Body Fluid

The fluids in the body are composed of water and dissolved substances, including electrolytes, which are essential for body function. Total amount of fluid in the human body is approximately 70% of body weight; about more than 2/3 of the whole body. The maintenance of a relatively constant volume and a stable composition of the body fluids are essential for homeostasis.

Water forms most of the fluid part of the body, it is the main constituent of cells, tissues and organs; and is vital for life. Drinking enough water is essential for physiological processes such as circulation, metabolism, temperature regulation, and waste removal.

Total body fluid has been divided into two compartments:

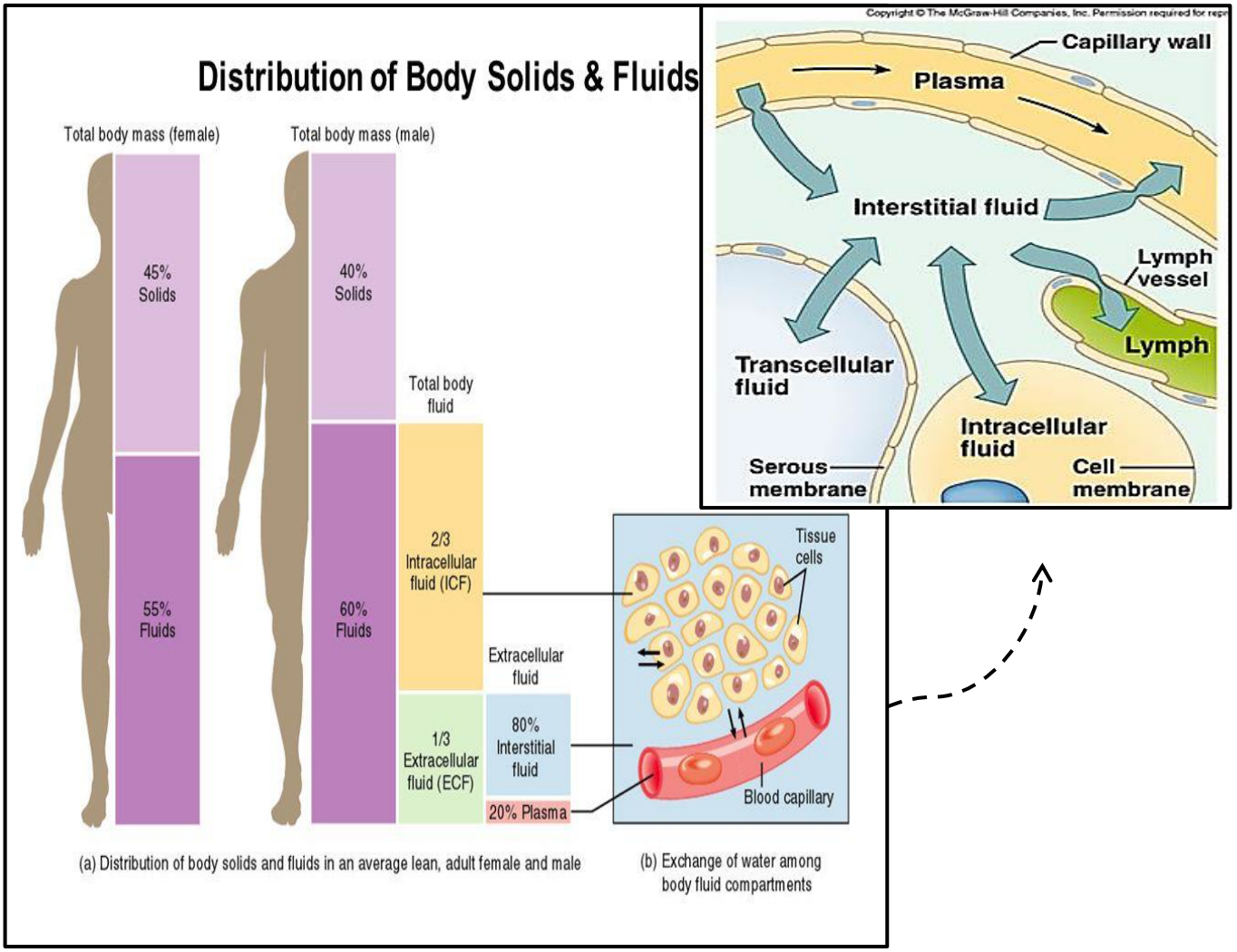
1- Intracellular fluid (ICF)

About 40% of total body weight (28 from 42 liters of total body weight) are inside the cells and are collectively called the intracellular fluid. The fluid of each cell contains its individual mixture of different constituents, but the concentrations of these substances are similar from one cell to another. In fact, the composition of cell fluids is remarkably similar even in different animals, ranging from microorganisms to humans.

2- Extracellular fluid (ECF)

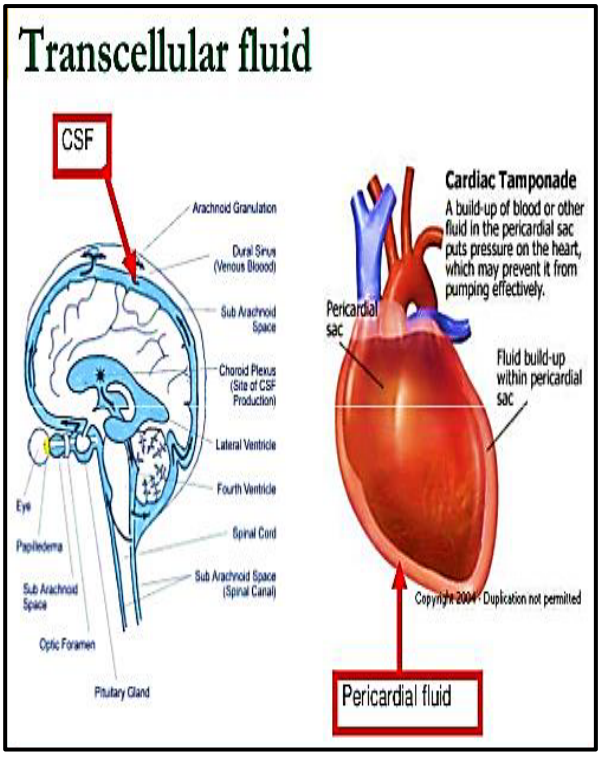
All the fluids outside the cells are collectively called the extracellular fluid. Together these fluids account for about 20% of total body weight, or about 14 liters in a 70-kg man. The two largest compartments of the extracellular fluid are:

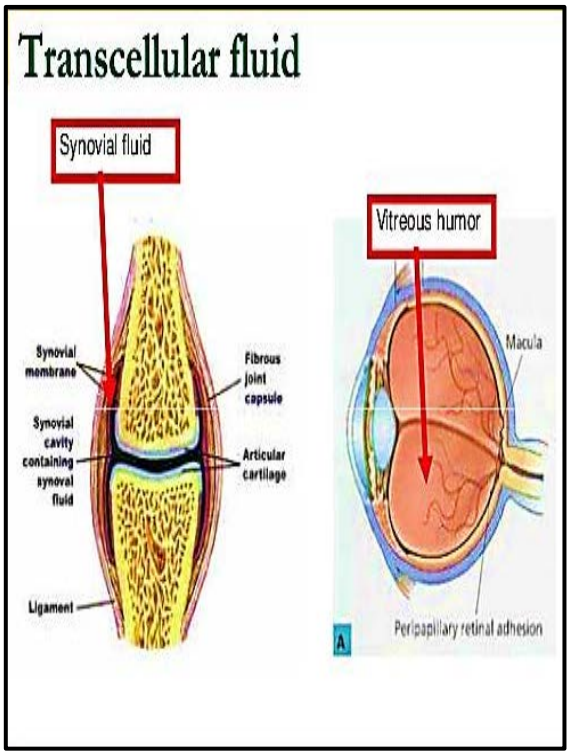
1) ***The interstitial fluid***, which makes up more than three fourths (3/4) or (11 liters) of the extracellular fluid.
2) ***The plasma***, which makes up almost one fourth (1/4) of the extracellular fluid, or about 3 liters. The plasma is the non-cellular part of the blood; it exchanges substances continuously with the interstitial fluid through the pores of the capillary membranes. These pores are highly permeable to almost all solutes in the extracellular fluid except the proteins.



3- **Also** there is another small compartment of fluid that is referred to as ***transcellular fluid*;** constitute about 1 to 2 liters. This compartment includes fluid in:

a) The synovial.
b) Peritoneal.
c) Pericardial.
d) Intraocular spaces (Vitreous humor)
e) The cerebrospinal fluid (CSF).

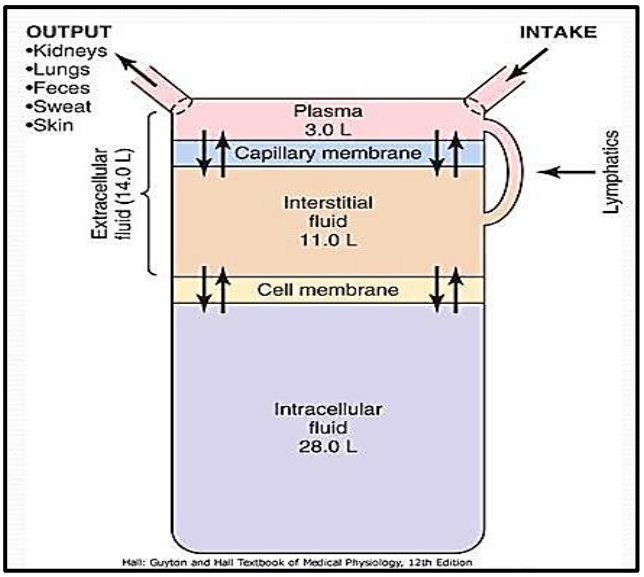




The total body water in human varies from 45-75 % of body weight, in a 70-kg ***adult man (60- 65) %***, or about 42 liters. This percentage depends on **age, gender, and degree of obesity (percentage of body fat).** As a person grows older, the percentage of total fluid gradually decreases. This decrease is due in part to the fact that aging is usually associated with an increased percentage of the body weight being fat, which decreases the percentage of water in the body. ***In women, total body water averages about (50- 55) %*** of the body weight because normally there are greater percentage of body fat compared with men. In premature and newborn babies, the total body water ranges from (70- 75) % of body weight.

Barriers separate ICF and ECF (interstitial fluid and plasma):

a. Cell membrane. Separates intra cellular fluid (ICF) from extra cellular fluid (ECF) including surrounding interstitial fluid.
b. Blood vessel wall. Separate interstitial fluid from plasma.



Daily intake of water

Water is added to the body by two major sources:

1. It is ingested in the form of liquids or water in food, which together normally adds about 2100 ml/day to the body fluids.
2. It is synthesized in the body by oxidation of carbohydrates, adding about 200 ml/day.

These mechanisms provide a total water intake of about 2300 ml/day.

However, intake of water is highly variable among different people and even within the same person on different days, depending on climate, habits, and level of physical activity.

Daily loss of body water

1- ***Insensible Water Loss*:** Some water losses cannot be specifically regulated. Ex: humans experience a continuous loss of water by evaporation from the respiratory tract and diffusion through the skin, which together account for about 700 ml/day of water loss under normal conditions. It occurs continually in all living humans.

Insensible water loss through skin occurs independently of sweating and is present even in people who are born without sweat gland. This loss is minimized by the cornified layer of skin, which provides a barrier against excessive loss by diffusion.

2- ***Water Loss in Sweat*:** The amount of water lost by sweating is highly variable, depending on physical activity and environmental temperature. The volume of sweat normally is about (100 ml/day), but in very hot weather or during heavy exercise fluid loss in sweat occasionally increases to 1-2 L/hour.

3- ***Water Loss in Feces*:** Only a small amount of water (100 ml/day) normally is lost in the feces. This loss can increase to several liters a day in people with severe diarrhea.

4- ***Water Loss by the Kidneys*:** The remaining water loss from the body occurs in the urine excreted by the kidneys. Multiple mechanisms control the rate of urine excretion. In fact, the most important means by which the body maintains a balance between water and electrolytes in the body, intake and output, are by controlling the rates of excretion by the kidneys.

Constituents of extracellular and intracellular fluids

Extracellular fluid constituents

Ionic composition of plasma and interstitial fluid is similar, because the plasma and interstitial fluid are separated only by highly permeable capillary membranes. The most important difference between these two compartments is the higher concentration of protein in the plasma; because the capillaries have a low permeability to the plasma proteins, only small amounts of proteins are leaked into the interstitial spaces.

The composition of extracellular fluid is carefully regulated by various mechanisms, but especially by the kidneys. This regulation allows the cells to remain continually bathed in a fluid that contains the proper concentration of electrolytes and nutrients for optimal cell function. The extracellular fluid, including the plasma and the interstitial fluid, contains large amounts of sodium (Na^{+}) and chloride ions (Cl^{-}), reasonably large amounts of bicarbonate ions ($HCO3^{-}$), but only small quantities of potassium (K^{+}), calcium (Ca^{++}), magnesium (Mg^{++}), phosphate, (Po_4^{-3}) and organic acid ions.

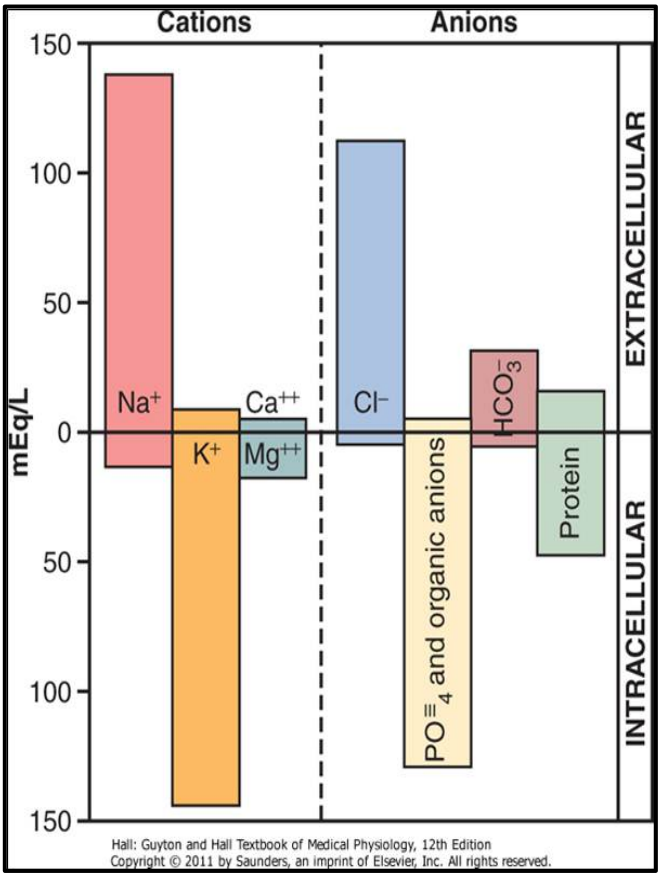
Intracellular fluid constituents

The intracellular fluid is separated from the extracellular fluid by a cell membrane that is highly permeable to water but is not permeable to most of the electrolytes in the body.

In contrast to the extracellular fluid, the intracellular fluid contains only small quantities of Na^+ and Cl^- ions and almost no Ca^{++} ions. Instead, it contains large amounts of K^+ and Po_4^{-3} ions plus moderate quantities of Mg^{++} and So_4^{-2} ions, all of which have low concentrations in the extracellular fluid. Also, ***cells contain large amounts of protein-almost 4 times as much as in the plasma.***

Most body fluids are neutral in charge. Thus, cations, or positively charged ions, and anions, or negatively charged ions, are balanced in fluids. Na^+ and Cl^- ions are concentrated in the ECF of the body, whereas K^+ and Po_4^{-3} ions are concentrated inside cells (ICF).

Intracellular Fluid	**Extracellular Fluid**
Major Cations	**Major Cations**
Potassium (K^+)	Sodium (Na^+)
Magnesium (Mg^{++})	Potassium (K^+)
Sodium (Na^+)	Magnesium (Mg^{++})
	Calcium (Ca^{++})
Major Anions	**Major Anions**
Phosphate (Po_4^{-3})	Chloride (Cl^-)
Chloride (Cl^-)	Bicarbonate (HCO_3^-)
Bicarbonate (HCO_3^-)	Phosphate (Po_4^{-3})
Sulfate (So_4^{-2})	



Differences between ECF and ICF

ECF	ICF
Most abundant cation - Na+	***Most abundant cation - K+***
Muscle contraction Impulse transmission Fluid and electrolyte balance	Resting membrane potential Action potentials Maintains intracellular volume Regulation of pH
Most abundant anion – Cl^-	***Anion are proteins and phosphates (Po_4^{-3})***
Regulates osmotic pressure Forms HCl in gastric acid	

Two major factors contribute to the movement of fluid from one compartment to another: **1- hydrostatic pressure, and 2- osmotic pressure**

1-Hydrostatic pressure

The pressure (or force) exerted by a fluid against a wall at equilibrium, at a given point within the fluid, due to the force of gravity causes movement of fluid between compartments. Hydrostatic pressure increases in proportion to depth measured from the surface because of the increasing weight of fluid exerting downward force from above.

- The hydrostatic pressure of blood is the pressure exerted by blood against the walls of the blood vessels by the pumping action of the heart.

2- Osmotic pressure

Osmotic pressure is the minimum pressure which needs to be applied to a solution to prevent the inward flow of its pure solvent across a semipermeable membrane. It is also defined as the measure of the tendency of a solution to take in pure fluid by osmosis.

- In blood vessels, fluids leave the plasma at the arteriolar ends of capillaries and enter the interstitial spaces because of the net outward force of hydrostatic pressure (blood pressure). Fluid returns to the plasma from the interstitial spaces at the venular ends of capillaries because of the net inward force of colloid osmotic pressure due to the plasma proteins.

Specialized Fluids of the Body

- ❖ Lymph
- ❖ Milk
- ❖ Cerebrospinal fluid
- ❖ Amniotic fluid
- ❖ Aqueous humor
- ❖ Sweat
- ❖ Tears

Lymph

Clear and colorless fluid 96% water and 4% solids

Functions of Lymph

1. Return protein from tissue spaces into blood
2. Redistribution of fluid
3. Removal of bacteria, toxins and other foreign bodies from tissues
4. Maintain structural and functional integrity of tissue
5. Route for intestinal fat absorption
6. Transport lymphocytes

Milk

It is secreted by mammary glands; complete natural food. Contain 83-87% water and 13-17% solids

Functions of Milk

1. Milk sugar provides galactose, a structural unit for growing infant.
2. In intestine, it gets metabolized to lactic acid which eliminates harmful bacteria.
3. Source of protein, mineral and vitamins

Cerebrospinal fluid (CSF)

Clear, colorless liquid formed within the cavities of brain and around spinal cord

Functions of CSF

1. Hydraulic shock absorber
2. Regulation of intracranial pressure
3. Influences the hunger sensation and eating behaviors

Amniotic Fluid

Liquid produced by membranes and fetus. Its volume increases with gestational age

Functions of Amniotic Fluid

1. Physical protection to the fetus
2. Medium for exchange of various chemical

Tears

Tears are fluid produced by lachrymal glands. It is isotonic but becomes hypertonic due to evaporation as fluid passes over the cornea.

Functions of tears

1. Lysozyme protects eye from infectious agents
2. Lubricate the surface of the cornea
3. Fill the irregularities of the corneal surface to improve optical properties
4. Protects eyes from injury

Aqueous Humor

It is a clear fluid filling the space in the front of the eyeball between the lens and cornea. Blockade in the flow of aqueous humor causes glaucoma due to increased intraocular pressure.

Sweat

It is secretion of sweat gland, regulates body temperature by cooling and evaporation. Water content of sweat varies from 99.2-99.7%