Body Water
ANS 215
Physiology and Anatomy of Domesticated Animals

I. Body Water

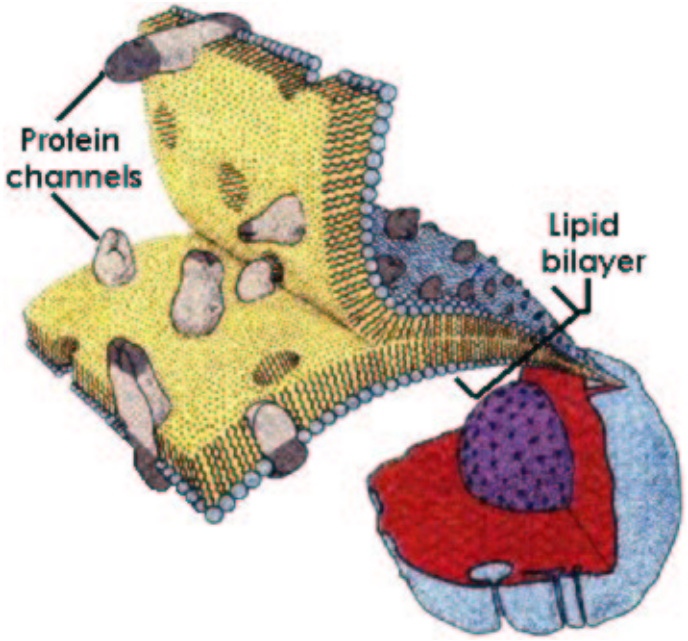
A. Water is the most abundant constituent comprising 60% of total body weight.

1. Solvent for many chemicals of the body
    a. Solutions formed provide diffusion media for the body cells to receive and expel materials.
2. Physical properties of water make it ideal for this transport function.
    a. High specific heat (can absorb energy with minimum change in temperature).
    b. Provides lubrication

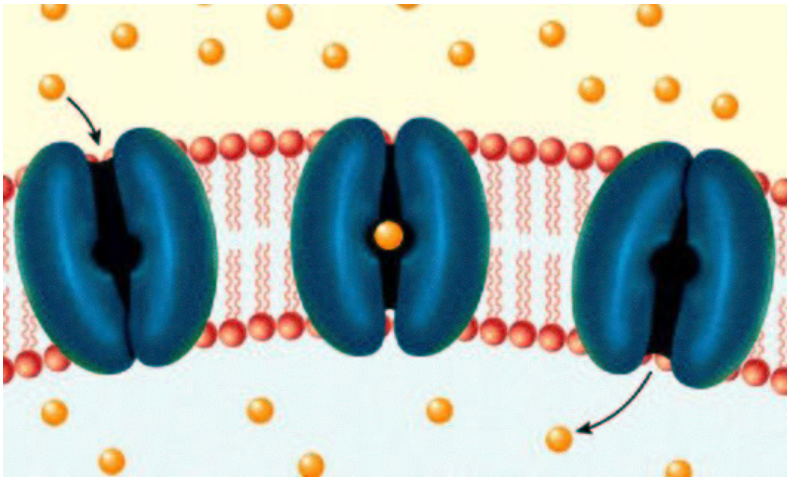
II. Physiochemical Properties of Solutions

A. Diffusion

1. Simple diffusion refers to the random movement of molecules, ions, and suspended colloid particles under the influence of Brownian (thermal) motion.
2. If a concentration gradient (differential) exists, molecules, ions, and colloidal particles tend to move from area of higher concentration to the area of lower concentration.
3. Movement is specific to each substance regardless of the concentration of other substances.
4. If molecules and ions are dispersed equally, the random motion continues but does not accomplish net movement or flow. This represents equilibrium
5. Barriers to diffusion are generally membranes of cells.



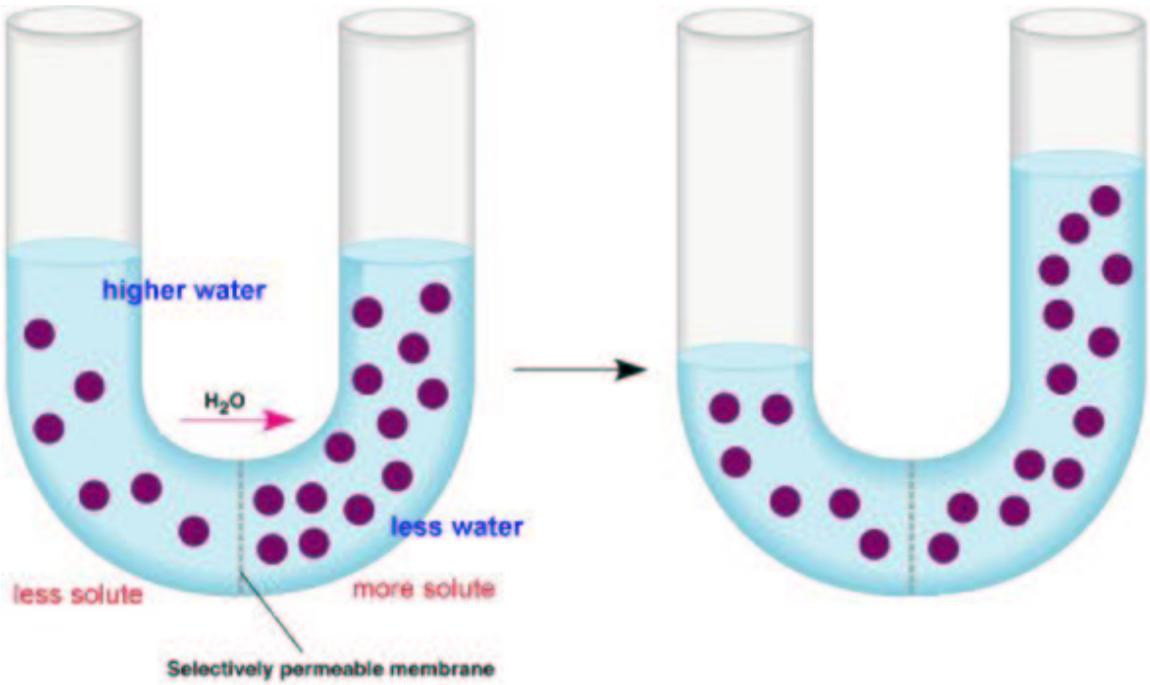
6. Cell membranes consist of lipid bilayer (two molecules thick) through which fat-soluble substances can readily diffuse.
7. There is also facilitated diffusion for other substances in which a carrier is required.



Facilitated diffusion: The transported molecule enters the carrier protein channel and binds with the receptor. Subsequent to binding, the carrier protein undergoes a conformational change to open the channel on the opposite side, and the transported molecule is released, causing the return of the carrier protein to its original conformation.

8. Facilitated diffusion still follows a concentration gradient
9. Water does not readily move through lipid bilayer, but moves through protein channels
10. Protein channels are interspersed in the lipid film
    a. large structural proteins
    b. act as “pores” for water and water soluble substances
11. Other protein channels act as carrier proteins for transport of substances in a direction opposite to their natural diffusion direction.

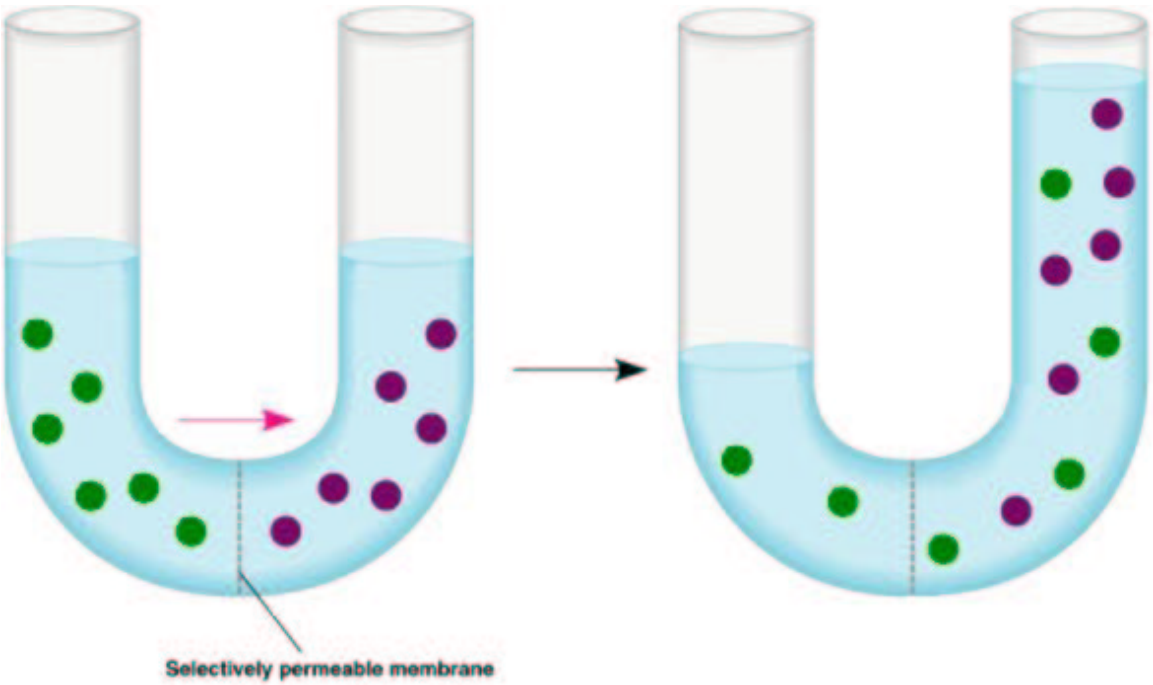
B. Osmosis and Osmotic Pressure
1. Most abundant substance that diffuses in the body is water.
2. Amount of diffusing into cells is balanced by amount diffusing out.
3. Osmosis is the process by which two aqueous solutions that differ in their concentration of water and are separated by a membrane that is permeable to water, but not its solutes, to equalize the concentration of water.



Osmosis: Equal volumes of aqueous solutions (solutes in red) are separated by a membrane selectively permeable only to water. The solution on the left side has the highest concentration of water and lowest concentration of solute. Osmosis occurs from left to right, here, until the concentrations achieve equilibrium, resulting in the taller column of solution on the right.

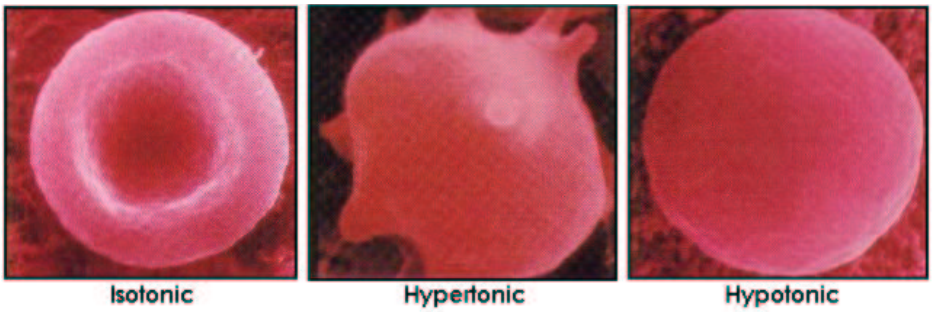
4. Quantitative measure of tendency of water to osmose is called osmotic pressure.
    a. Pressure that would be applied to the compartment with the lowest water concentration to prevent net diffusion of the water from the compartment with the highest water concentration
    b. Number of particles, not the mass of the solute in a solution determines its osmotic pressure.
    c. One mole of an undissociated substance is equal to 1 osmole (eg NaCl)
    d. Solutions of equal osmolarity exert equal osmotic pressure.

C. Tone of solutions
1. Membranes of cells vary in their permeabilities (selectively permeable membranes)
2. The measured osmotic pressure for a solution would therefore not measure its true tendency to cause osmosis.
3. Tone of solution is defined as effective osmotic pressure.
4. Only molecules not permeagble across the membrane contribute to a solutes tone.
5. Principles of osmosis continue to apply except now water diffuses to the greatest effective osmotic pressure.



A hypothetical example of tone of solutions before and after osmosis. Two aqueous solutions (solutes in red and green) of equal osmotic pressure are separated by a membrane permeable to water and green solutes. Effective osmotic pressure is exerted only by red solute, and water diffuses across the membrane. At equilibrium, the green solute has a new, lower concentration that is equal throughout the system.

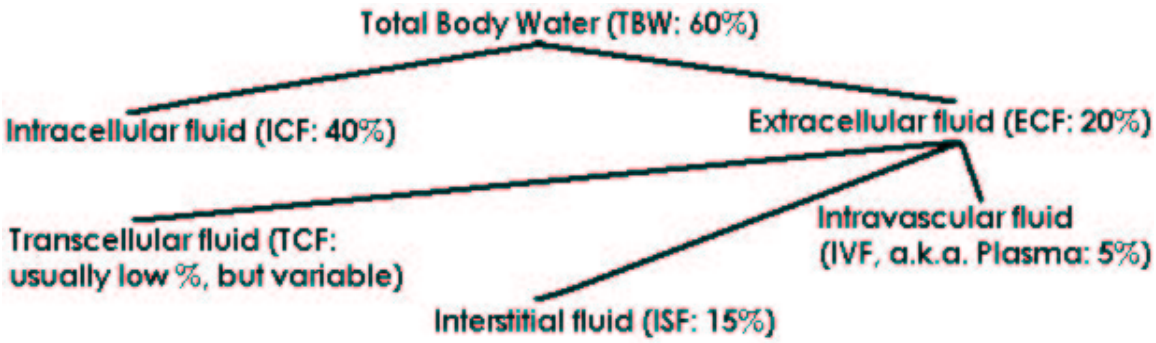
6. From a practical standpoint, the tone of solutions that can be infused into the blood of animals is compared to the solution inside red blood cells.
    a. Solution inside erythrocytes is in osmotic equilibrium with plasma (fluid part of blood).
    b. Infused solution is hypotonic if it has a lower effective osmotic pressure than the solution of erythrocytes and hypertonic if it has a higher effective osmotic pressure.
    c. Solutions that cause erythrocytes to enlarge can be sufficiently hypotonic to cause hemolysis (rupture) of the erythrocyte. Hemoglobin then escapes into plasma causing reddish coloration (hemeglobinemia). Sometimes hemolysis can occur to such an extent that it shows up in urine (hemeoglobinuria).



The effect of tone of solution on red blood cells (RBCs). An isotonic solution is at equilibrium and the RBCs exhibit no net change. Hypertonic solutions cause RBCs to shrink and deform. Hypotonic solutions cause RBCs to expand.

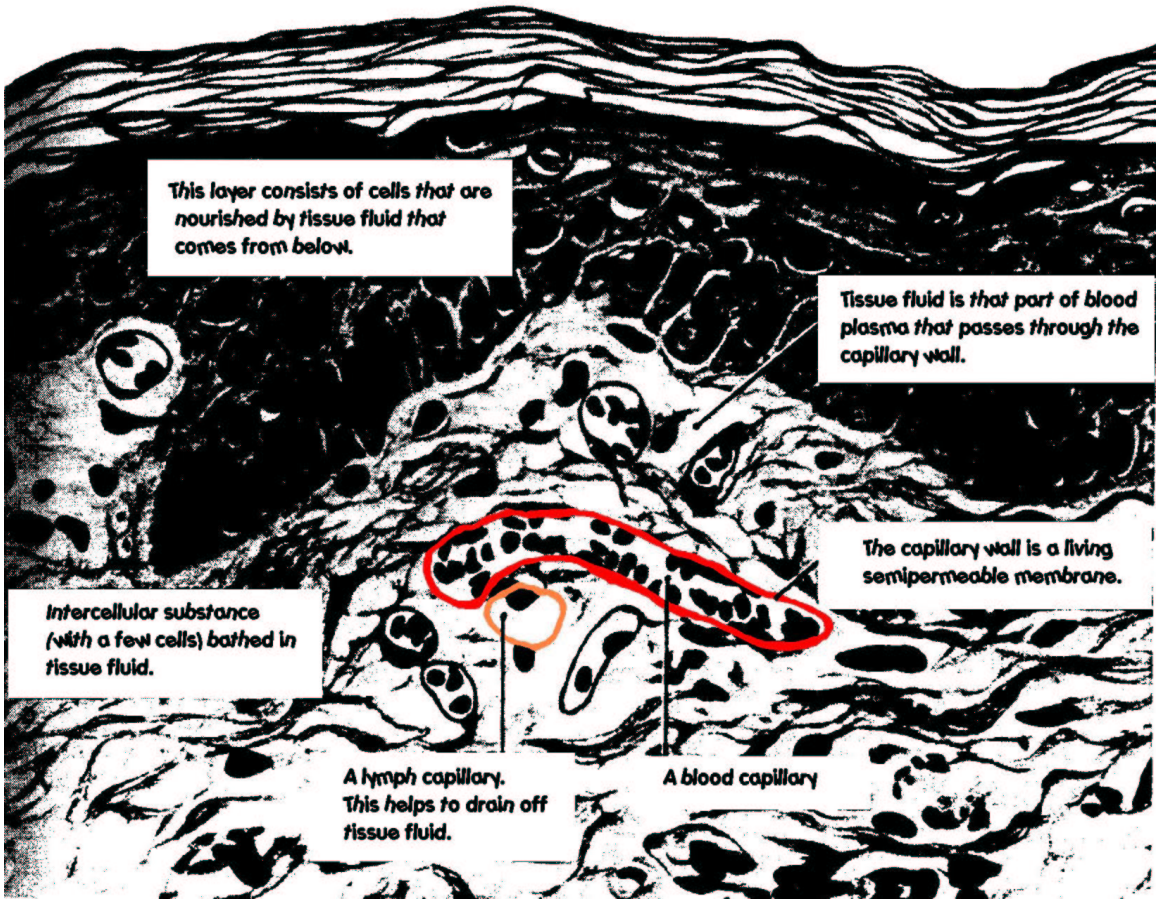
III. Distribution of Body Water

A. Total body water (TBW) is the sum of the water that is contained in arbitrary divisions of its distribution between the intracellular and extracellular compartments.
    1. Extracellular compartment can be divided further into interstitial, intravascular (plasma volume), and transcellular compartments



Total body water and its distribution among the fluid compartments.

B. Terms water and fluid are similar, but differ in that fluid contains not only water, but also solutes.
C. Measurement of a compartments volume usually includes the entire space occupied by water and solutes.
    1. Blood plasma is a fluid, and the measurement of its volume is larger than the space occupied by the water it contains.
    2. For practical purposes the body compartments are referred to as fluid compartments, because the fluid volume rather than the water volume is what is measured.
        a. TBW is variable and depends mostly on the fat in the body.
            i. Lean animal may be 70% water whereas an obese animal might have only 45% of its body weight as water.
D. About two thirds of the body water is found within the cells (intracellular fluid).
    1. All water not found in cells is considered extracellular fluid (ECF).
        a. Includes interstitial fluid (ISF), intravascular fluid (IVF) and transcellular fluid (TCF)
    2. ISF is found immediately around cells but is outside cells and capillaries
    3. IVF is liquid part of blood (plasma). 92% water, 8% protein
    4. TCF is fluid found in body cavities
        a. Intracellular, digestive tract, reproductive tract, mammary gland, cerebrospinal fluid



Skin and its subcutaneous composition as an example of the environment for cells. Elastic and collagen fibers are present, but the main substance is hyaluronic acid. Most interstitial water is in combination with hyaluronic acid, giving it the characteristics of a gel.

IV. Water Balance

A. From day to day in any one animal the water content of the body remains relatively constant.

Daily Water Balance of Holstein Cows Eating Legume Hay (values in liters)

	Balance	Nonlactating	Lactating
Intake			
	Drinking water	**26**	**51**
	Food water	**1**	**2**
	Metabolic water	**2**	**3**
	Total	**29**	**56**
Output			
	Feces	**12**	**19**
	Urine	**7**	**11**
	Vaporized	**10**	**14**
	Milk	**0**	**12**
	Total	**29**	**56**

B. Water output is balanced by intake. Pool size is constant, but turnover is increased.
    1. Water gain comes from food, drink, and metabolic water
        a. Metabolic water comes from combination of hydrogen and oxygen at the end of the electron transport chain. This is also a point at which oxygen is consumed by the body.
        b. Yield of water is greater for fat than protein or carbohydrate
            i. 100g protein yields 40ml water
            ii. 100 g carbohydrate yields 60ml water
            iii.100g of fat yields 110ml of water
    2. Water loss is classified as sensible or insensible
        a. Sensible loss are urine, feces, body secretions
        b. Insensible loss is water vapor or evaporation

V. Dehydration, Thirst, and Water Intake

A. In dehydration, the immediate source of water lost is ECF
    1. followed by a shift from ICF to ECF
    2. loss of 10% of body weight is considered severe
    3. Concentration of electrolytes in body fluids do not increase, but are excreted by the kidney during dehydration
    4. Rehydration requires not only water, but also appropriate electrolytes.
    5. Stimulus for thirst comes from hypothalamus.