

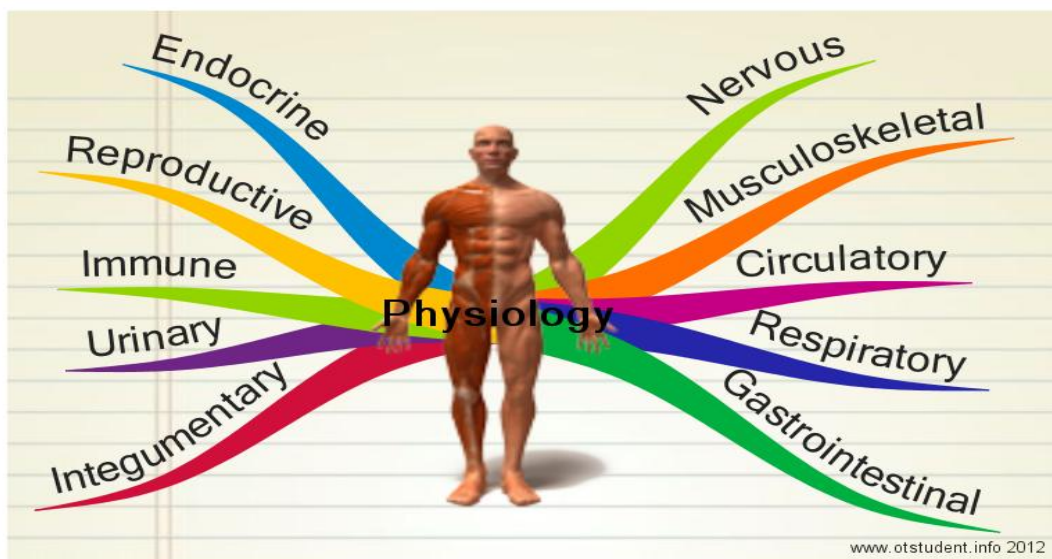
## Physiology

The branch of biology dealing with the functions and activities of living organisms and their parts, including all physical and chemical processes.

Cell physiology is a field of biology which focuses on studying the function of cells, and how cells interact with each other and with the larger organism they inhabit.

## Human physiology

Human physiology seeks to understand the mechanisms that work to keep the human body alive and functioning, through scientific enquiry into the nature of mechanical, physical, and biochemical functions of humans, their organs, and the cells of which they are composed.



## What is a Cell?

A cell is a structure as well as a functional unit of life-Every living thing has cells: bacteria, protozoans, fungi, plants, and animals are the main group of living things. Some organisms are made up of just one cell are called unicellular. (e.g. bacteria and protozoans), but animals, and human beings, are multi-cellular. An adult human body is composed of about 100,000,000,000,000 cells! Each cell has basic requirements to sustain it, and the body's organ systems are largely built around providing the many trillions of cells with those basic needs (such as oxygen, food, and waste removal).

There are about 200 different kinds of specialized cells in the human body. When many identical cells are organized together it is called a tissue (such as muscle tissue, nervous tissue, etc). Various tissues organized together for a common purpose are called organs (e.g. the stomach is an organ, and so is the skin, the brain, and the uterus).

## Cellular environment

Cells are bathed in an extracellular fluid (ECF) that contains ionized sodium ( $\text{Na}^+$ ), potassium ( $\text{K}^+$ ), magnesium ( $\text{Mg}^{2+}$ ), chloride ( $\text{Cl}^-$ ), phosphate ( $\text{Po}_4^{3-}$ ), bicarbonate ( $\text{HCO}_3^-$ ), glucose, and small amounts of protein. It also contains around 2 mmol free calcium ( $\text{Ca}^{2+}$ ).  $\text{Ca}^{2+}$  is essential to life, but many of the biochemical reactions required of cells can only occur if free  $\text{Ca}^{2+}$  concentrations are lowered ten-thousandfold, to around  $10^{-7}$  mol. Thus, cells erect a barrier that is impermeable to ions (the plasma membrane) to separate intracellular fluid ([ICF]) or **cytosol** from ECF and then selectively

modify the composition of ICF to facilitate the biochemical reactions that sustain life. ICF is characterized by low  $\text{Ca}^{2+}$ ,  $\text{Na}^{+}$ , and  $\text{Cl}^{-}$  concentrations compared with ECF, whereas the  $\text{K}^{+}$  concentration is increased. Cells also contain more free protein than does the ECF, and pH of ICF is slightly more acidic.

## **Specialized Cells of the Human Body**

Although there are specialized cells - both in structure and function - within the body, all cells have similarities in their structural organization and metabolic needs

Here are some of the different types of specialized cells within the human body.

- **Nerve Cells**: Also called Neurons, these cells are in the nervous system and function to process and transmit information . They are the core components of the brain, spinal cord and peripheral nerves. They use chemical synapses that can evoke electrical signals, called action potentials, to relay signals throughout the body.
- **Epithelial cells**: Functions of epithelial cells include secretion, absorption, protection, transcellular transport, sensation detection, and selective permeability. Epithelium lines both the outside (skin) and the inside cavities and lumen of bodies.
- **Exocrine cells**: These cells secrete products through ducts, such as mucus, sweat, or digestive enzymes. The products of these cells go directly to the target organ through the ducts. For example, the bile from the gall bladder is carried directly into the duodenum via the bile duct.

- **Endocrine cells**: These cells are similar to exocrine cells, but secrete their products directly into the bloodstream instead of through a duct. Endocrine cells are found throughout the body but are concentrated in hormone-secreting glands such as the pituitary. The products of the endocrine cells go throughout the body in the blood stream but act on specific organs by receptors on the cells of the target organs. For example, the hormone estrogen acts specifically on the uterus and breasts of females because there are estrogen receptors in the cells of these target organs.
- **Blood Cells**: The most common types of blood cells are:
  - **red blood cells (erythrocytes)**. The main function of red blood cells is to collect oxygen in the lungs and deliver it through the blood to the body tissues. Gas exchange is carried out by simple diffusion.
  - various types of **white blood cells (leukocytes)**. They are produced in the bone marrow and help the body to fight infectious disease and foreign objects in the immune system. White cells are found in the circulatory system, lymphatic system, spleen, and other body tissues.

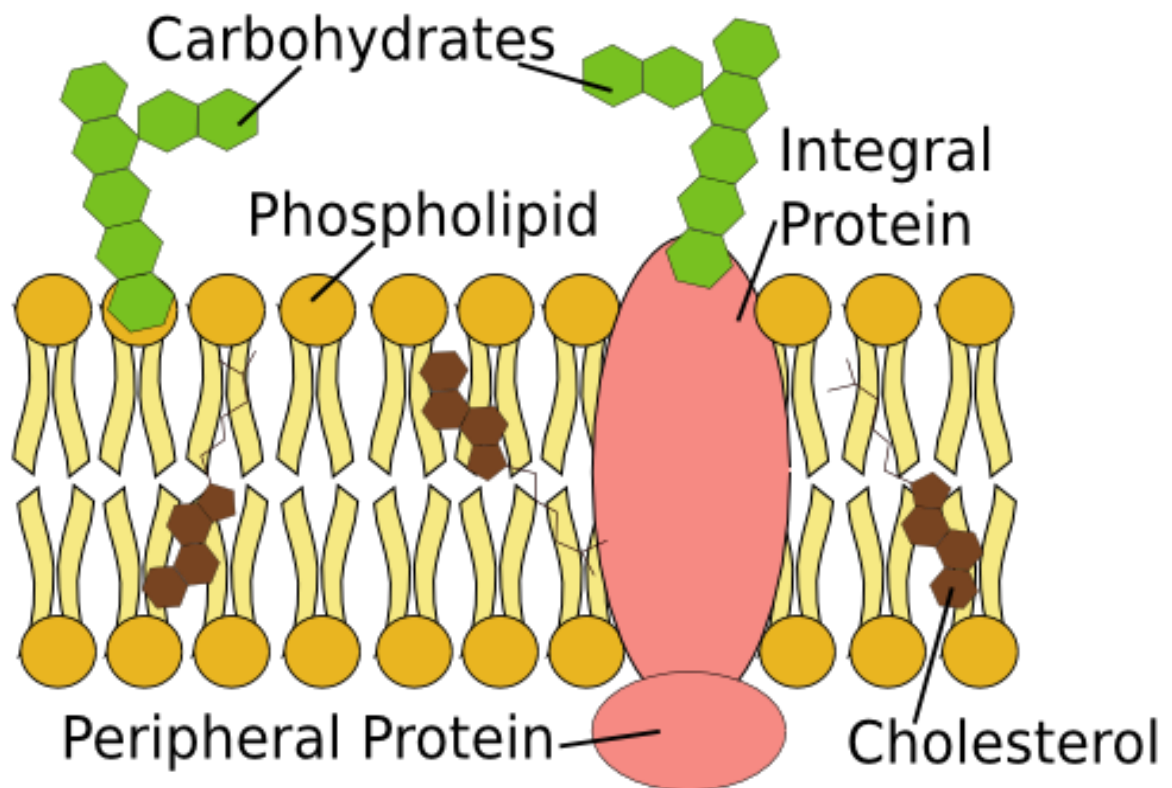
## Cell Membrane

It is a barrier that separates a cell from its surrounding environment. This outer boundary of the cell is also called the plasma membrane. Cell membranes protect and organize cells. All cells have an outer plasma membrane that regulates material enters the cell. The plasma membrane, is a double layer of lipids and proteins that surrounds a cell and separates the cytoplasm (the contents of the cell) from its surrounding environment. It is

selectively permeable, which means that it only lets certain molecules enter and exit. It can also control the amount of some substances that go into or out of the cell.

## Membrane Composition

Membranes comprise lipid and protein. Lipids form the core of all membranes. Lipids are ideally suited to a barrier function because they are **hydrophobic**: They repel water and anything dissolved in it (**hydrophilic** molecules). Proteins allow cells to interact with and communicate with each other, and they provide pathways that allow water and hydrophilic molecules to cross the lipid core.



## A. Lipids

Membranes contain three predominant types of lipids: phospholipids, cholesterol, and glycolipids. All are amphipathic in nature, meaning that they have polar (hydrophilic) region and nonpolar (hydrophobic) region. The polar region is referred to as the **head group**. The hydrophobic region is usually composed of fatty acid "tails" of variable length. When the membrane is assembled, the lipids naturally gather into a continuous bilayer. The polar head groups gather at the internal and external surfaces where the two layers interface with ICF and ECF, respectively. The hydrophobic tail groups dangle down from the head groups to form the fatty membrane core. Although the two halves of the bilayer are closely apposed, there is no significant lipid exchange between the two membrane leaflets.

**1. Phospholipids:** Phospholipids are the most common membrane lipid type. Phospholipids comprise a fatty acid tail coupled via glycerol to a head group that contains phosphate and an attached alcohol. Dominant phospholipids include phosphatidylserine, phosphatidylethanolamine, phosphatidylcholine, phosphatidylinositol, and phosphatidylglycerol. Sphingomyelin is a related phospholipid in which glycerol has been replaced by sphingosine. The alcohol group in sphingomyelin is choline.

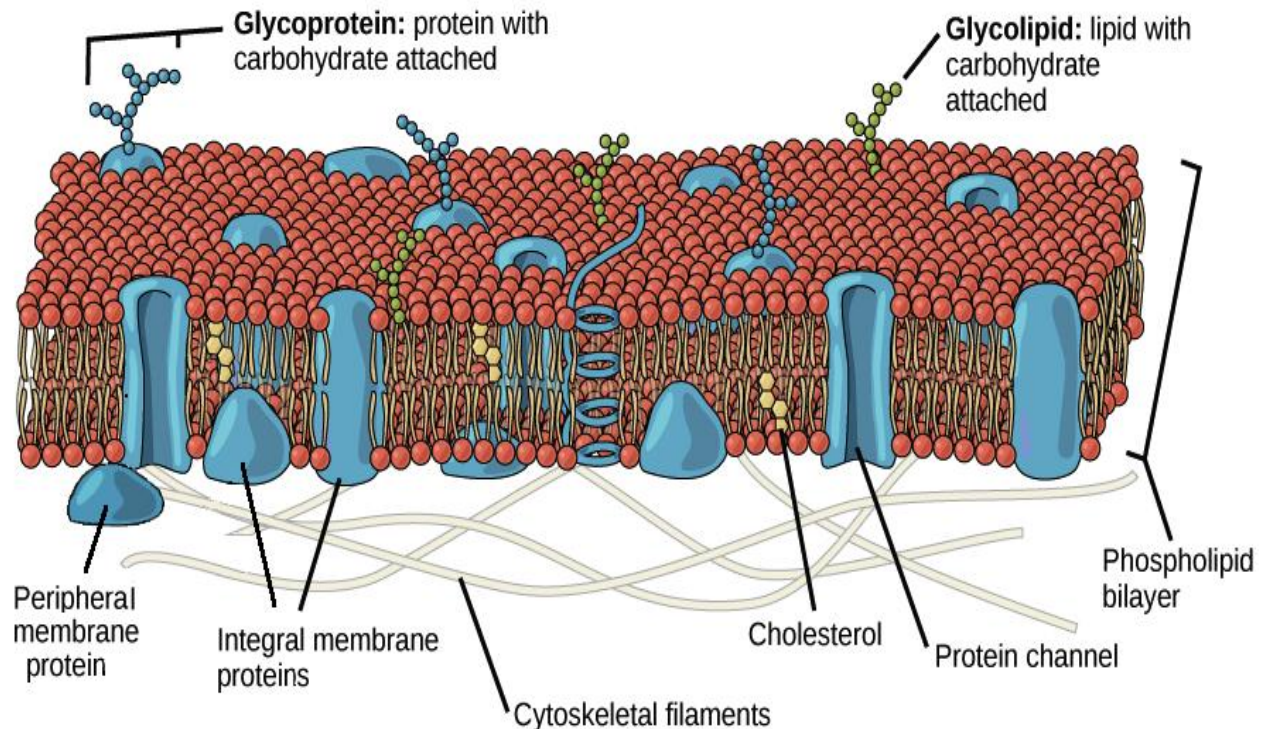
**2. Cholesterol:** Cholesterol is the second most common membrane lipid. It is hydrophobic but contains a polar hydroxyl group that draws it to the bilayer's outer surface, where it nestles between adjacent phospholipids. Between the hydroxyl group and the hydrocarbon tail is a steroid nucleus.

The four steroid carbon ring make it relatively inflexible, so adding cholesterol to a membrane reduces its fluidity and makes it stronger and more rigid.

**3. Glycolipids:** The outer leaflet of the bilayer contains glycolipids, a minor but physiologically significant lipid type comprising a fatty acid tail coupled via sphingosine to a carbohydrate head group. The glycolipids create a carbohydrate coat that is involved in cell-to-cell interaction and that conveys antigenicity.

It is important to mention that **carbohydrates** is present in cell membrane composition. Carbohydrates, or sugars, are sometimes found attached to proteins or lipids on the outside of a cell membrane. That is, they are only found on the extracellular side of a cell membrane. Together, these carbohydrates form the glycocalyx.

The **glycocalyx** of a cell has many functions. It provides cushioning and protection for the plasma membrane, and it is also important in cell recognition. Based on the structure and types of carbohydrates in the glycocalyx, your body can recognize cells and determine if they should be there or not. The glycocalyx can also act as a glue to attach cells together.



## B. Proteins

The membrane's lipid core seals the cell in an envelope across which only lipid-soluble materials, such as  $O_2$ ,  $CO_2$ , and alcohol can cross. Cells exist in an aqueous world, however, and most of the molecules that they need to thrive are hydrophilic and cannot penetrate the lipid core. Thus, the surface (**plasma**) membrane also contains **proteins** whose function is to help ions and other charged molecules across the lipid barrier. Membrane proteins also allow for intercellular communication and provide cells with sensory information about the external environment. Proteins are grouped on the basis whether they localize to the membrane surface (**peripheral**) or are integral to the lipid bilayer.



**1. Peripheral:** Peripheral proteins are found on the membrane surface. Their link to the membrane is relatively weak and, thus, they can easily be washed free using simple salt solutions. Peripheral proteins associate with both the intracellular and extracellular plasma membrane surfaces.

**a. Intracellular:** Proteins that localize to the intracellular surface include many enzymes; regulatory subunits of ion channels, receptors, and transporters; and proteins involved in vesicle trafficking and membrane fusion as well as proteins that tether (join) the membrane to a dense network of fibrils lying just beneath its inner surface. The network is composed of spectrin, actin, ankyrin, and several other molecules that link together to form a subcortical cytoskeleton.

**b. Extracellular:** Proteins located on the extracellular surface include enzymes, antigen, and adhesion molecules. Many peripheral proteins are attached to the membrane via **glycophosphatidylinositol** ([GPI] a glycosylated phospholipid) and are known collectively as **GPI-anchored proteins**.

**2. Integral:** Integral membrane proteins penetrate (go in) the lipid core. They are anchored by covalent bonds to surrounding structures and can only be removed by experimentally treating the membrane with a detergent. Some integral proteins may remain localized to one or the other of the two membrane leaflets without actually traversing its width. Others may weave across the membrane many times (**transmembrane proteins**). Examples include various of ion channels, transporters, and receptors.

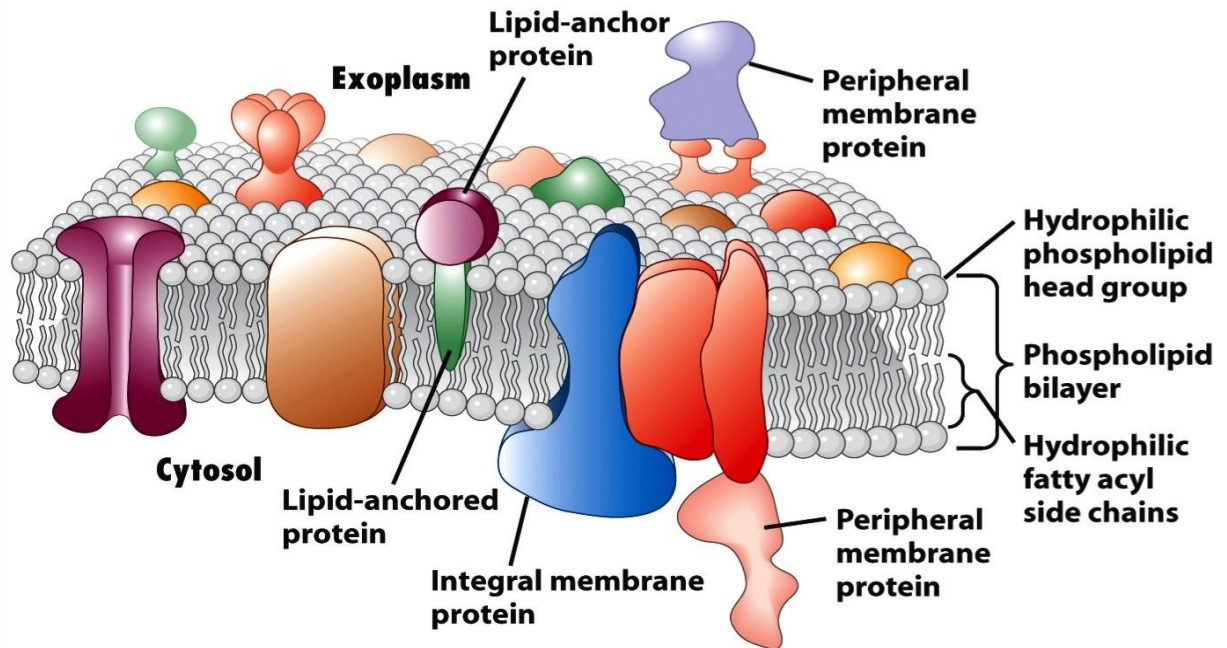


Figure 10-1  
*Molecular Cell Biology, Sixth Edition*  
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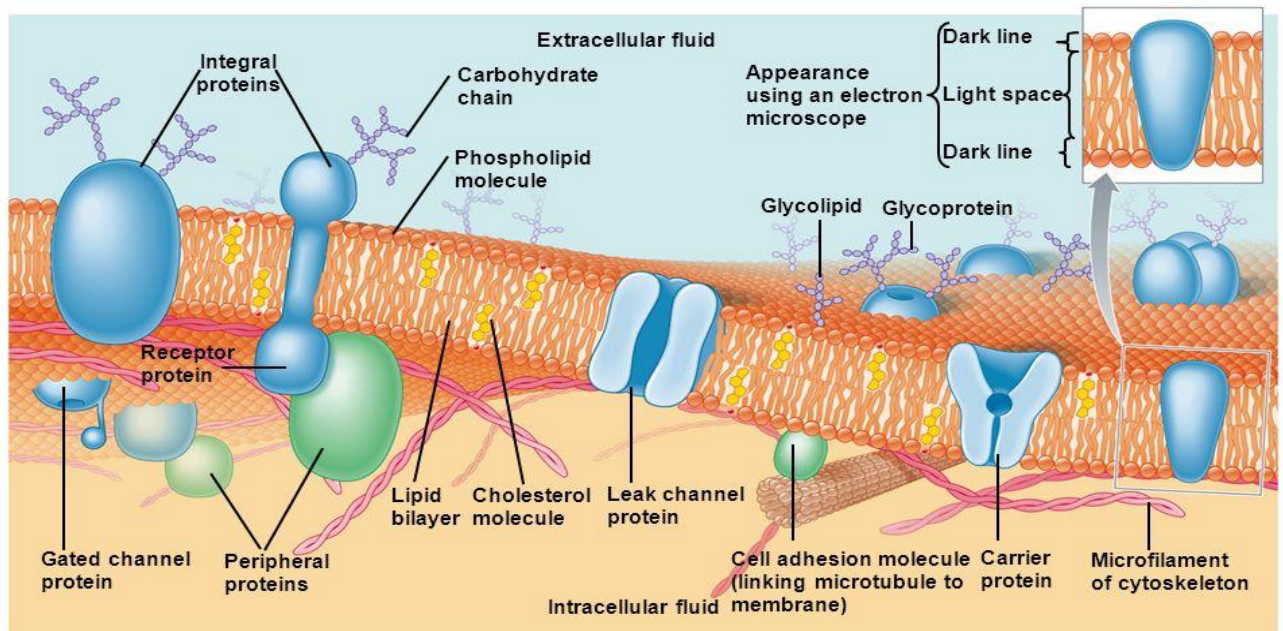


Figure 3-3 p72

# Cell Membrane Functions

## 1. Mechanical Structure (physical barrier)

A cell membrane encloses and defines the cell. There are different ways to express this, e.g.

### (a). Defines/encloses the cell

-The cell membrane **maintains the physical integrity of the cell**. The cell membrane holds the cell together **by enclosing the cytoplasm and organelles** within it.

-The cell membrane **forms a barrier between the inside of the cell and the environment outside the cell** - enclosing cytoplasm and any organelles within the cell, and enabling different chemical environments to exist on each side of the cell membrane.

- The cell membrane **physically separates the intracellular components** (e.g. organelles) **from the extracellular environment**.

### (b). Re. Cytoskeleton

In many cases the cell membrane also helps to hold the [cytoskeleton](#) (which is within the cell) in place. This is achieved by some proteins in the cell membrane attaching to some cytoskeletal fibres and helps to define and maintain the shape of the cell.

### **(c). Extracellular Matrix**

In many cases the cell membrane interacts with the cell membrane of adjacent cells.

### **(d). Protection**

The cell membrane protects the cell from some harmful chemicals in its external environment.

It also protects the cell from loss of useful biological macromolecules held within the cell by its plasma membrane.

## **2. Selective permeability**

The cell membranes that enclose cells are **selectively permeable**. That is, the structure of these membranes is such that they allow certain particles, such as certain molecules, - but not others - to pass through the membrane, hence into or out of the cell.

*(This cell membrane function is one of several functions that facilitate the transport of materials needed for survival of the cell, others include "active transport", "exocytosis" and "endocytosis".)*

## **3. Active Transport**

Cell membranes can allow active transport of specific molecules across the cell membrane in either direction, i.e. either into or out of the cell.

That is - cell membranes **can allow some particular molecules to move against a concentration gradient e.g. from a lower concentration outside the cell to a higher concentration inside the cell, or vice-versa.** Active transport (movement against the concentration gradient) requires, that is it uses, energy.

#### **4. Bulk Transport: Exocytosis and Endocytosis**

**-Exocytosis:** Is the process by which a cell moves the contents of secretory vesicles out of the cell via the cell membrane.

**-Endocytosis:** Is the opposite process by which the contents of secretory vesicles are moved into the cell via the cell membrane.

#### **5. Markers & Signalling (for communication with other cells & the external environment)**

Proteins called **surface protein markers** embedded in the cell membrane identify the cell, enabling nearby cells to communicate with each other.

Cell membranes often include receptor sites for interaction with specific biochemicals such as certain hormones, neurotransmitters and immune proteins. In this way the cell can recognize and process some signals received from the extracellular environment.

## 6. Metabolic Activities

Plasma membranes include as part of their structures certain proteins and enzymes that are involved in some of the metabolic processes of the cell.

It can be concluded that cell membrane has some main roles:

- It is a physical barrier.

- It regulates exchange of materials with its surroundings.

The cell membrane is important because it separates and protects a cell from its surroundings. This allows the intracellular conditions of a cell to be very different from the extracellular conditions. For example, nerve cells in your body will maintain a high concentration of potassium inside. Outside, in the extracellular fluid, there is very little potassium and lots of sodium. These concentration differences are absolutely necessary for the function of nerve cells, which is to send signals or nerve impulses.