

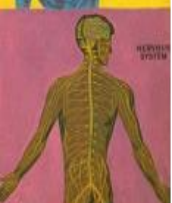
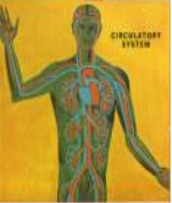
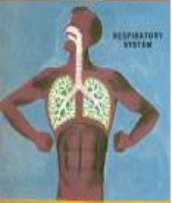
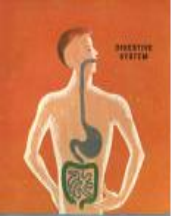
# Introduction to Physiology Levels of Organisation

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Maha Saja

# Objectives

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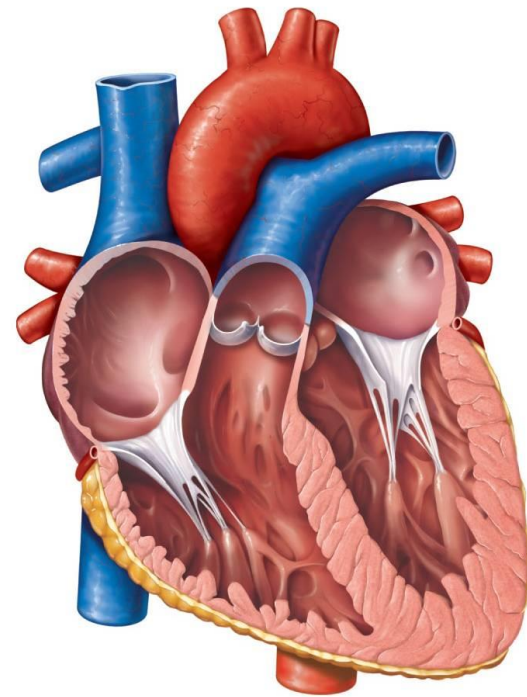


- Define physiology.
- Describe the levels of organisation of an organism.
- Discuss the internal environment and its importance in physiology.

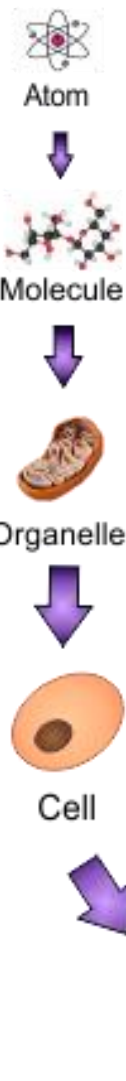
# What is *Physiology*?

- = Physio- + -logy
  - *Physio-*: nature
  - *-logy*: science or study of
- ***Physiology*** = The science dealing with the way a normal organism and their body parts function.
- It is a cornerstone to medicine.

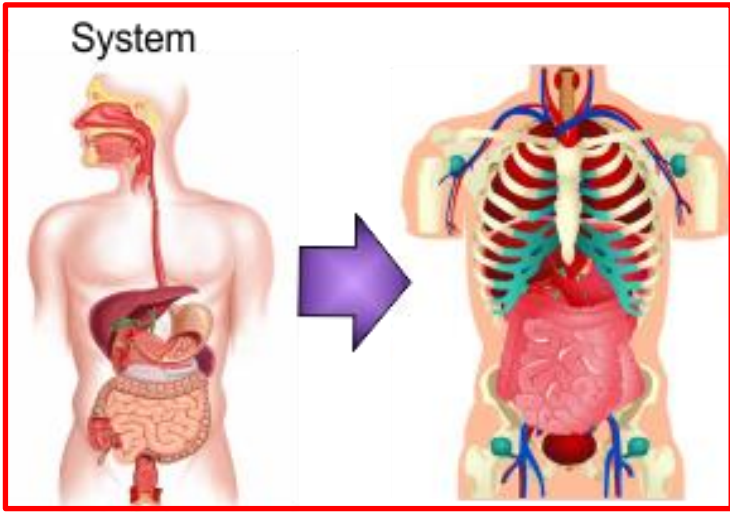
What is the difference between ***anatomy*** and ***physiology*** of the heart?



# Levels of Organisation

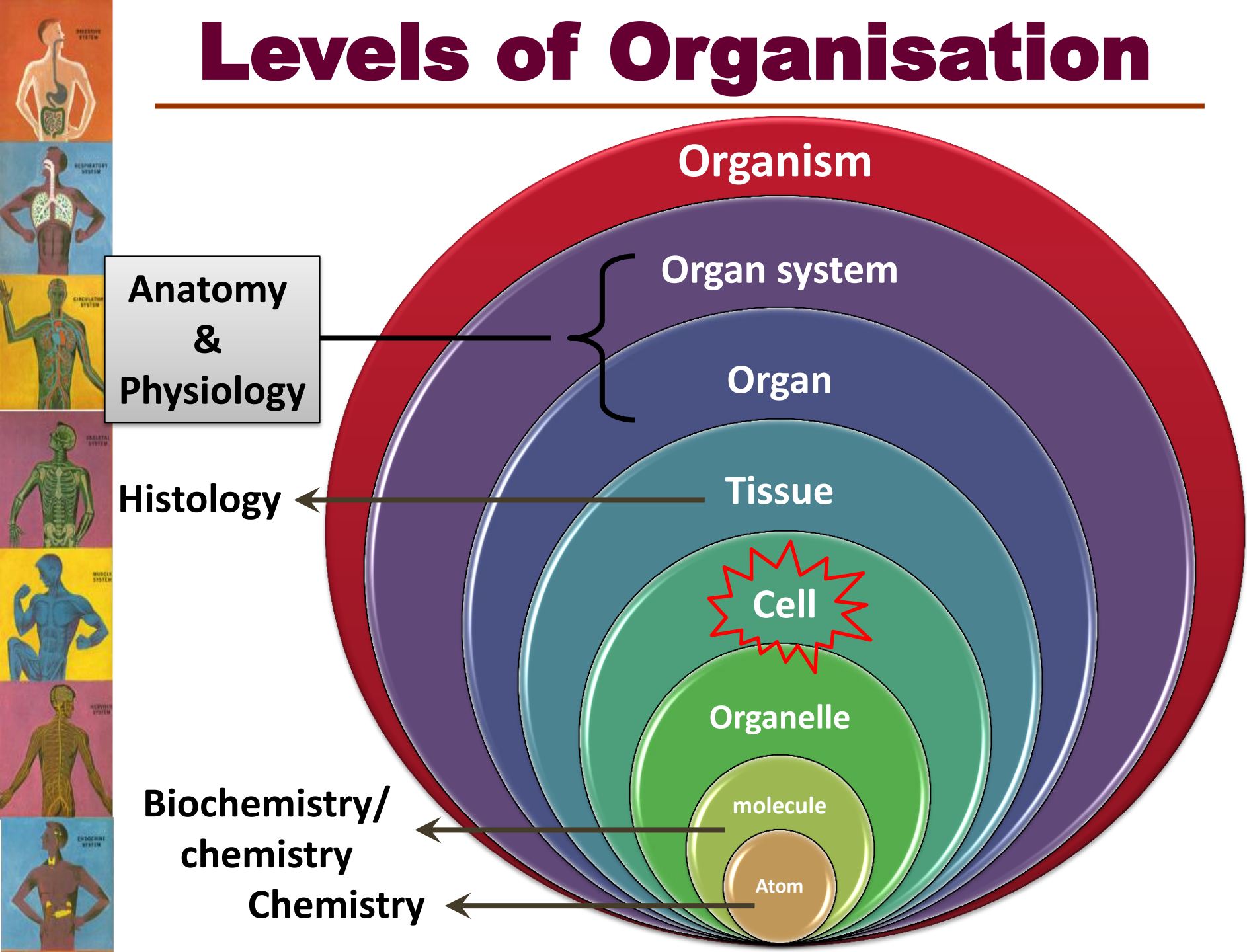


The basic living unit of the body



Human (organism)

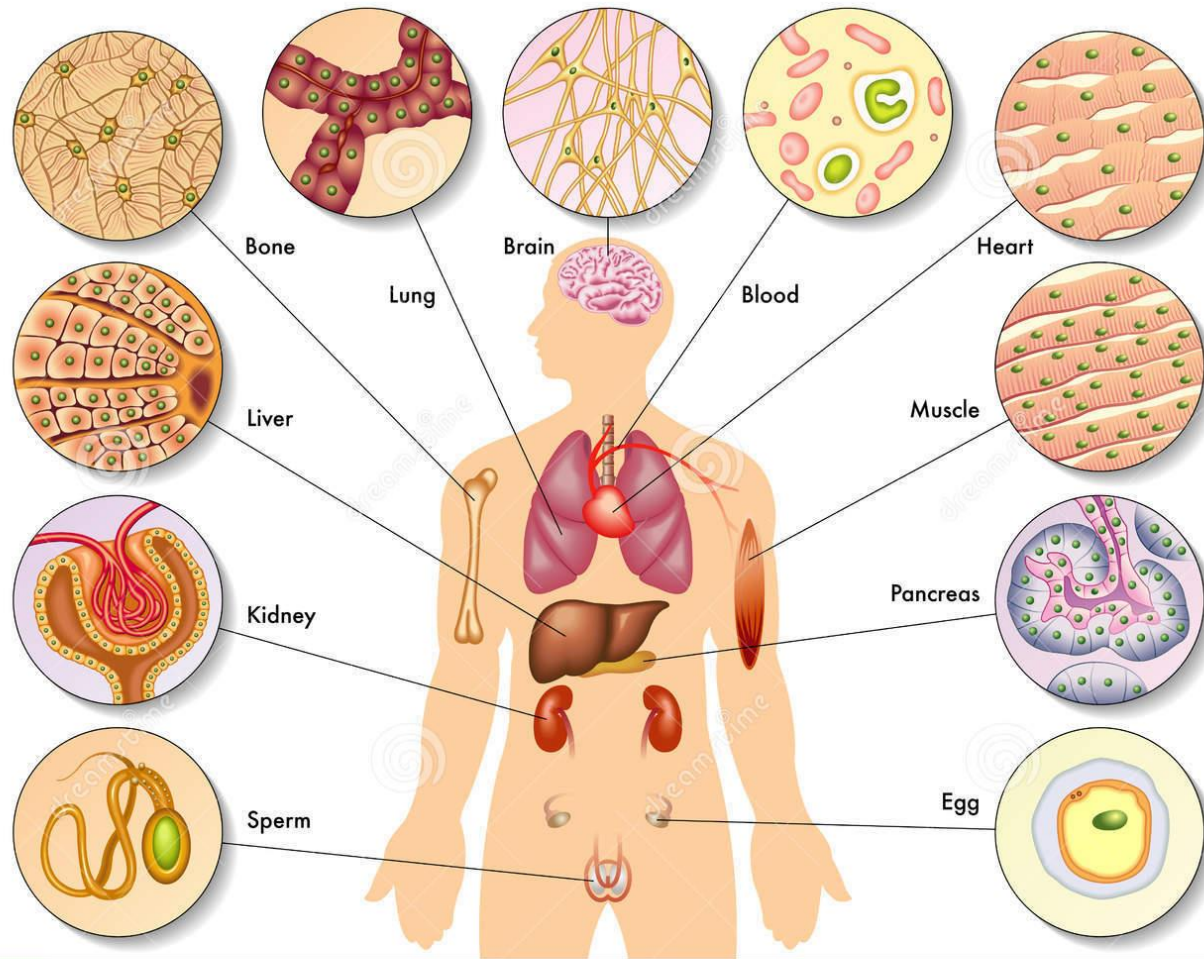
# Levels of Organisation



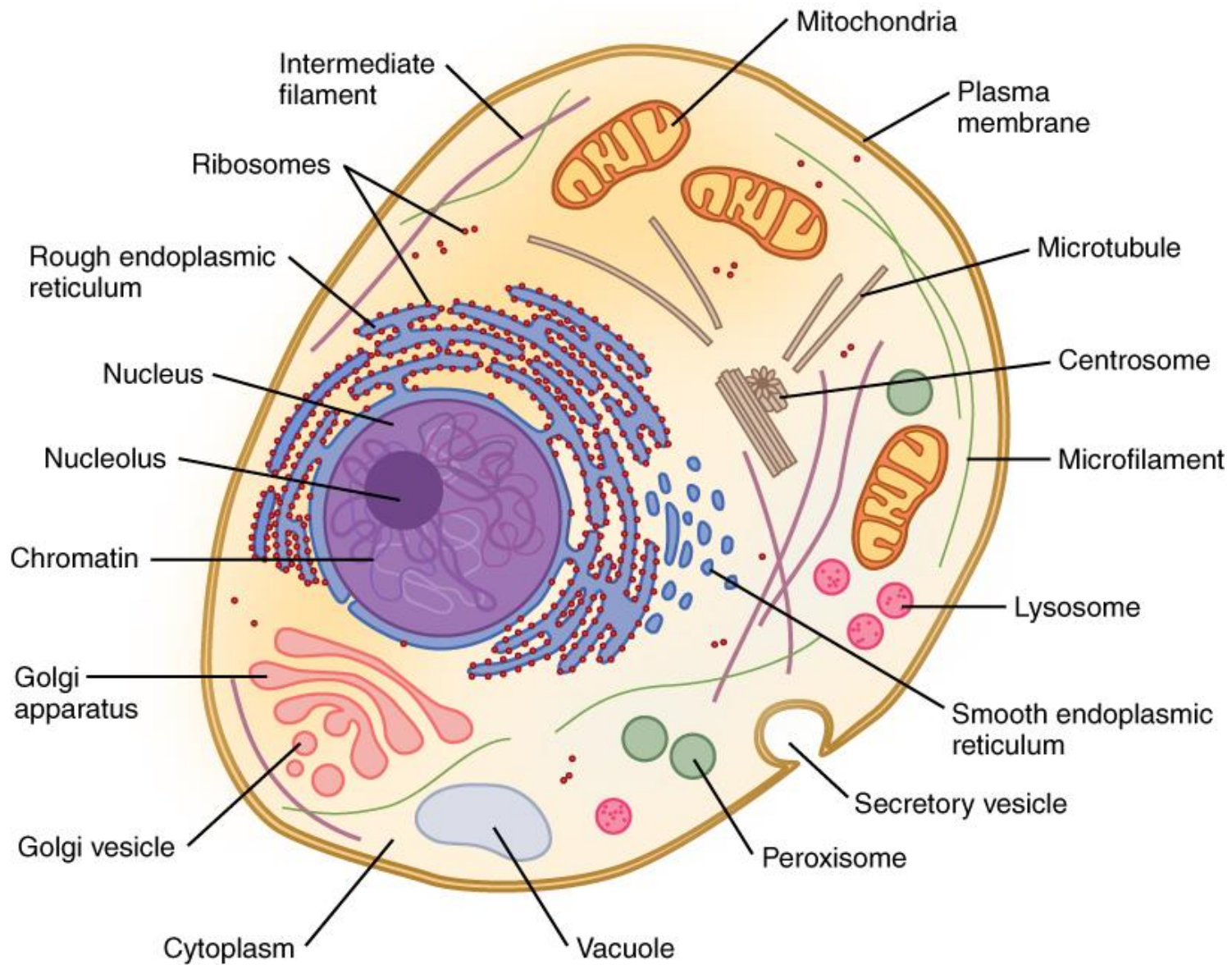


# The Cell

*The cell is the basic living unit of the body*



- Cells may differ markedly from one another, but they all share certain basic characteristics.



# The Internal Environment

## “Milieu Intérieur”

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- All the cells in the body are continuously bathing in fluid.
- Because this fluid is *outside* the cell, it is called extracellular fluid (ECF).
- It is from the ECF that cells get the ions and nutrients needed to maintain life.
- *All cells in the body live in the same environment i.e. ECF*



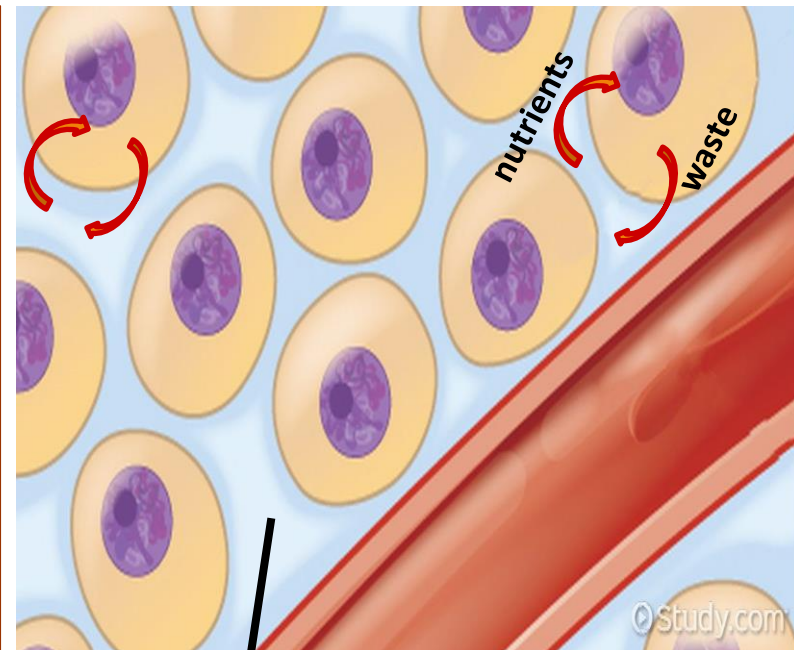
# “Milieu Intérieur”

*All cells of the body are constantly bathing in fluid.*

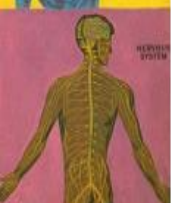
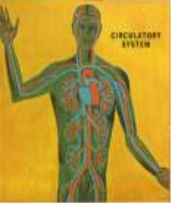
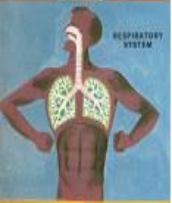
- From the ECF cells receive ions, nutrients and oxygen needed to maintain life.

1. All body cells live in the same environment i.e. ECF.
2. The composition of ECF is almost similar between the different species.

→ it was called ***the internal environment (milieu interieur)*** by the French physiologist Claude Bernard.



Because this fluid is ***outside*** the cells it is called “***extracellular fluid (ECF)***”



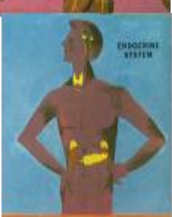
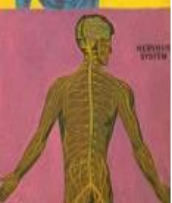
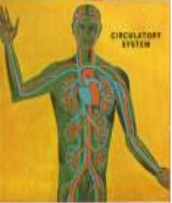
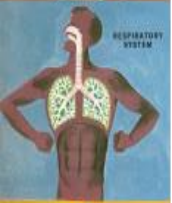
# Body Fluids

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# Objectives

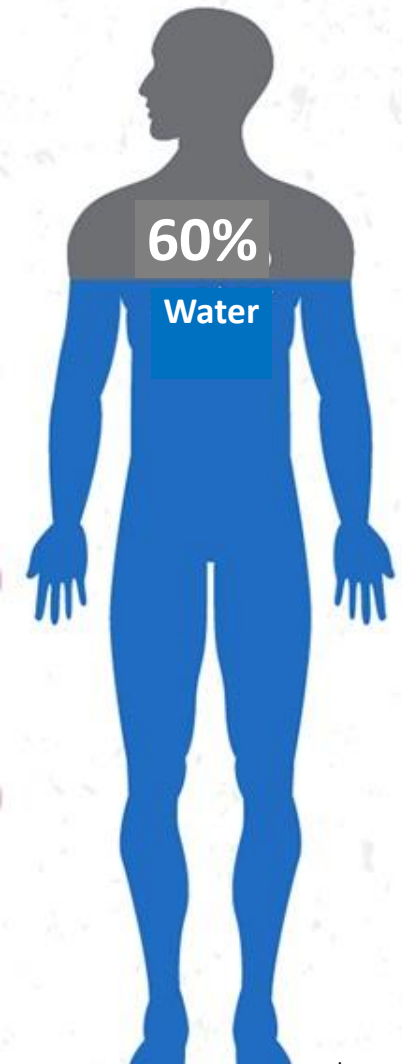
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- State the water content of the body.
- Describe the physiologic factors that determine the body's water content.
- Discuss water balance in the body with regards to intake and output.
- Describe the physiologic mechanisms involved in water balance (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.
- Define edema and describe its various kinds.

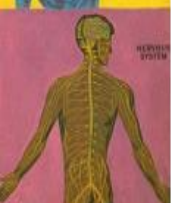
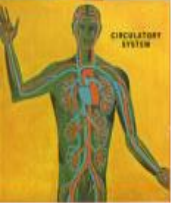
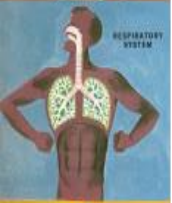
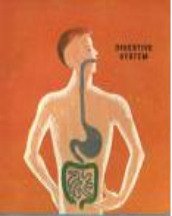


# Body Fluid Content

- Total body fluids  $\approx$  60% (50-70%) of total body weight (TBW).
- Body fluids = water + dissolved solutes.
  - Solutes
    - **Electrolytes**  
(Na<sup>+</sup>, K<sup>+</sup>, Cl<sup>-</sup>, HCO<sub>3</sub><sup>-</sup>, Mg<sup>+2</sup>, Ca<sup>+2</sup>)
    - **Non-electrolytes**  
(glucose, urea, creatinine)
- Total body water  $\approx$  60% of TBW.







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

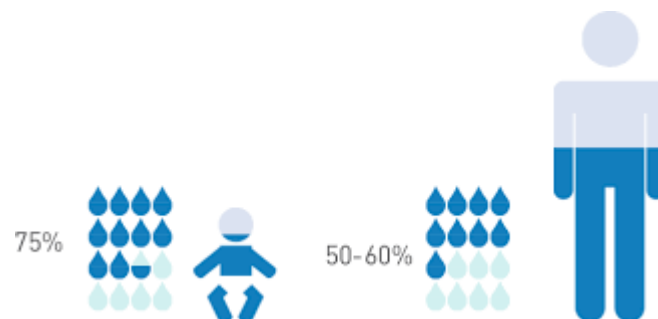
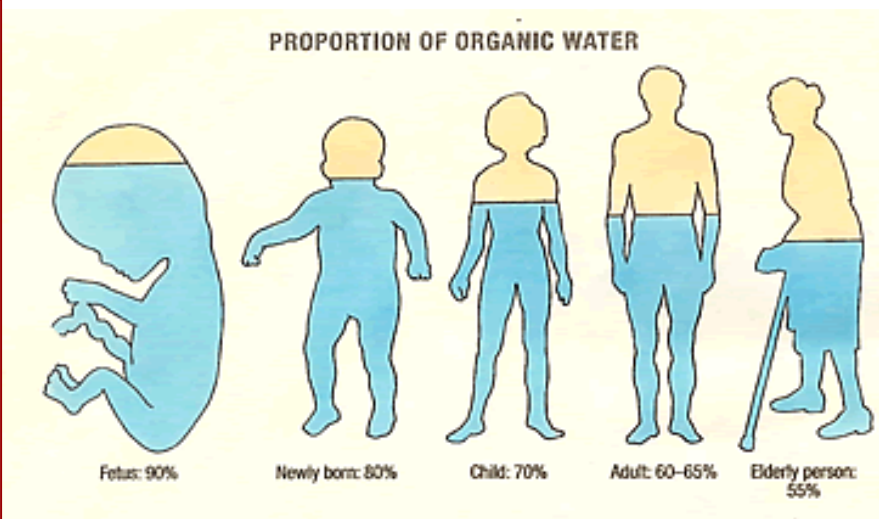
# Physiologic factors affecting body water content

- *Is body fluid/water content similar between;*

➤ Child & adult?

➤ Young & old?

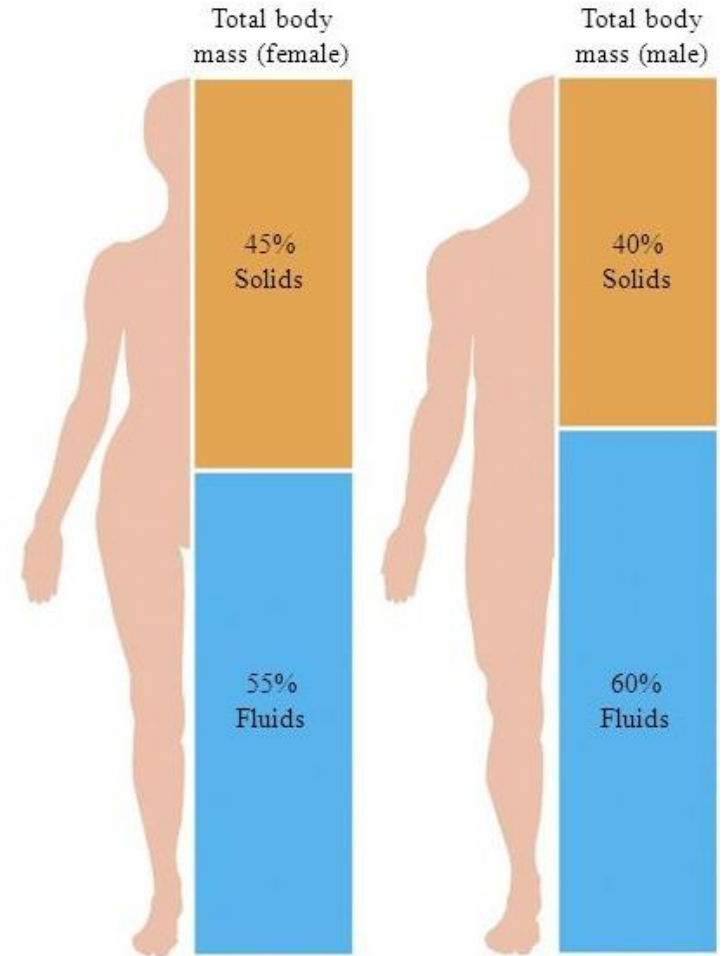
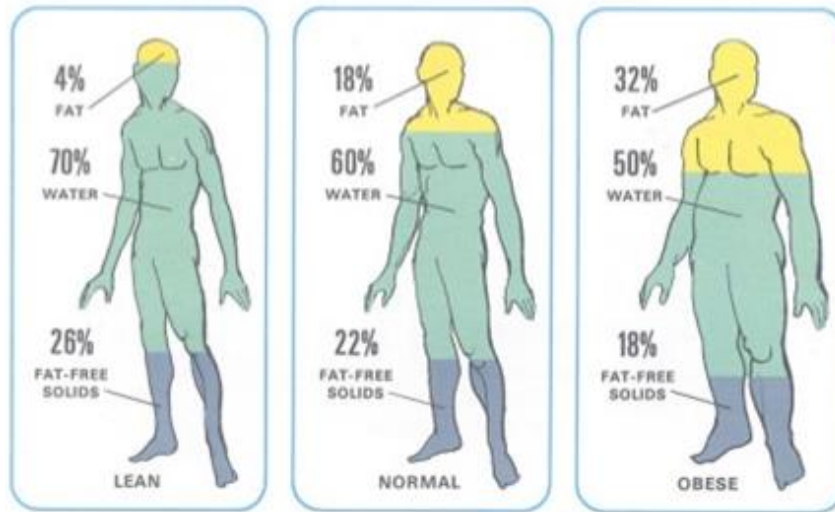
➤ Male & female?



# Continue.. Physiologic Factors Affecting Body Fluid Content

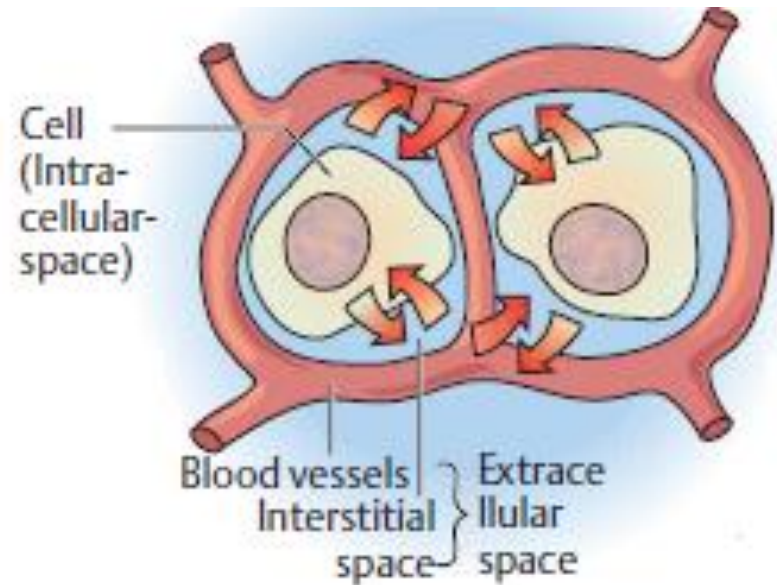


TOTAL BODY WATER VARIES IN EACH INDIVIDUAL BASED ON THE FAT CONTENT OF THE BODY



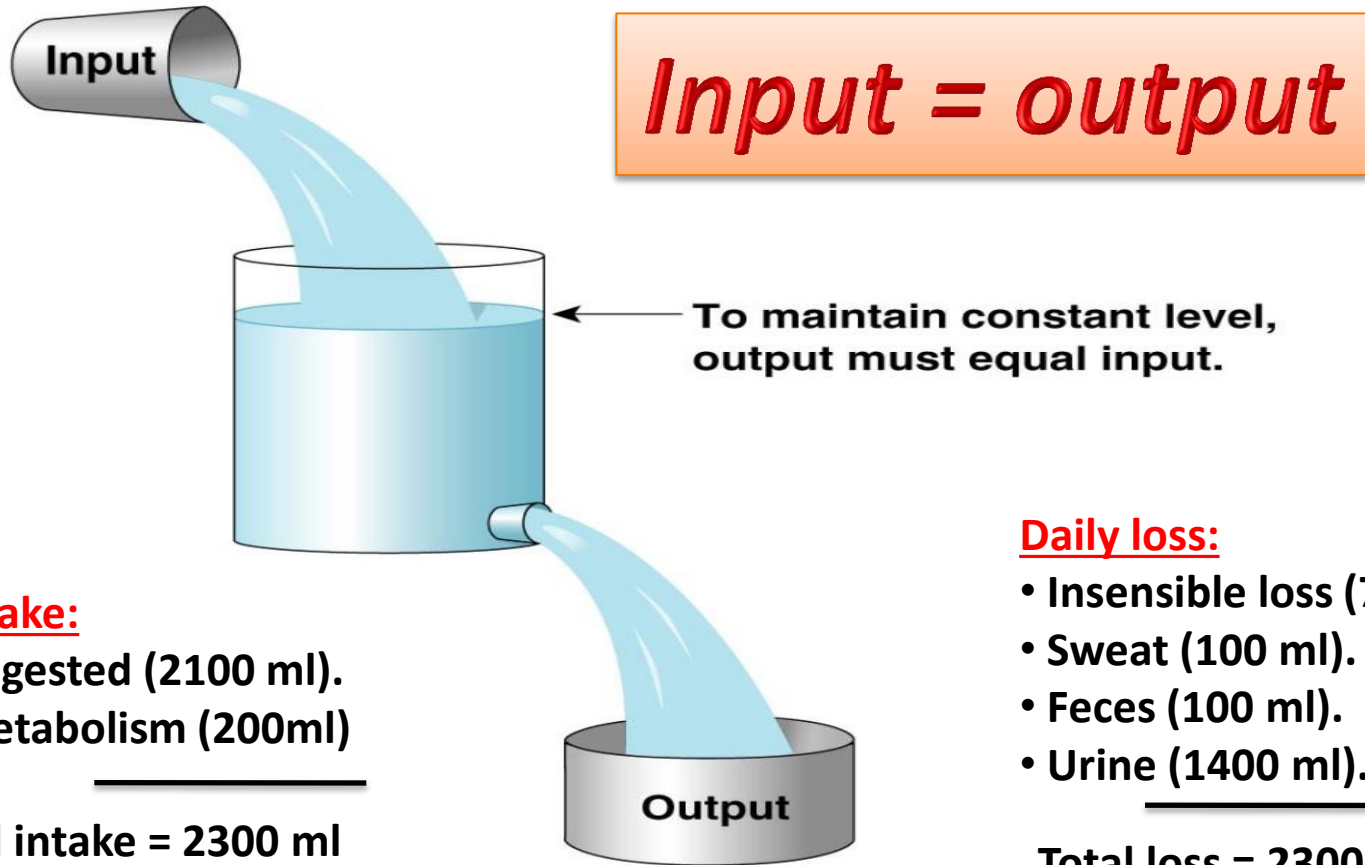
# Water Balance

- 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



## 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

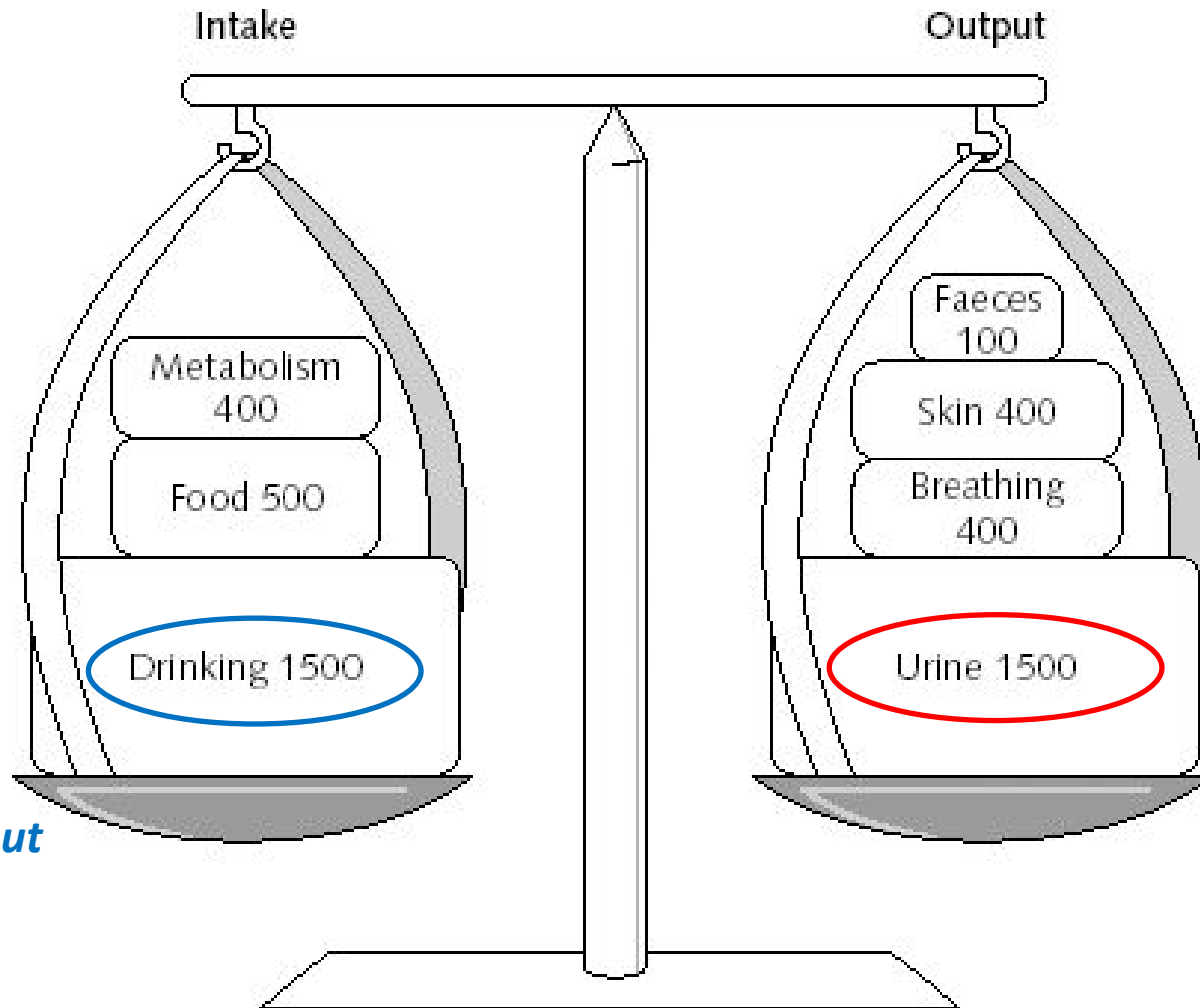
- Burns
- Exercise
- Hot weather.
- Diarrhea
- Vomiting
- Blood loss
- Diabetes



# Regulation of Fluid Balance

*Modify intake → thirst*

*Modify output → Kidney excretion*



*Major input*

*Major output*



# Regulation of Fluid Balance

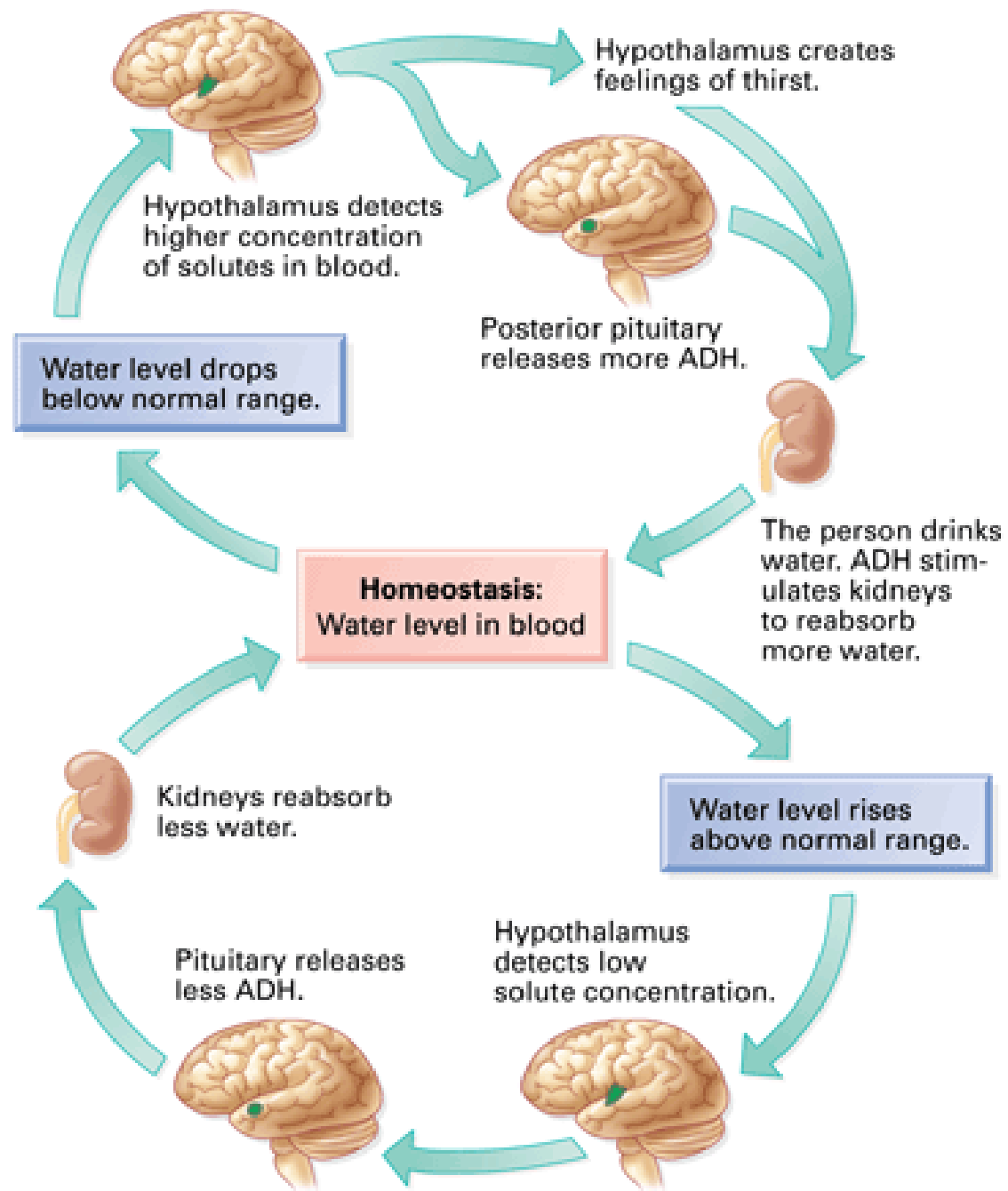
## Water deficit

- 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**



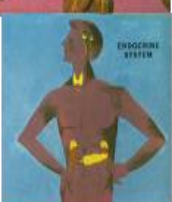
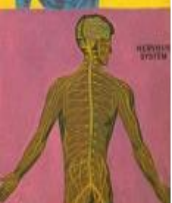
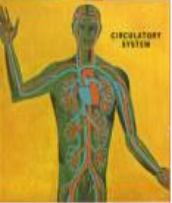
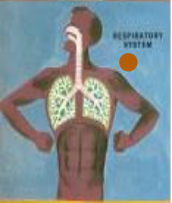
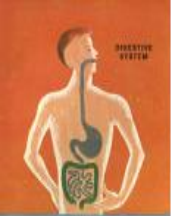


# Oedema

## What is “*edema*”?

- Edema = swelling
- The presence of abnormally large amounts of fluid in the intercellular tissue spaces of the body.

## What causes edema?



# Oedema



## Oedema

### Intracellular

- Due to intracellular swelling.
- ***Caused by:***
  - Hyponatremia.
  - Depressed metabolism
  - Lack of nutrition to the cells.
  - Inflammation.

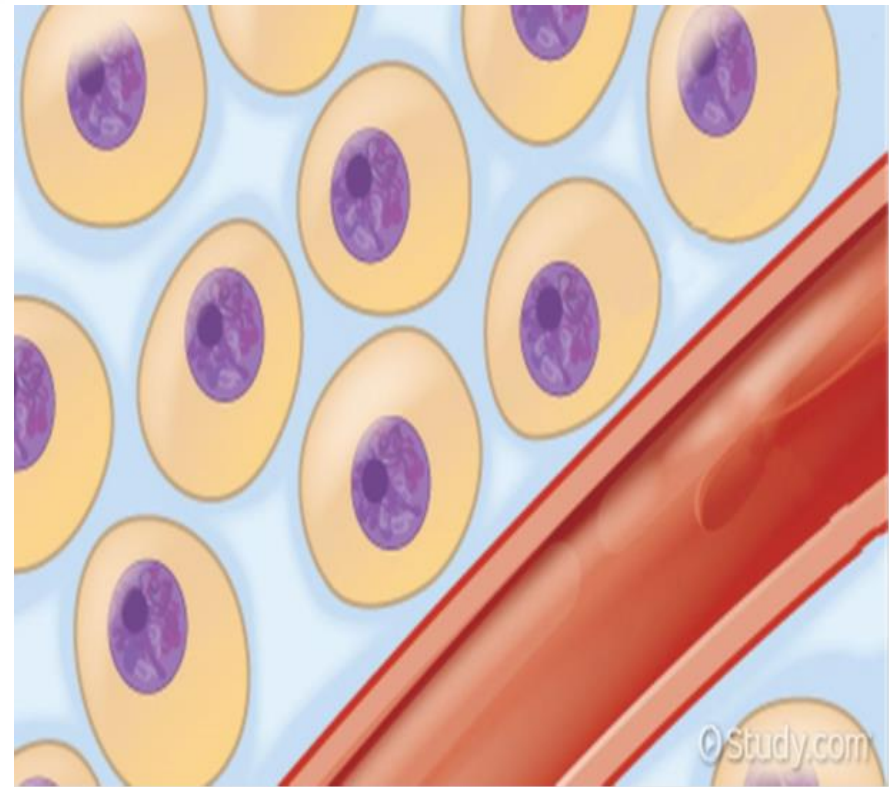
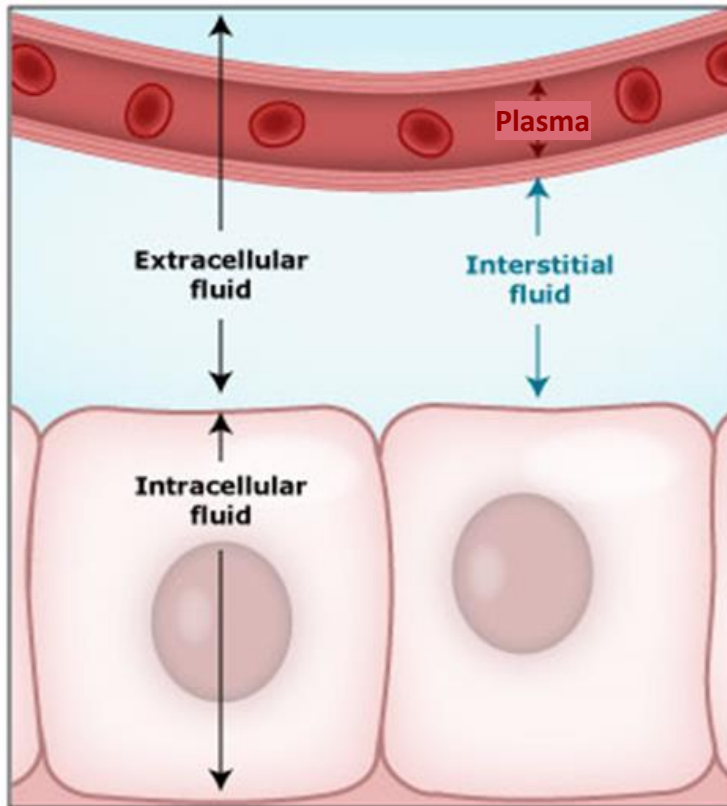
### Extracellular

- More common clinically
- Due to accumulation of fluid in the extracellular space
- ***Can be seen in:***
  - Heart failure
  - Kidney disease

# How is this water/fluid distributed in the body?

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

## Cellular Fluids



# Body Fluid Compartments

Total body water = 60% TBW

\* $\frac{2}{3}$  (40% of TBW)  
Intracellular

$\frac{1}{3}$  (20% of TBW)  
Extracellular

$\frac{3}{4}$  (15%)  
Interstitial Fluid

$\frac{1}{4}$  (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 TBW***



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

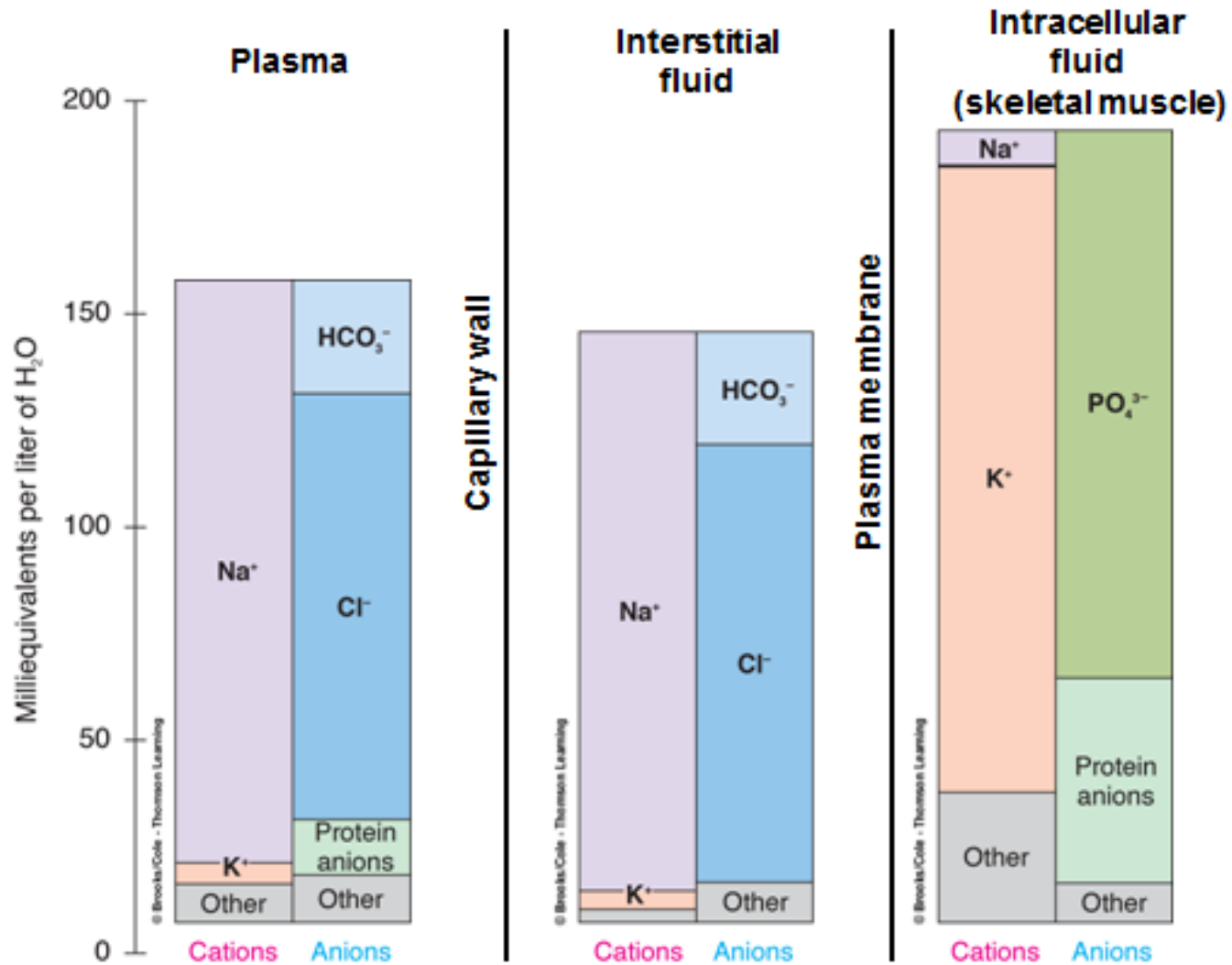
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Calculate the total body water content of a 40-year-old 70kg man?

- TBW = 42 litres
- ***How many litres lie intracellularly?***
  - $42 \times \frac{2}{3} = 28\text{L}$  **OR**  $70 \times \frac{40}{100} = 28\text{L}$ .
- ***How many litres lie extracellularly?***
  - $42 \times \frac{1}{3} = 14\text{L}$  **OR**  $70 \times \frac{20}{100} = 14\text{L}$ .
- ***How many litres constitute the interstitial fluid?***
- ***How many litres are plasma?***



# Does the composition of the different differ?



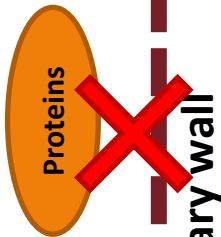
[Figure 15-2; Sherwood]

# 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.*

Intracellular compartment

↑↑ K+  
↑↑ Phosphate (PO4-3)  
↑ Proteins  
  
↓↓ Na+  
↓↓ Cl-

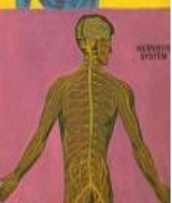
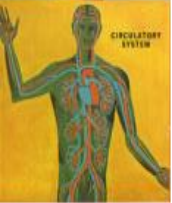
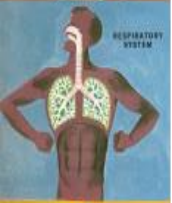
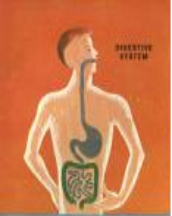
*Cations = anions*

*Osmolarity is the same ≈300 mOsm/L*



# What is Osmolarity?

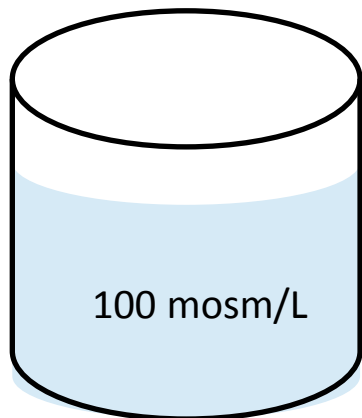
- A unit of concentration.
- It measures how concentrated or diluted a solution is.
- Defined as = the number of osmoles of a solute per litre of solution.
- The normal osmolarity of body fluids is  $\approx 300$  mOsm/L



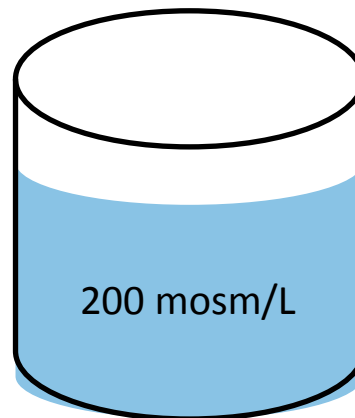
# What is Tonicity?

- **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.

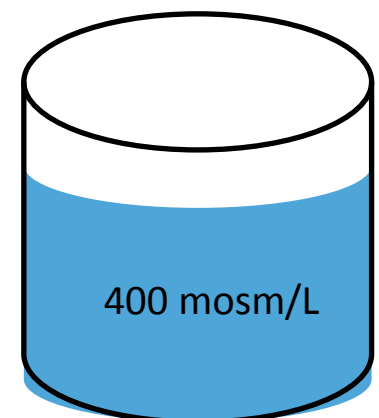
*Which solution is hypertonic to B?*



**A**



**B**



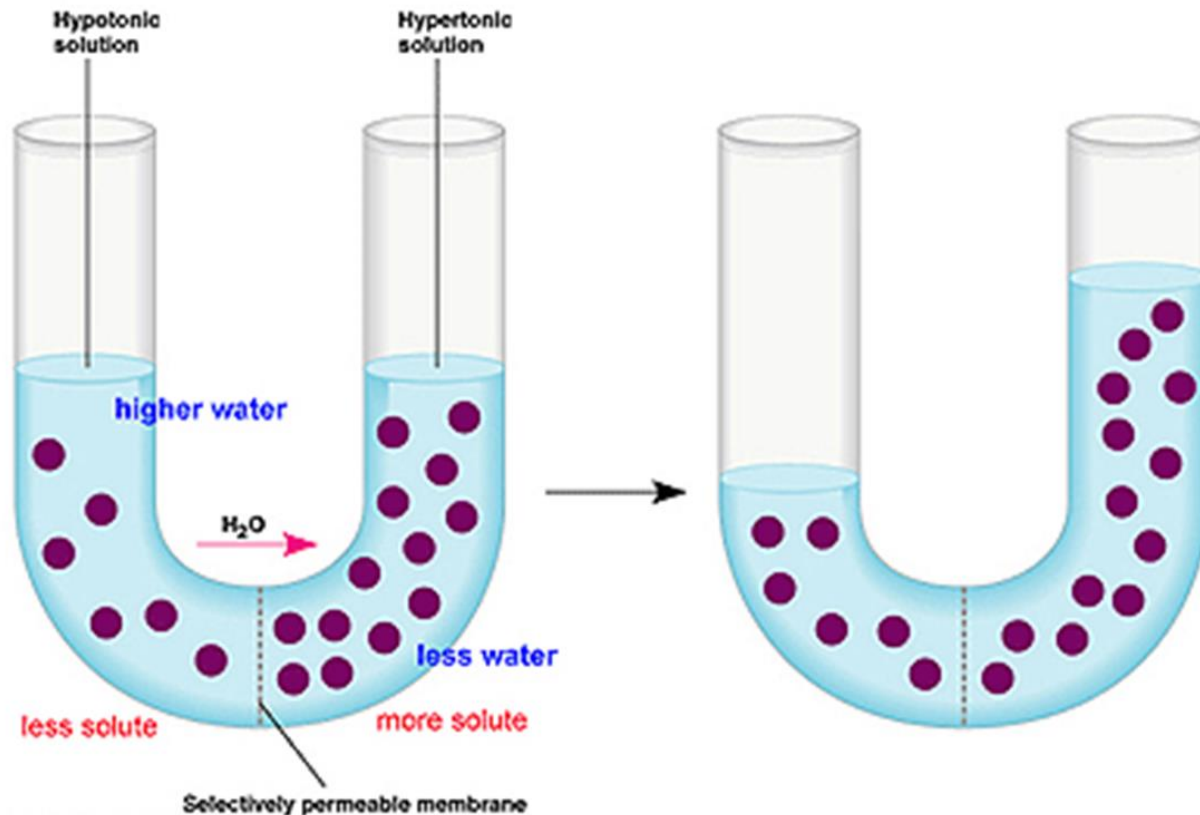
**C**





# Why is it important?

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



# Osmosis

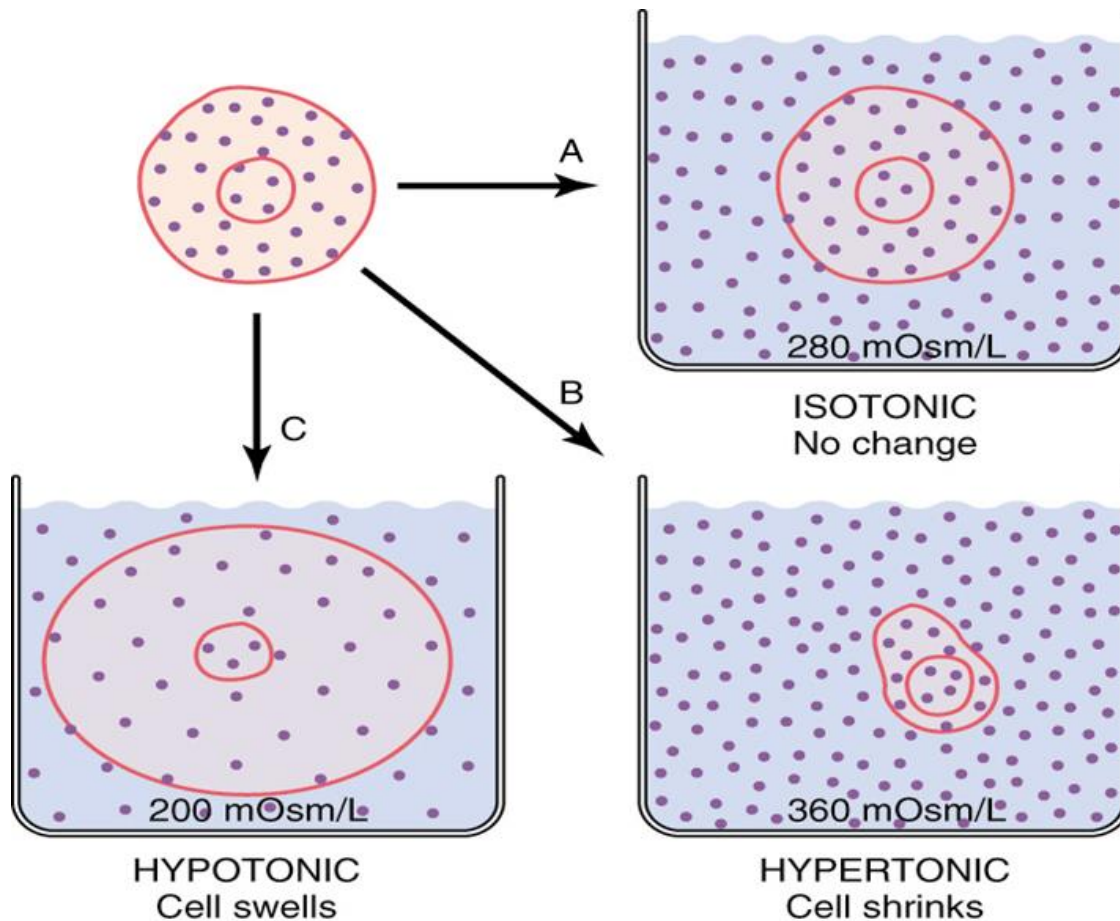
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- It is the movement of water across a semi-permeable membrane from a region of low solute concentration to a region of high solute concentration.



# How does it apply to physiology?

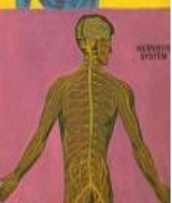
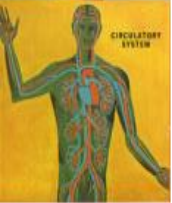
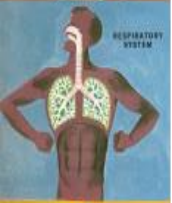
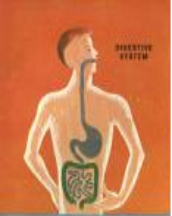
The cell membrane is a semi-permeable membrane  
(Allows only water to move freely across it)



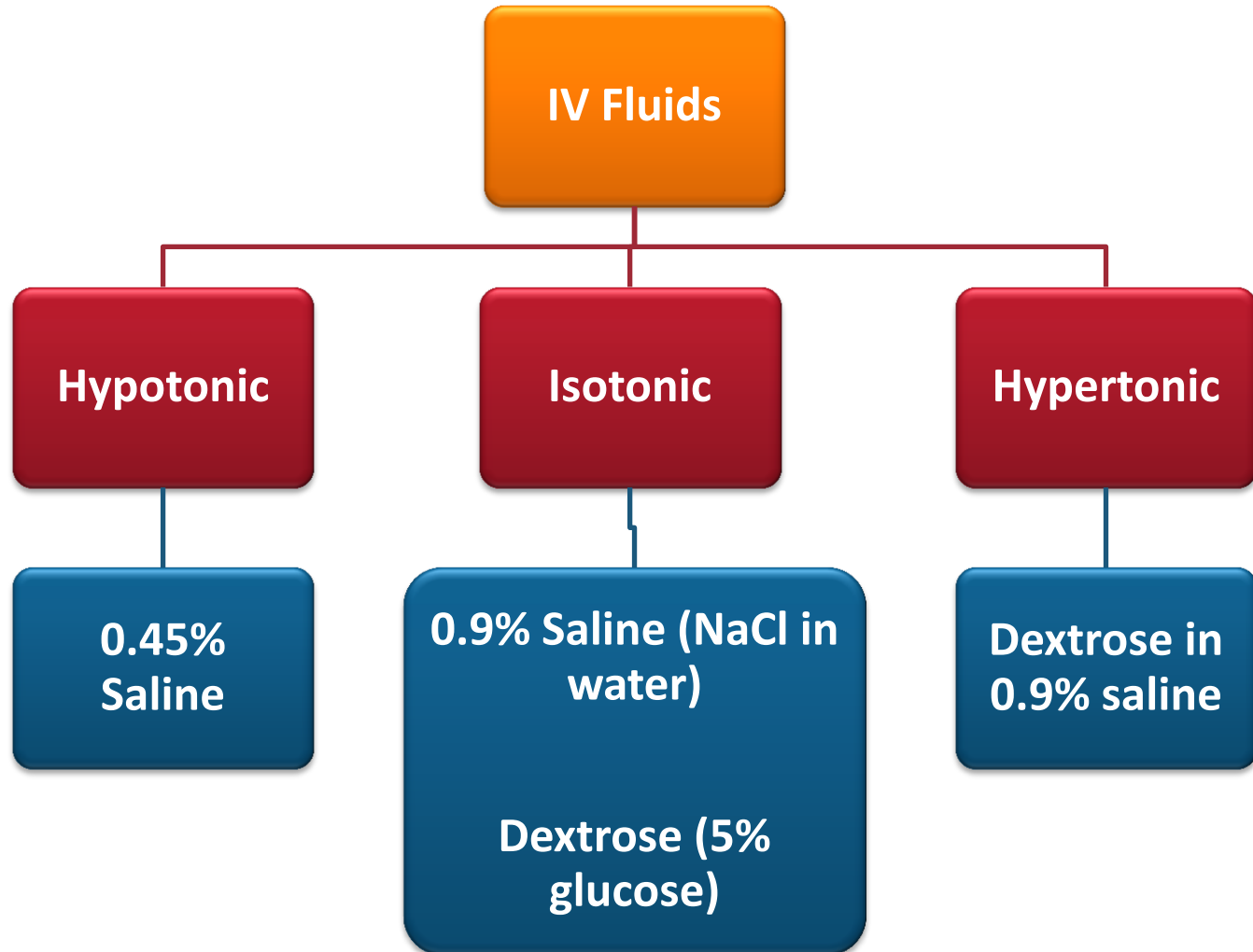
# How is it related to patient care?

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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** ( $\uparrow$  Na conc. In ECF)
    - b. **Hyponatremia** ( $\downarrow$  Na conc. In ECF)
- There are many types of IV fluids with different tonicities.



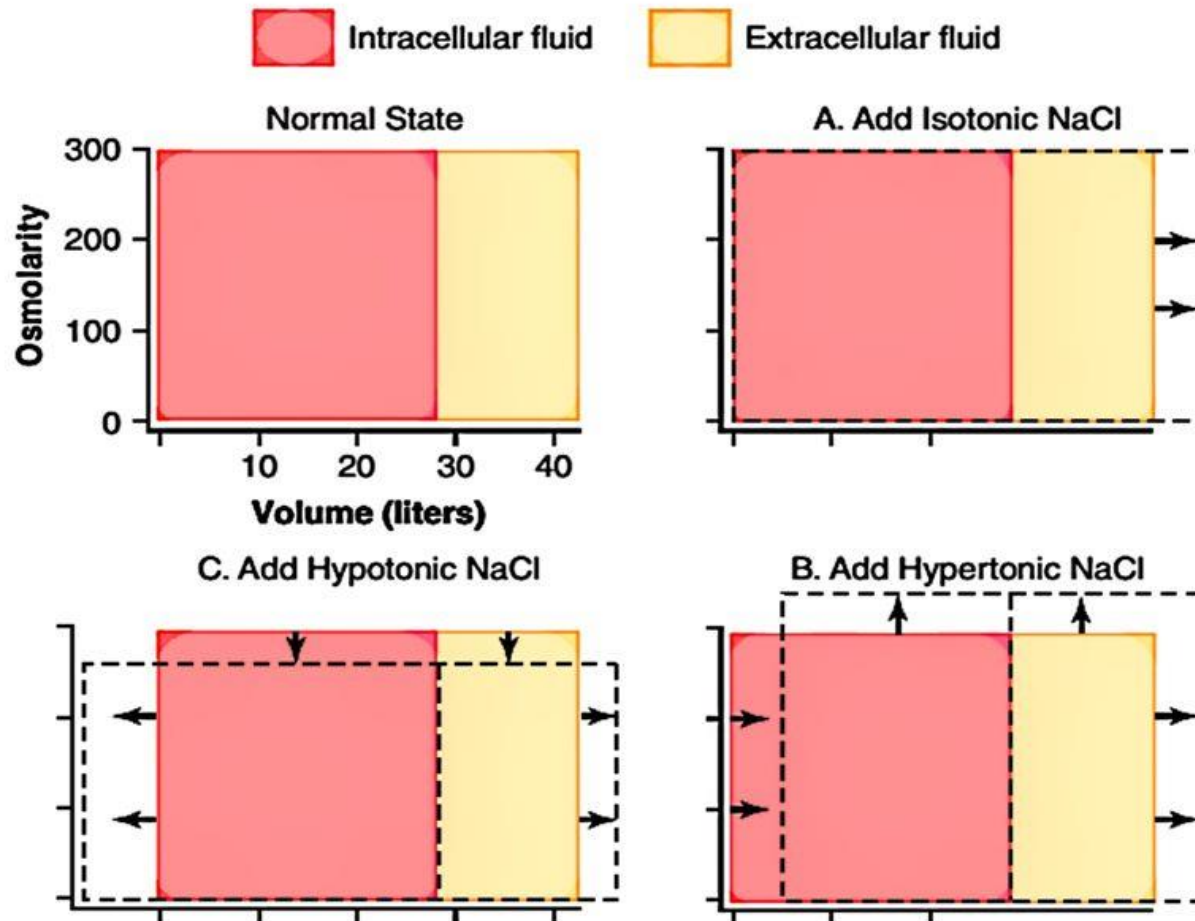
# Types of IV Fluids





# 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

- $\uparrow$  ECF osmolarity
- Water moves out of cells into ECF.
- ICF volume decreases.
- ECF volume increases.
- $\uparrow$  ICF osmolarity

Adding *isotonic* solution

- No change in ECF osmolarity.
- No osmosis occurs through cell membrane.
- ECF volume increases.

Adding *hypotonic* solution

?

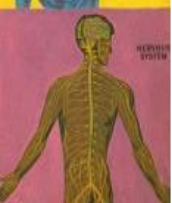
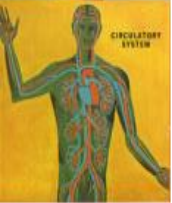
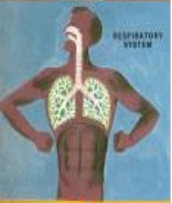
Activity



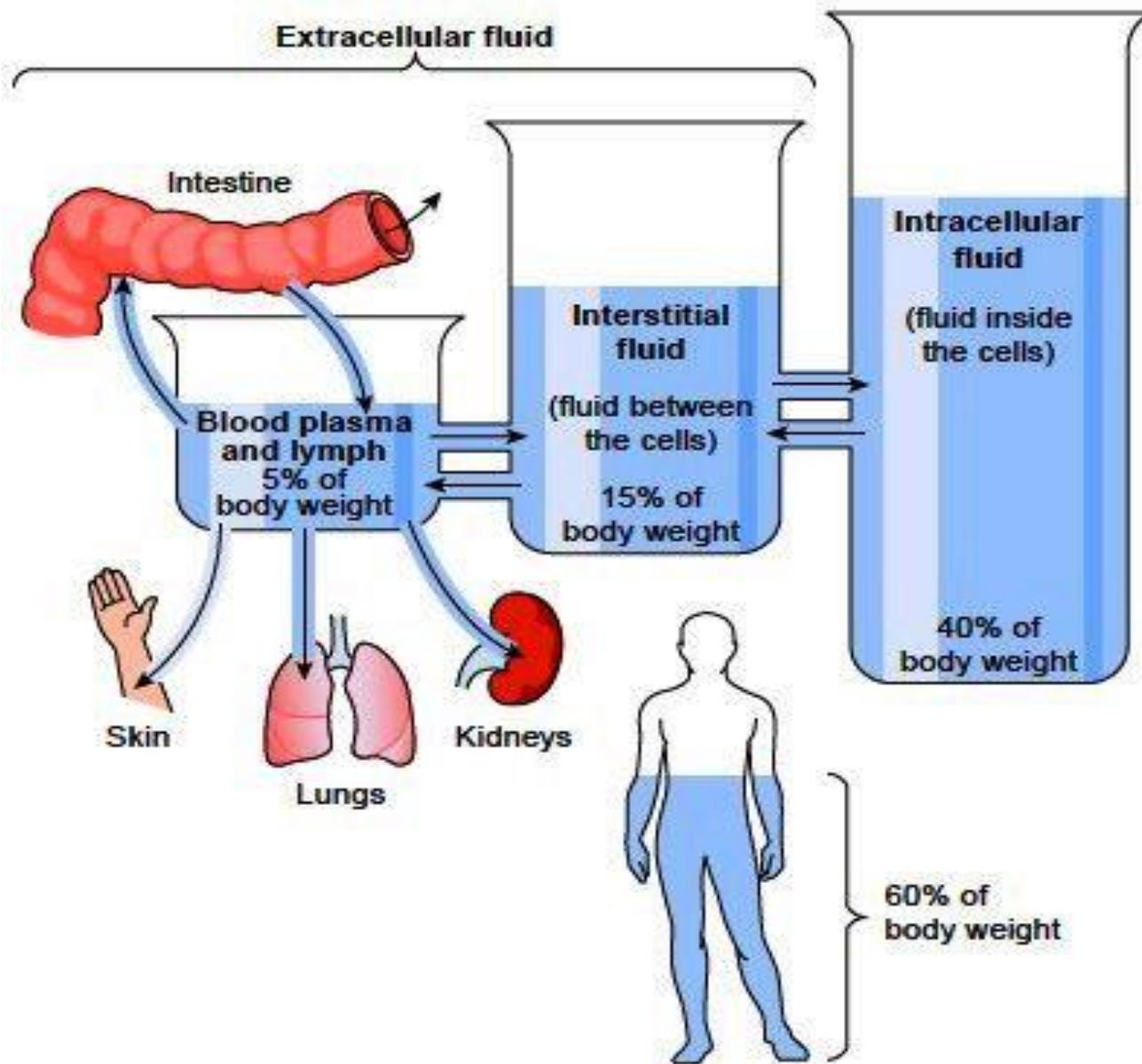
# Water distribution in the body

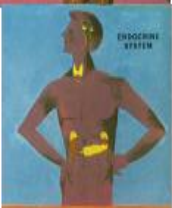
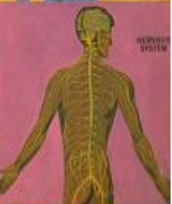
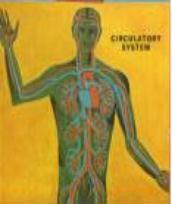
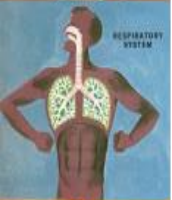
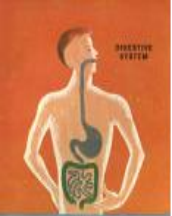
## *An exercise*

- 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





**Thank you**