Cell Membrane Structure & Function

Learning Objectives:

- ❖ Describe the chemical composition of the plasma membrane and relate it to membrane functions.
- ❖ Describe the fluid mosaic model.
- ❖ List the factors affecting fluidity and protein mosaic within the membrane.
- ❖ Define the term phospholipid bilayer and explain how it is formed.
- ❖ List the functions of membrane proteins.
- ❖ Define the term "Glycocalyx" and explain its function.
- ❖ List the functions of the cell membrane.

Cell Membrane – *Structure:*

- The flexible **plasma membrane defines the extent of a cell,** thereby separating two of the body's major fluid compartments; the *intracellular fluid within cells and the extracellular fluid (ECF);* outside cells.

- The "**Fluid Mosaic Model**" of membrane structure was proposed in 1972 by Singer & Nicholson, to show how the protein component of cell membranes relates to the phospholipid bilayer. It has two key features:

  - **Fluid nature** is suggested by the fact that some of the ***proteins*** move around within the membrane, as if they were "***floating in a sea of fluid phospholipids***".

  - **Mosaic** is suggested by the fact ***that proteins are discontinuously embedded in the phospholipid bilayer***, like a mosaic embedded in cement.

Cell Membrane – *Structure - Fluid Mosaic Model :*

❖ **Factors Affecting Fluidity:**

➢ **Temperature:** On a cold day your fingers and toes go numb because the cell membranes cannot conduct nerve impulses, because they have lost their fluidity.

➢ **Proportion of saturated vs unsaturated triglycerides**, and ***cholesterol***. Organisms with low body temperatures have more unsaturated triglycerides and less cholesterol, to prevent their cell membranes from freezing. Conversely, if homeotherms had too many unsaturated fats in membranes, they would be too fluid and become leaky.

Cell Membrane – *Structure - Fluid Mosaic Model :*

❖ **Factors affecting the protein mosaic within the membrane:**

- Some of the proteins ***have hydrophobic R groups*** on their component amino acids, and these ***become embedded in the hydrophobic part*** of the lipid bilayer.

- Many of the proteins are ***"glycoproteins"***, meaning that they have a sugar chain attached to them, which is always on the ***outside of the cell membrane.***

- Many ***proteins move laterally*** (parallel to the membrane) through the lipid bilayer.

- ***Transverse movement*** (perpendicular to the membrane) ***is harder*** because it involves breaking hydrophobic and hydrophilic interactions. This is called "***flip-floopping"*** of proteins, and happens during membrane biogenesis, but it is very slow.

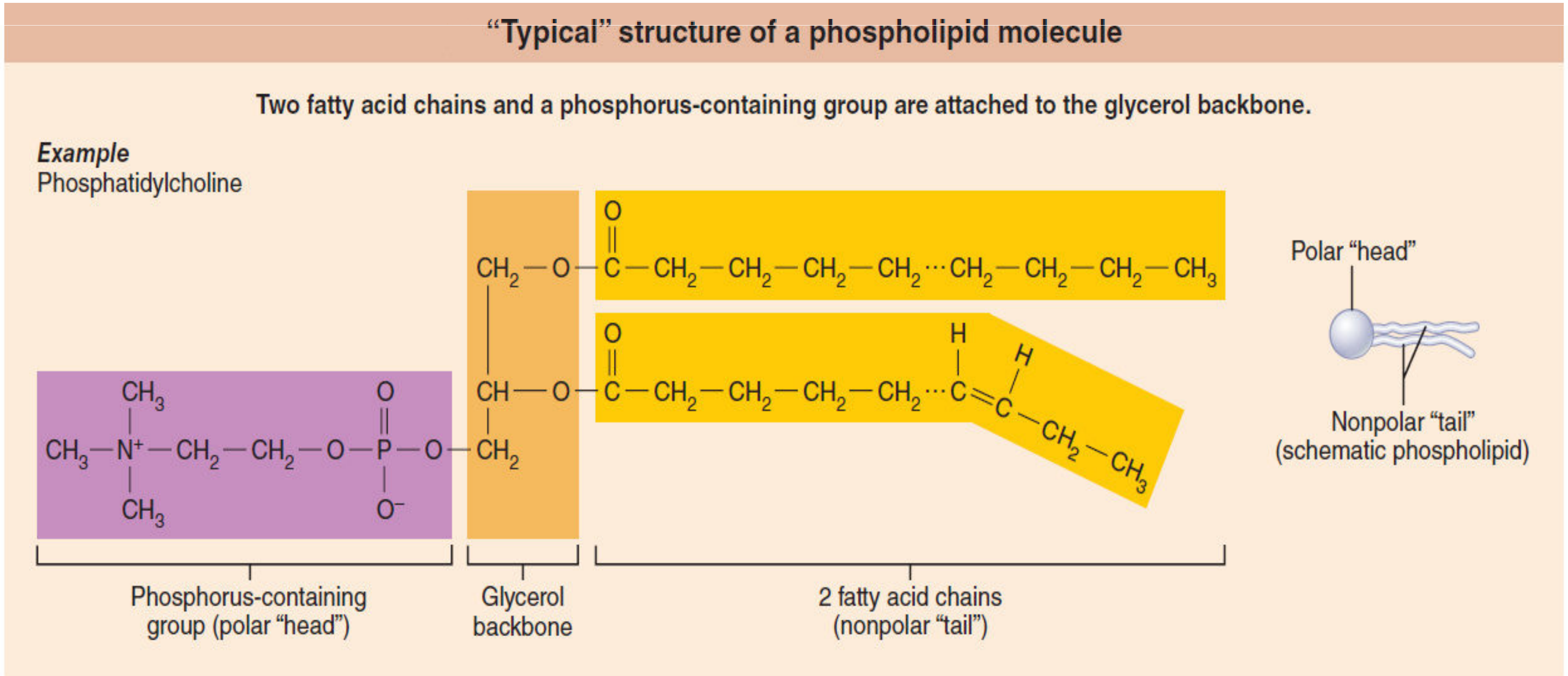
- During ***biogenesis of membrane*** , proteins are being gradually inserted into the membrane, and there is considerable membrane asymmetry.

- ***Some proteins do not move at all through the membrane***, because they form ***"anchors"*** to attach the cell membrane to the underlying cytoskeleton.

Cell Membrane – *Structure:*

- **Membrane Lipids**: ***The lipid bilayer*** forms the basic "fabric" of the membrane. It is constructed largely of ***phospholipids****, with smaller amounts of* ***glycolipids****,* ***cholesterol****, and areas called* ***lipid rafts*** *(protein receptors organized in glycolipoprotein microdomains).*

- ***Phospholipids:*** Each lollipop-shaped phospholipid molecule has a **polar "head"** that is charged and is hydrophilic, and an uncharged, **nonpolar "tail"** that is made of two fatty acid chains and is hydrophobic.



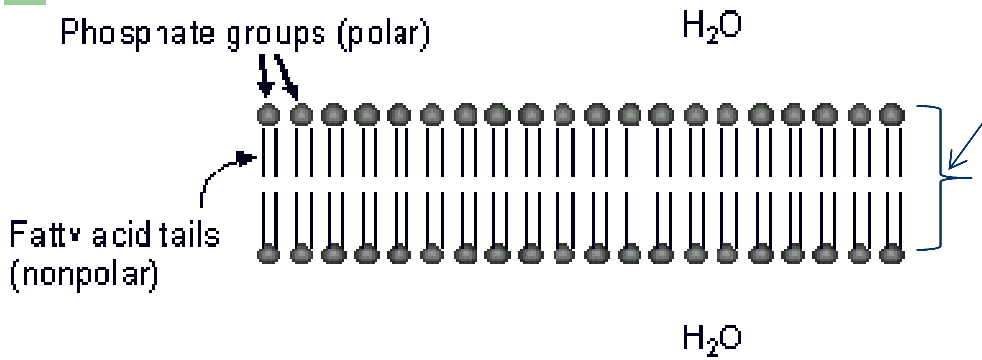
Cell Membrane – *Structure - Phospholipid Bilayer:*

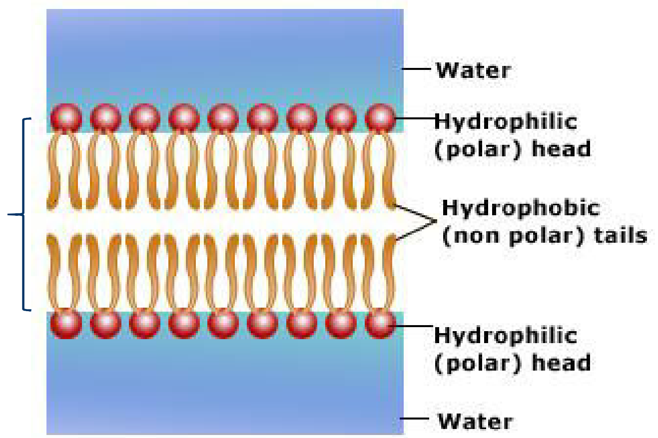
- ***The polar heads are attracted to water***, the main constituent of both the intracellular and extracellular fluids, and so they lie on both the inner and outer surfaces of the membrane.

- ***The nonpolar tails, being hydrophobic, avoid water*** and line up in the center of the membrane. The result is that all plasma membranes, indeed all biological membranes, share ***a sandwich-like structure:***

  - They are composed of ***two parallel sheets of phospholipid molecules lying tail to tail, with their polar heads exposed to water on either side of the membrane or organelle.***
  - This self-orienting property of phospholipids encourages biological membranes to ***self assemble into closed, generally spherical, structures and to reseal themselves when torn***.

Phospholipid Bilayer

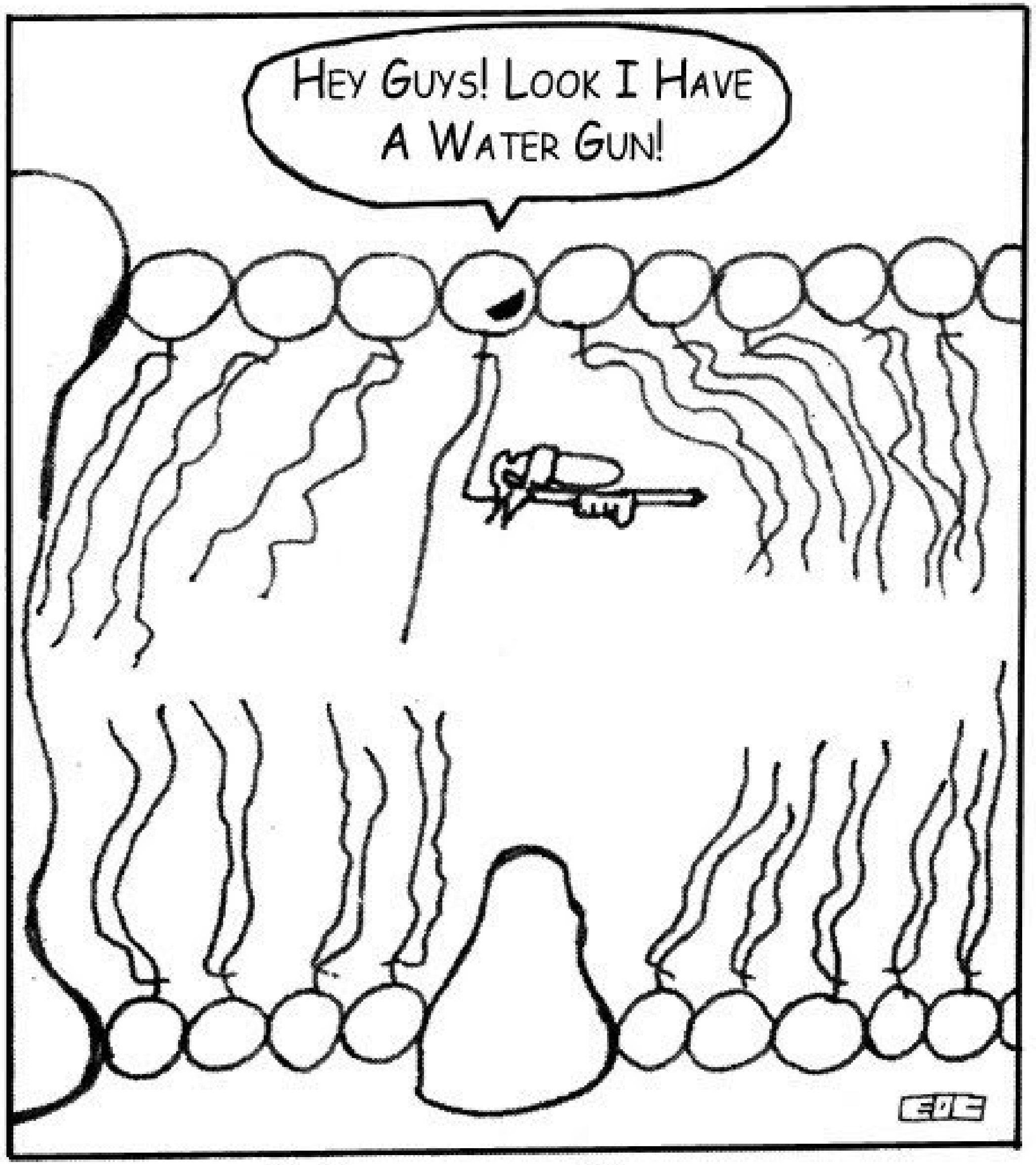




Phospholipid Bilayer:

Heads love water

Tails are scared from water



MEMBRANE PRANKS

Cell Membrane – *Structure:*

- ***Glycolipids***: are lipids with attached sugar groups. *Found only on the outer plasma membrane surface*, glycolipids account for about **5%** of total membrane lipids. Their sugar groups, like the phosphate-containing groups of phospholipids, make that end of the glycolipid molecule polar, whereas the fatty acid tails are nonpolar.

- ***Cholesterol :*** Some **20%** of membrane lipid is cholesterol. Like phospholipids, cholesterol has a polar region (its hydroxyl group) and a nonpolar region (its fused ring system). It wedges its plate like hydrocarbon rings between the phospholipid tails, stabilizing the membrane, while decreasing the mobility of the phospholipids and the fluidity of the membrane.

- **Membrane Proteins:** A cell's plasma membrane bristles with proteins that allow it to communicate with its environment. Proteins make up about ***half of the plasma membrane by mass***. Some membrane proteins float freely. Others are "tethered" to intracellular structures *(cytoskeleton)*.There are two distinct populations of membrane proteins, ***integral*** and ***peripheral:***

Cell Membrane – *Structure:*

- ***Integral Proteins***: are firmly inserted into the lipid bilayer. Some protrude from one membrane face only, but most are ***transmembrane proteins that span the entire membrane and protrude on both sides***. ***All integral proteins have both hydrophobic and hydrophilic regions*** and can interact with both the lipid head & tail. Some of these proteins act as ***channels, carriers, or receptors.***

- ***Peripheral Proteins:*** Unlike integral proteins, peripheral proteins are not embedded in the lipid bilayer. Instead, they attach loosely to integral proteins and are easily removed without disrupting the membrane. Peripheral proteins include a ***network of filaments that helps support the membrane from its cytoplasmic side***. Some of these proteins are ***enzymes, motor proteins*** (changes shape during mitosis and muscle contraction), and others act to ***link cells together.***

Cell Membrane – *Structure* – *Functions of Membrane Proteins:*

- **Communication:** Receptor are proteins acting in one or more of these ways:

  - Lock & Key interaction between external stimulus and receptor.
  - Glycoproteins may recognize vibratory input, like antennae.
  - Glycoproteins are involved in cell-cell interactions, such as ***cell adhesion***.

- **Transport proteins** can move substances across an otherwise impermeable membrane. Transport proteins are of tow types:

  - They may facilitate the flow of ions or molecules down a concentration gradient, so they just form channels which can be opened or closed.
  - They may actively carry materials cross membranes, using energy to do so, so they may need to have enzyme function.

- **Enzymes:** are often membrane bound, particularly within organelles, e.g*. Krebs cycle enzymes are bound on to mitochondrial membranes*. This enables the steps of a biochemical pathway to take place in the right order.

- **Anchor proteins** are bound on to cytoskeletal elements.

Cell Membrane – ***Structure - Glycoproteins Structure :***

- These consist of proteins which are glycoslated with a sugar chain.

- The sugar chain is a branched oligosaccharide made from about ***14-15 sugar subunits.***

- The sugar subunits are mainly unusual monosaccharides, either simple as mannose, galactose and fructose, or N-acetylated like acetyl glucosamine, N-acetyl neuraminic acid.

- Glycoproteins always have the sugar chain projecting on the outside of the cell.

- The collective structure formed by glycoproteins all over the outside of the cell, is called the ***glycocalyx***, and it may ***act like velcro in cell adhesion***.

Cell Membrane – *Structure - Glycoproteins Structure :*

- **The Glycocalyx:** The term **glycocalyx** describes the fuzzy, sticky, carbohydrate-rich area at the cell surface. ***We can think of cells as sugar-coated***. The glycocalyx on each cell's surface is enriched both by glycolipids and by glycoproteins secreted by the cell.

- Because every cell type has a different pattern of sugars in its glycocalyx, ***the glycocalyx provides highly specific biological markers by which approaching cells recognize each other***, e.g. a sperm recognizes an ovum (egg cell) by the ovum's unique glycocalyx. Cells of the immune system identify a bacterium by binding to certain membrane glycoproteins in the bacterial glycocalyx.

- Glycosylation initially takes place within the ***rough endoplasmic reticulum***. The incomplete glycoprotein then goes to ***the Golgi apparatus***, where the oligosaccharide is trimmed down and more complex sugars added, all this taking place on the inside of the Golgi saccules.

- Glycoproteins are then packed into vesicles which have the sugar chain projecting onto the inside of the vesicle membrane. The vesicles go to the plasma membrane where they turn inside out as the become incorporated into the membrane, ad the sugar chains end up projecting onto the outside of the plasma membrane.

Functions of The Cell Membrane:

- Define and compartmentalize the cell.

- Forms the cell boundary, for communication with the outside world. Receptors are embedded in the cell membrane for receiving informational input.

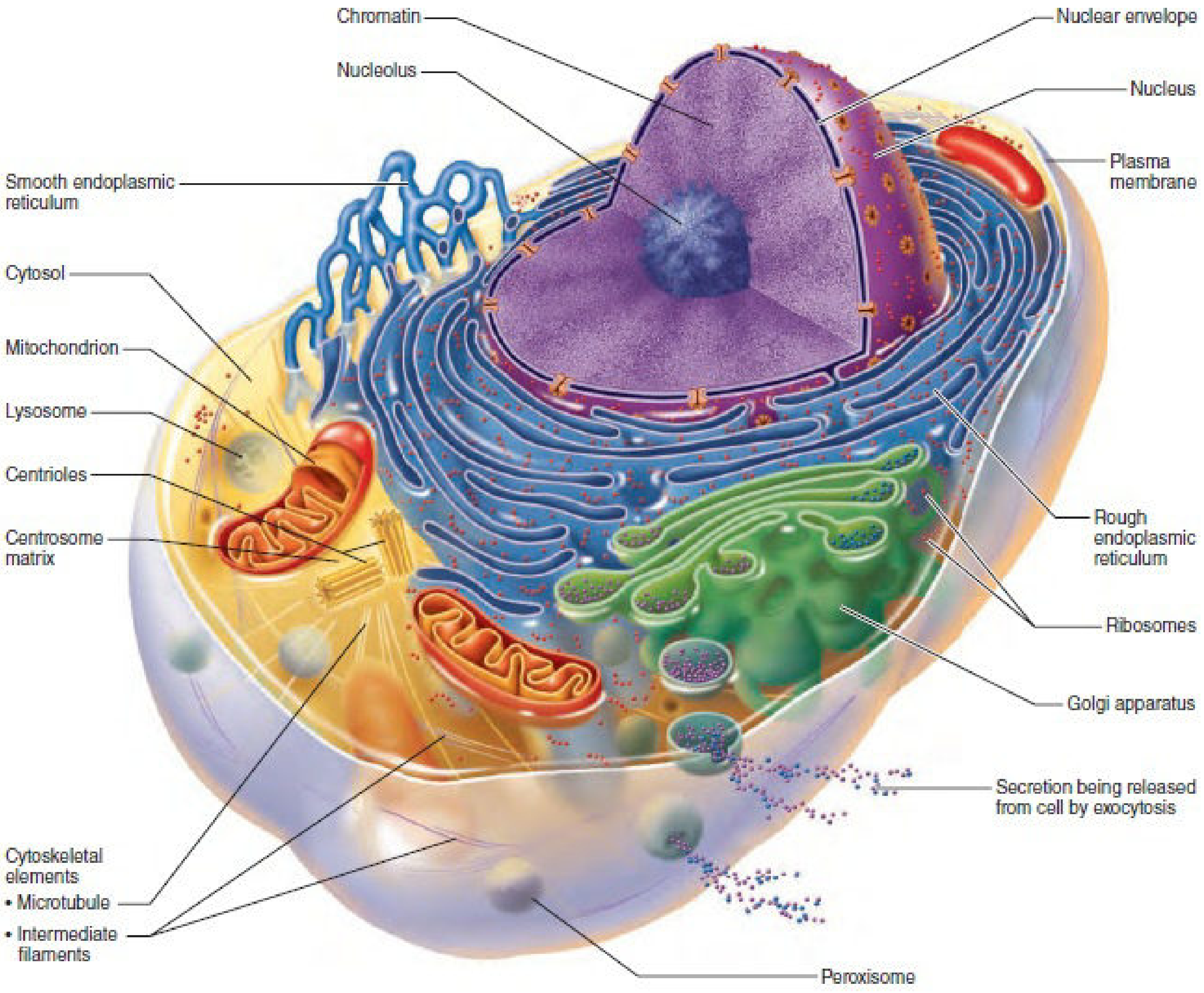
- Forms a "***locus of function***" for many membrane-bound biochemical processes.

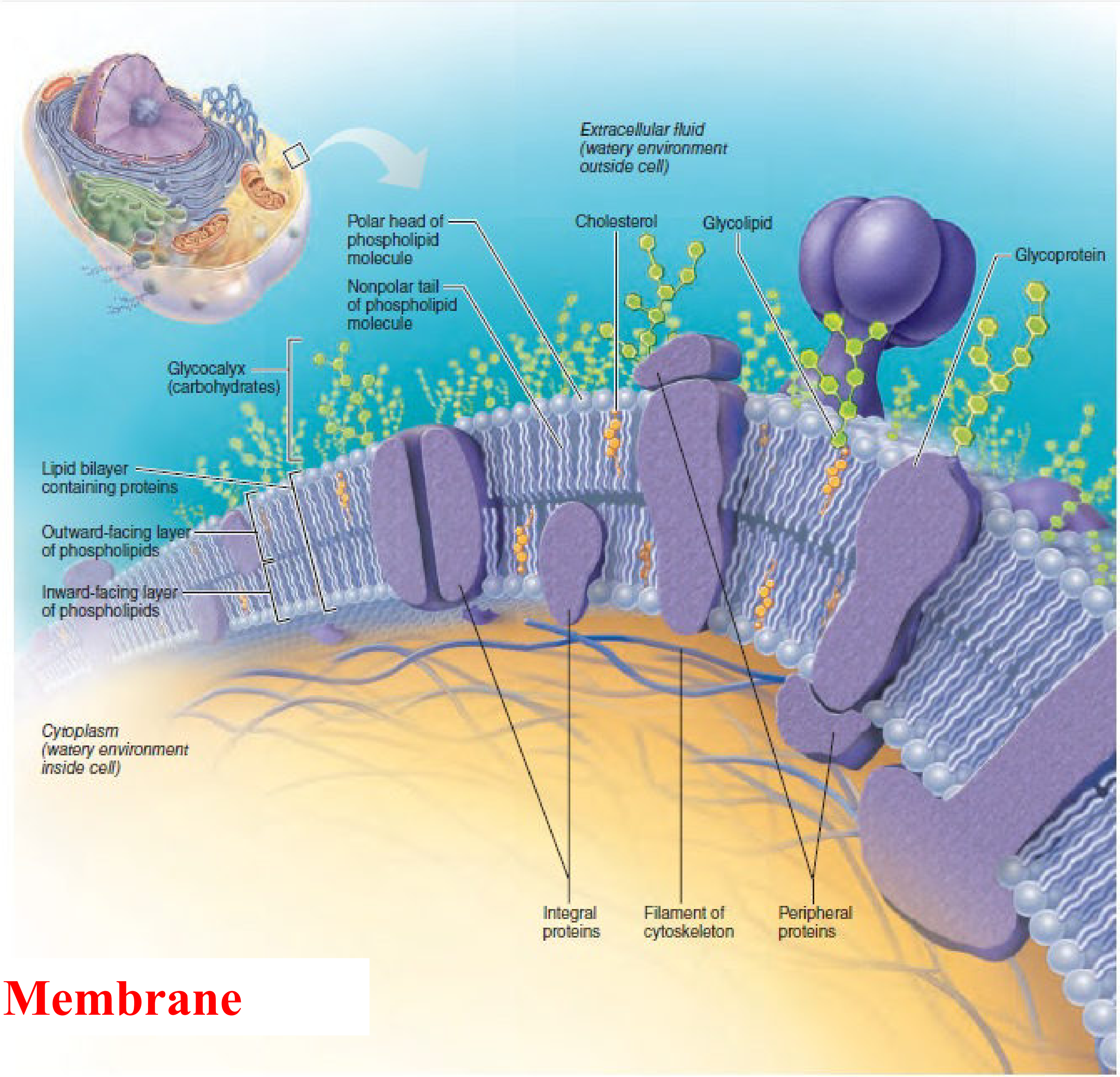
- Regulation of transport of molecules into and out of the cell. Membranes are differentially permeable to different molecules, allowing some to cross the membrane easily, promoting the crossing of others actively, while completely excluding others:

  - Transport functions include all of the following:

    - ✓ Nutrient intake
    - ✓ Respiratory gas exchange
    - ✓ Removal of wastes
    - ✓ Regulation of ionic composition inside & outside the cell.

Structure of The Cell





The Plasma Membrane