Animal physiology- /2022-2023/ 1ST semester

Lecture 1

Physiology

Physiology is the study of the functions of living organisms and the changes which occur during activity. physiology is experimental science because the data are obtained by experiments, while most of the biological sciences are descriptive sciences because the data are obtained through descriptions and observations. Despite the diversity there are many commonalities within physiology-unifying themes that apply to all physiological processes.

First of all, physiological processes obey physical and chemical laws. The following chemical and physical laws and concepts relate to various physiological processes.

1- ohms law: Blood flow and blood pressure, ionic current.
2- Boyles law and the ideal gas law: Respiration
3- Gravity: Blood flow
4- Kinetic and potential energy: Muscle contraction, chest movements during exhalation.
5- velocity: Animal locomotion.

Second, physiological processes are regulated to maintain internal conditions within acceptable ranges. This internal constancy, known as homeostasis.

Third, the physiological state of an animal is part of its phenotype, which arises as the product of the genotype, and its interaction with the environment.

Fourth, the genotype is a product of evolutionary change in a group of organisms-populations or species-over many generations.

Means of research in animal physiology

Some of important means of research in physiology including the following

1- Microscopes
2- Histochemistry

Histochemistry is a method used to study the distribution of chemical compounds (as enzymes) in different regions of the cell. The method depends on reactions between a certain substance in the cell and chemical substance(s) added to the medium. As a result the product with specific color precipitate where the compound is found.

3-Spectroscopy

The method depends on wave length absorption (visible or ultraviolet) by bsorbing molecules in a solution. Each chemical compound has its specific wave length, which is selected to its determination.

4-Isotopes

Isotopes are two or more forms of the same element that have the same number of protons and electrons but different number of neutrons. The nuclei of some isotopes are stable and don't change. Radioactive isotopes, however, have unstable nuclei that lose neutrons or protons. Several different kind of radiations can be produced, and released from the nucleus of the isotope,

α- rays: nuclei of helium
β- rays: beam of electrons
γ- rays: electromagnetic rays

most of the isotopes are used in biology are C^{14}, Na^{24}, K^{42}, Deuterium (H^2), Tritium (H^3), I^{129}, I^{131}, I 1^{135}, and S^{35}. C^{14}: suitable for labeling carbon dioxide, glucose, amino acids, or any chemical compound which comprises living organism. Na^{24}, and K^{42} are used in research of permeability and nerve impulse. When radioactive sodium is taken (as NaCl) into the alimentary canal, within 5 minutes the Gieger counter shows the presence of the labeled sodium in the fingers. H^2 used as heavy water in research. Radioactive isotopes of iodine are used in research of thyroid gland because iodine used in the formation of thyroid hormones (T3, and T4).

Cell membrane

The cells are covered by membranes called cell membrane or plasma membrane, composed primarily of **lipids** and **proteins**. Most organelles also are covered by membranes, as nuclear membrane, membrane of the endoplasmic reticulum, and membranes of the mitochondria, lysosomes, and Golgi apparatus.

Cell membrane (fig.1-1,fig.1-2,fig.1-3, and fig.1-4) is composed primarily of

1-Lipid bilayer:two layers of phospholipid with small amount of cholesterol.

Phospholipids have a polar head containing a negatively charged phosphate group which is hydrophilic, and two nonpolar fatty acid tails which are hydrophobic. largely responsible for the fluidity of the membrane. Cholesterol interacts weakly with adjacent phospholipids in the membrane, partially immobilizing their fatty acyl chains. As a result the membrane is less fluid but mechanically stronger. Lipid-soluble substances (e.g., O_2, CO_2, steroid hormones) cross cell membranes because they can dissolve in the hydrophobic lipid bilayer. Water-soluble

substances (e.g., Na^+, Cl^-, and glucose) cannot dissolve in the lipid of the membrane, but may cross through water-filled channels, or may be transported by carriers.

2-Proteins

a-Integral proteins

Integral proteins are imbedded in the cell membrane through hydrophobic interactions. may span the cell membrane. include ion channels, carriers, receptors, enzymes, and cell recognition proteins).

b-peripheral proteins

peripheral proteins are not imbedded in the cell membrane. They are not covalently bound to membrane components, but loosely attached to the cell membrane by electrostatic interactions. (functions as enzymes, and cytoskeletal proteins) (fig1-1.fig-2, fig1-5)).

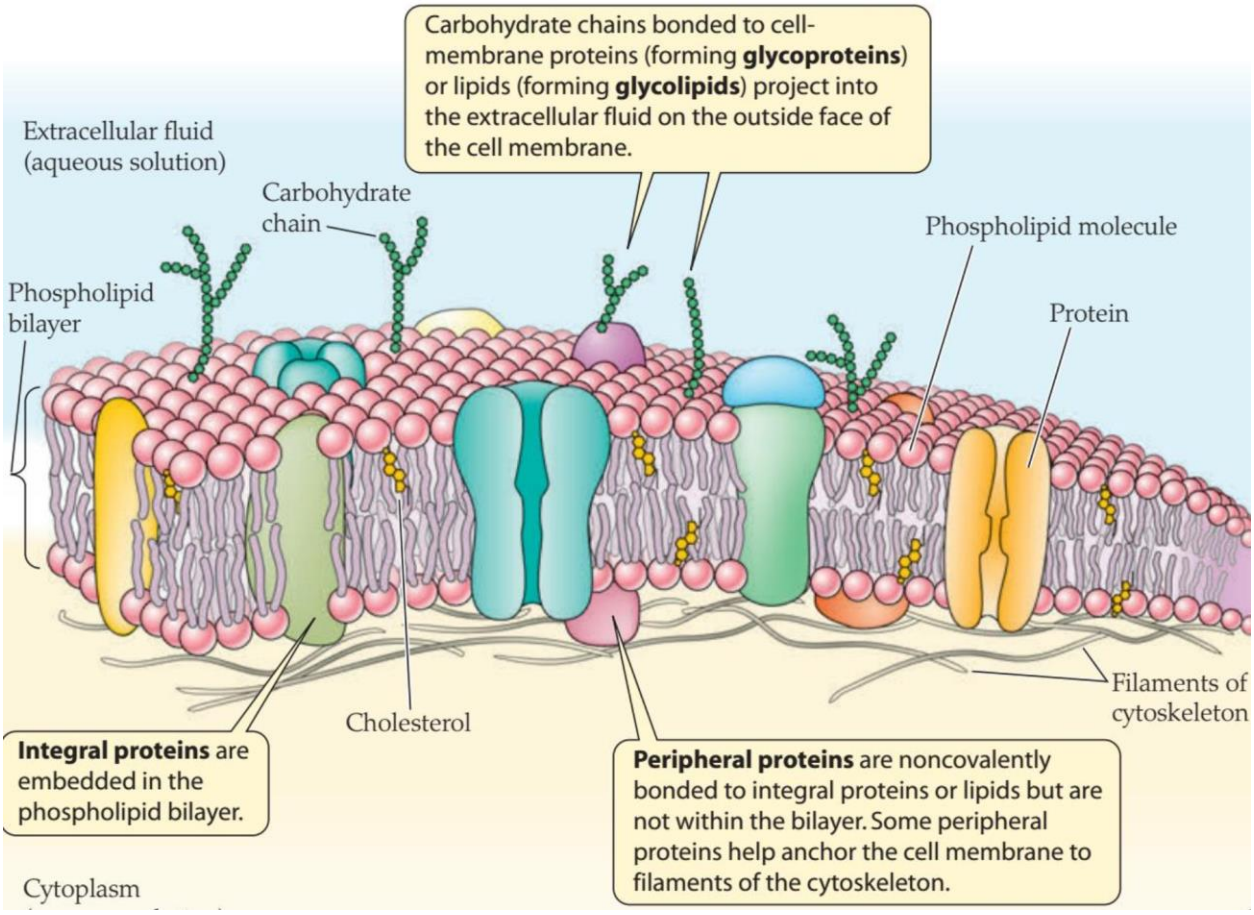

Figure 1-1: Fluid mosaic model of cell membrane structure

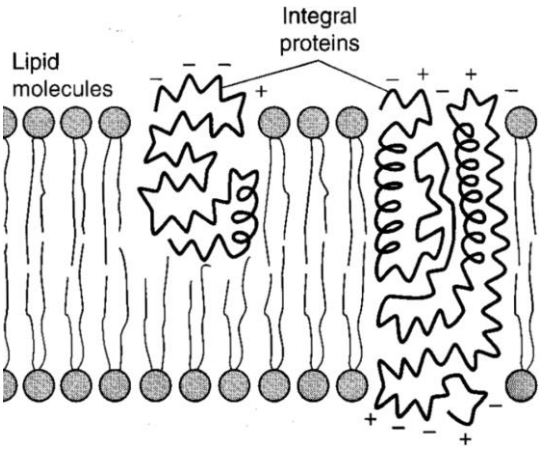

Figure1-2 : A cross-sectional view shows the complexity of the mosaic bilayer model.

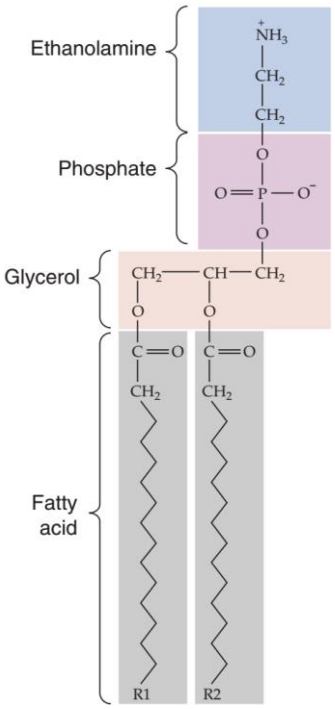

Figure 1-3: A Phospholipid (phosphatidylethanolamine)

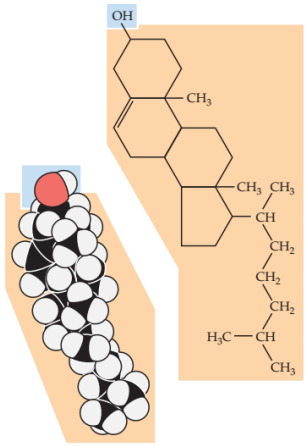

Figure 1-4: c- cholesterol

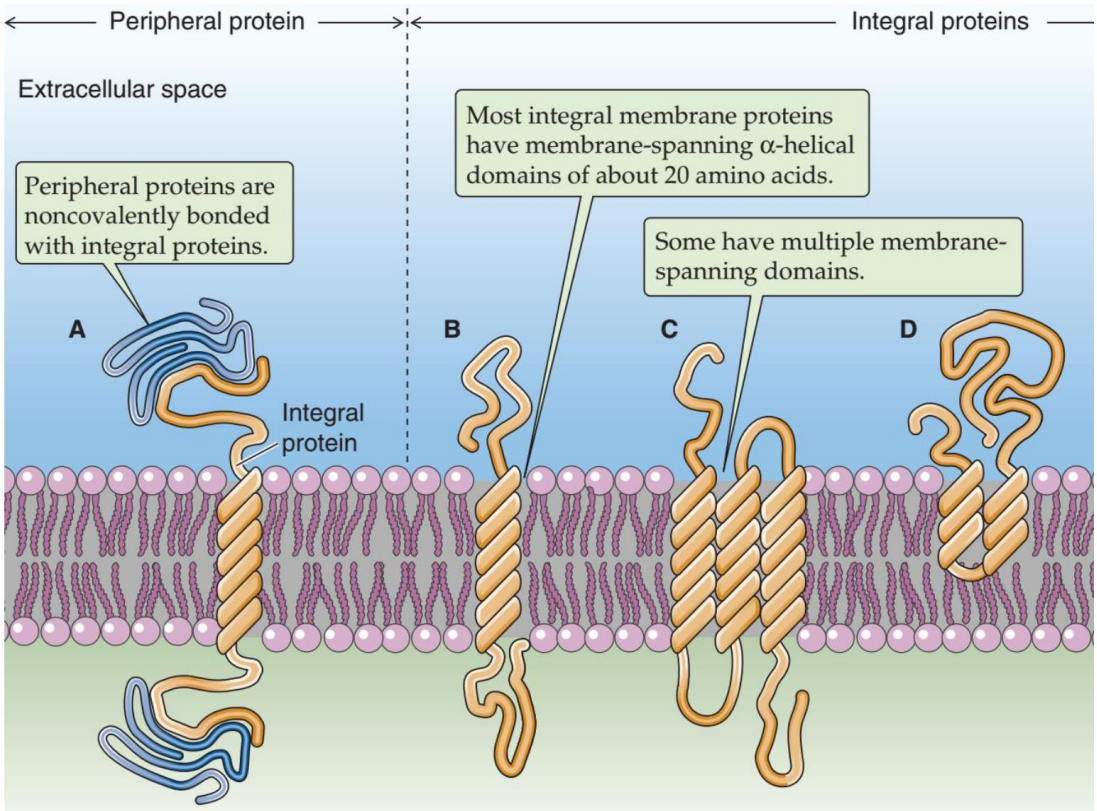

Figure 1-5: Classes of membrane proteins

Transport across cell membranes

1-**Simple diffusion**

Simple diffusion is not carrier-mediated. Occurs down an electrochemical gradient (downhill). It does not require metabolic energy and therefore is passive.

Diffusion can be measured using the following equation

$J = PA (C_1 - C_2)$

where:

J = flux (flow) [mmol/sec]

p = permeability (cm/sec)

A = area (cm^2)

C1 = concentration 1 (mmol/L)

C2 = concentration 2 (mmol/L)

Sample calculation for diffusion

The urea concentration of blood is 10 mg/l00 ml. The urea concentration of proximal tubular fluid (fig.1-5) is 20 mg/100 ml. If the permeability to urea is $1x1o^{-5}$ cm/sec and the surface area is 100 cm^2, what are the magnitude and direction of the urea flux?

$$\text{Flux} = \left(\frac{1\times10^{-5}\ \text{cm}}{\text{sec}}\right)\left(100\ \text{cm}^2\right)\left(\frac{20\ \text{mg}}{100\ \text{mL}}\right) - \left(\frac{10\ \text{mg}}{100\ \text{mL}}\right)$$

$$= \left(\frac{1\times10^{-5}\ \text{cm}}{\text{sec}}\right)\left(100\ \text{cm}^2\right)\left(\frac{10\ \text{mg}}{100\ \text{mL}}\right)$$

$$= \left(\frac{1\times10^{-5}\ \text{cm}}{\text{sec}}\right)\left(100\ \text{cm}^2\right)\left(\frac{0.1\ \text{mg}}{\text{cm}^3}\right)$$

$= 1x10^{-4}$ mg/sec from lumen to blood (high to low concentration)

Note: The higher concentration is called C1 and the lower concentration is called C2.
Also note: $1mL=1cm^3$.

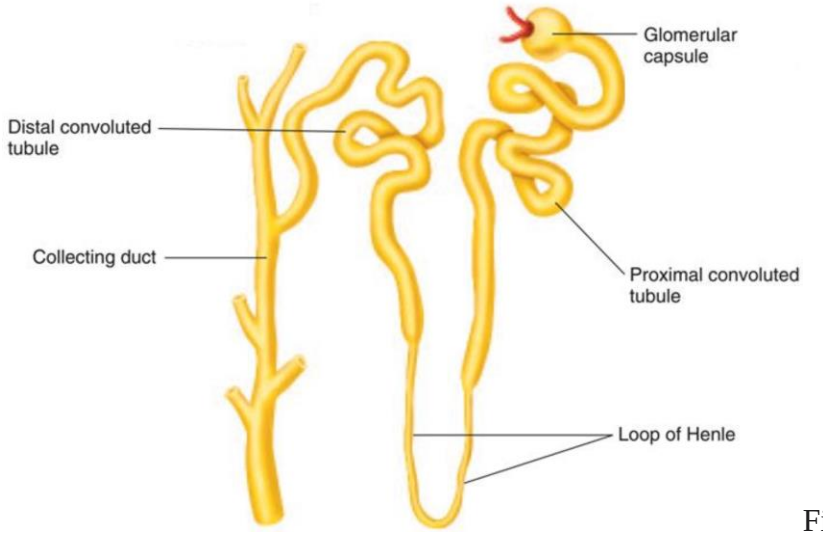

Figure 1-5: A single nephron

2- **Osmosis**

Osmosis is the flow of water across a semipermeable membrane or selectively permeable membrane from a solution with low solute concentration to a solution with high solute concentration (fig. 1-6).

Osmotic pressure: The force in a solution is produced from concentration of solute, and cause transportation of solvent molecule through semipermeable or selectively permeable membrane from a solution with low solute concentration to a solution with high solute concentration.

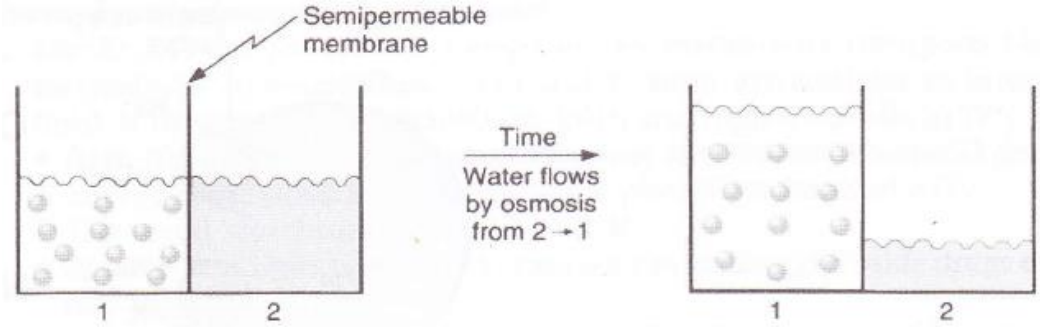

Figure 1-6: Osmosis of water across a semipermeable membrane. Solutions 1 and 2 are separated by a semipermeable membrane. Solution 1 contains a solute that is too large to cross the membrane. Solution 2 is pure water. The presence of the solute in solution 1 produces an osmotic pressure. The osmotic pressure difference across the membrane causes water to flow from solution 2 (which has no solute) to solution 1 (which has the solute and the higher osmotic pressure). With time, the volume of solution 1 increases and the volume of solution 2 decreases.

Calculating osmotic pressure

The osmotic pressure of solution can be calculated by van't Hoff's law.

$\pi = IRTC$

where:

π = osmotic pressure (atmosphere)

I = number of particles dissociated from each molecule in solution

R = gas constant (0.082 L-atm/mol-K)

T = absolute temperature (K) [C˚+273]

C = concentration (mol/L)

Examples: Calculate osmotic pressure of the following solutions: 0.9% NaCl, 0.7% NaC, and 2% glucose .

Osmolarity: is the concentration of osmotically active particles in a solution (osmol/L)

Therefore, for example Osmolarity of NaCl 150 mmol /L= 2x150 mosmol/L

Questions

1- What is the difference between experimental sciences and descriptive sciences

2- choose the correct answer: K^{42} is used in the study of

a- nerve impulse b- thyroid hormones c- insulin d- protein synthesis

3-Draw a figure in which explain fluid mosaic model of cell membrane structure

3- Calculate osmotic pressure of 0.9% NaCl

Dr. Karim R. Hamad