

Biochemistry of biological fluids (BIOCH 472)

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Class 1:

The Body Fluid Compartments: Extracellular and Intracellular Fluids

Textbook Of Medical Physiology, by Guyton

Objectives for this lecture

- Understand the balance between fluid intake and output.
- Gain familiarity with the constituents of extracellular and intracellular fluids
- Define and explain the importance of quality assurance in the laboratory

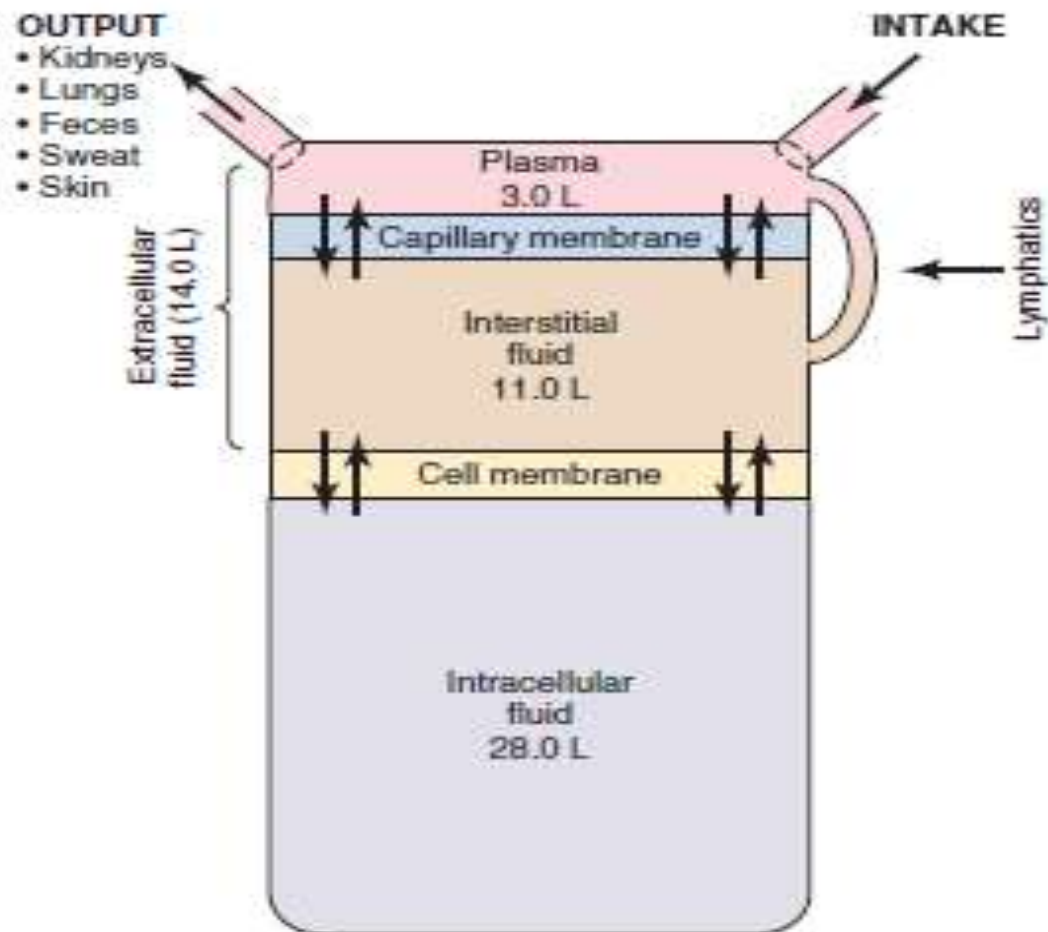
Fluid intake and output are balanced during steady-state conditions.

- Daily intake of water:
 - Ingested in the form of liquids or water in food
(add 2100 ml/day to body fluids).
 - Synthesized in the body by oxidation of carbohydrates
(add 200 ml/day).
 - Water intake is variable among people, days climate, habits, physical activity.

● Daily loss of body water:

- Insensible water loss
(evaporation from respiratory tract and skin (700 ml/day)).
- Fluid loss in sweat
(by physical activity, environmental temperature)
- Water loss in Feces
(only small amount)
- Water loss by the kidneys
(It is controlled by the balance of electrolytes)
(Must take into consideration dehydrated person or those who drink tremendous amount of water)

Summary of body fluid regulation, including the major body fluid compartments and the membranes that separate these compartments. The values shown are for an average 70-kilogram adult man.



Body Fluids

- In 70 kg adult man, the total body water is approximately 60% of body weight (42 L).
- This percentage depend on age, gender, and degree of obesity.
- Body fluid has been divided into two compartments –
 - **Intracellular fluid (ICF)**
 - Inside the cells
 - 40% of total body weight
 - **Extracellular fluid**
 - Outside the cells
 - 20% of total body weight

Intracellular Fluid Compartments

- The fluid of each cell contains its individual mixture.
- The concentrations of cell substances are similar from one cell to another.

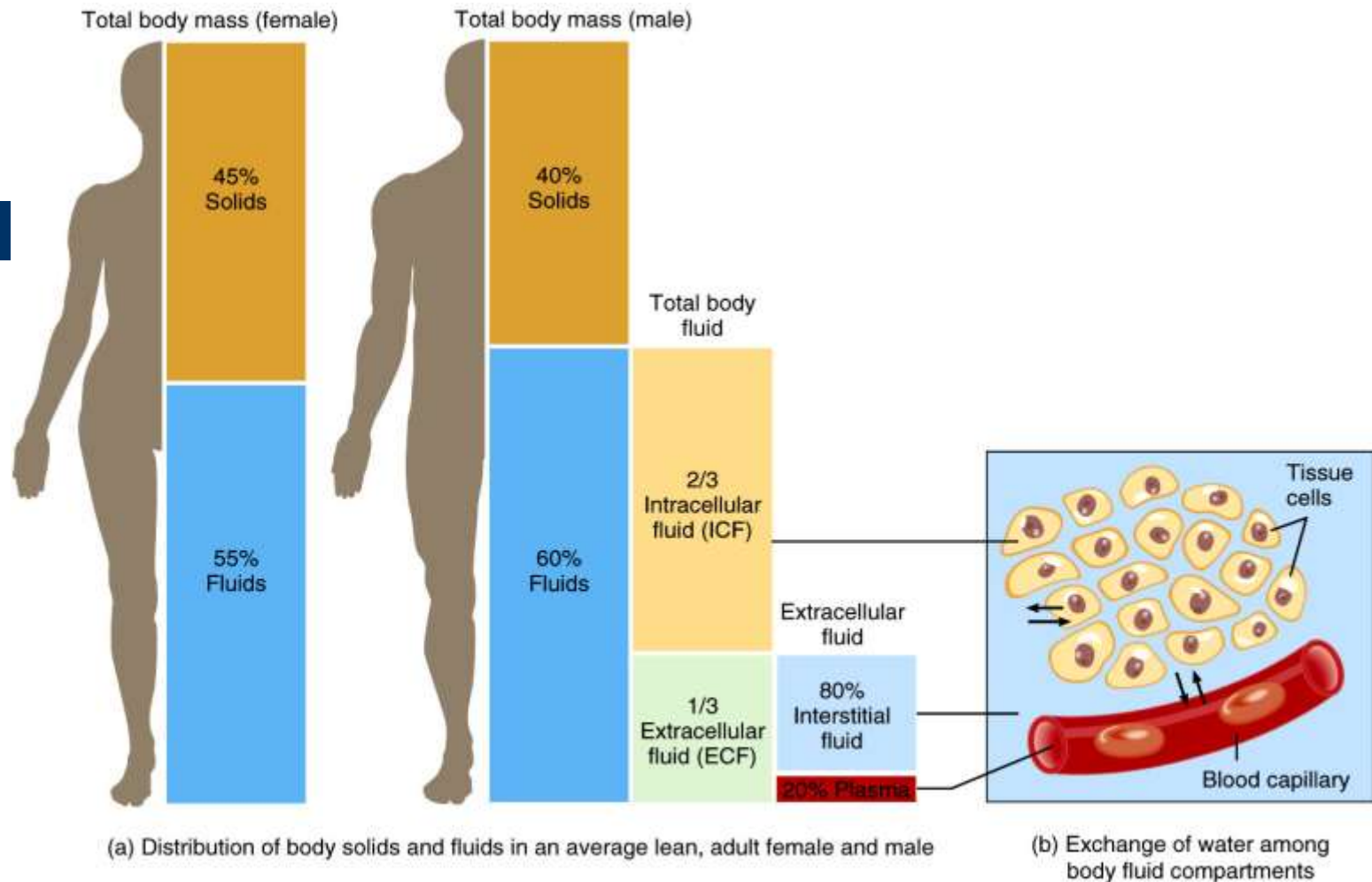


Figure 27.01 Tortora - PAP 12/e
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- Why percentage of water in the body is decreased with person grows older, and with women?

Extracellular Fluid Compartments

- ***Interstitial fluid***
 - Present between the cells
 - Approximately 3/4 of ECF
- ***Blood Plasma***
 - Present in blood
 - Approximately 1/4 of ECF
- **Also includes (*Transcellular fluid*)**
 - Lymph
 - synovial fluid
 - aqueous humor
 - cerebrospinal fluid
 - vitreous body,
 - endolymph,
 - perilymph,
 - Peritoneal, Pericardial and intraocular spaces

Barriers separate ICF, interstitial fluid and plasma

- Plasma membrane
 - Separates ICF from surrounding interstitial fluid
 - Plasma exchange substances with interstitial fluid through the pores in the membrane
 - Permeable to all solutes in ECF except proteins
- Blood vessel wall (circulatory system)
 - Separate interstitial fluid from plasma
 - Blood volume of adults is 7% of body weight

Composition of body fluids

- Organic substances
 - Glucose
 - Amino acids
 - Fatty acids
 - Hormones
 - Enzymes
- Inorganic substances
 - Sodium
 - Potassium
 - Calcium
 - Magnesium
 - Chloride
 - Phosphate
 - Sulphate

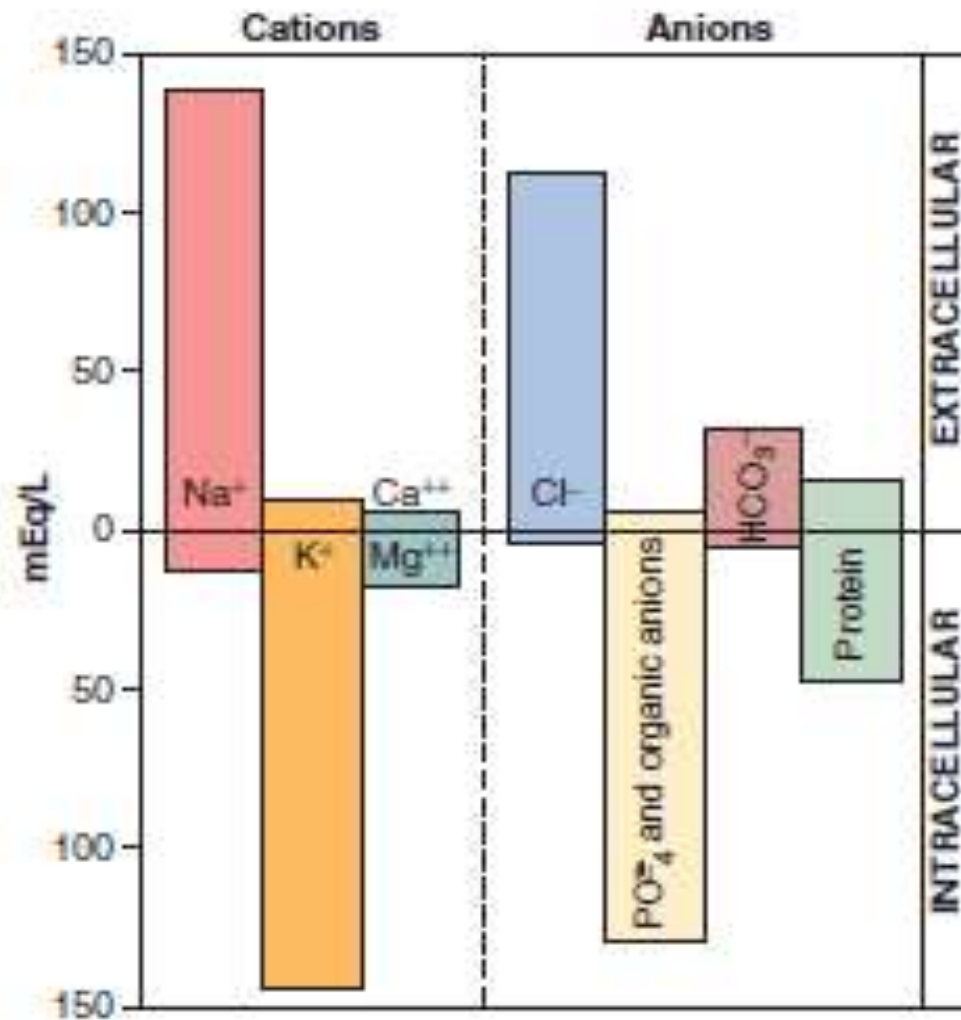


Figure 25-2. Major cations and anions of the intracellular and extracellular fluids. The concentrations of Ca⁺⁺ and Mg⁺⁺ represent the sum of these two ions. The concentrations shown represent the total of free ions and complexed ions.

Difference

ECF

- Most abundant cation - Na⁺,
 - muscle contraction
 - Impulse transmission
 - fluid and electrolyte balance
- Most abundant anion - Cl⁻
 - Regulates osmotic pressure
 - Forms HCl in gastric acid

ICF

- Most abundant cation - K⁺
 - Resting membrane potential
 - Action potentials
 - Maintains intracellular volume
 - Regulation of pH
- **Anion** are proteins and phosphates (HPO₄²⁻)

- **Na⁺ /K⁺ pumps play major role in keeping K⁺ high inside cells and Na⁺ high outside cell.**
- **ECF composition is regulated by kidneys and various mechanisms.**

Sodium Na⁺

- Most abundant ion in ECF
- 90% of extracellular cations
- Plays pivotal role in fluid and electrolyte balance as it accounts for half of the osmolarity of ECF

Chloride Cl⁻

- Most prevalent anion in ECF
- Moves easily between ECF and ICF because most plasma membranes contain Cl⁻ leakage channels and transporters
- Can help balance levels of anions in different fluids

Bicarbonate HCO_3^-

- Second most prevalent extracellular anion
- Concentration increases in blood passing through systemic capillaries picking up carbon dioxide
- Chloride shift helps maintain correct balance of anions in ECF and ICF

Potassium K^+

- Most abundant cation in ICF
- Establish resting membrane potential in neurons and muscle fibers
- Maintains normal ICF fluid volume
- Helps regulate pH of body fluids when exchanged for H^+

Magnesium

- Mg^{2+} in ICF (45%) or ECF (1%)
- Second most common intracellular cation
- Cofactor for certain enzymes and sodium-potassium pump
- Essential for synaptic transmission, normal neuromuscular activity and myocardial function

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
- Solids –
 - **Proteins**
 - 2-6% of solids
 - albumin, globulin, fibrinogen, prothrombin, clotting factors, antibodies, enzymes
 - **Lipids**
 - 5-15%
 - Chylomicrons
 - Lipoproteins
 - **Carbohydrates**
 - Glucose mainly
 - **NPN**
 - Urea and creatinine
 - **Electrolytes**
 - Sodium, calcium, potassium, chloride, bicarbonates

Functions of Lymph

- **Return protein from tissue spaces into blood**
- **Redistribution of fluid**
- **Removal of bacteria, toxins and other foreign bodies from tissues**
- **Maintain structural and functional integrity of tissue**
- **Route for intestinal fat absorption**
- **Transport lymphocytes**

Milk

- Secreted by mammary glands
- Complete natural food
- 83-87% water and 13-17% solids
- Solids
 - Carbohydrates
 - Lactose
 - Lipids
 - Triacylglycerols
 - Palmitic acid, myristic acid, stearic acid, lauric acid, butyric acid, oleic acid
 - Proteins
 - Caesin (80%), Lactalbumin
 - Enzymes (proteases, xanthine oxidase, lysozyme), immunoglobulins
 - Minerals
 - Ca, Mg, P, Na, K, Cl
 - Vitamins
 - Fat and water soluble vitamins except Vit - C

Functions of Milk

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

Cerebrospinal fluid (CSF)

- Clear, colorless liquid formed within the cavities of brain and around spinal cord
- 500ml CSF is formed everyday
- At any given time, there is 120-150ml CSF in the system
- CSF is completely replaced about three times a day.

Functions of CSF

- Hydrolic shock absorber
- Regulation of intracranial pressure
- Influences the hunger sensation and eating behaviours

Amniotic Fluid

- Liquid produced by membranes and fetus
- Volume of fluid increases with gestational age
- Clear with some desquamated fetal cell and a little lipid.

Functions of AF

- Physical protection to the fetus
- Medium for exchange of various chemical

Aqueous Humor

- Fluid that fills the interior chamber of eye
- Secreted by ciliary body, enters anterior chamber
- Blockade in the flow of aqueous humor causes glaucoma due to increased intraocular pressure.
- Posterior chamber of eye is filled with vitreous humor which contains a gel (vitreous body of hyaluronic acid secreted by retina)

Sweat

- Secretion of sweat gland
- Regulates body temperature by cooling and evaporation
- Sweat glands controlled by ANS, Adrenal cortical steroid - which affect the quantity of electrolyte present

Sweat

- Insensible perspiration amounts to 800-1200ml/day
- Volume of sweat produced/day during muscular exercise at elevated temperature may range from 10-14l, which may lead to water and electrolyte imbalance
- Water content of sweat varies from 99.2-99.7%
- pH – 4.7 to 7.5
- Total non protein nitrogen (urea) varies from 0.07-1% per hour during copius sweating

Sweat

- Electrolyte in sweat varies
 - Na+ 12.6-127 meq/l
 - K+ 5-32 meq/l
 - Cl- 8.5-85 meq/l

Tears

- Produced by lachrymal glands
- Isotonic but becomes hypertonic due to evaporation as fluid passes over the cornea
- When the tear flow is copius, fluid is isotonic
- Under stimulus with a slow rate of tear flow, the fluid is about 25m osm hypertonic

Copius – Rapid tear flow induction

Tears

- pH – 7 to 7.6 due to loss of CO₂
- Protein content is 0.6 to 0.18g/dl with an albumin/globulin ratio of 1:5 or 2:1
- Small amount of mucin is also present
- Lysozyme – lyses the cells of a number of micro-organisms by breaking down the polysaccharides of their outer layer

Functions of Tears

- Lysozyme protects eye from infectious agents
- Lubricate the surface of the cornea
- Fill the irregularities of the corneal surface to improve optical properties
- Protects eyes from injury