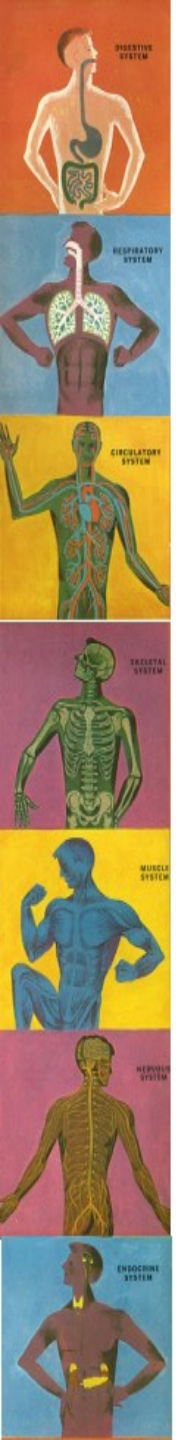
Modify intake → thirst

Modify output→ Kidney excretion



Major input

Major ouput



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%)

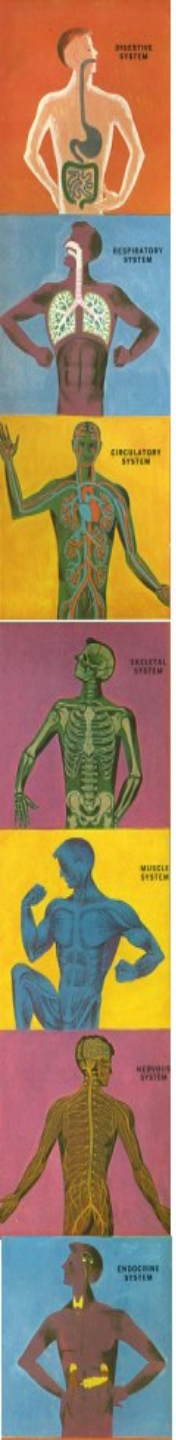
2. ***↑ ADH secretion by posterior pituitary → ↑ water reabsorption by the kidney.***

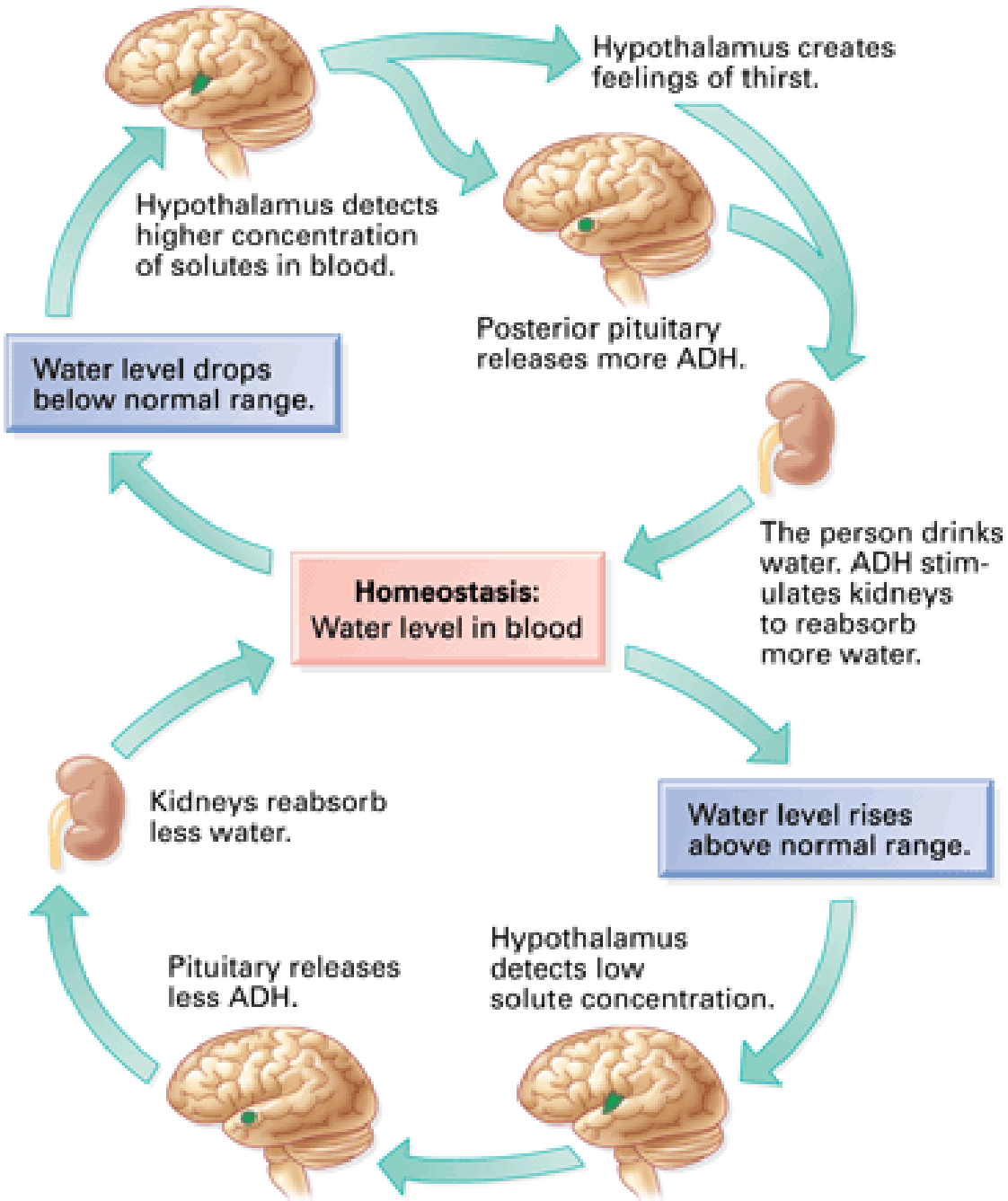
Water excess

- Input > output
- Leads to:
  - Hypervolemia.
  - Edema.

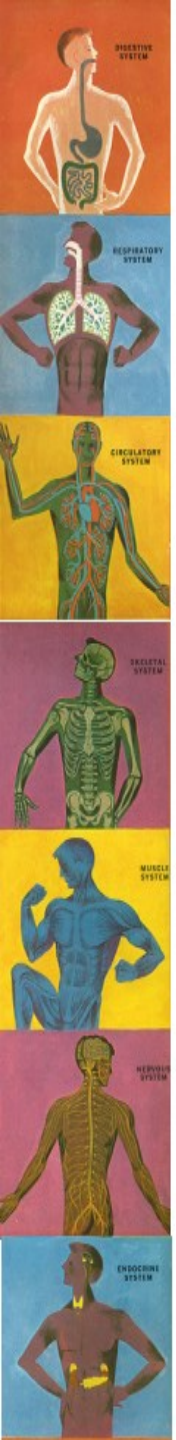
- **Physiologic regulation:**

1. ***↓ ADH secretion → ↓ water reabsorption → ↑ water excretion by kidney.***
2. ***Decrease thirst***



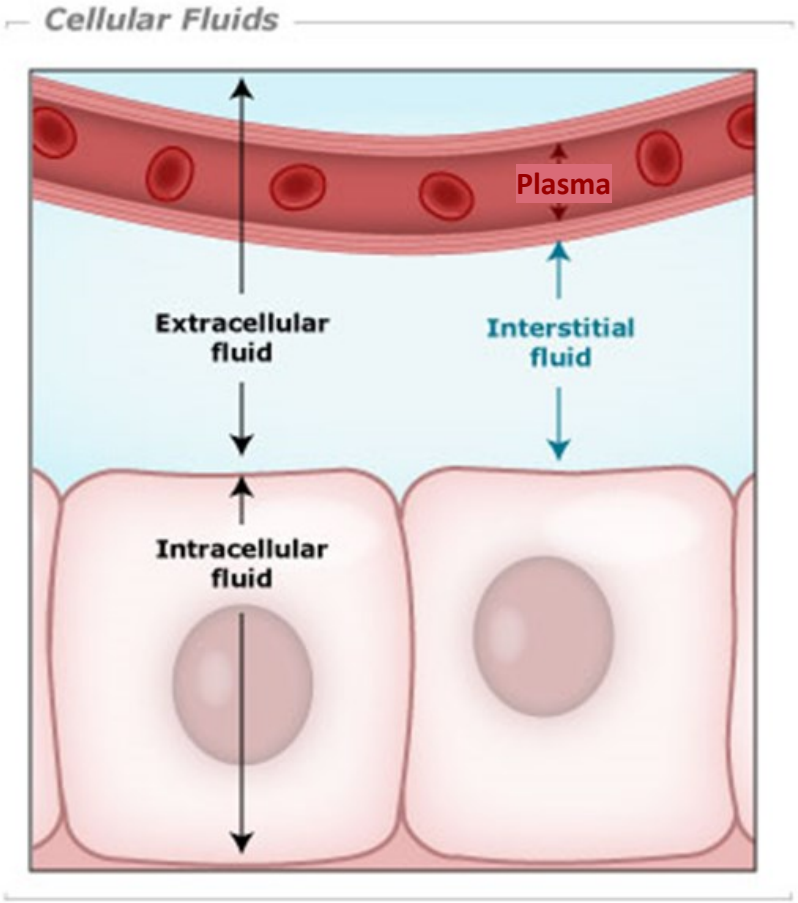

Hypothalamus creates feelings of thirst.
Hypothalamus detects higher concentration of solutes in blood.
Posterior pituitary releases more ADH.
Water level drops below normal range.
The person drinks water. ADH stimulates kidneys to reabsorb more water.
Homeostasis: Water level in blood
Kidneys reabsorb less water.
Water level rises above normal range.
Pituitary releases less ADH.
Hypothalamus detects low solute concentration.

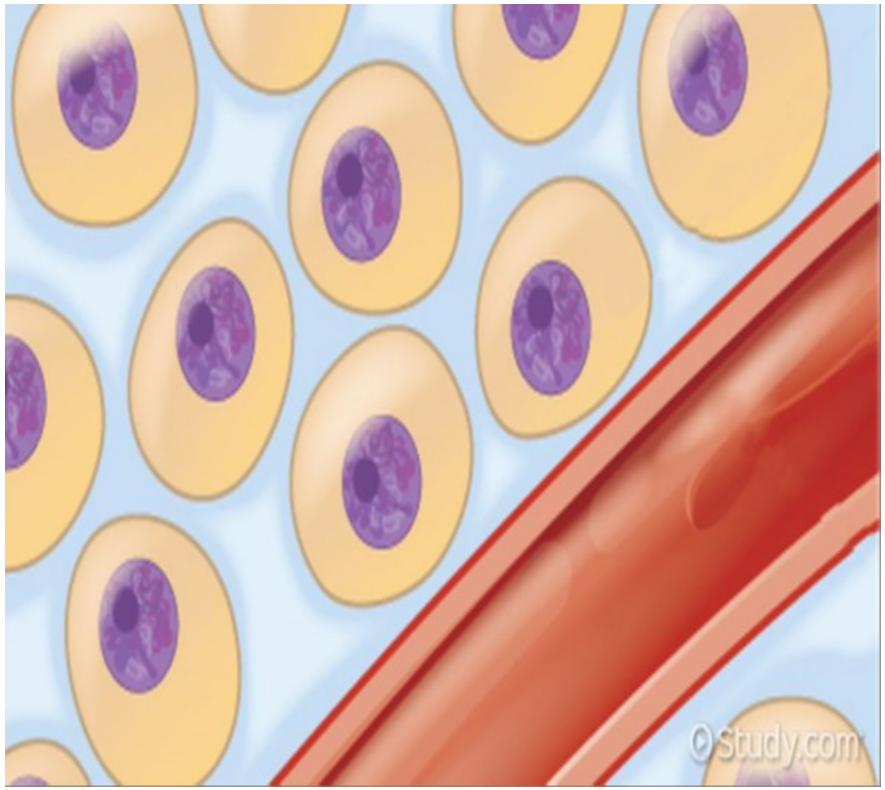
DISTRIBUTION OF BODY FLUID CONTENT

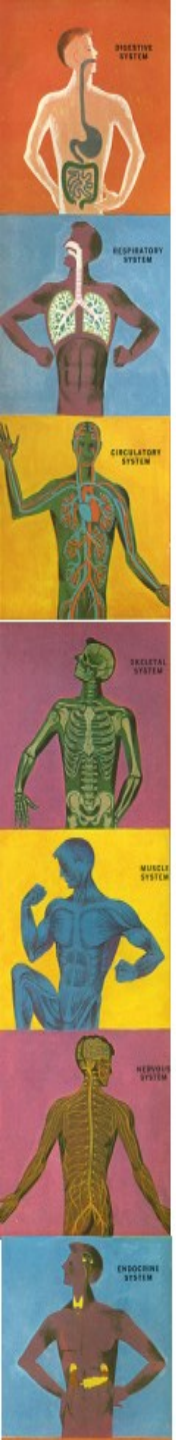


How is this water/fluid distributed in the body?

Where is this 60% of fluid/water located in the body?







Body Fluid Compartments

Total body water = 60% TBW

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

1/3 (20% of TBW)
Extracellular

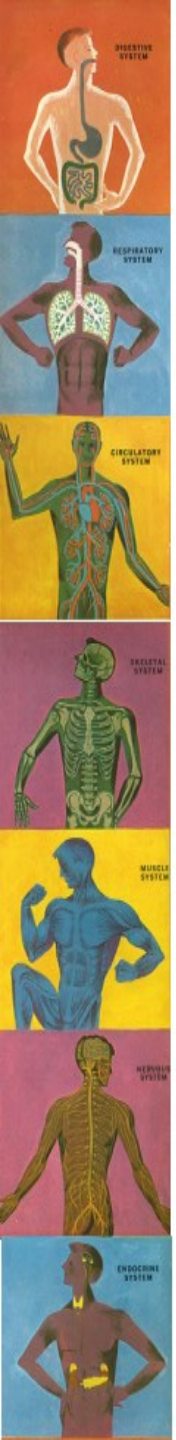
¾ (15%)
Interstitial Fluid

¼ (5%)
Plasma

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

N. B. the fractions refer to its relation with the preceding compartment. While the percentage refers to its relation to Total Body Weight)

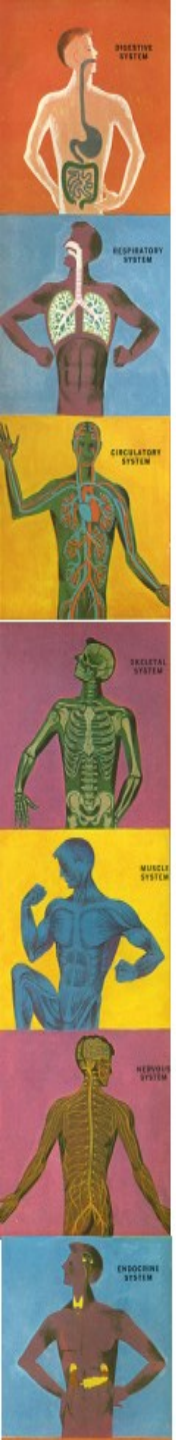
(Guyton and Hall Textbook of Medical Physiology. 13th ed. Ch-25)



Let's go back to our 30-year-old man

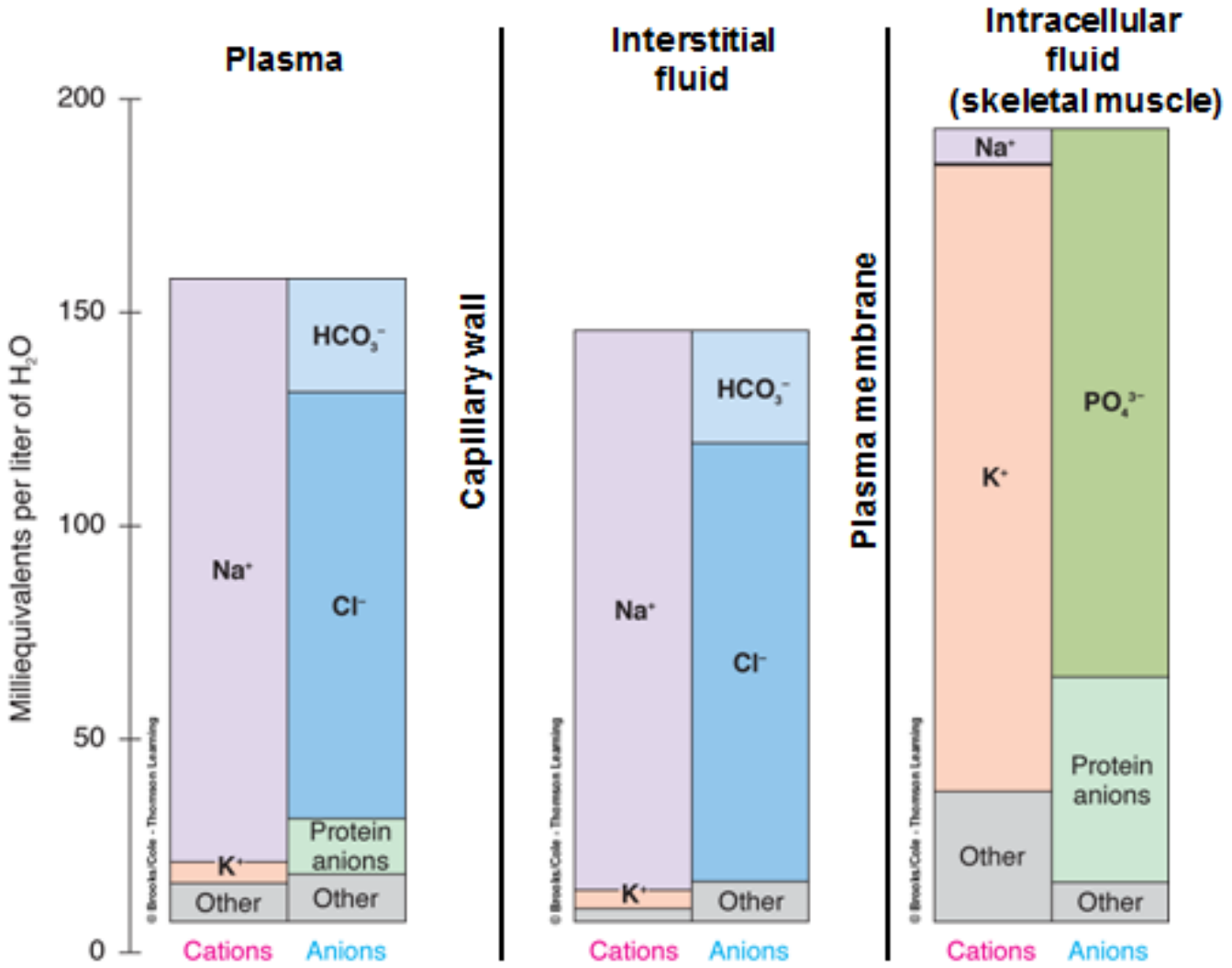
Calculate the total body water content of a 40-year-old 70kg man?

- TBW = 42 litres
- ***How many litres lie intracellularly?***
  - 42 X ⅔ = 28L ***OR*** 70 X 40/100 = 28L.
- ***How many litres lie extracellularly?***
  - 42 X ⅓ = 14L ***OR*** 70 X 20/100 = 14L.
- ***How many litres constitute the interstitial fluid?***
- ***How many litres are plasma?***

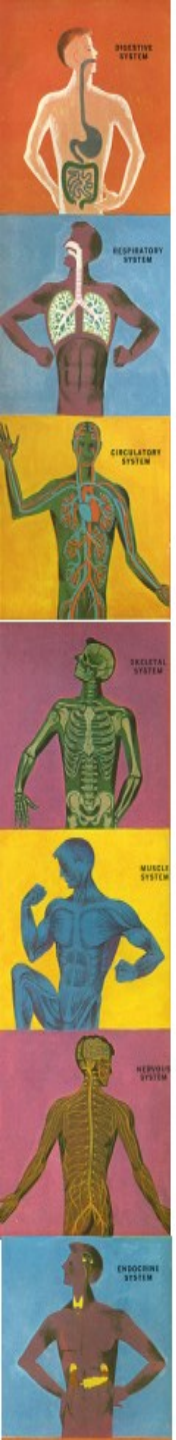


COMPOSITION OF BODY FLUIDS

Does the composition of the different body fluid compartments differ?



[Figure 15-2; Sherwood]

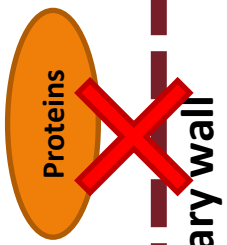


Constituents of the Different Body Fluid Compartments

Extracellular compartment

Plasma

Interstitial fluid



Capillary wall

↑↑ Na+
↑↑ Cl-, HCO3-

↓↓ K+

Cations = anions

ECFs are constantly mixing and have the same composition except for proteins.

Cell membrane

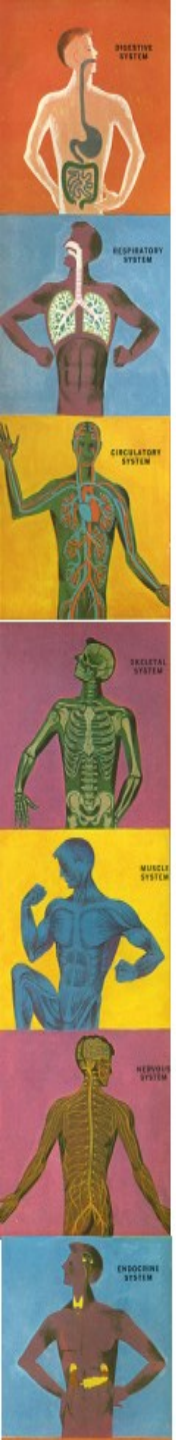
Intracellular compartment

↑↑ K+
↑↑ Phosphate (PO4-3)
↑ Proteins

↓↓Na+
↓↓ Cl-

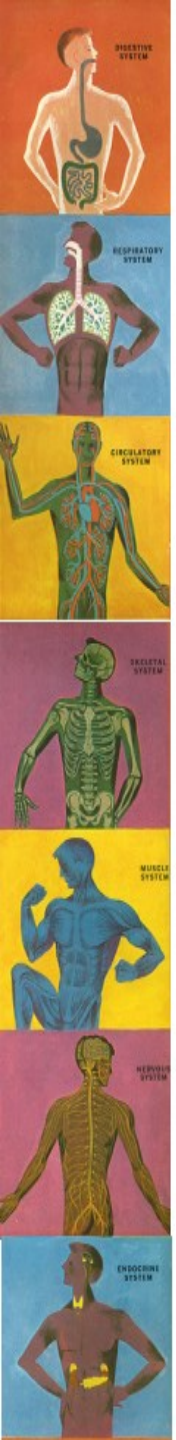
Cations = anions

Osmolarity is the same ≈300 mOsm/L



What is Osmolarity?

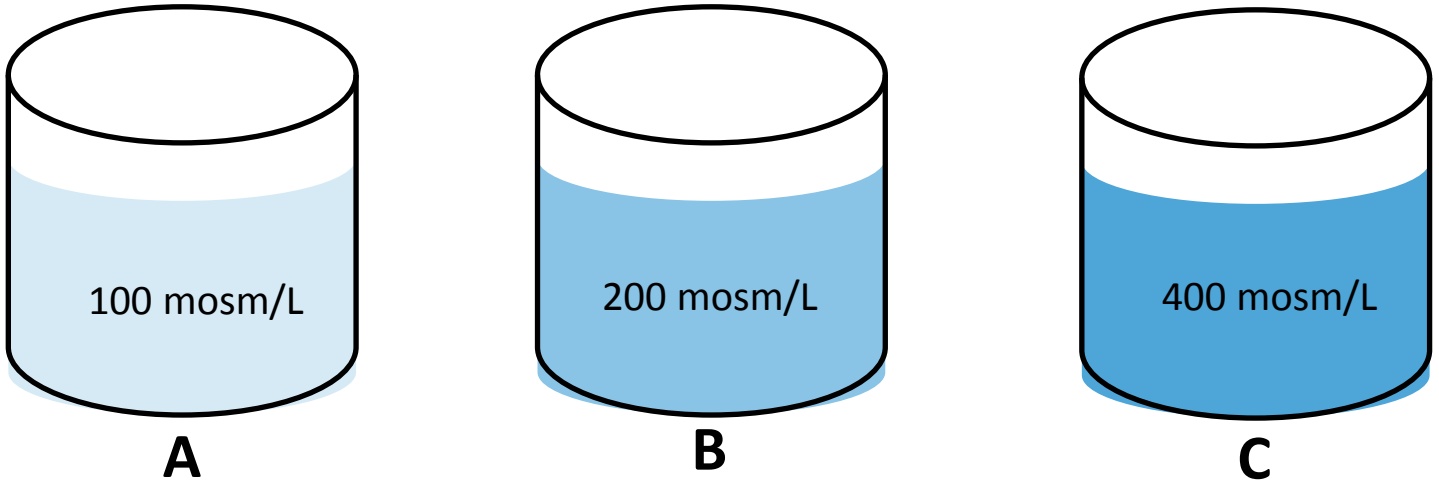
- A unit of concentration.
- It measures how concentrated or diluted a solution is.
- Defined as = the number of osmoles of a solute per litre of solution.
- The normal osmolarity of body fluids is ≈ 300 mOsm/L

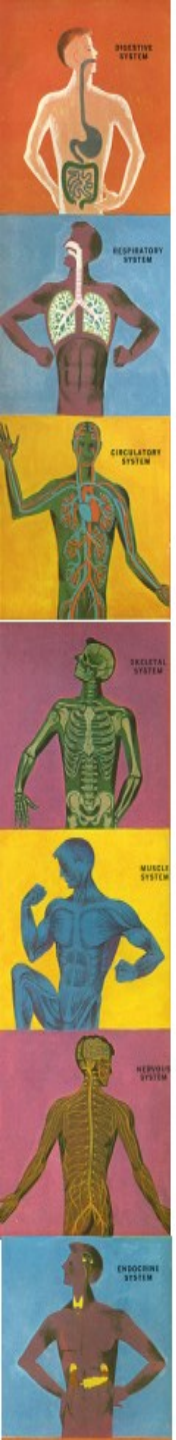


What is Tonicity?

- ***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.

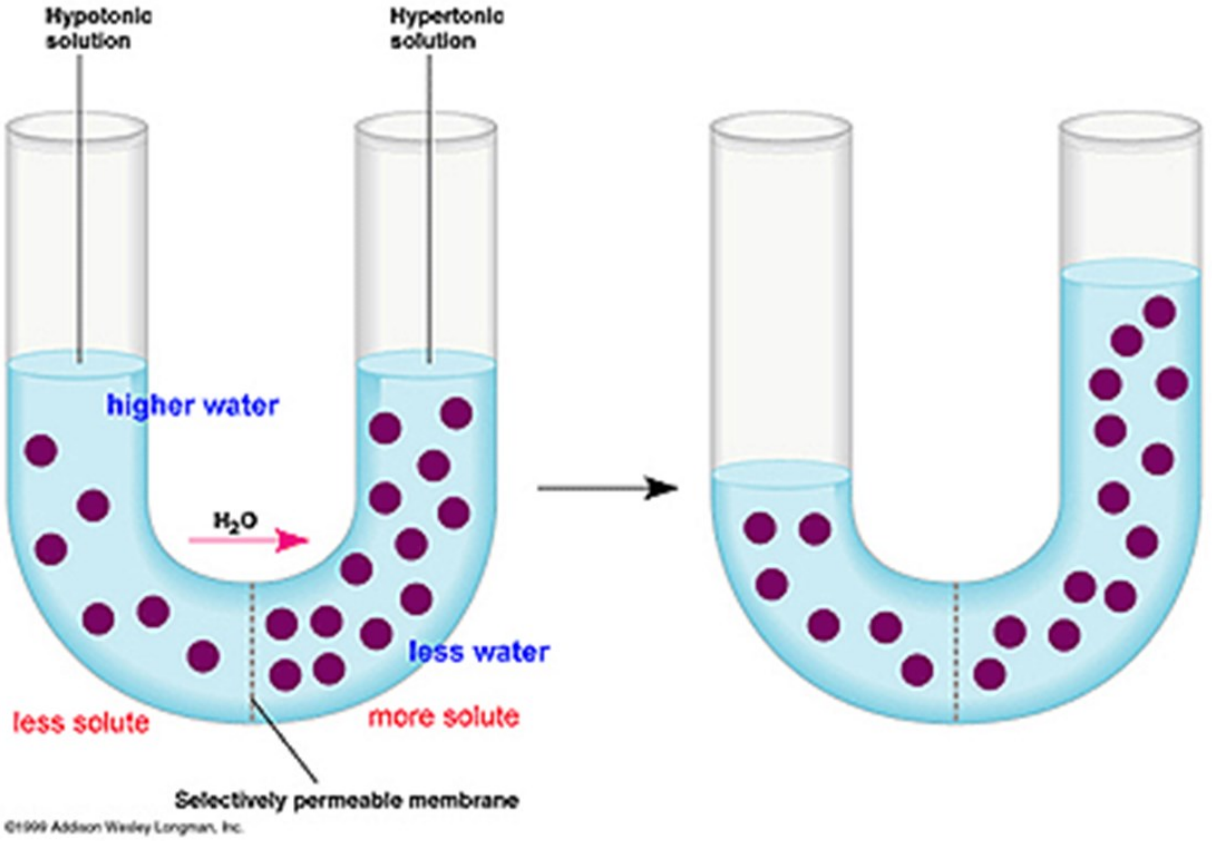
Which solution is hypertonic to B?

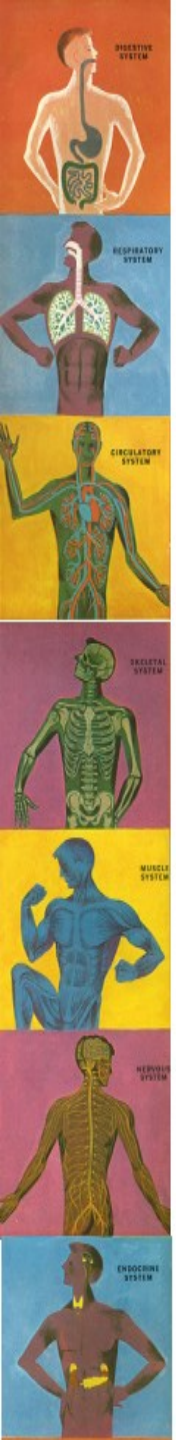




Why is it important?

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



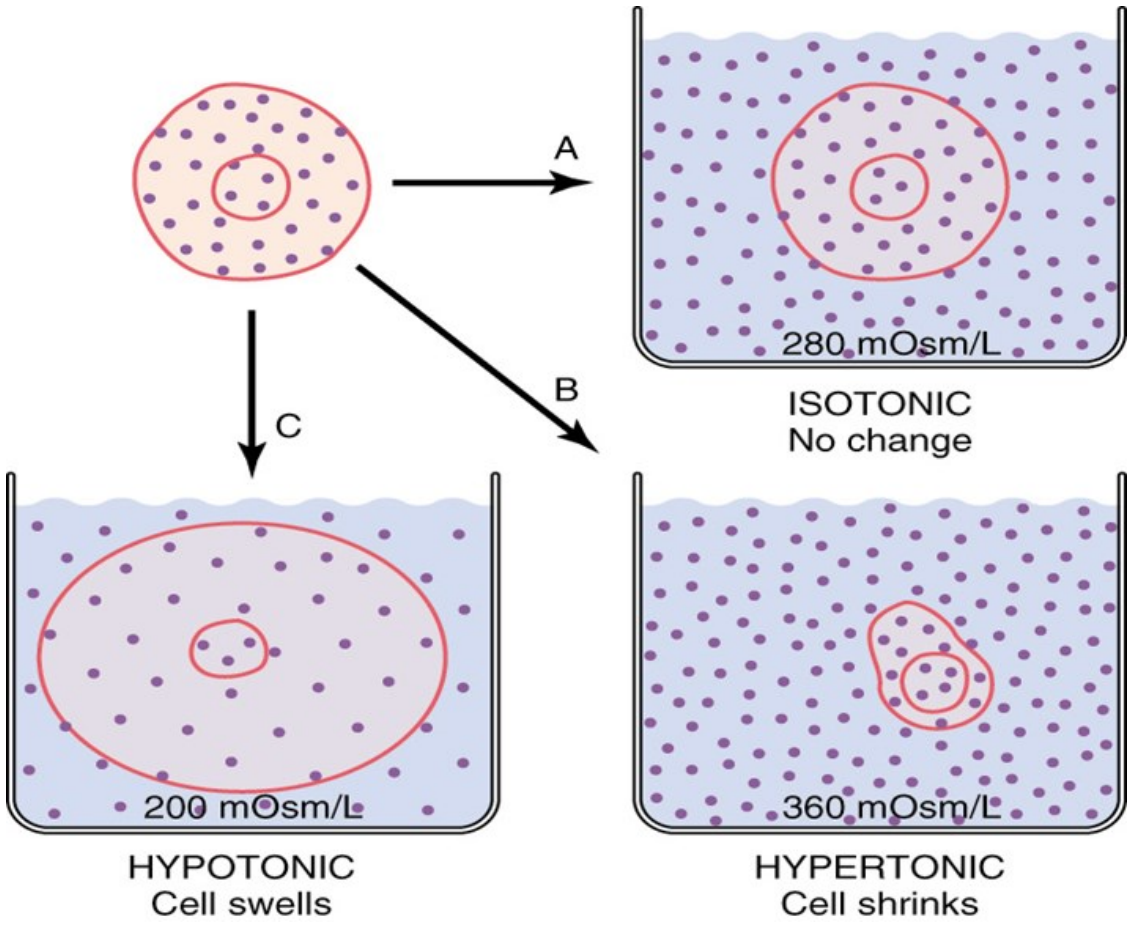


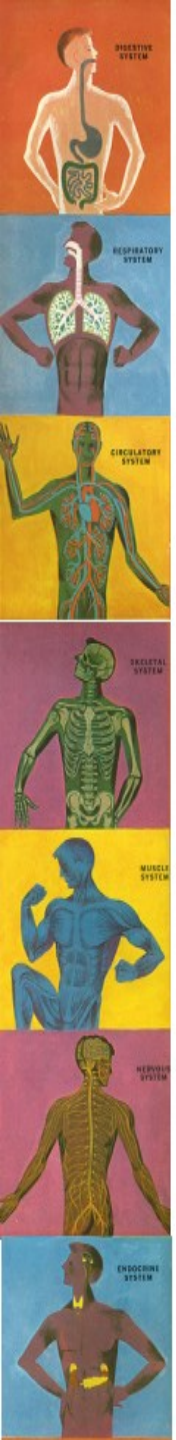
Osmosis

- It is the movement of water across a semi-permeable membrane from a region of low solute concentration to a region of high solute concentration.

How does it apply to physiology?

The cell membrane is a semi-permeable membrane (Allows only water to move freely across it)



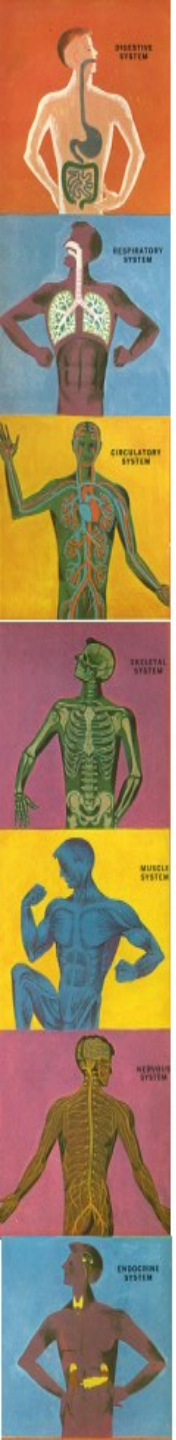


How is it related to patient care?

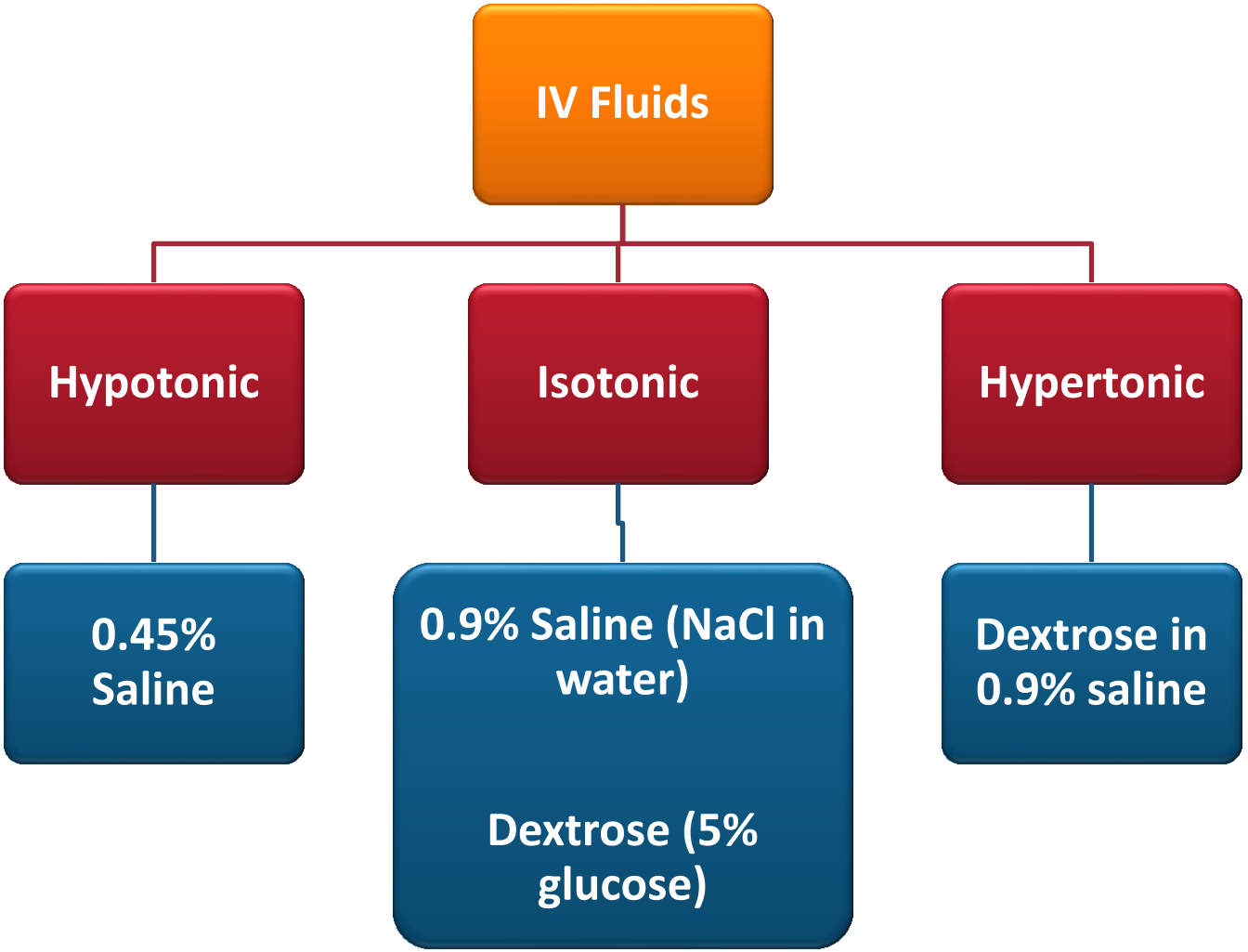
1. Physicians administer fluids to patients for various reasons that may change the osmolarity of ECF.

2. 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)

- There are many types of IV fluids with different tonicities.

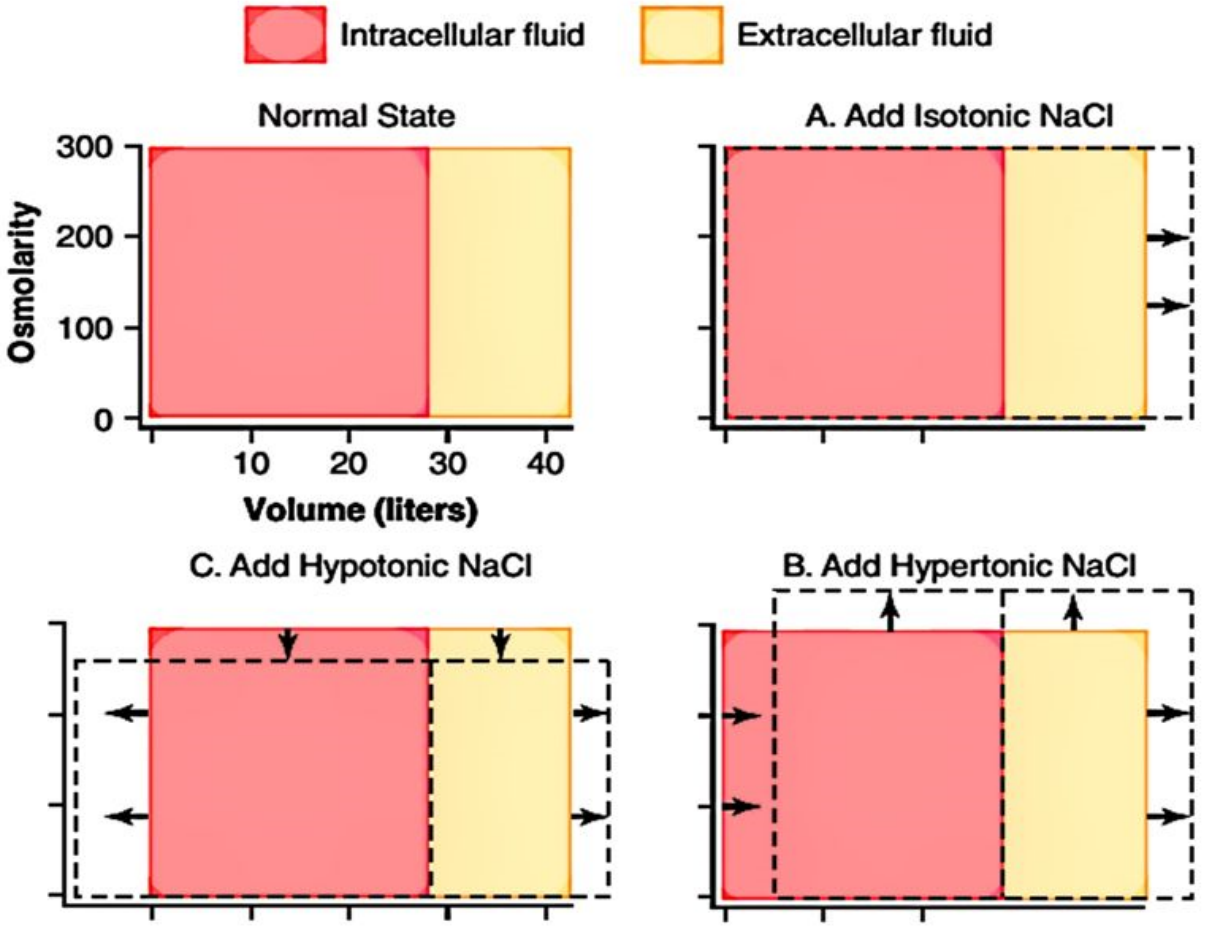


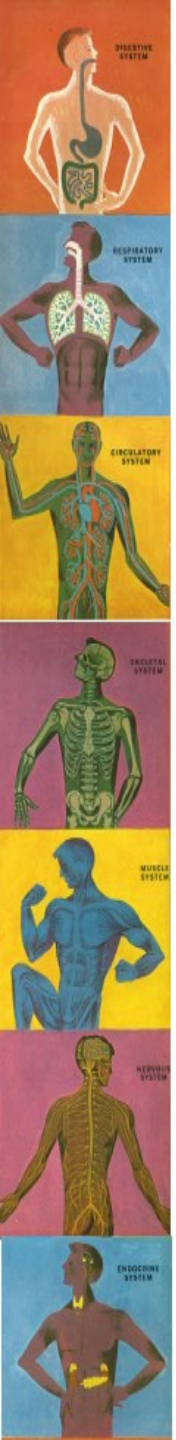
Types of IV Fluids



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

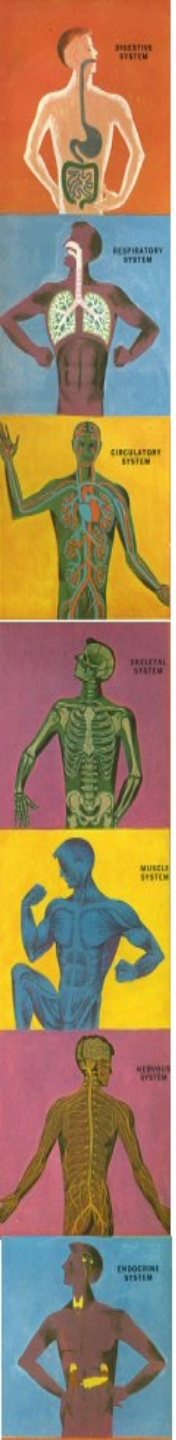
Effect of adding isotonic, hypertonic, and hypotonic solutions to the extracellular fluid after osmotic equilibrium. The normal state is indicated by the solid lines, and the shifts from normal are shown by the shaded areas.





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

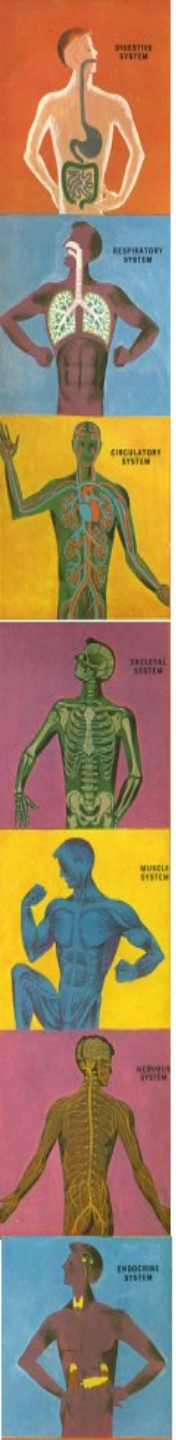
Adding ***hypertonic*** solution	Adding ***isotonic*** solution	Adding ***hypotonic*** solution
• ↑ ECF osmolarity • Water moves out of cells into ECF. • ICF volume decreases. • ECF volume increases. • ↑ ICF osmolarity	• No change in ECF osmolarity. • No osmosis occurs through cell membrane. • ECF volume increases.	? Activity



Clinical Abnormalities of Fluid Volume Regulation
(Hypo- & Hypernatremia)

Plasma Na+ concentration

- **↑ [Na+] "Hypernatremia"**
  - **Excess Na+ in ECF**
    - Excess aldosterone hormone
    - → Hypernatremia + overhydration
  - **Loss of water from ECF**
    - ADH deficiency
    - Water intake less than water loss (excessive sweating)
    - → Hypernatremia + dehydration
- **↓ [Na+] "Hyponatremia"**
  - **Loss of Na+ from ECF**
    - Decrease aldosterone secretion
    - Overuse of diuretics
    - Vomiting & diarrhea
    - → Hyponatremia + dehydration
  - **Excess water in ECF**
    - Excess ADH (SIADH)
    - → Hyponatremia + overhydration



Clinical Manifestations of Hypo- & Hypernatremia

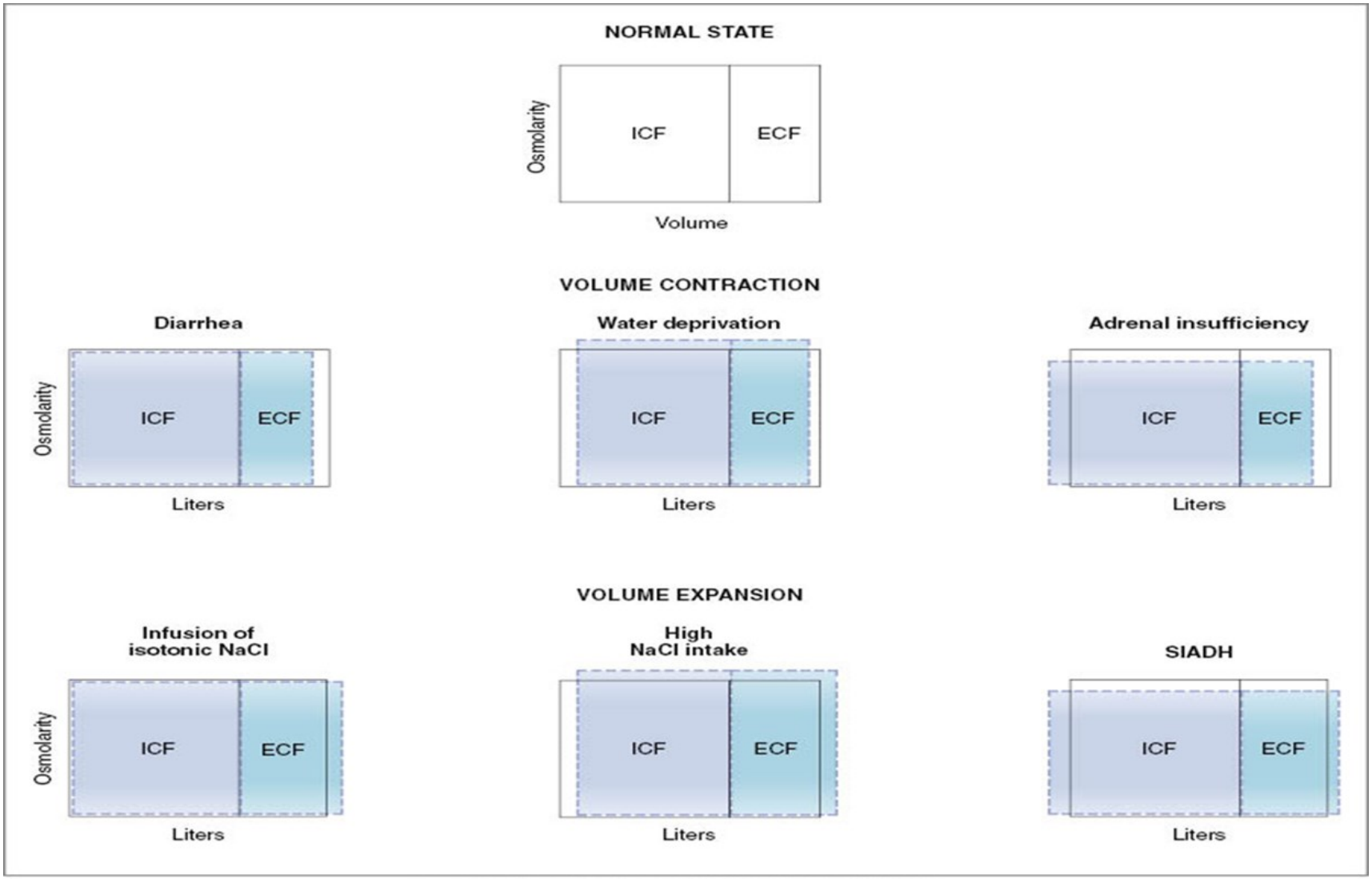
Hyponatremia

- ↓↓ Plasma [Na+] → ↓↓ECF osmolarity causing cells to swell.
- Brain cell edema leads to neurologic symptoms;
  - Headache.
  - Nausea.
  - Lethargy & disorientation.
- [Na+] < 115-120mmol/L → seizures, coma, permanent brain damage & death.

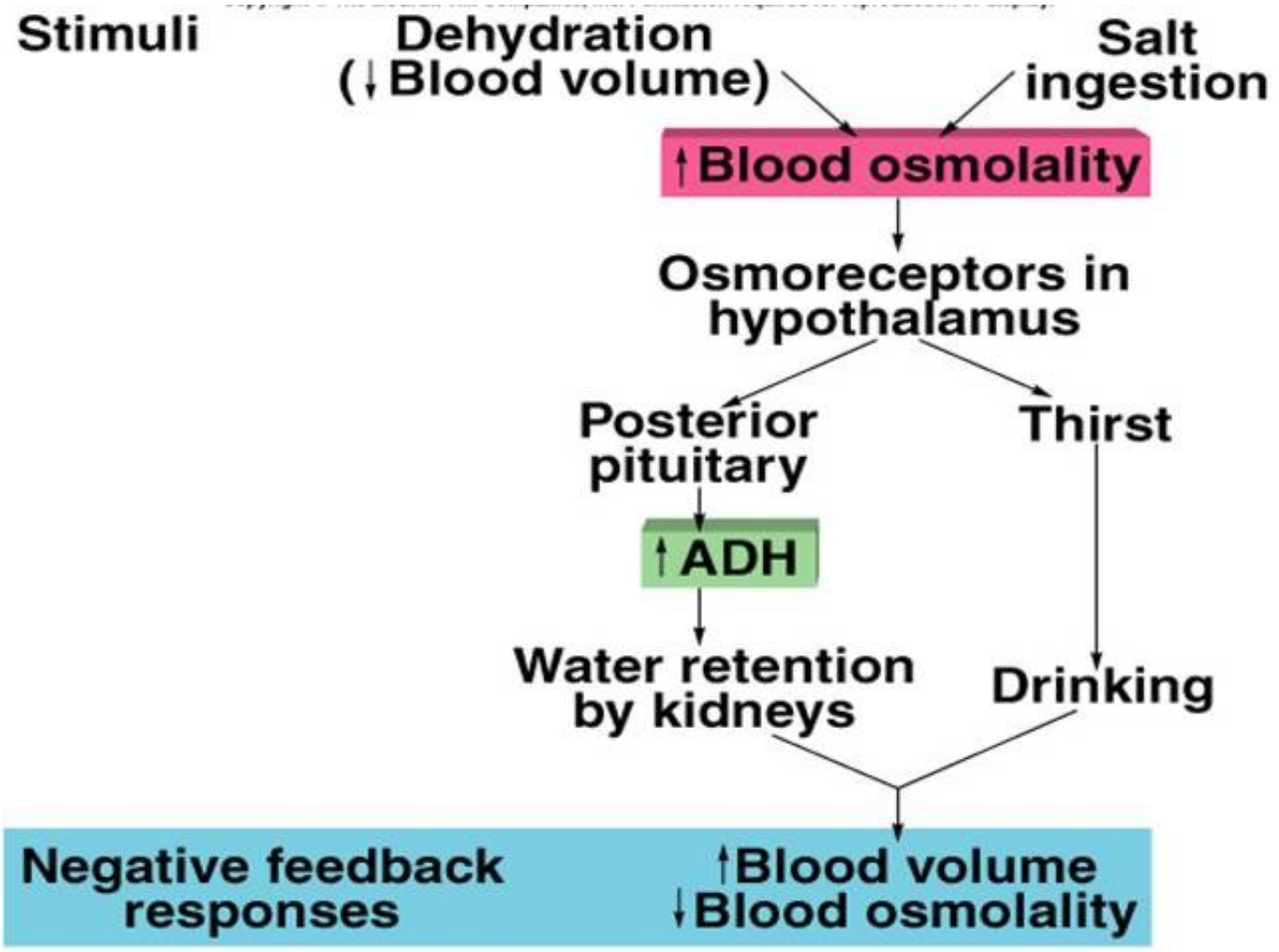
Hypernatremia

- ↑↑ Plasma [Na+] → ↑↑ ECF osmolarity causing cells to shrink.

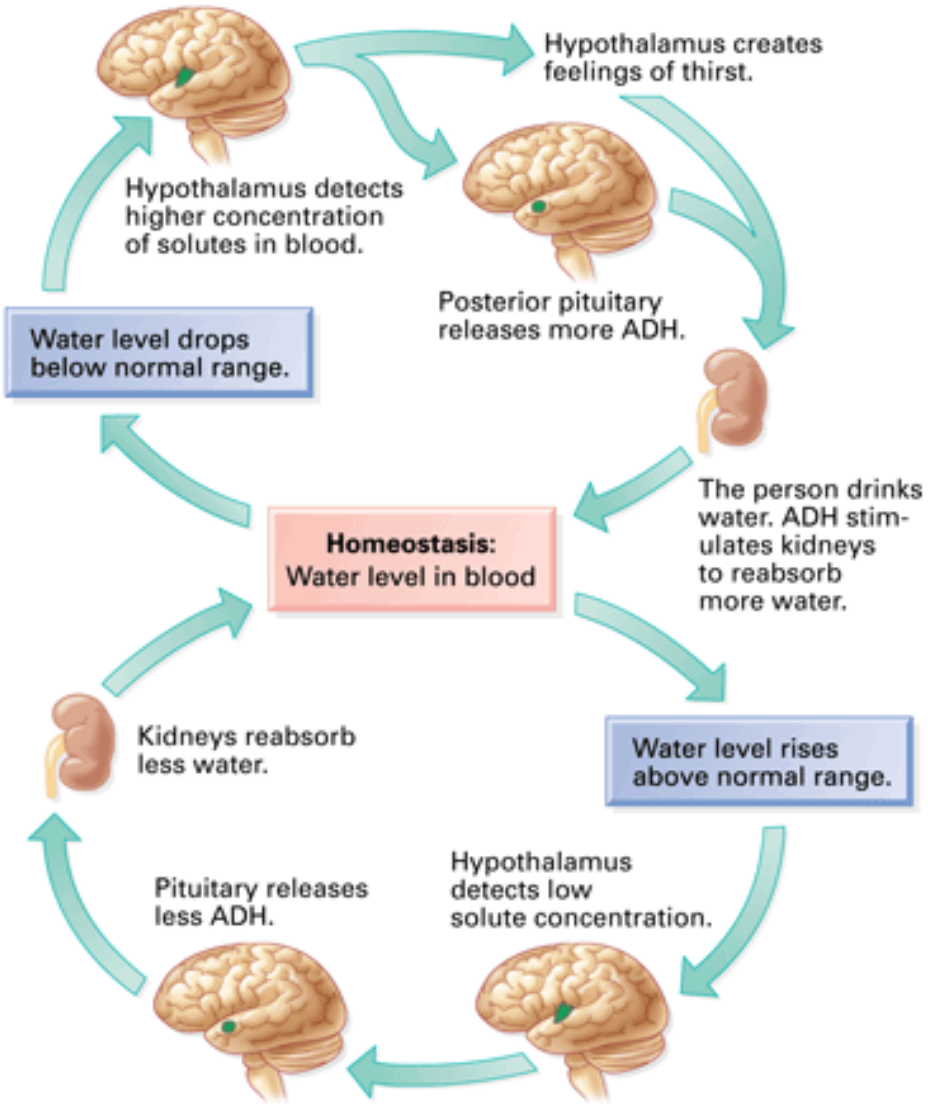
What happens to body fluid compartments in different clinical situations?



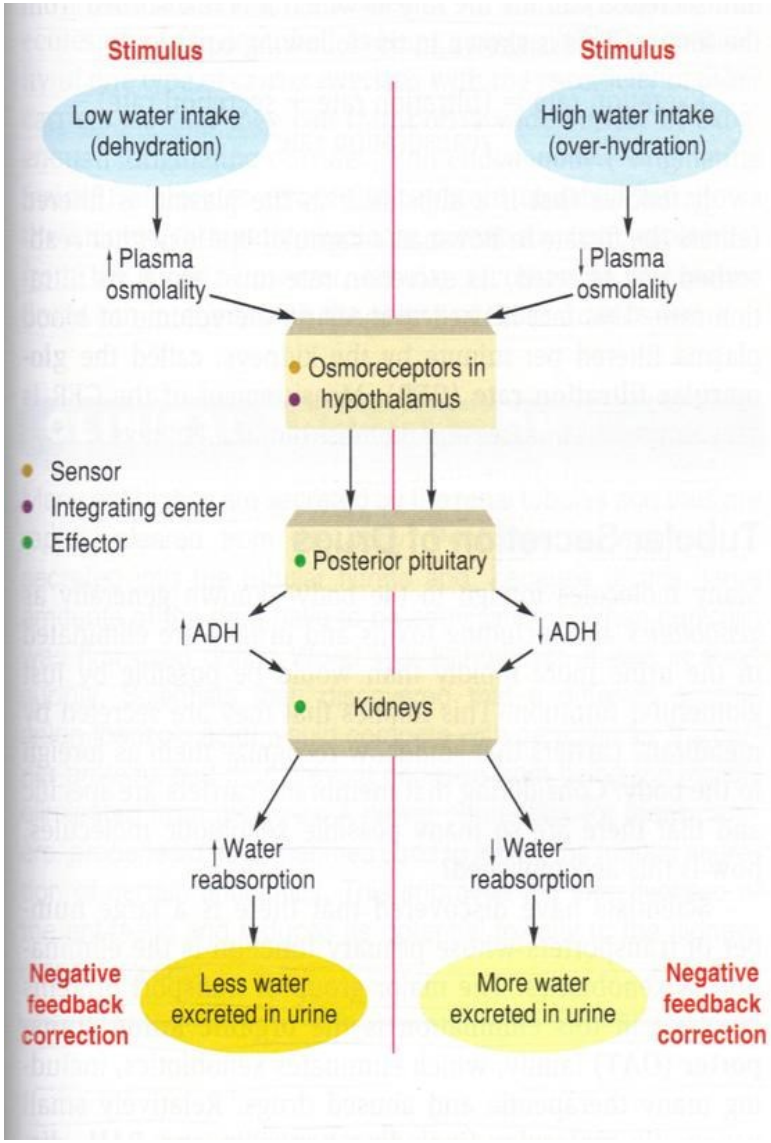
What are the feedback mechanisms operating in fluid balance control?

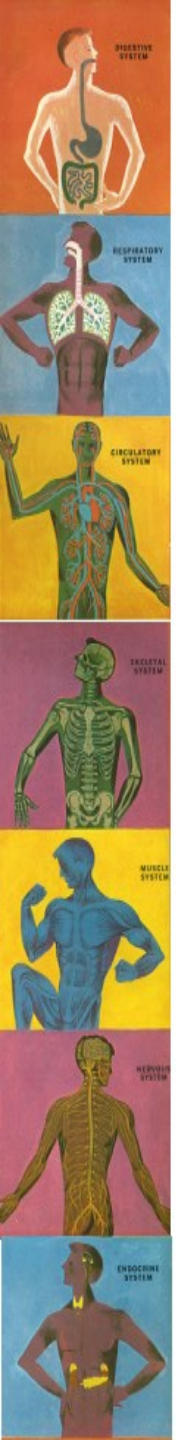


Feedback Mechanisms Controlling Fluid Balance



Feedback Mechanisms Controlling Fluid Balance





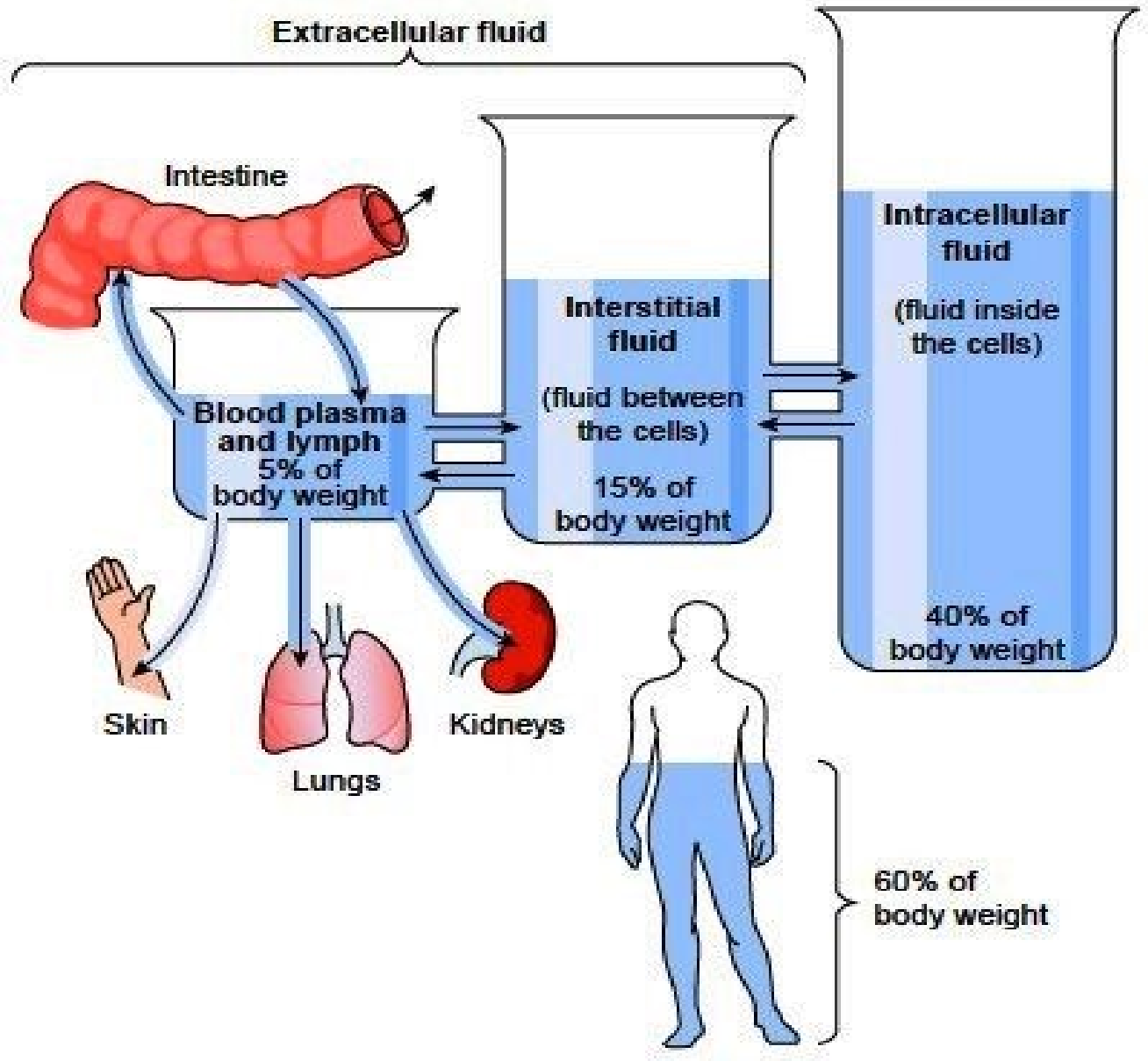
Water distribution in the body

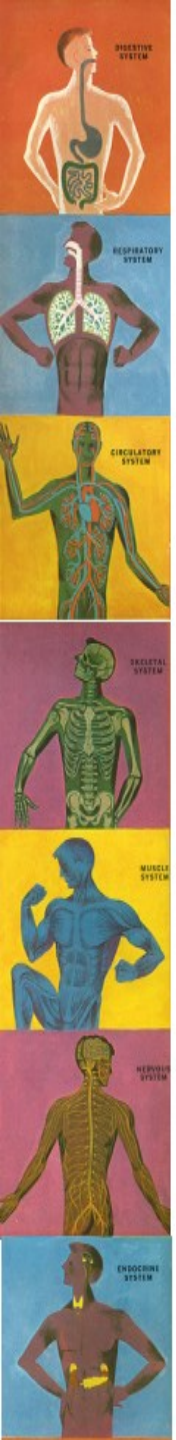
An exercise

- After learning about water content of the human body, a ***60kg*** medical student was curious to calculate her own body water content. What would you expect the ***total volume of her body water*** to be?

- And what is the volume of the following compartments?
  - ICF
  - ECF
  - IF
  - Plasma

In summary


Extracellular fluid
Intestine
Intracellular fluid
(fluid inside the cells)
Interstitial fluid
(fluid between the cells)
15% of body weight
Blood plasma and lymph
5% of body weight
40% of body weight
Skin
Lungs
Kidneys
60% of body weight


DIGESTIVE SYSTEM
RESPIRATORY SYSTEM
CIRCULATORY SYSTEM
SKELETAL SYSTEM
MUSCLE SYSTEM
NERVOUS SYSTEM
ENDOCRINE SYSTEM

Thank you