

Lecture 10
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Circulatory Fluid

BODY FLUIDS AND FLUID COMPARTMENTS

- Body Water Content
- Fluid Compartments
 - Intracellular Fluid
 - Extracellular Fluid
- Composition of Body Fluids

Body Water Content

- Human beings are mostly water,
 - About 75 percent of body mass in infants to
 - About 50–60 percent in adult men and women
 - Could be as low as 45 percent in old age
- Percent of body water changes with development
 - The proportions of the body given over to each organ and to muscles, fat, bone, and other tissues change from infancy to adulthood.

The chemical reactions of life take place in aqueous solutions. The dissolved substances in a solution are called solutes.

In the human body, solutes vary in different parts of the body, but may include proteins—including those that transport lipids, carbohydrates, and, very importantly, electrolytes.

Often in medicine, a mineral dissociated from a salt that carries an electrical charge (an ion) is called an electrolyte. For instance, sodium ions (Na^+) and chloride ions (Cl^-) are often referred to as electrolytes.

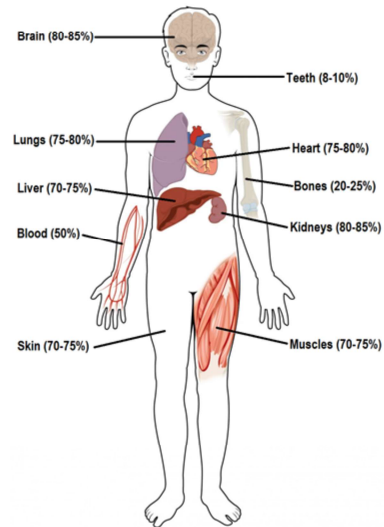
In the body, water moves through semi-permeable membranes of cells and from one compartment of the body to another by a process called osmosis. Osmosis is basically the diffusion of water from regions of higher concentration to regions of lower concentration, along an osmotic gradient across a semi-permeable membrane.

As a result, water will move into and out of cells and tissues, depending on the relative concentrations of the water and solutes found there. An appropriate balance of solutes inside and outside of cells must be maintained to ensure normal function.

Body Water Content

Water Content of the Body's Organs and Tissues

Water content varies in different body organs and tissues, from as little as 8 percent in the teeth to as much as 85 percent in the brain.



Human beings are mostly water, ranging from about 75 percent of body mass in infants to about 50–60 percent in adult men and women, to as low as 45 percent in old age.

The percent of body water changes with development, because the proportions of the body given over to each organ and to muscles, fat, bone, and other tissues change from infancy to adulthood (Figure).

Your brain and kidneys have the highest proportions of water, which composes 80–85 percent of their masses. In contrast, teeth have the lowest proportion of water, at 8–10 percent.

Fluid Compartments

- The intracellular fluid (ICF) compartment
 - Includes all fluid enclosed in cells by their plasma membranes.
- Extracellular fluid (ECF) surrounds all cells in the body and has two primary constituents
 - The fluid component of the blood (called plasma)
 - The interstitial fluid (IF) that surrounds all cells not in the blood

Body fluids can be discussed in terms of their specific fluid compartment, a location that is largely separate from another compartment by some form of a physical barrier.

The intracellular fluid (ICF) compartment is the system that includes all fluid enclosed in cells by their plasma membranes.

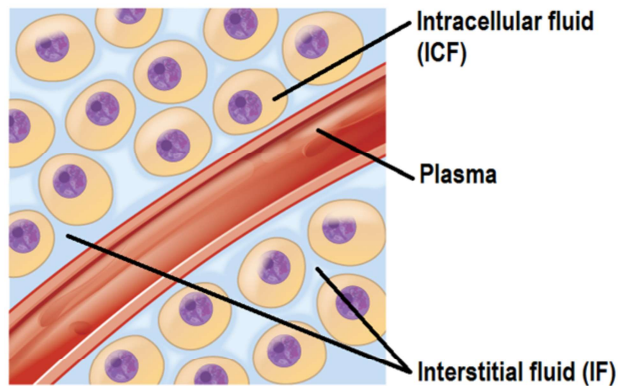
Extracellular fluid (ECF) surrounds all cells in the body. Extracellular fluid has two primary constituents: the fluid component of the blood (called plasma) and the interstitial fluid (IF) that surrounds all cells not in the blood (Figure)

Fluid Compartments

Fluid Compartments in the Human Body

The intracellular fluid (ICF) is the fluid within cells. The interstitial fluid (IF) is part of the extracellular fluid (ECF) between the cells. Blood plasma is the second part of the ECF.

Materials travel between cells and the plasma in capillaries through the IF.



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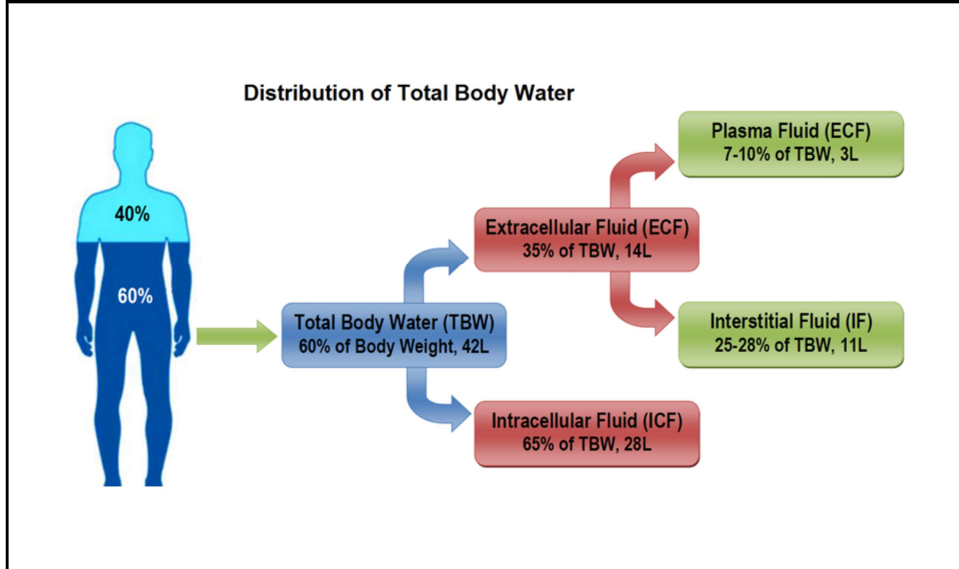
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Intracellular Fluid (ICF)

- The ICF lies within cells and is the principal component of the cytosol/cytoplasm.
- Amount of water inside a cell falls to a value that is too low
 - The cytosol becomes too concentrated with solutes to carry on normal cellular activities
- If too much water enters a cell
 - The cell may burst and be destroyed

The ICF makes up about 65 percent of the total water in the human body, and in an average-size adult male, the ICF accounts for about 25 liters (seven gallons) of fluid (Figure). This fluid volume tends to be very stable, because the amount of water in living cells is closely regulated.

Distribution of Water

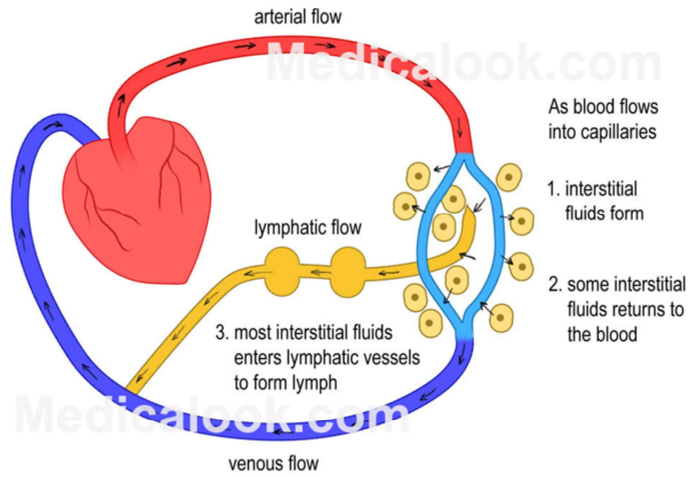


Extracellular Fluid

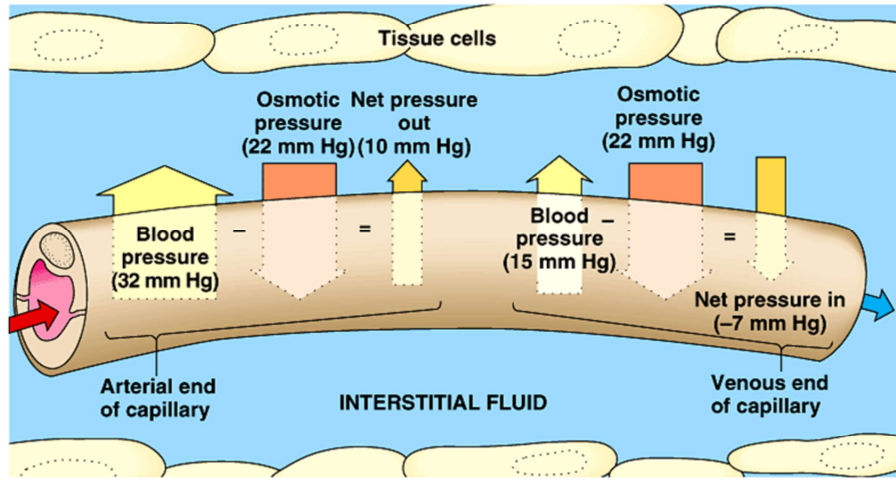
- The ECF accounts for the other one-third of the body's water content. Approximately 7-10 percent of the ECF is found in plasma.
- Plasma transports a range of materials through blood vessels
 - Blood Cells
 - Proteins (Including Clotting Factors And Antibodies)
 - Electrolytes
 - Gases, Nutrients and Wastes
 - travel between capillaries and cells through the IF.
- Cells are separated from the IF by a selectively permeable cell membrane
 - helps regulate the passage of materials between the IF and the interior of the cell.

The ECF accounts for the other one-third of the body's water content. Approximately 20 percent of the ECF is found in plasma. Plasma travels through the body in blood vessels and transports a range of materials, including blood cells, proteins (including clotting factors and antibodies), electrolytes, nutrients, gases, and wastes. Gases, nutrients, and waste materials travel between capillaries and cells through the IF. Cells are separated from the IF by a selectively permeable cell membrane that helps regulate the passage of materials between the IF and the interior of the cell.

Interstitial Fluid

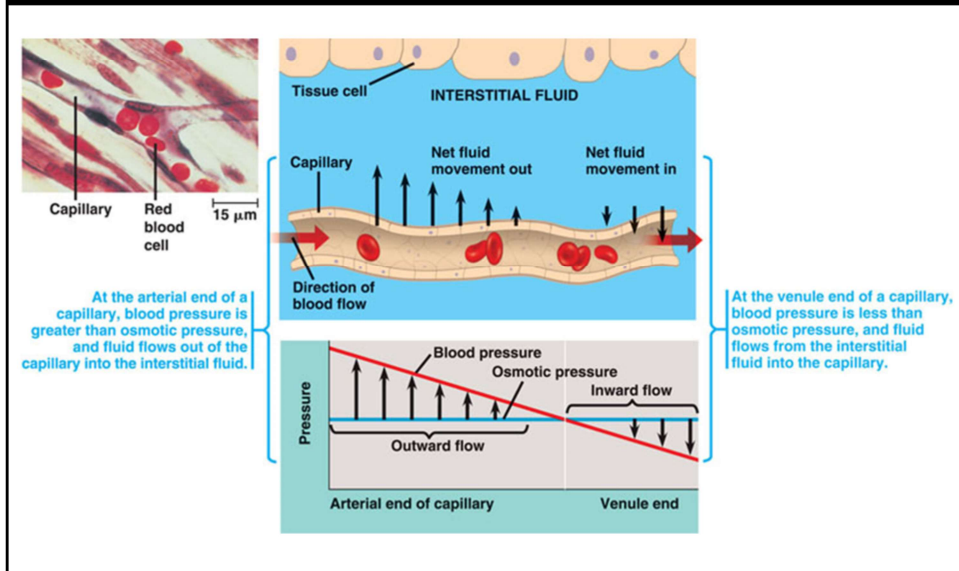


Capillary Exchange



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Fluid Movement



Other Fluids

- The body has other water-based ECF
 - Cerebrospinal fluid that bathes the brain and spinal cord
 - Lymphatic fluid
 - Synovial fluid in joints
 - Pleural fluid in the pleural cavities
 - Pericardial fluid in the cardiac sac
 - Peritoneal fluid in the peritoneal cavity
 - Aqueous humor of the eye
- These fluids are outside of cells, therefore also considered components of the ECF compartment.

Composition of Body Fluids

- 7 major electrolytes found in body fluids
 - Sodium (Na^+)
 - Chloride (Cl^-)
 - Potassium (K^+)
 - Magnesium (Mg^{++})
 - Calcium (Ca^{++})
 - Phosphate (HPO_4^-)
 - Bicarbonate (HCO_3^-)

Often in medicine, a mineral dissociated from a salt that carries an electrical charge (an ion) is called an electrolyte. For instance, sodium ions (Na^+) and chloride ions (Cl^-) are often referred to as electrolytes.

Electrolytes

- Electrolytes are minerals in our blood and other body fluids that carry an electric charge.
- Electrolytes affect
 - The amount of water in the body
 - The acidity of the blood (pH)
 - The muscle function
 - Some other important processes
- The body loses electrolytes when it sweats.

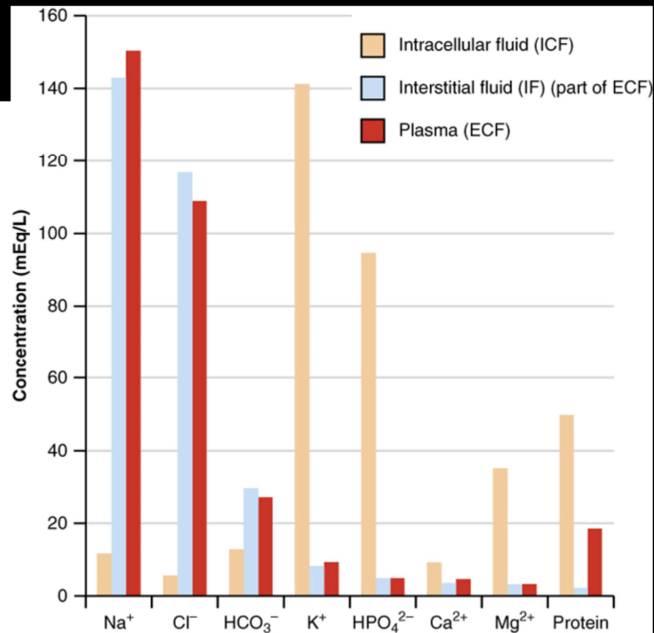
Functions and Sources

Nutrient	Deficiency Symptoms	Food Sources
Sodium	Muscle cramps, loss of appetite, dizziness	Dill pickle, tomato juice, sauce, soup, table salt
Chloride	Changes in pH, irregular heartbeat	Table salt, some fruits and vegetables (tomatoes, lettuce, olives)
Magnesium	Muscle cramps, nausea, confusion	Halibut, pumpkin seeds, spinach
Potassium	Muscle weakness, muscle paralysis, mental confusion	Potato with skin, plain yogurt, banana
Calcium	Osteoporosis, osteopenia, muscle spasms	Dairy (yogurt, milk, ricotta), collard greens, spinach, kale, sardines

Composition of Body Fluids

The Concentrations of Different Elements in Key Bodily Fluids.

The graph shows the composition of the ICF, IF, and plasma. The compositions of plasma and IF are similar to one another but are quite different from the composition of the ICF.



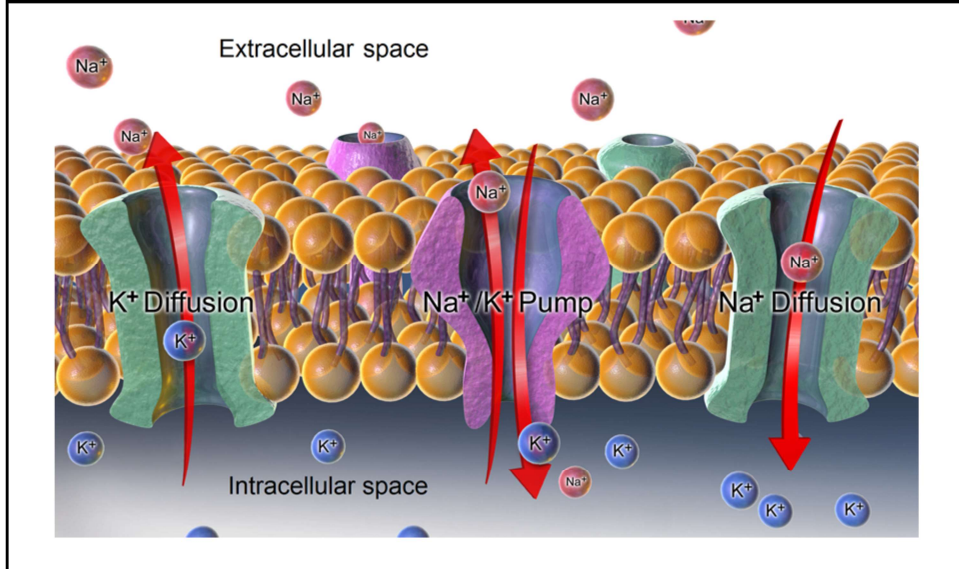
The compositions of the two components of the ECF—plasma and IF—are more similar to each other than either is to the ICF (Figure).

Blood plasma has high concentrations of sodium, chloride, bicarbonate, and protein.

The IF has high concentrations of sodium, chloride, and bicarbonate, but a relatively lower concentration of protein.

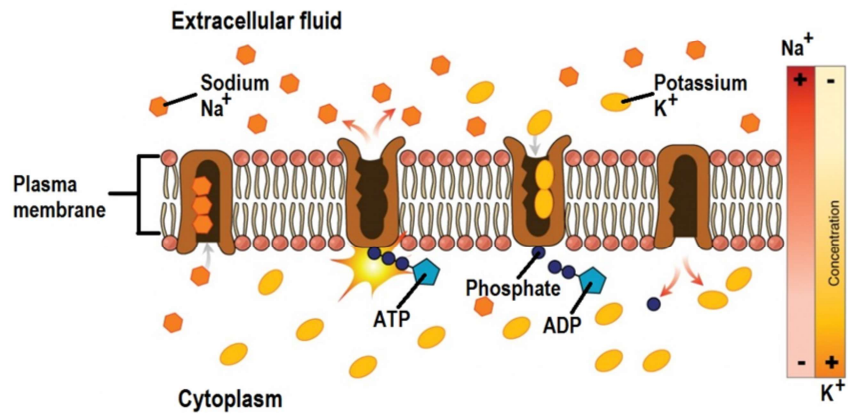
In contrast, the ICF has elevated amounts of potassium, phosphate, magnesium, and protein. Overall, the ICF contains high concentrations of potassium and phosphate (HPO₄²⁻), whereas both plasma and the ECF contain high concentrations of sodium and chloride.

Sodium-Potassium Pump



Na⁺/K⁺-ATPase (sodium-potassium adenosine triphosphatase, also known as the Na⁺/K⁺ pump or sodium-potassium pump) is an enzyme (an electrogenic transmembrane ATPase) found in the plasma membrane of all animal cells. The Na⁺/K⁺-ATPase enzyme is a solute pump that pumps sodium out of cells while pumping potassium into cells, both against their concentration gradients. This pumping is active (i.e. it uses energy from ATP) and is important for cell physiology. An example application is nerve conduction.

The Sodium-Potassium Pump



The sodium-potassium pump is powered by ATP to transfer sodium out of the cytoplasm and into the ECF. The pump also transfers potassium out of the ECF and into the cytoplasm. (credit: modification of work by Mariana Ruiz Villarreal)

Most body fluids are neutral in charge. Thus, cations, or positively charged ions, and anions, or negatively charged ions, are balanced in fluids.

As seen in the previous graph, sodium (Na^+) ions and chloride (Cl^-) ions are concentrated in the ECF of the body, whereas potassium (K^+) ions are concentrated inside cells. Although sodium and potassium can “leak” through “pores” into and out of cells, respectively.

The high levels of potassium and low levels of sodium in the ICF are maintained by sodium-potassium pumps in the cell membranes. These pumps use the energy supplied by ATP to pump sodium out of the cell and potassium into the cell (Figure)

Next Class

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