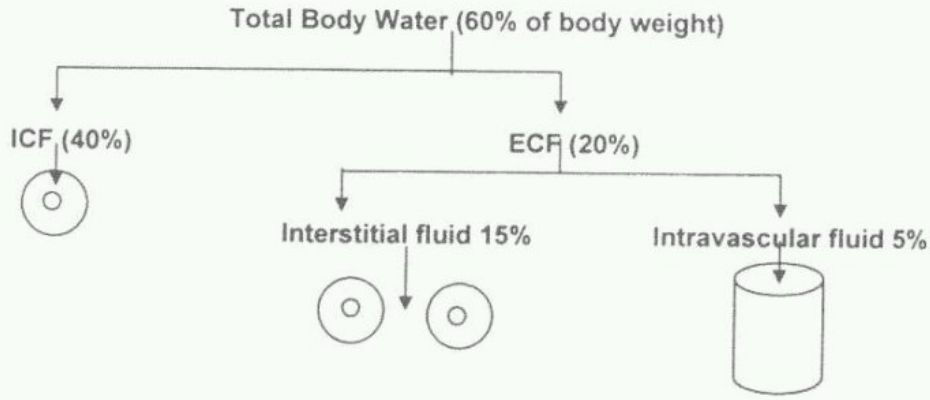
Body Water

- Water constitutes about 60% of body weight, i.e. about 42 L in 70Kg adult male.
- **Compartments:** Total Body Water (TBW) is divided into 2 compartments:-
  1- Intracellular fluid (ICF):- present inside the cells and constitute about 40% of body weight, i.e., 2/3 total body water.
  2- Extracellular fluid (ECF):- present outside the cells and constitute about 20% of body weight, i.e., 1/3 total body water. ECF is divided into:-
     a- Interstitial fluid:- present between the cells and constitute about 15% of body weight.
     b- Intravascular fluid (plasma):- present inside blood vessels and constitute about 5% of body weight.



Note:- Interstitial fluid or the ECF as a whole is called the internal environment of the body because it is the environment in which cells are living.

- **Normal variation**
  1- **Variation with age**:-
     1- TBW is more in infants and children (about 75% of body weight)
     2- Reaches adult level at puberty (60% of body weight)
     3- Decrease in old age (about 45% of body weight)

Note: the increase in TBW in children is mainly in ECF i.e. ECF/ICF ratio is more than adults and as ECF is easier to be lost in dehydration thus dehydration develops more rapid and more severe in children than adults.

2- **Variation with sex :-**TBW is less in females than males (about 50% of body weight in adult females) because of high fat content in their bodies (body fat is relatively free of water).

3- Variation with fat content in body: TBW is less in obese persons.

❖ Distribution of ions in ICF and ECF (in mEq/L)

	ICF	ECF
Cations (+ve ions)		
Na^+	14	140
K^+	140	4
Ca^{2+}	0.0001	2.4
Anions(-ve ions)		
Cl^-	4	104
HCO^{3-}	10	28
Phosphates(PO_4^{3-})	75	4
Proteins	40 (16 gm%)	4 (2 gm%)

Notes:-

1- The 2 components of ECF (ISF and plasma) are nearly similar in ionic composition except for protein which is higher in plasma (17 mEq/L, 7gm%) than ICF (4mEq/L, 2 gm%).

2- Simply, the main cation in ICF is K^+ and in ECF is Na^+, and the main anions in ICF are phosphates and proteins and in ECF are Cl^- and HCO^-_3

❖ Functions (importance) of body water

1- Medium for most biological processes as:-
   A. Digestion in GIT:-
      i. Essential component for all digestive secretions.
      ii. Medium for all secretions to work.
   B. Absorption:- in GIT, renal tubules and venous end of capillaries,
   C. Excretion:- through GIT, kidney and skin (sweat)
   D. Filtration:- in glomeruli of the kidney and arterial end of capillaries

2- Medium for exchange process:-
   a. Exchange of O_2 & CO_2 through alveolar membrane in lungs.
   b. Exchange of nutrients, waste products, and CO_2 through capillary wall.
   c. Exchange of ions and nutrients through cell membrane.

3- Medium for chemical and enzymatic reactions as occur in metabolic processes in the cell.

4- Transport medium:- Transport of substances (as nutrients, waste products O_2 and CO_2, hormones, vitamins etc.)to different parts of the body.

5- Regulation of body temperature through heat distribution and evaporation.

6- Essential for homeostatic processes as regulation of pH and osmolarity.

7- Lubricant in:- a-mouth b-joints
c-potential spaces as pleura pericardium and peritoneum

8- Refractive medium in the eye.

9- Mechanical buffer (shock absorber):- Distributes mechanical trauma applied to any part of the body to a large area, so it becomes less harmful.

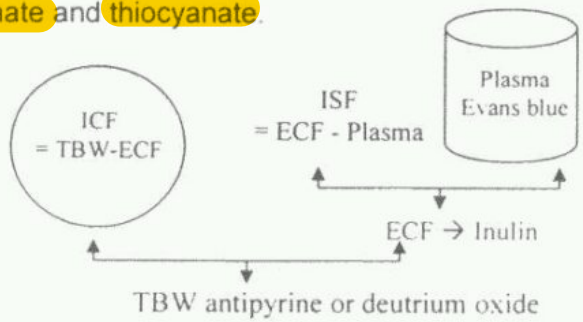
❖ Measurement of body water compartments

This is done using indicator dilution principle in which a known amount of substance that will stay in only one compartment is injected intravenously. Time is allowed for the substance to distribute uniformly in the compartment then a blood sample is taken and the concentration of the substance in plasma is determined. Then, the volume of water compartment is calculated using the following equation:-

$$\text{Volume of compartment} = \frac{\text{Amount of substance injected}}{\text{Concentration of the substance in plasma}}$$

1- TBW is measured using either:-
   - Antipyrine which is very lipid soluble and can rapidly penetrate cell membrane.
   - Deuterium oxide (heavy water, ^2H_2O) or tritium oxide (isotopically labeled water, ^3H_2O), these forms of water mix with total body water.

2- ECF is measured using substance that distributes in plasma and ISF but do not readily penetrate cell membrane as inulin, sucrose, mannitol thiosulphate and thiocyanate.



3- ICF can not be measured directly. However, it can be calculated as follows: ICF = TBW – ECF.

4- Plasma volume measured using substances that does not readily penetrate capillary membrane but remain in vascular system as Evans blue or albumin labeled with radioactive iodine.

5- ISF can not be measured directly, However, it is calculated as follows: - ISF = ECF – plasma.

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Homeostasis

❖ **Definition**

Homeostasis means keeping the composition of internal environment of the body (interstitial fluid or ECF) constant regarding:

1- Volume (water content).

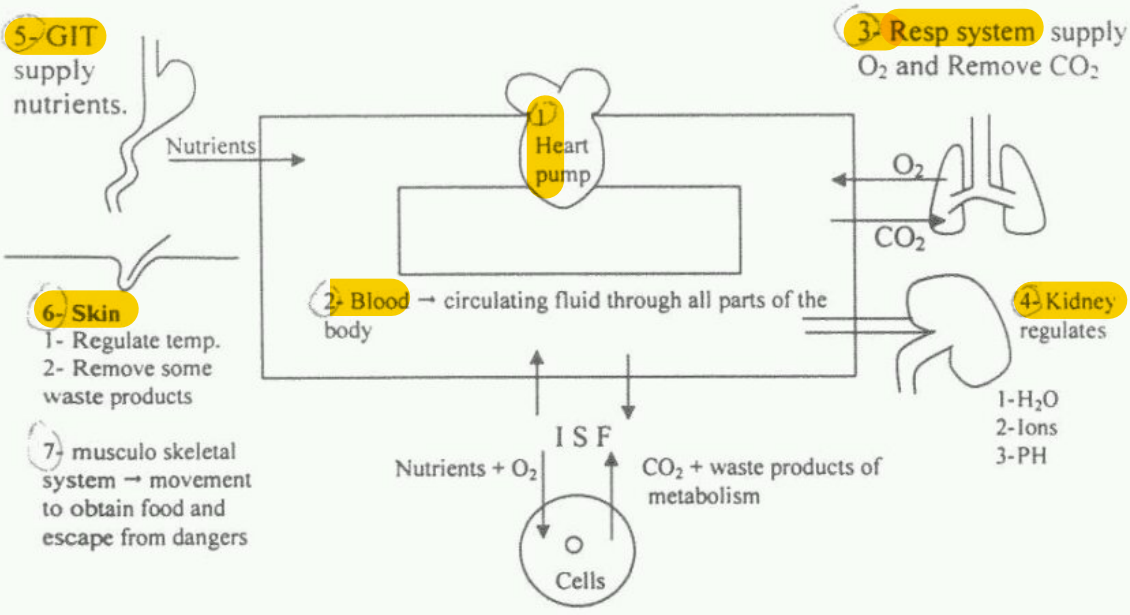
2- Ions (Na^+, K^+, Cl^-, HCO^{3-})

3-temperature

4-pH.

❖ Interstitial fluid or ECF is called the internal environment of the body because it is the environment that surrounds the body cells. Life is possible within narrow limits of change in the chemical or physical properties of internal environment.

❖ Most biological systems in the body work, either directly or indirectly, to maintain homeostasis i.e. to keep the internal environment optimum for cellular function.



❖ The function of these biological systems is regulated by 2 control systems:-

1- Nervous system ⟶ rapid control system.

2- Endocrinal (hormonal) system ⟶ slow control system.

❖ **Feedback control of the homeostatic mechanisms**

- **Definition:** - feedback control means the control of certain function by the resultant effect of this function.
- **Types:**

1. **Negative feedback control**
   - The most common, in which the resultant effect of a function inhibits that function.
   - Negative feedback control leads to stability of internal environment
   - Examples:-

a) Regulation of blood glucose level:-

↑ Blood glucose ⟶ ↑ insulin secretion ⟶ ↑ glucose utilization by tissues ⟶ ↓ blood glucose back to normal.

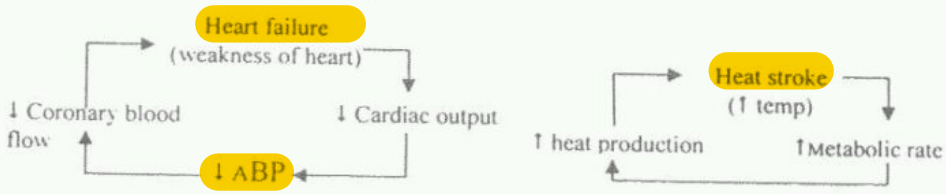
b) Regulation of CO_2 in blood:-

↑ CO_2 in blood ⟶ hyperventilation ⟶ CO_2 wash ⟶ ↓ CO_2 back to normal

c) Regulation of arterial blood pressure (ABP)

↑ ABP ⟶ ↓ heart rate and vasodilatation ⟶ ↓ ABP back to normal

2. **Positive feedback control**:-
   - Less common, in which the resultant effect of a function stimulates that function.
   - It leads to instability of internal environment and often death due to vicious circle (death cycles) e.g.



   - Positive feedback can some times be useful, i.e., operate in the body to complete certain function e.g., process of parturition (labor) : Stretch of uterine cervix → reflex uterine contraction→ descend of baby → more stretch of cervix → more uterine contraction → more descend of baby and so on until labor is complete.