Physiology | Lecture 2 / A

Plasma Membrane

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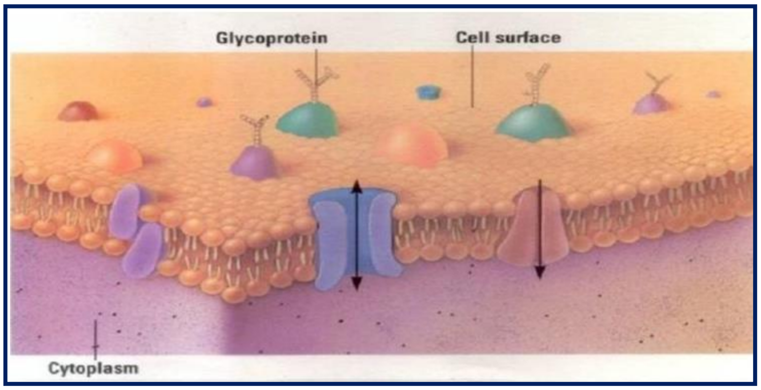
PLASMA MEMBRANE

■In this chapter, we will be talking about the *plasma membrane* , it's structure and function.



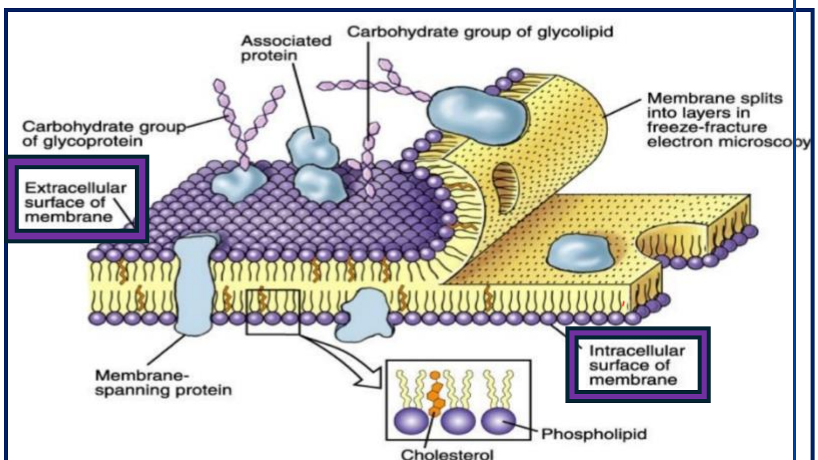
■ So , as we can see in this table :

Membrane Structure	*Function*
Phospholipid Bilayer	▪ The phospholipids are arranged in a bilayer, with their polar, hydrophilic phosphate heads facing outwards, and their non-polar, hydrophobic fatty acid tails facing each other in the middle of the bilayer. ▪ This hydrophobic layer acts as a barrier to all but the smallest molecules (oxygen & Carbon Dioxide), effectively isolating the two sides of the membrane. ▪ Phospholipids can exchange position in the horizontal plane but not the vertical.
Integral Proteins	▪ Usually span from one side of the phospholipid bilayer to the other. ▪ Proteins that span the membrane are usually involved in transporting substances across the membrane (more detail below)
Peripheral Proteins	▪ These proteins sit on one of the surfaces (peripheral proteins). They can slide around the membrane very quickly and collide with each other, but can never flip from one side to the other. ▪ Proteins on the inside surface of plasma membrane are often involved in maintaining the cell's shape, or in cell motility. ▪ They may also be enzymes, catalysing reactions in the cytoplasm.
Glycoproteins	▪ Usually involved in cell recognition which is part of the immune system. They can also acts as receptors in cell signaling such as with hormones.
Cholesterol	▪ Binds together lipid in the plasma membrane reducing its fluidity as conferring structural stability

Bilayer structure is formed of lipids (most abundant are **phospholipids**) , also we have **cholesterol** molecules , beside that we have a lot of types of **proteins** embedded in the plasma membrane and **glycoproteins** .

☆So we are going to analyze the function of these structures that we have in the plasma membranes.

-Lipids in Plasma membrane

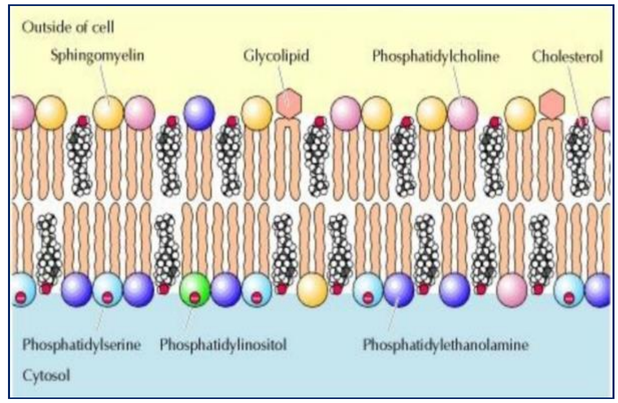


Plasma membrane is considered as a functional organelles , which is separating two compartments (**the Intracellular compartment from the Extracellular compartment**), that membrane is composed of a lipid Bilayer structure in which a lot of proteins are embedded .

-Lipid function in Plasma membrane

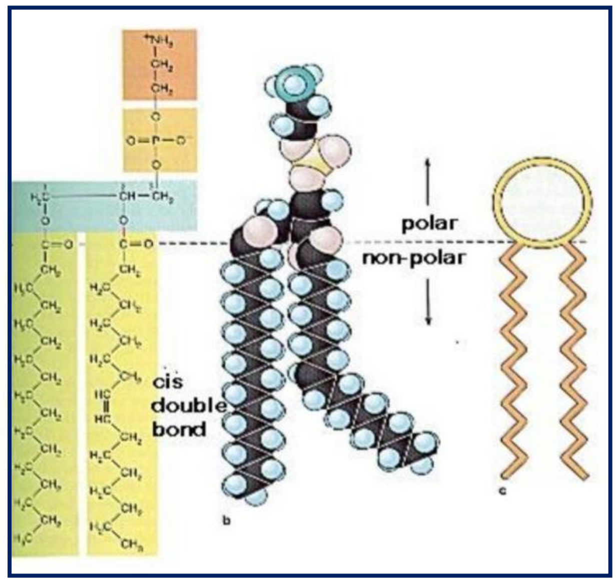
this organelle is forming at **37°** degrees , which is the norml body temperature (***At the normal body temperature of 37 degrees the Membrane is in <u>fluid</u> state*.**)

The fluidity is determined by the fatty acids as in the figure.

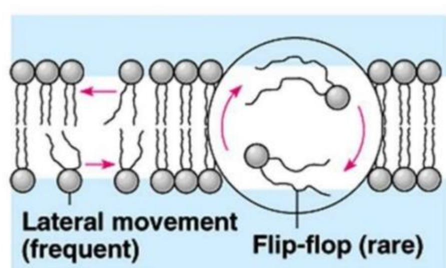


And once we are getting packing of these lipid structures ,we are not getting compact packing because of having double bonds at certain points over the fatty acids.

(The electrical properties of phospholipids Permit self assembly in a bilayer structure when found themselves in **Hydrophilic** medium).



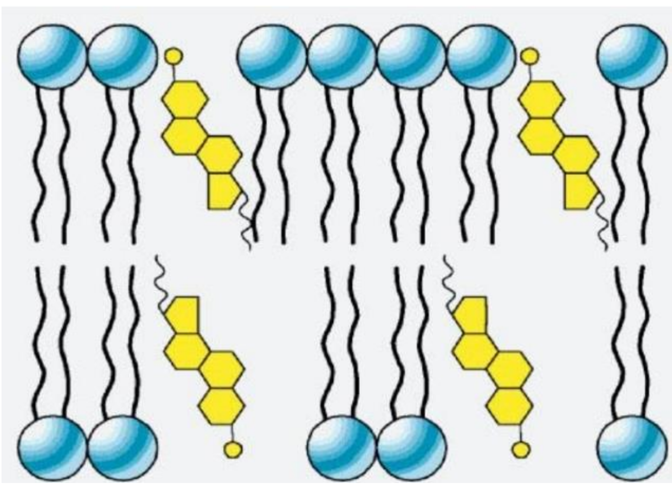
Because of the **fluidity** that we have at 37°, all the time we have movements of lipid particles along the membrane (2 types of them) which is called the **lateral movement** and is **more frequent** to occur . Also we can have **flip-flop movements** which is more **rare movements** because of *<u>the size</u>* of the phospholipids.

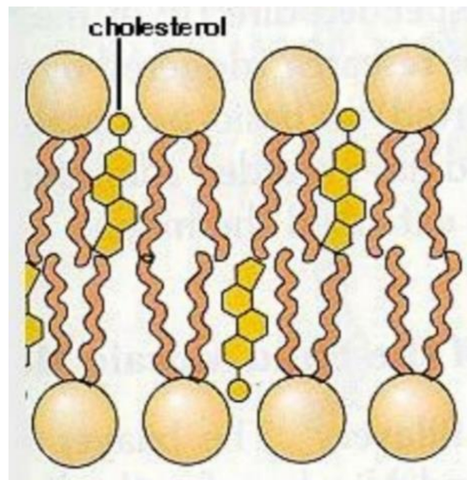


(a) Movement of phospholipids

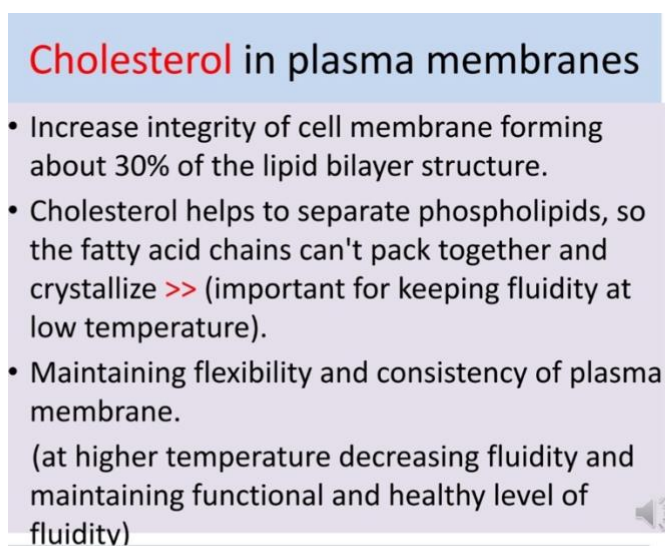
Cholesterol in plasma membranes

Beside phospholipids, we have **<u>cholesterol</u>** molecules embedded between phospholipids molecules, and they are also involved in ***controlling the fluidity*** of the plasma membranes .





Cholesterol which is Separating phospholipids has an important role in keeping fluidity of that membrane . and it maintains the integrity of the plasma membrane.

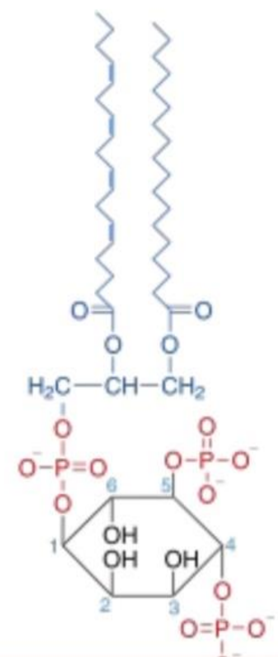


PIP2 Functional phospholipids in Plasma

One of the phospholipids , which is found at the plasma membranes , has a functional Importance. the structure of that molecule is shown in the figure:-

We'll see the function of this molecule later ^^)

On the glycerol : at the carbon position 1&2 we have fatty acids, at the carbon position we have 3 a molecule with phosphate groups and its a sugar called ***inositol***.



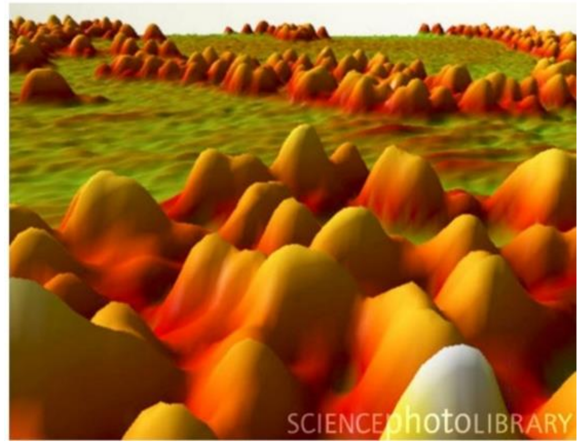
Phosphatidylinositol 4,5-bisphosphate (PIP2)

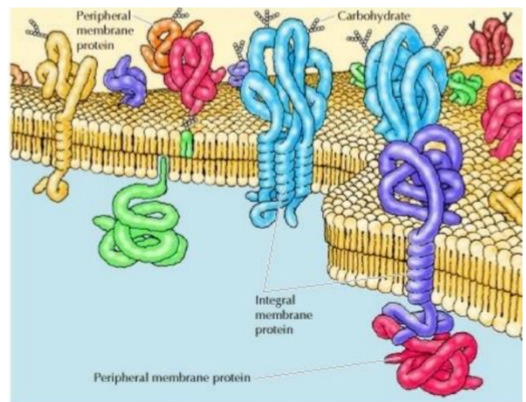
We will see the function of this molecule when we talk about signal transduction mechanism

Proteins in Plasma membrane

We have plenty of proteins that are found in the *plasma membranes*.

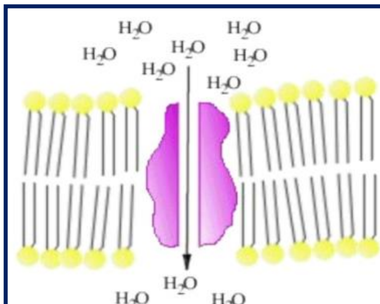
(as shown previously in the table above)
Many protein structures are found at the membrane.
Most of these have also a carbohydrate moiety. Some of these proteins are penetrating the whole bilayer structure (**integral** proteins) others are found at one Surface of the membrane (**peripheral** proteins).
These proteins perform specific functions .





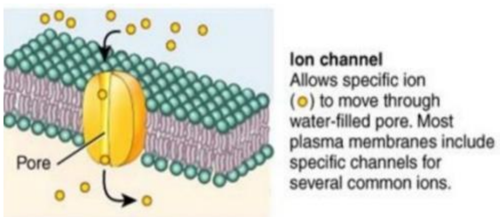
Proteins functions

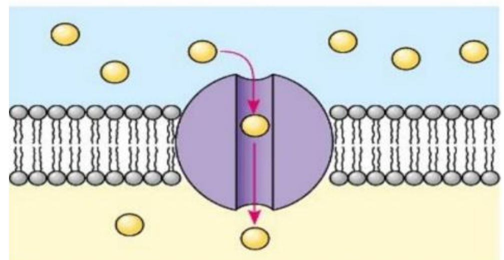
● Some proteins that span the membrane form a water filled Pathways (**Channels**) which enables water soluble substances to diffuse across the membrane through these Structures. Also, the hydrophilic particles cannot pass through the Lipid bilayer structure so they could pass the plasma membrane with the help of these channels.



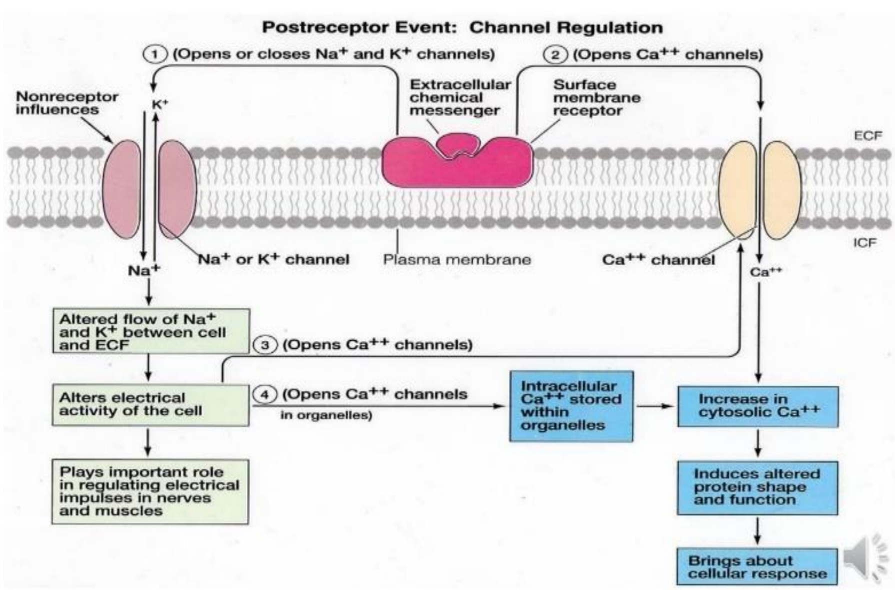
Diffusion through a protein channel

Channels that are at the plasma membrane are important for the **transportation of ion** from one side to another. One thing that you have to know is that these channels are **very specific** and **highly selective** , that means every ion has its own protein that is different from the other ones (Na+ can Pass only through sodium channels and K+ can pass only Through K+ channels).

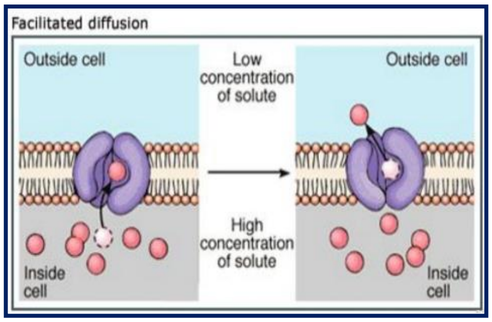


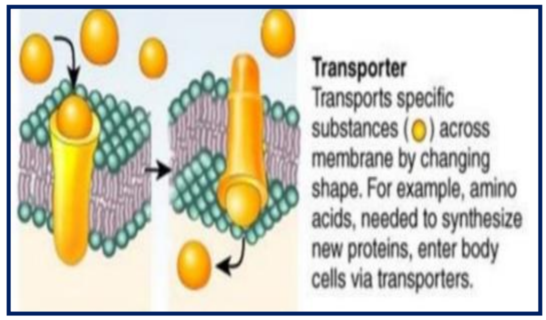


The activity of these channels is under controlling mechanisms that govern the channels activity. Some of These channels change their activity when the membrane potential is changed (voltagedependent (sensitive) Channels). Other channels can open when a specific ligand Binds to its receptor and causes opening of channel (chemical gated channels).

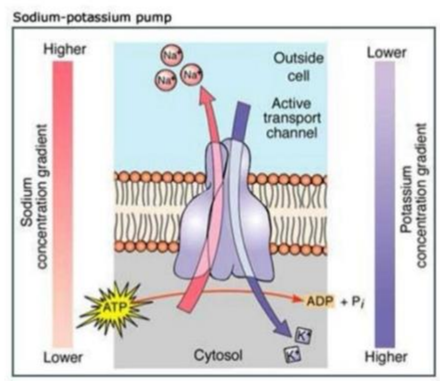


Other proteins serve as **<u>Carrier molecules</u>** which help other molecules (**bigger particles** such as glucose, galactose and fructose) to cross membrane. These Transport proteins are ***highly selective to substances***. They Bind to a substance and move it through the interstices to the other side of the membrane.

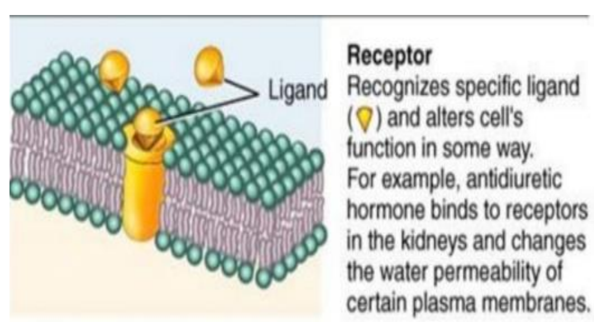




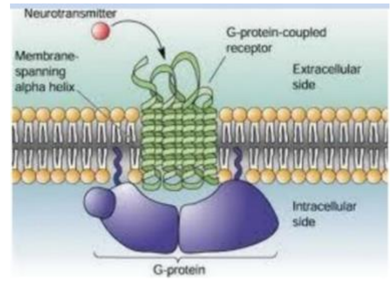
● We can even have carriers that helps ions to move across the membrane from the low concentration to the high concentration (**against their concentration gradient)** These carriers are called **ATP dependent carriers.**



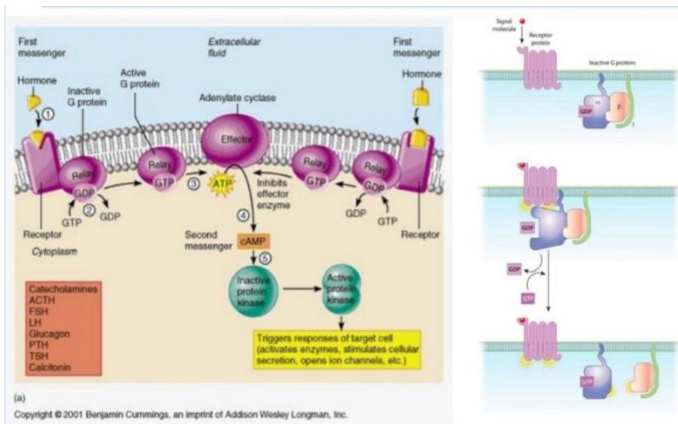
● Other proteins are **<u>Receptors</u>** for ligands found in the Extracellular fluid. The binding of ligand to receptor will
Initiate cellular events that alter the activity of the cell
(an ex. Activation of Na+ channels in striated muscle after binding of acetylcholine (Ach) to its receptor on the Muscle membrane). The receptors are important for communication between the control system and that specific cell.



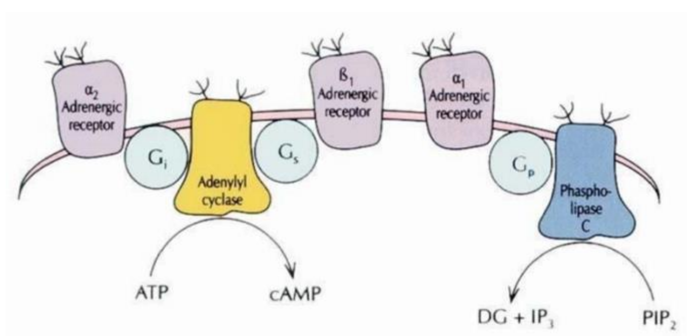
Some of these receptors are linked to other protein structures which are calld G Protein-receptors, they can modify the activity of certain structures like enzymes for example .



**** In the figure, a receptor that can activate an enzyme called Adenylate cyclase***

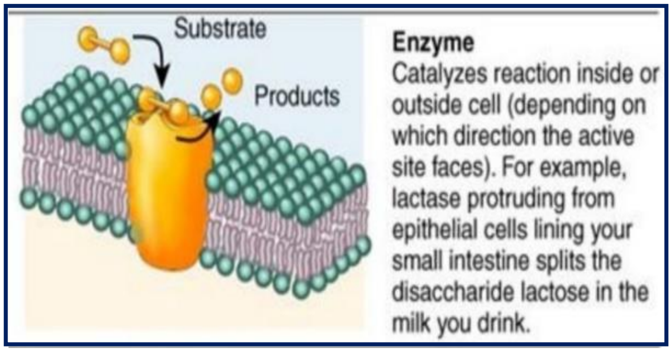


There are many types of Gproteins that can be found at the inner part of the plasma membrane. These proteins are linking receptors to enzymes like adenyly cyclase as we mentioned before. Also, another type is Gp protein that links a receptor to an enzyme called PHASPHOLIPASE-C .

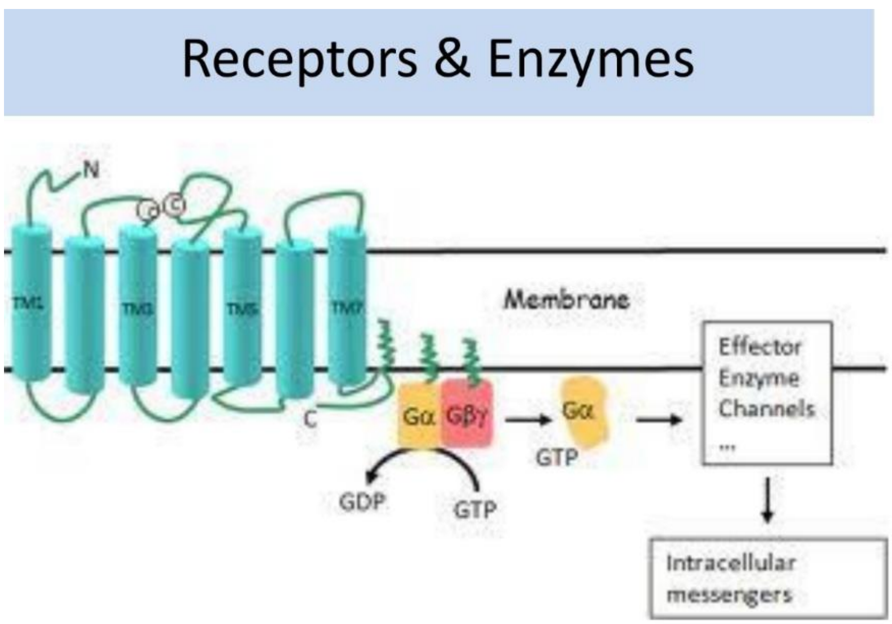


G- Proteins can act as activator or inhibitor like GS proteins which can stimulate the activity of the adenylase cyclase and GI protein which is inhibit the activity of the adenylase cyclase

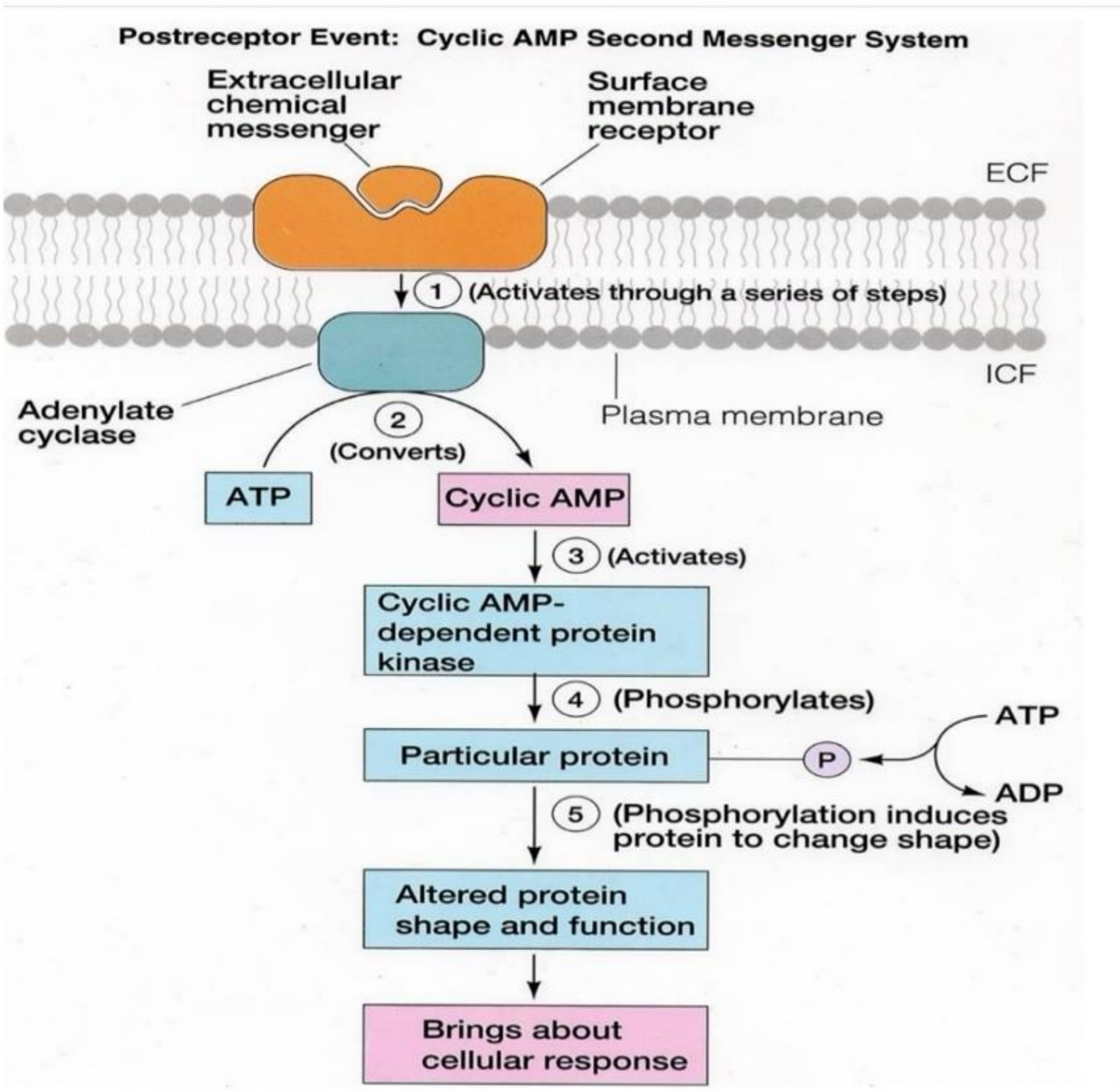
●Other proteins function as **membrane bound enzymes** Which control enzymatic reactions either inside or outside The cell.

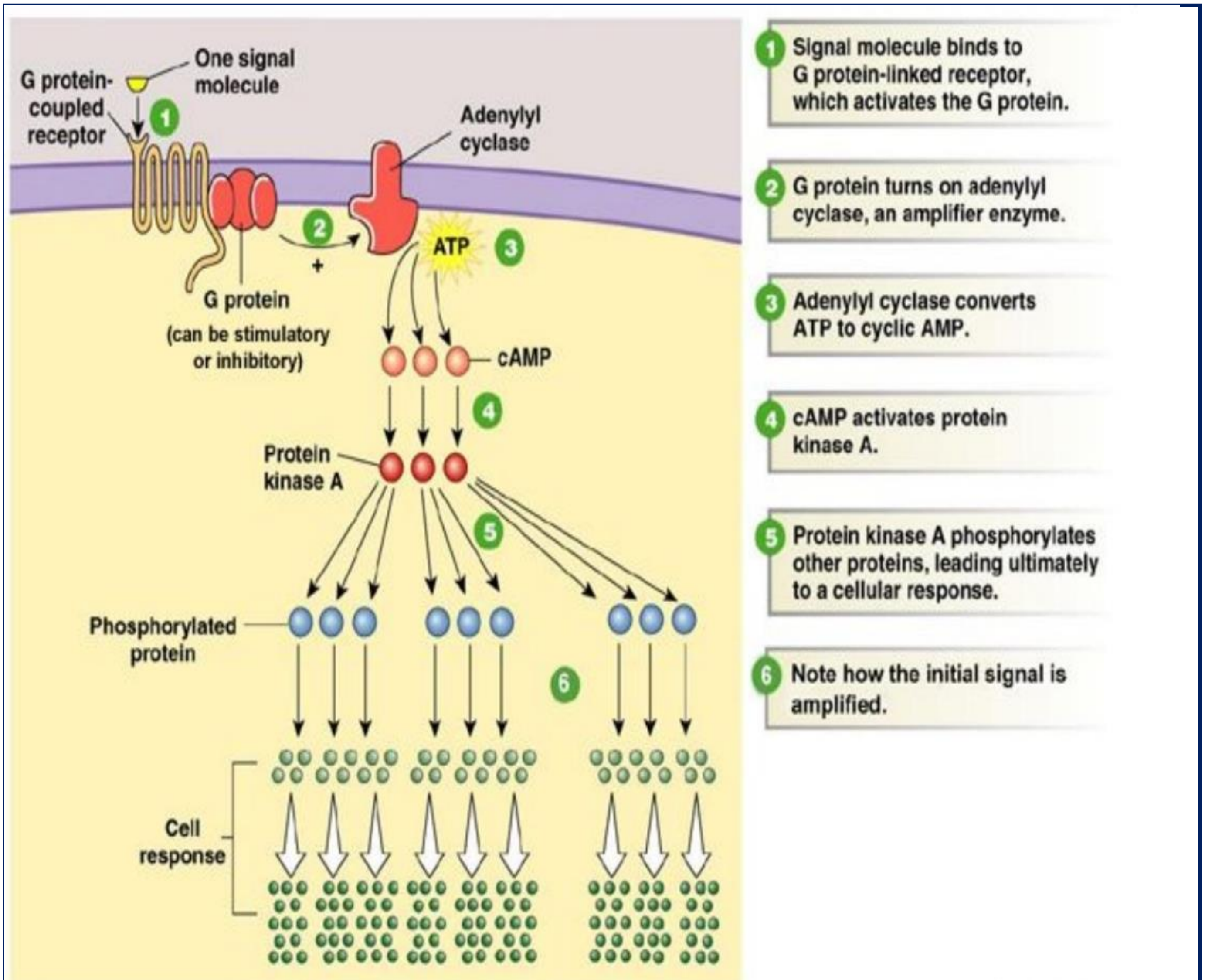


Some of the receptors that we have talked about are linked to certain structures which are Enzymes that can be found at that membrane.
 By activating these enzymes, we’re getting what we call **The Second Messenger**.



For example, by the activation of Adenylate cyclase we can convert ***ATP into cyclic AMP*** (the cyclic AMP is considered the second massenger) and this will bring some changes to the activity of the cell, now it can activate some cyclic AMP dependent proteins kinase. Once you get a kinase , you well get phosphoralation of a specific type of protein. By this process you are altering the shape and the function of these proteins and this would bring changes -cellular responses- by the activation of the enzyme

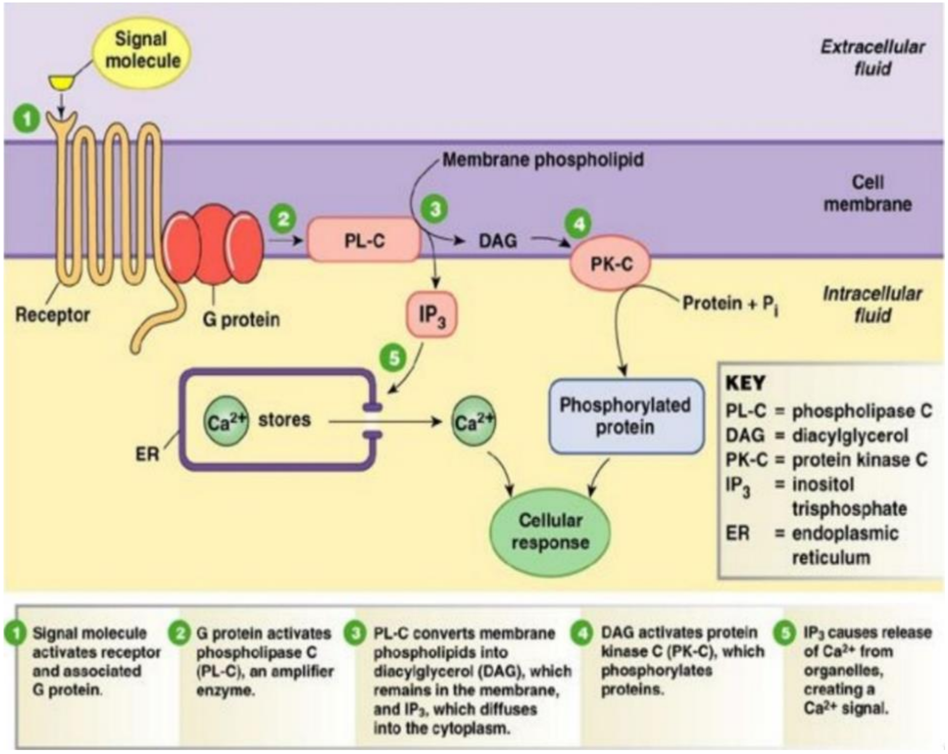




* The adenylyl cyclase converts three ATP into three cAMP ,each cAMPs activates proteins kinase

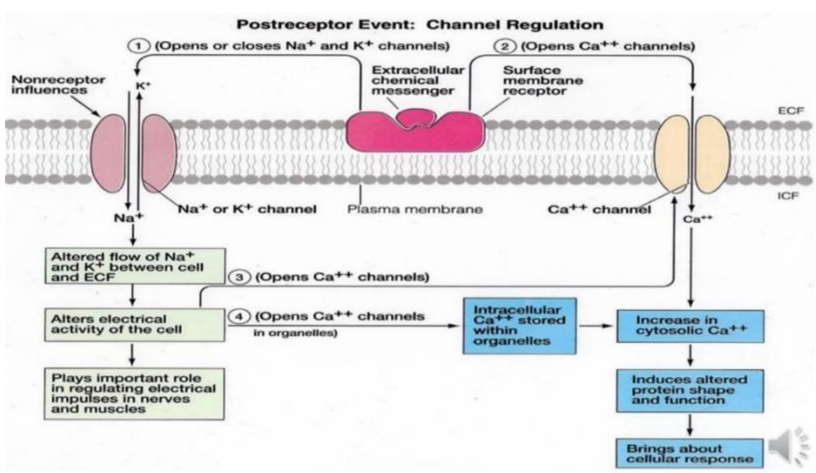
Protein Kinase can phosphorylate many specific targeted particles

So, we can get millions of responses by the activation of one molecule of Adenylyl cyclase
Another type of an enzyme that can be found at the plasma membrane and is activated by specific receptors Is called **PHOSPHOLIPASE-C.** By the activating of this enzyme we can get splitting of a phospholipids (**PIP2** the functional phospholipid) to get **IP3**, which can cause changes inside the cell
(**IP3** can be called as a second Messenger).

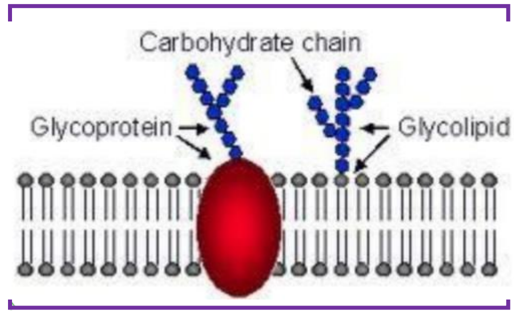


When some receptors bind into specific ligand it causes a specific activation of a channel , by activating this channel we are increasing transport of certain ion-for example-from one side to another side of the cell.

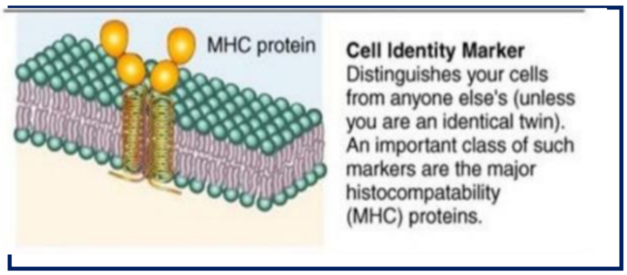
In this case, we are calling them(**ligand gated channels**.)

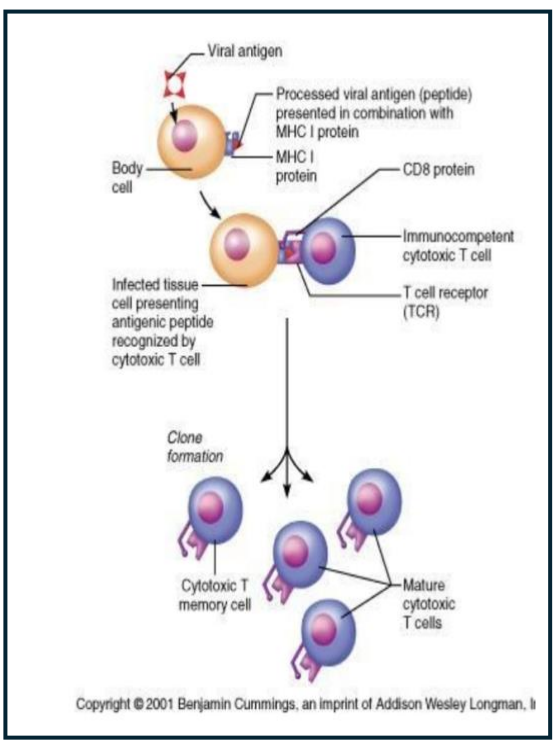


For example:if we activate sodium channels we are getting more transport of sodium ions from outside to inside or if we have activated potassium channels we can get more transport of potassium from inside to outside.



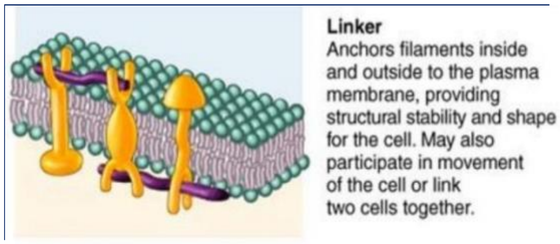
We have **glycoproteins that has Carbohydrate chains** linked to the proteins, these are important for identifying cells (cell identity markers)
For example:antigens
*__Note:each cell in our body has antigens__





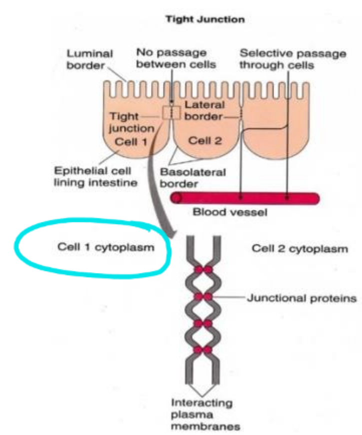
These antigens are important for helping our immune system recognize the self antibodies from the foreign antibodies.
That is important for the immune systems in our bodies.
A quick reminder:
((An antigen is a foreign substance that enters your body. This can include bacteria, viruses, fungi, allergens, venom and other various toxins. An antibody is a protein produced by your immune system. to attack and fight off these antigens.)

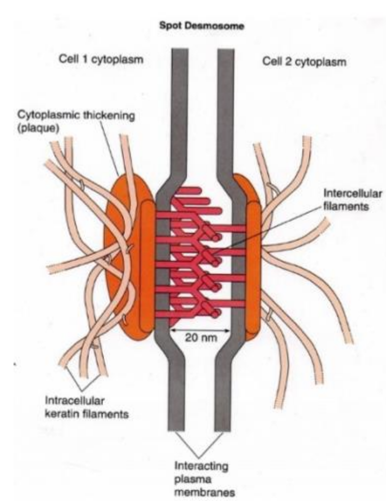
● Some proteins in the outer surface participate with **Carbohydrates** to form adhesion molecules between the Cells in tissue structure known as ***C*ell *A*dhesion *M*olecules** (CAMs). One example of these molecules is cadherin.



In Addition to the cohesion provided by ***CAMs*** and Extracellular matrix, some cells are directly linked by Specialized junctions. Such as desmosomes (adhering Junction), tight junction (impermeable junction), and gap
Junction (communicating junction).

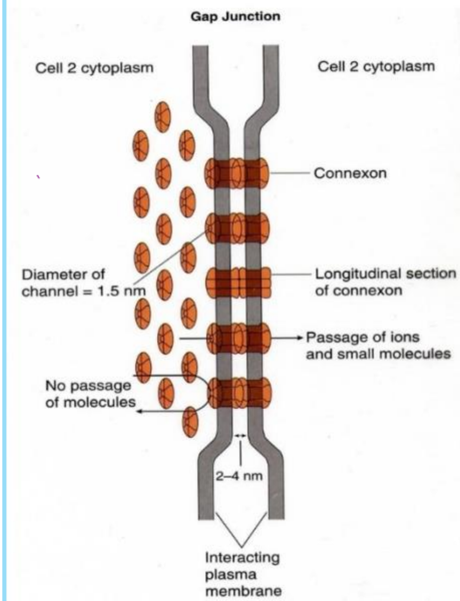
The ***impermeable junction*** (**tight**) is found between epithelial cells, which are joined together to form a sheet, which serve as high selective barrier that separates 2 different compartments. For ex. Epithelial cells that line the digestive tract separate the internal environment from the content of the hollow organs of the digestive system. Cells are held together by tight junctions, which form a tight belt around each cell and prevent passage of any substance between the cells.

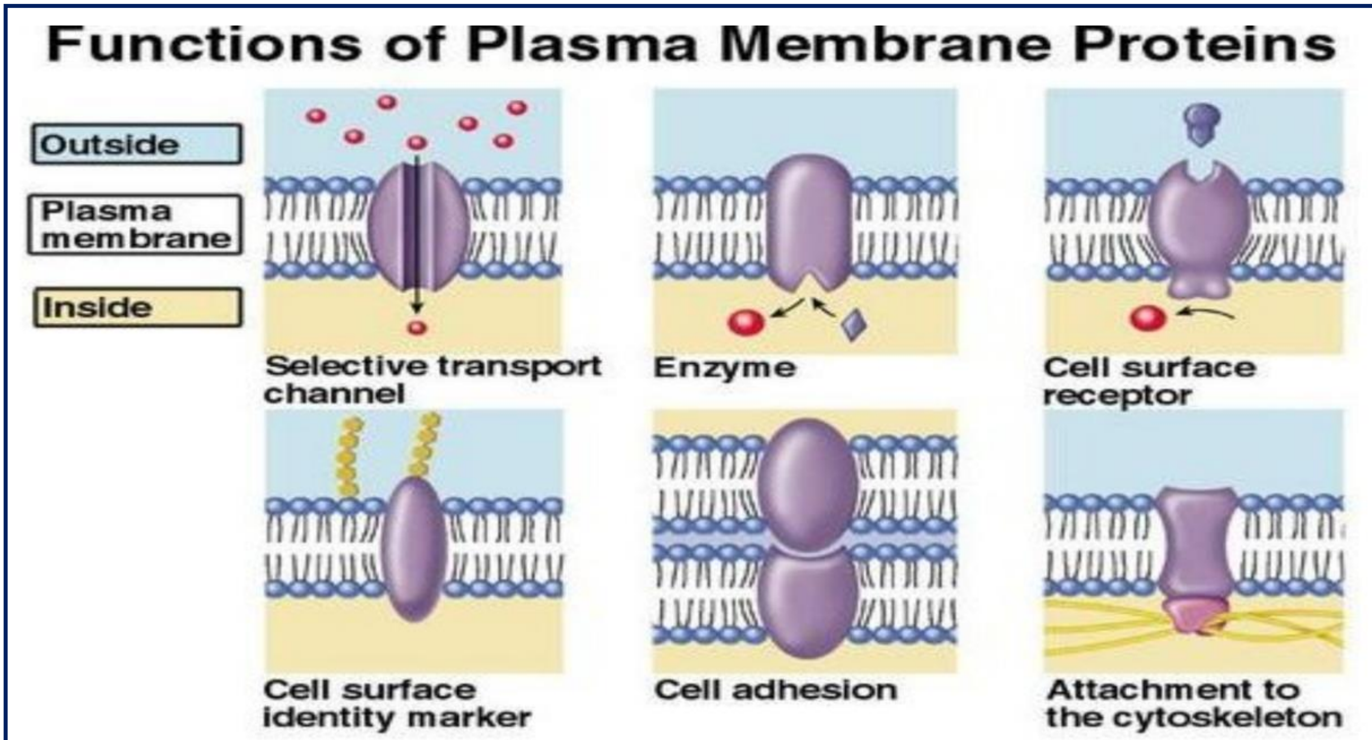




At the ***adhering junction*** (**desmosome**), filaments of unknown composition extend between the plasma membranes of two closely adjacent cells anchoring them together by maintaining a distance of about 20 nm between the two plasma membranes.

The ***communication junctions*** (**gap**) between the cells form small (tunnels) between adjacent cells which enable neighboring cell to communicate with each other. This tunnel is composed of protein known as connexons. These connexons extend outward from the plasma membrane to join other connexon from the adjacent cell. The tunnel permits small water soluble particles to pass between the connected cells. An example of this type of junction is found in the heart and between smooth muscle cells. This form of communication between neighboring cells has an importance in spreading the electrical activity (action potential) to adjacent cells and these cells are forming together a functional syncytium. This sort of communication enables synchronizing heart and smooth muscle activity.





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