Physiology

Doctor 2019 | Medicine | JU

◉ Sheet ○ Slides

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A Quick Review: (00:00-07:22)

-Our body is made up of different systems, each system with a general function and every system contributes to homeostasis.

-We have two control systems:

- 1- The nervous system
- 2- The endocrine system

-Different systems control the variables to keep them almost constant, and that what we call feedback.

Feedback Gain(07:22-14:35)

-Feedback gain: A measure of the effectiveness of a feedback system.

$$\text{Gain} = \frac{\text{Correction}}{\text{Error}}$$

توضيح

Example: **Blood pressure** is normally 100 mmHg, for a certain reason it may increase to 120 mmHg.

Baroreceptors will respond to this change trying to decrease it back to 105 mm Hg, the correction is 15 and the error is 5 so the gain is 3 **(very small)**

-The correction (the first value- the second value): is how much we decrease the value to be closer to normal.

-The error: how the second value differs due to the controller affect.

-Another example for better understanding:

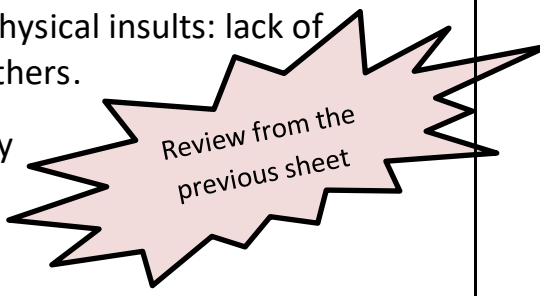
There are other systems that control blood pressure such as endocrine system: epinephrine (adrenaline) and others, these controllers bring the pressure back to 100.0001 the correction now is almost 20 and the error is almost zero so the gain is infinity **(any number divided by zero gives infinity).**

-The more effective system is the system with a higher gain and the better the control system is.

-The nervous system's gain is very small(disadvantage) though it works very fast (advantage), while the endocrine system's gain is very large (advantage) though it works very slow (disadvantage).

Homeostatic Imbalances (14:35-17:14)

-There are some insults that disturbs the homeostasis, like physical insults: lack of oxygen, drop in glucose, drop in calcium or potassium and others.



-The abnormality (disruptions) can be: **a-** mild and temporary
b- intense and prolonged (it may cause a disease)

-Normal equilibrium of body processes are disrupted

-Moderate imbalance: (It will cause a disease)

Disorder or abnormality of structure and function

Disease specific for an illness with recognizable signs and symptoms

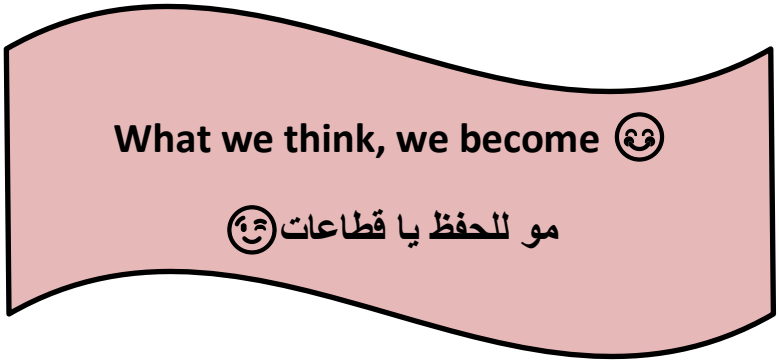
Signs are objective changes such as a fever or swelling (something that you measure or determine)

Symptoms are subjective changes such as headache (something that the patient complain of and you can't measure)

-Severe imbalance: (It may cause death)

Introduction to transport (17:15-47:35)

-Transport: movement of substances from inside **(ICF)** the cell to the outside of the cell **(ECF)** across the cell membrane or vice versa.



Generalized Body Cell:

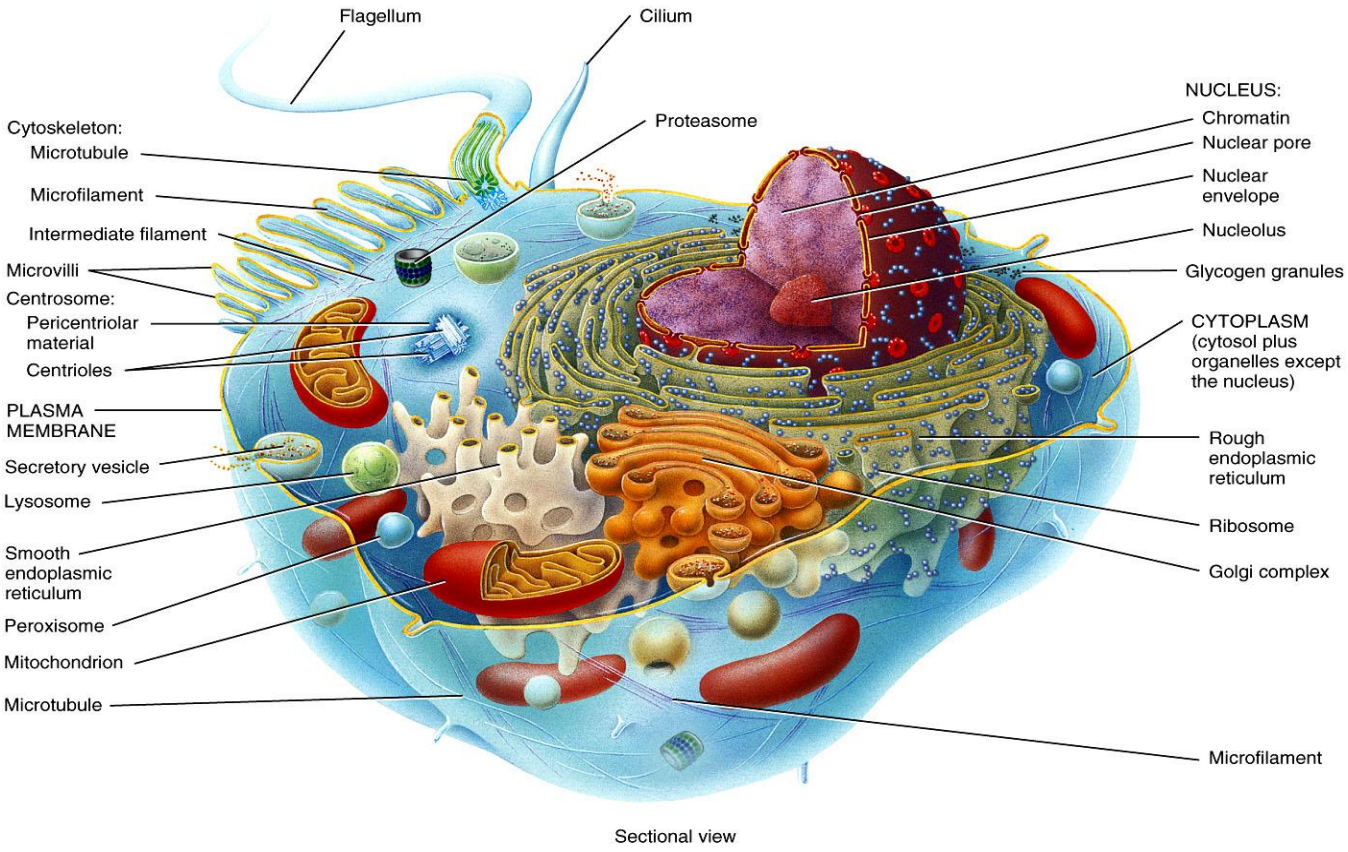


Figure 03.01 Tortora - PAP 12/e

A Generalized Cell:

1. Plasma membrane

- Cell membrane is a phospholipid bilayer, for each phospholipid **(which is the major component)** there's a hydrophilic head and a hydrophobic tail.

-It's essential for the membrane to be composed of two layers, because if it was made of one layer the **ICF** can't be aqueous solution. (because of the hydrophobic tails)

The cell membrane isn't static, it's moveable(dynamic)

-The other component of the membrane is protein

- forms the cell's outer boundary

- separates the cell's internal environment from the outside environment

- is a selective barrier

- plays a role in cellular communication

-It's a flexible yet sturdy barrier

-**The *fluid mosaic model*:** the arrangement of molecules within the membrane resembles a sea of lipids containing many types of proteins

-The lipids act as a barrier to certain substances

-The proteins act as "gatekeepers" to certain molecules and ions

Structure of a Membrane:

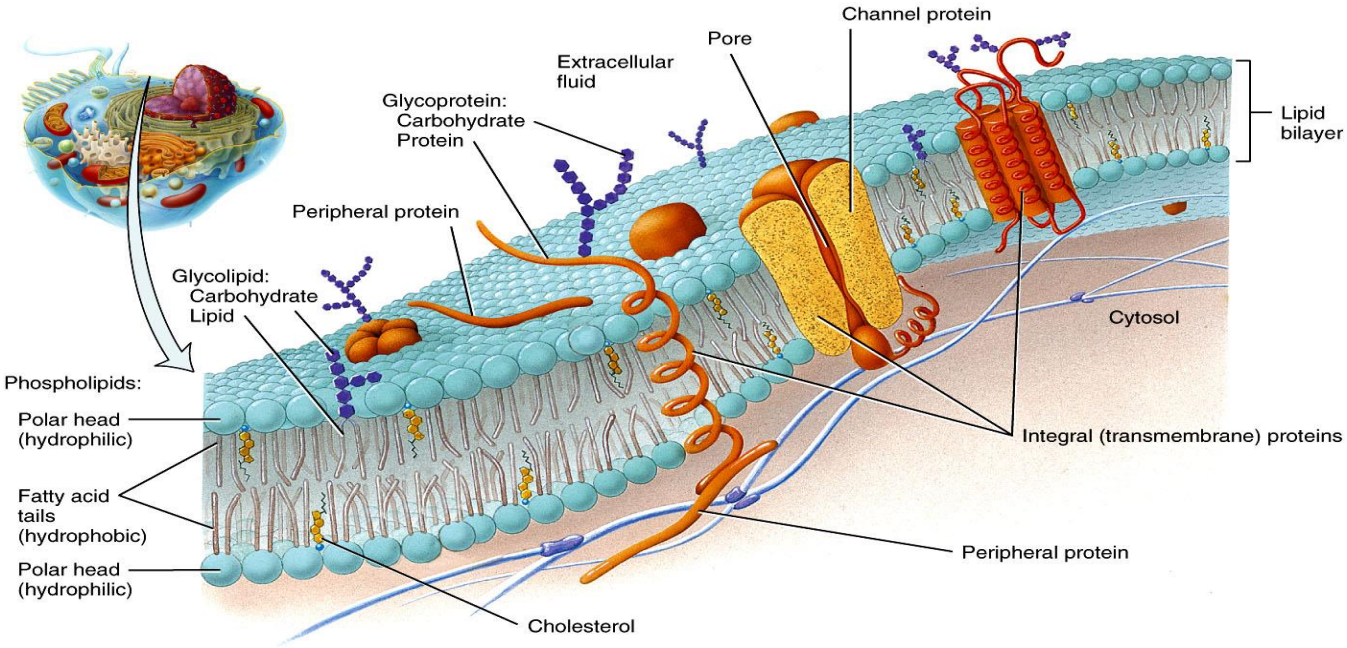


Figure 03.02 Tortora - PAP 12/e

-Consists of a lipid bilayer made up of phospholipids, cholesterol and glycolipids

-**Integral (structural) proteins**: extend into or through the lipid bilayer (through all the thickness of the membrane)

-**Transmembrane proteins:** most integral proteins, span the entire lipid bilayer-

-**Peripheral (surface) proteins:** attached to the inner or outer surface of the membrane, do not extend through it

-Glycoproteins: membrane proteins with a carbohydrate group attached that protrudes into the extracellular fluid (such as ABO blood grouping) a

-Glycolipids: membrane lipids attached with a carbohydrate group

-Glycocalyx: the "sugary coating" surrounding the membrane made up of the carbohydrate portions of the glycolipids and glycoproteins

-The percentage of proteins in the cell membrane depends on the function of the cell. (for example, the light receptors' membrane in the visual system contain 40% proteins)

Functions of Membrane Proteins:

-Some integral proteins are **ion channels** (what pass through the membrane is lipid cellular substances, charged and hydrophilic substances don't pass so they need channel and these channels are specific)

Some channels have gates and these gates open or change their permeability according to the change in voltage -these channels are called voltage gated channels- **or** to the presence or absence of a chemical attached to this channel -these channels are called chemically gated channels- and sometimes there's leaky channels(gives small amounts)

-**Transporters -** selectively move substances through the membrane

Some hydrophilic big molecules can't pass the membrane so they need carriers

-Cell linkers

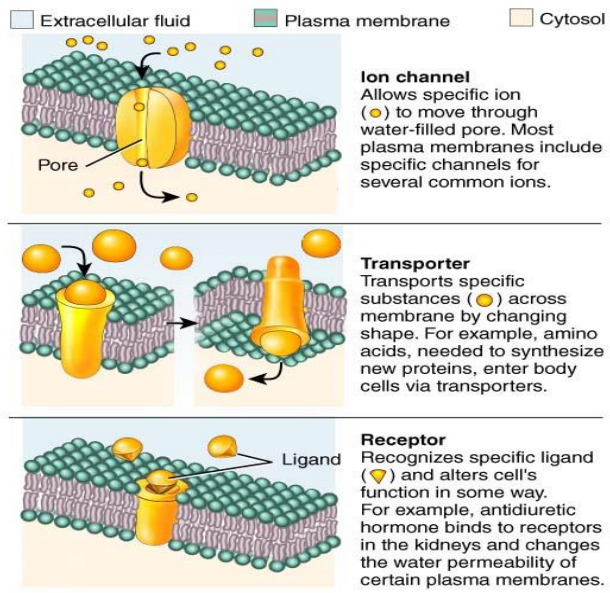
-**Receptors** (they are specific) - for cellular recognition; a **ligand** is a molecule that binds with a receptor

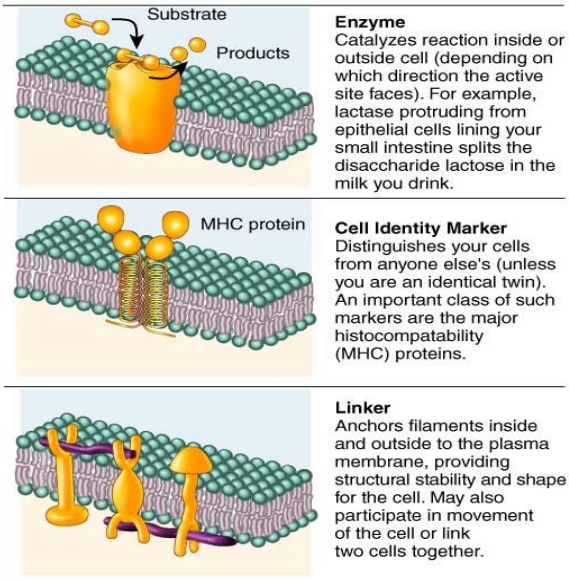
-**Enzymes** - catalyze chemical reactions

Examples of disaccharides: lactose, sucrose and maltose that must be hydrolysed and the enzyme that is responsible for that is a peripheral protein (they're called disaccharidase-lactase, sucrase and maltase-).

-Others act as **cell-identity markers**

These proteins can be antigens (plasma membrane proteins that will produce antibodies in your body if it's different than your proteins like immunizations) such as antigens for blood grouping (specific) on the cell surface of red blood cells.





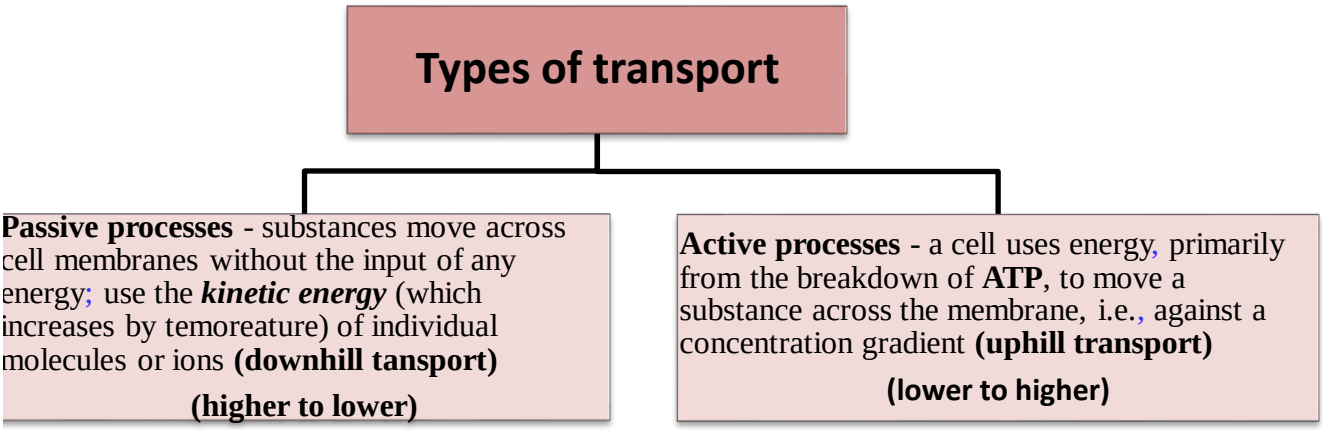
-Some people have lactase deficiency for genetic reasons which leads to diarrhea.

Membrane Permeability:

-The cell is either permeable or impermeable to certain substances

-The lipid bilayer is *permeable* to oxygen, carbon dioxide, water and steroids, but *impermeable* to glucose

-Transmembrane proteins act as channels and transporters to assist the entrance of certain substances, for example, glucose and ions (diffusion **just if** the channel is opened)



-We classify transport types according to the concentration gradient.

-The thickness of the membrane is about 1 Mm

-The permeability of CO_2 is 24 times more than the permeability of O_2, for example If you want export 250 mL per min of CO_2 out of the cell and import 250 mL per min of O_2 into the cell you just need 5 mm Hg gradient of CO_2 while for O_2 you need 60 mm Hg gradient (this difference is because the difference in permeability)

-What passes through the membrane **(passive transport)** depends on the concentration gradient (the pressure gradient) **which is the first factor**: the more the gradient, more amount will pass through the membrane and the less the gradient is, less amount will pass through the membrane.

-**Another factor** is the surface area: as the surface area increases the rate of permeability will increase (passive transport is directly proportional to surface area)

-**Also,** passive transport is directly proportional to the permeability.

-Passive transport is inversely proportional to the thickness of the membrane **(which is caused by diseases 'not normal').**

-The more the molecular weight of the substance is, the less efficient the passive transport will be.

Diffusion:

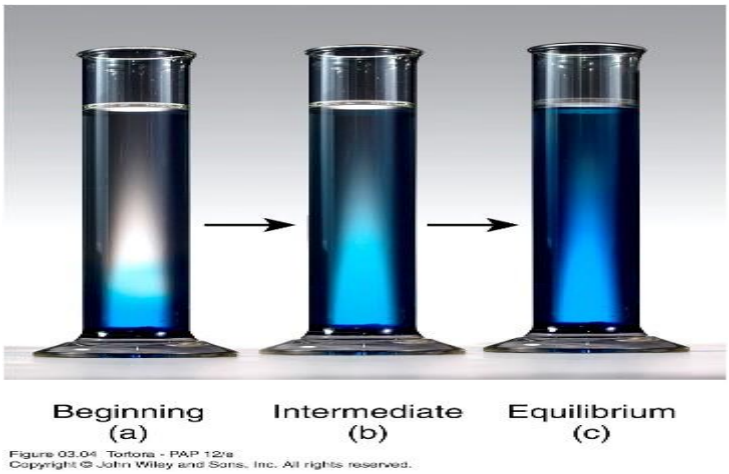
-Steepness of concentration gradient

-Temperature

-Mass of diffusing substance

-Surface area

-Diffusion distance



Simple diffusion: is the best example for passive transport (such as CO2, O2, fat soluble vitamins such as vitamin D, A, K, E)

-Vitamin C and B aren't soluble vitamins and they don't pass by simple diffusion.

Diffusion rate (J) is directly proportional to the concentration gradients and solubility in lipids. It is inversely proportional to the square root of the molecular weight and thickness of the membrane.

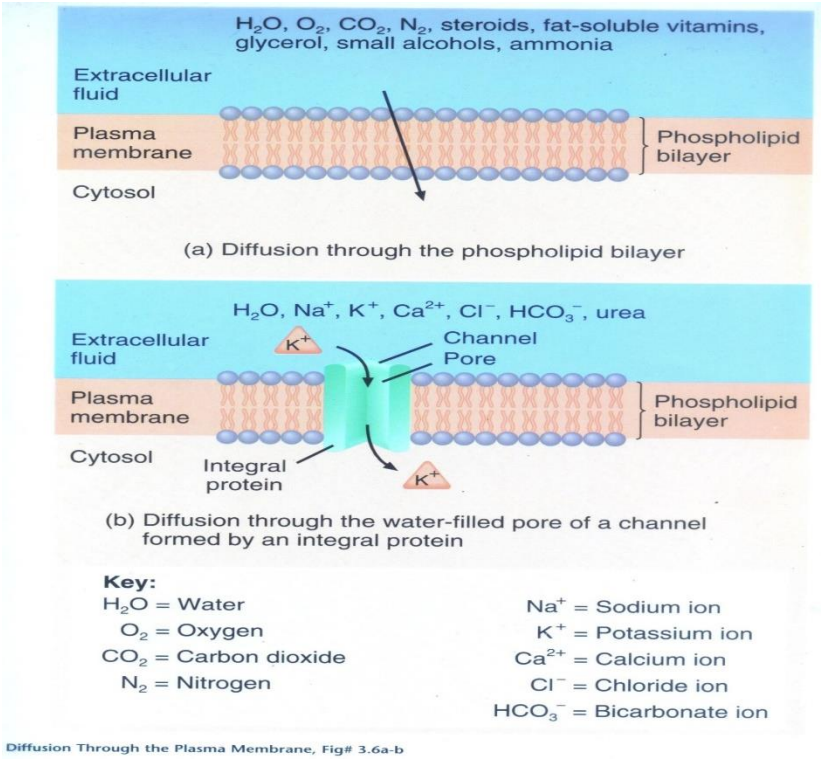
Fick's law of diffusion

$J = P(C_2-C_1) * S$ where P=permeability in lipid

(C_2-C_1) = concentration gradient, S=surface area.

Or J=DA*(ΔC/ ΔX), ΔC=concentration gradient, A=Area, ΔX=Thickness of the membrane, D=diffusion coefficient (depends on the solubility in lipids, molecular weight **and it's constant for each substance**).

-***NOTE***: the permeability of the substance is inversely proportional to the square root of the molecular weight.



Diffusion Through the Plasma Membrane, Fig# 3.6a-b

This figure represents simple diffusion through the membrane of lipid soluble substances

THE END

GOOD LUCK ☺