Cell membrane structures 1

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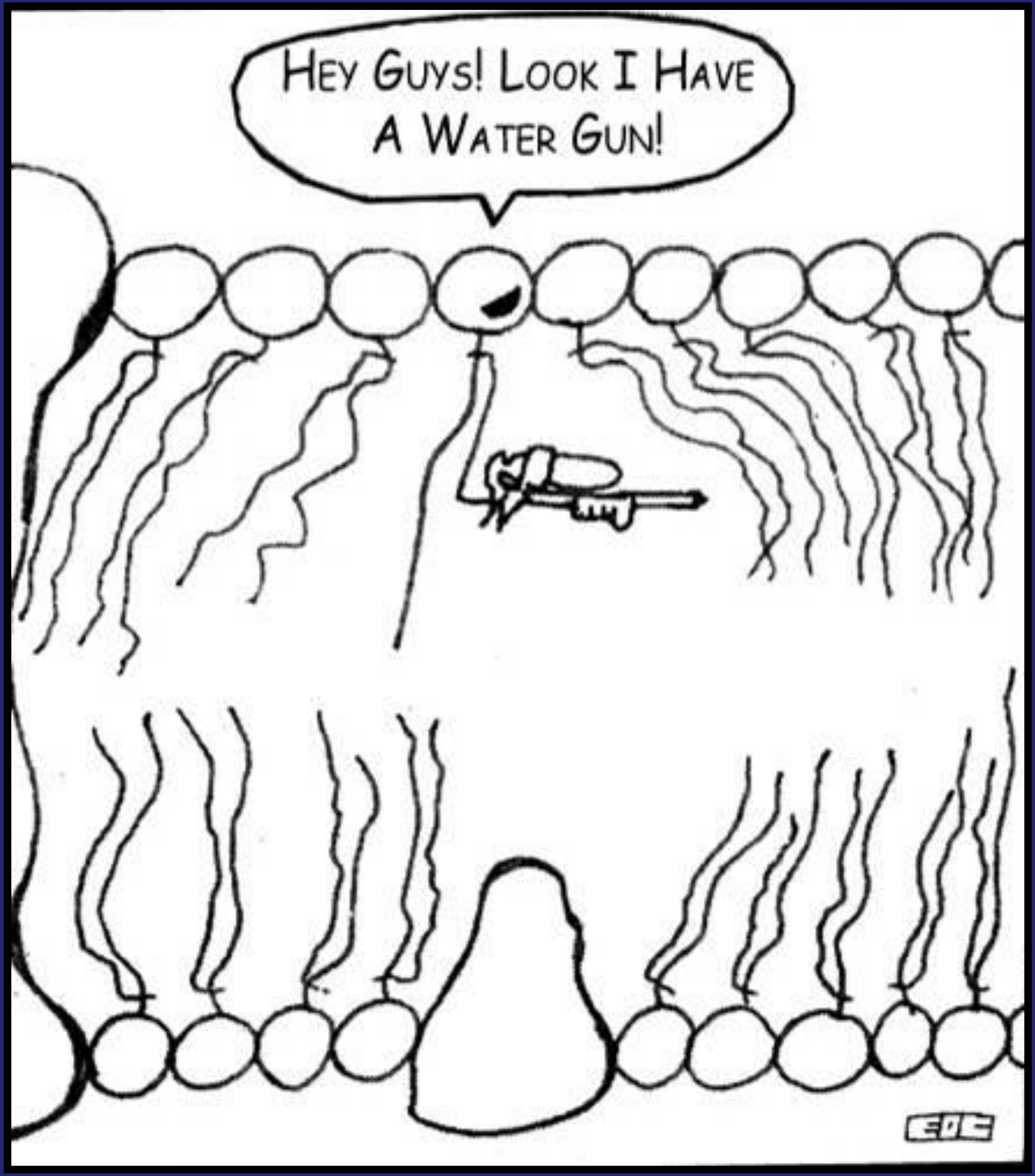
HEY GUYS! LOOK I HAVE A WATER GUN!
EOC

Schedule

1. The Plasma Membrane, the Lipid Bilayer

- *Chemical structure of cell membranes*
- *Membrane proteins*

2. Principles of Membrane Transport

- *Transporters, passive and active membrane transport*
- *Ion channels and the electrical properties of membranes*

Schedule of the present lecture

1. The Plasma Membrane, the Lipid Bilayer

- ❖ *Chemical structure of cell membranes*
- ❖ *Membrane proteins*

2. Principles of Membrane Transport

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- ❖ *Ion channels and the electrical properties of membranes*

1. Plasma Membrane, Lipid Bilayer

Chemical Structure of Cell Membranes

Cell membranes are crucial to the life of the cell

The plasma membrane

- encloses the cell
- defines its boundaries
- maintains the essential differences between cytosol and extracellular environment
- Encloses organelles inside eukaryotic cells:

  endoplasmic reticulum, Golgi apparatus, mitochondria …

Cell structures with the membrane

- *Cytoplasmic membrane*
- *Nucleus membrane*
- *Membrane of endoplasmatic reticulum*
- *Membrane of Golgiho complex*
- *Mitochondrion*
- *Chloroplast, chromoplasts, and leukoplasts*
- *Lysozomes and spherosomes*
- *Peroxisomes and glyoxisomes*
- *Vacuoles*

The role of the cell membranes

- in ATP (adenosin triphosphate) synthesis
- in the transmembrane transport

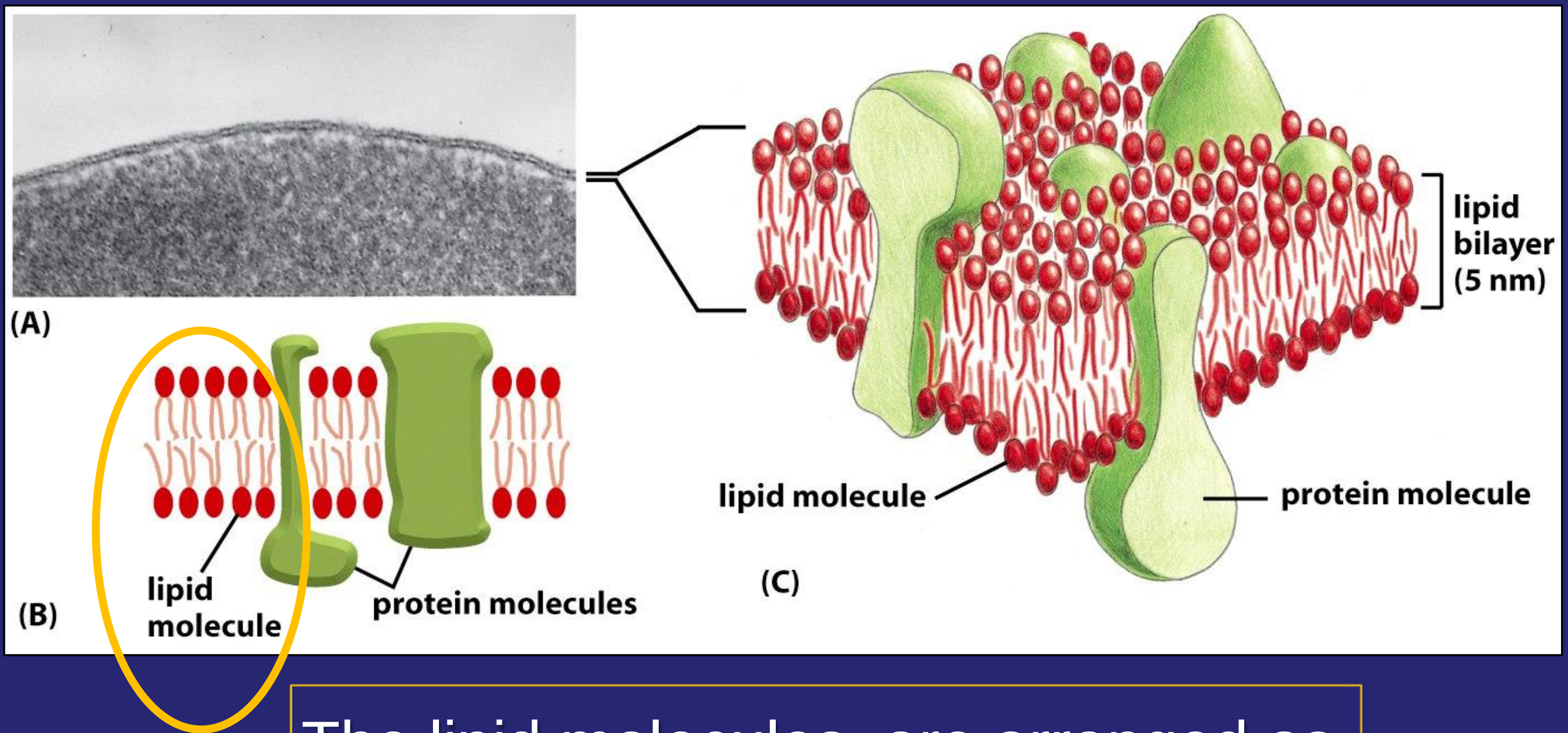
  of small molecules
- in cell signalling and cell adhesion
- protein traffic in cell compartments

Despite of their different functions, all biological membranes have a <u>common general structure</u>

<u>The plasma membrane</u> is

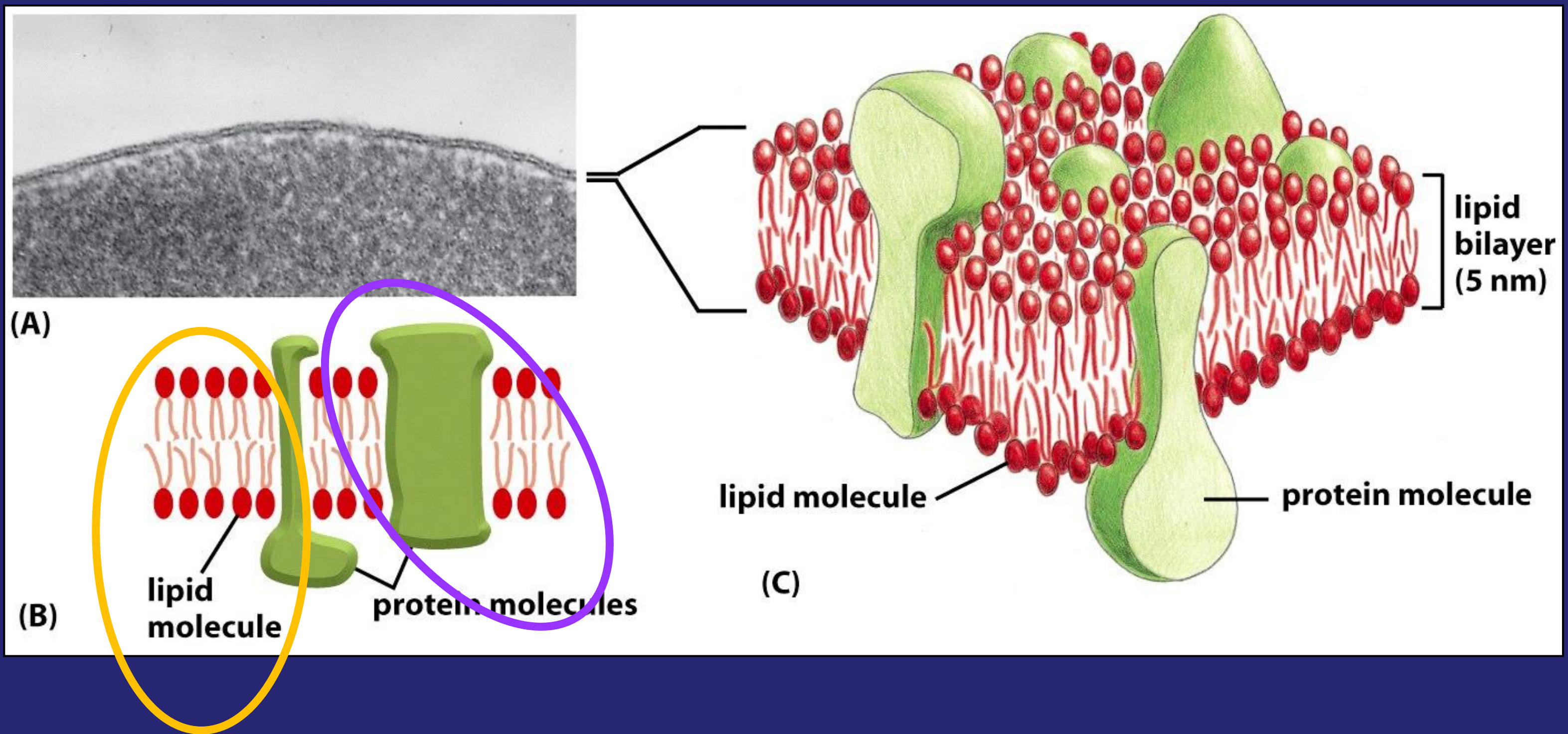
- ❖ very thin film of lipid (fatty) and protein molecules
- ❖ these molecules are hold together by noncovalent interactions

Cell membranes are dynamic, fluid structures. Most of their molecules move about in the plane of the membrane.



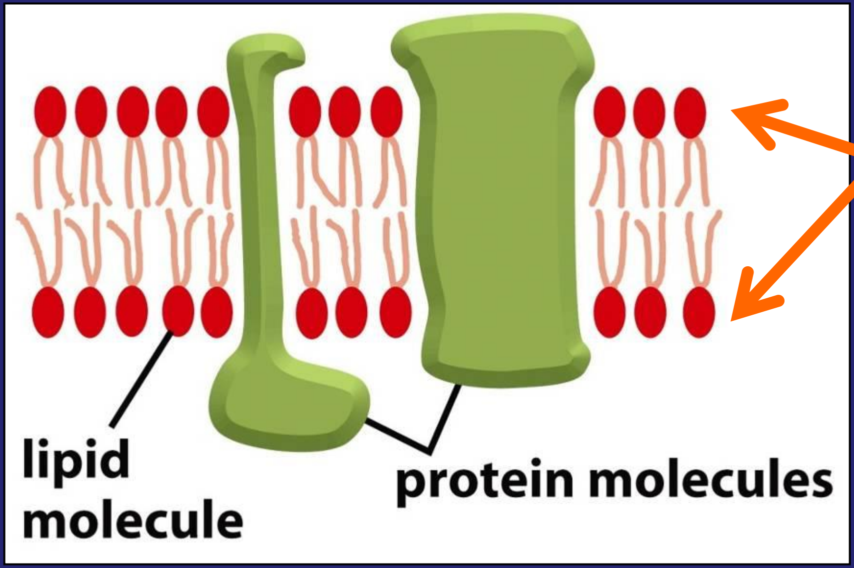
The lipid molecules are arranged as a continuous double layer

Cell membranes are dynamic, fluid structures. Most of their molecules move about in the plane of the membrane.



Protein molecules span the lipid bilayer and serve structural links through the lipid bilayer to the extracellular environment or an adjacent cell.

The lipid bilayer constitute the basic structure of all cell membranes



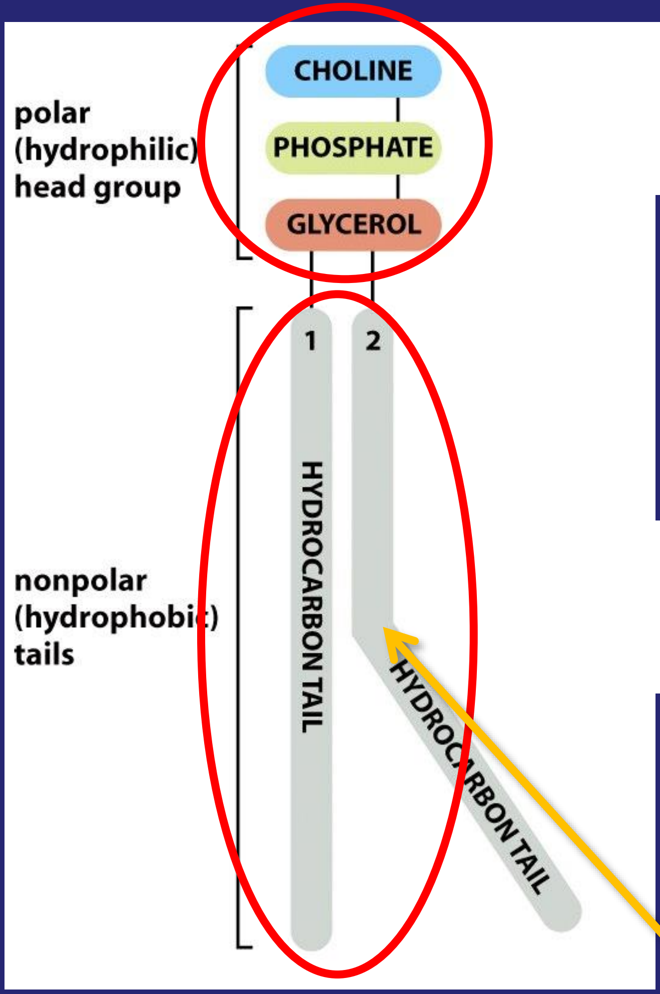
Lipid molecules constitute about 50 % of the mass of the cell membranes

Lipid molecules in cell membranes are **amphiphilic =**
= they have:

- **hydrophilic (polar) end** ("water-loving")
- **hydrophobic (nonpolar) end** ("water-fearing")

Phospholipids are the most abundant membrane lipids

Picture : The parts of phosphoglyceride molecule

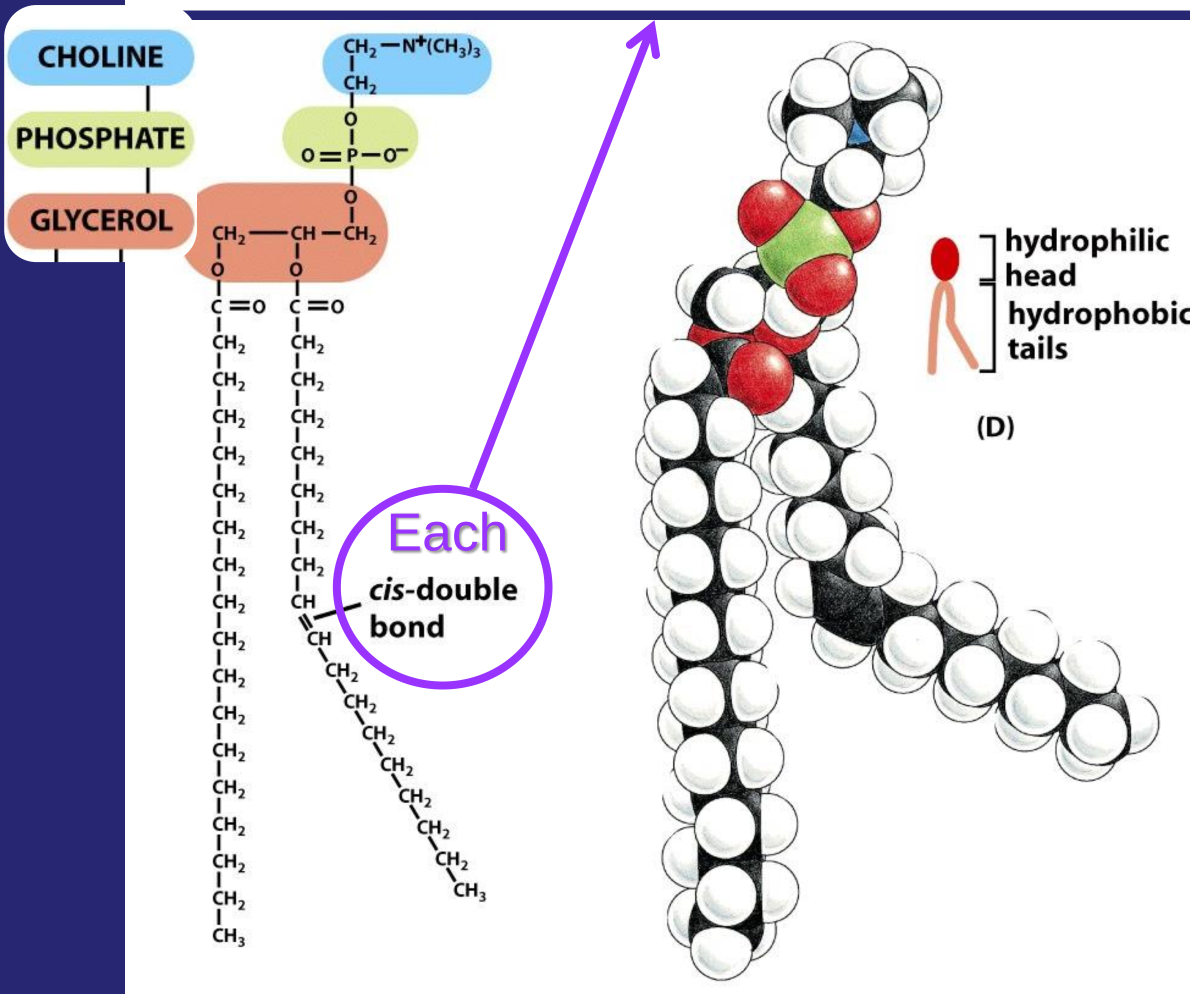


HYDROPHILIC (POLAR) HEAD GROUP

TWO HYDROPHOBIC (NONPOLAR) TAILS

The tails are usually fatty acids
They can differ in lengthy
One tail has one or more
cis double bonds

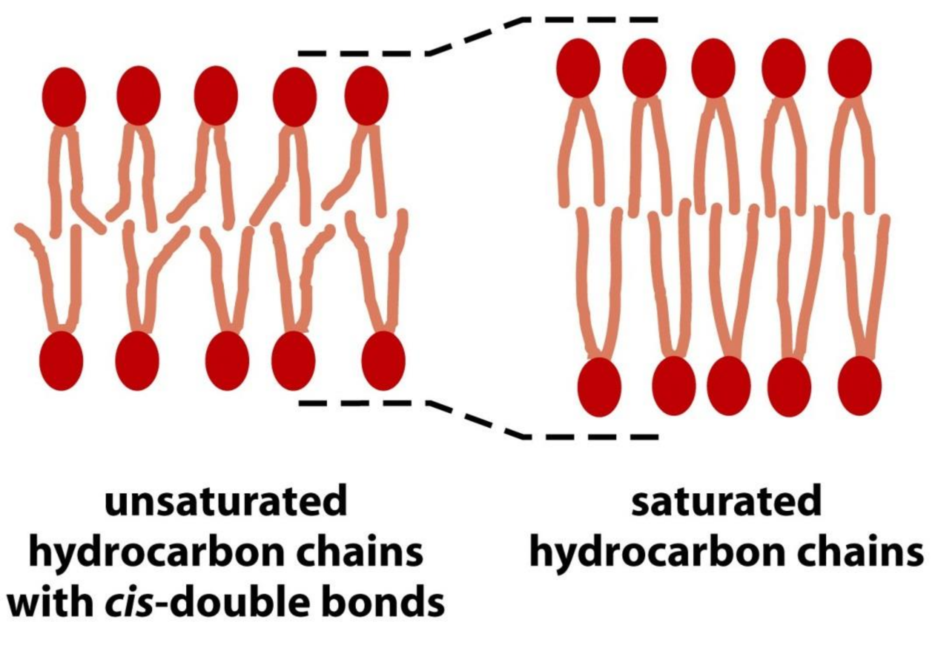
…creates a small kink in the tail



Differences in the <u>length</u> and <u>saturation</u> of the fatty acid tails influence how phospholipid molecules pack against one another thereby affecting <u>the fluidity</u> of the membrane.

Picture : The parts of phosphoglyceride molecule

The influence of cis-double bonds in hydrocarbon chains



The double bonds make it more difficult to pack the chains together, thereby making the lipid bilayer more difficult to freeze.

In addition, because the hydrocarbon chains of unsaturated lipids are more spread apart, lipid bilayer containing them are thinner than bilayers formed exclusively from saturated lipids.

The lipid layers

in many cell membranes contain:

<u>Phosphatidyl -</u>
- ethanolamine
- serine
- choline

❖ **Phospholipids**

phosphoglycerides (they have glycerol)

sphingomyeline (it have sphingosine)

❖ **Cholesterol**

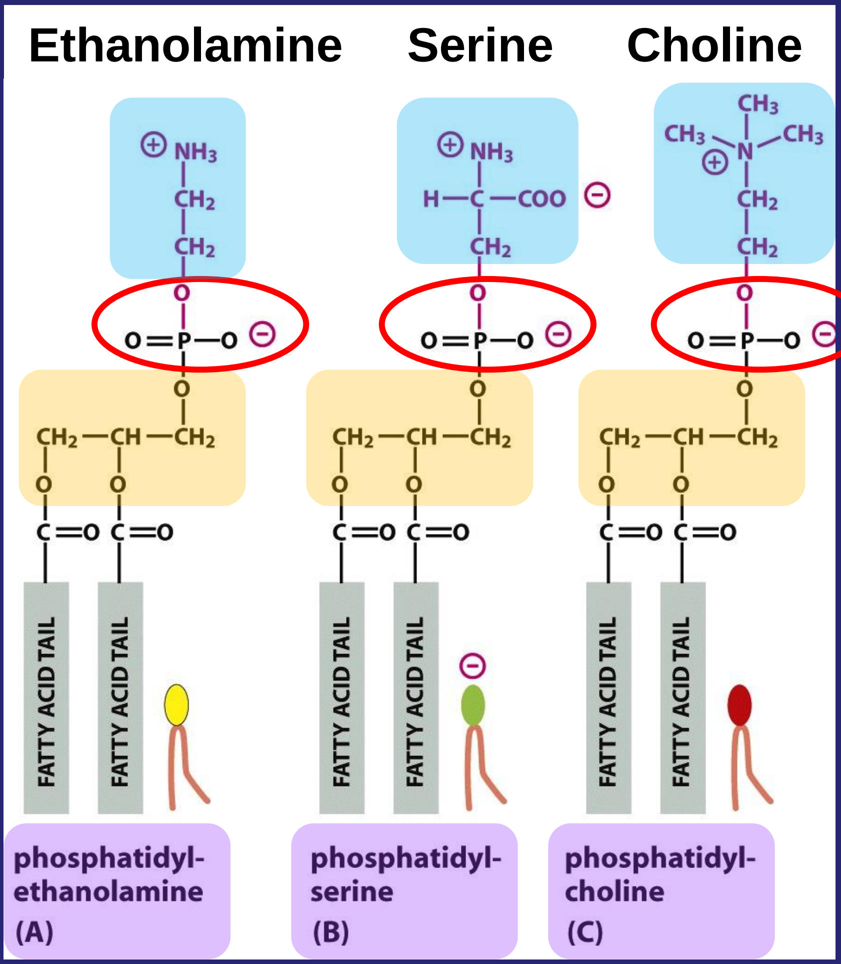
❖ **Glycolipids**

galactocerebrosides

gangliosides

❖ Phospholipids

Chemical Structure of Three Groups of Phosphoglycerides:



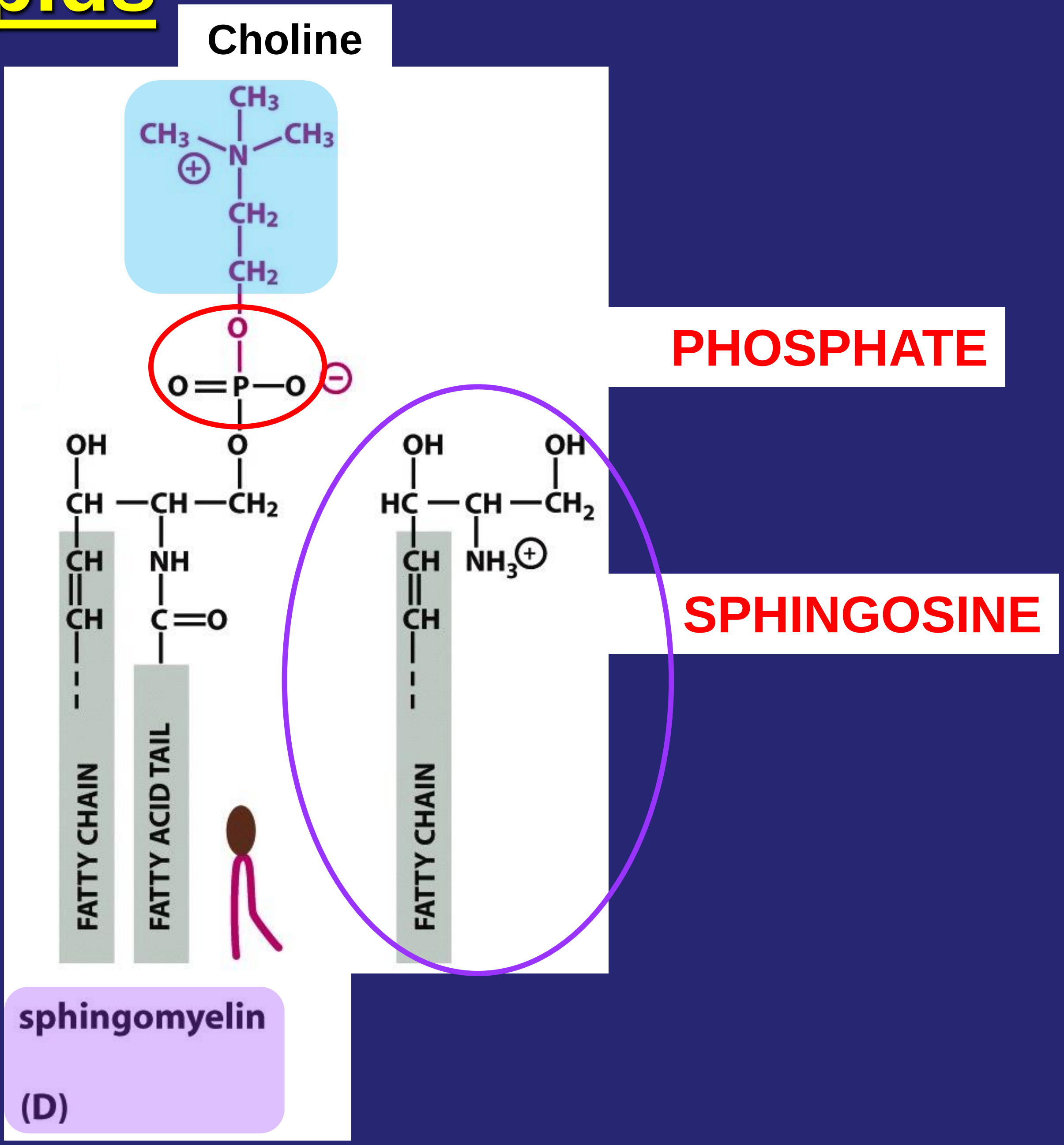
1. Phosphatidyl-ethanolamine
2. Phosphatidyl-serine
3. Phosphatidyl-choline

PHOSPHATE

GLYCEROL

❖ Phospholipids

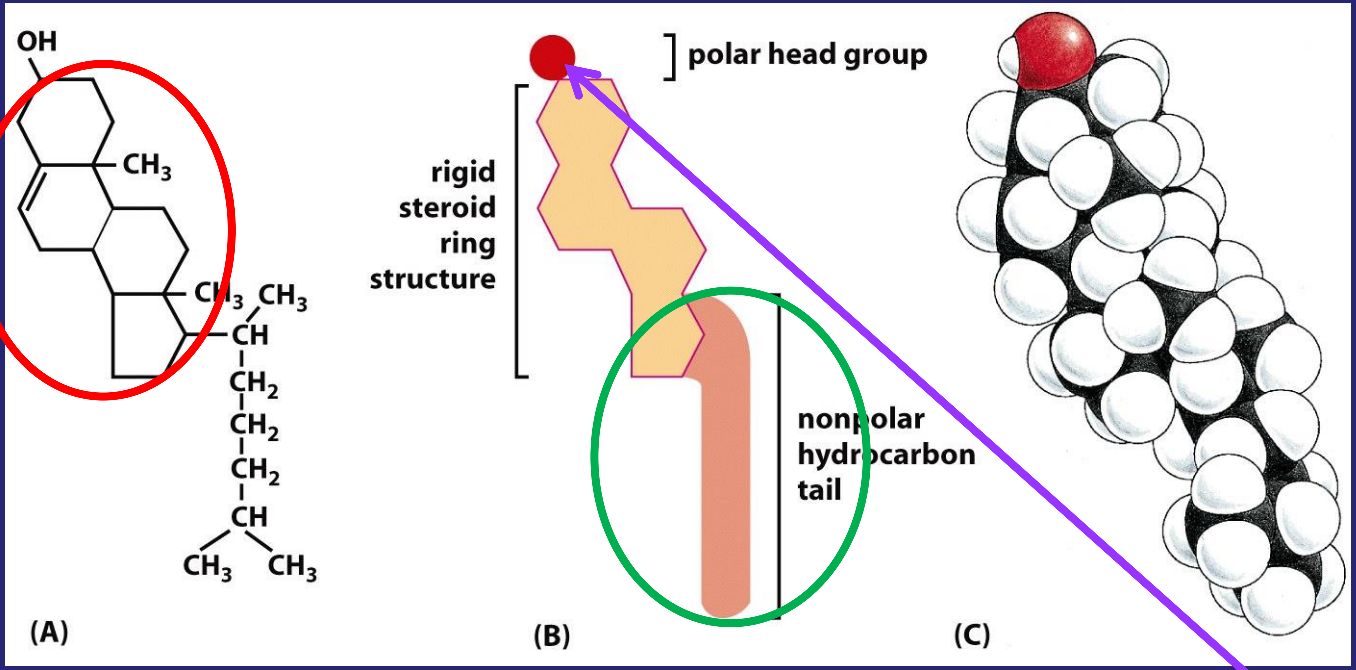
Chemical Structure of Sphingomyelins



❖ Cholesterol

Eukaryotic plasma membranes contain large amounts of cholesterol. **Cholesterol is sterol.**

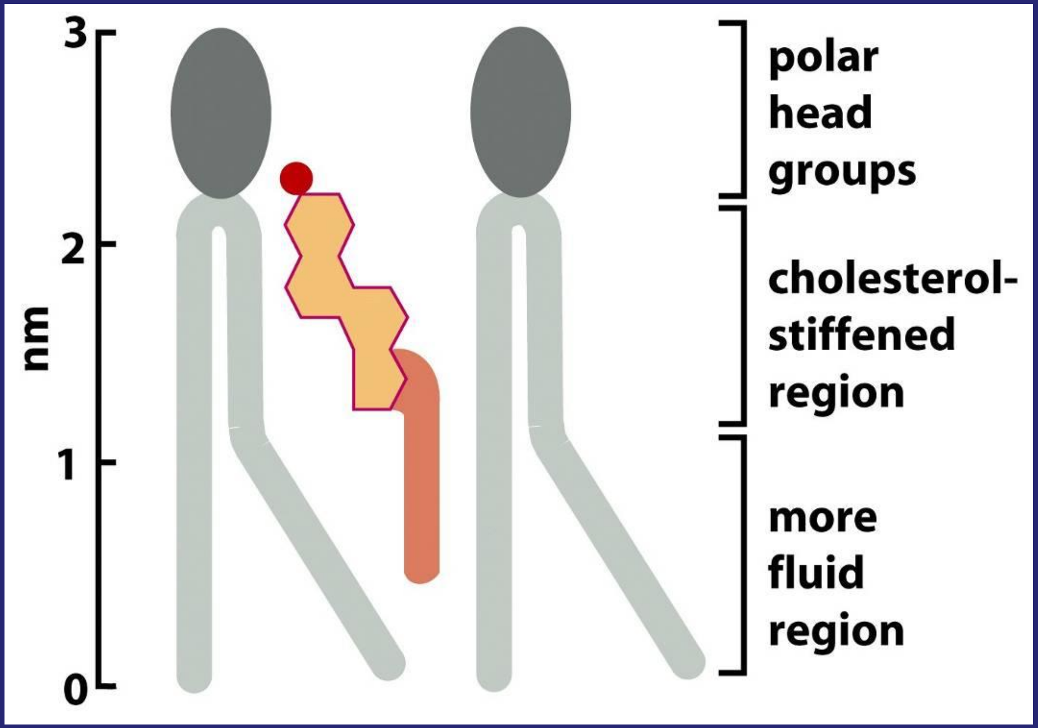
It contains a rigid ring structure….



..to which is attached a single polar hydroxyl group and a short non polar hydrocarbon chain

❖ Cholesterol

Cholesterol molecule interacts with two phospholipid molecules in one monolayer of a lipid bilayer



❖ Glycolipids

- Lipid molecules which contain sugar are called glycolipids.

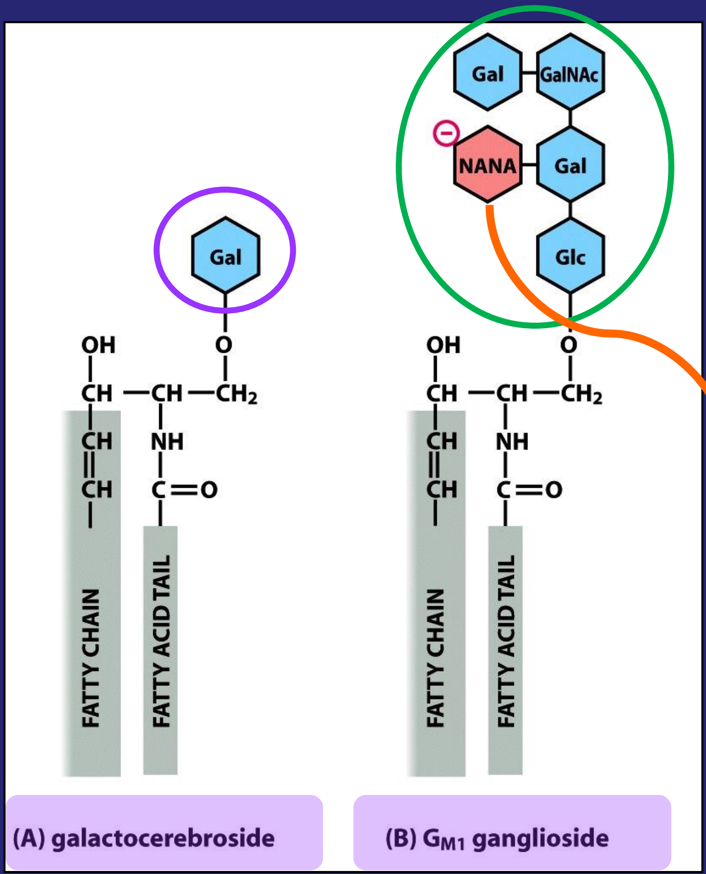
- Glycolipids are found **on the surface** of all plasma membranes. They have the most extreme asymmetry in their membrane distribution.

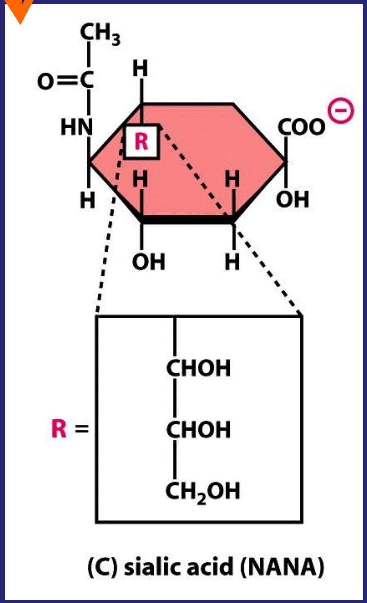
- They generally constitute about 5% of the lipid molecules in the outer monolayer. They are also found in some intracellular membranes.

- In the plasma membrane of nerve cells have been identified more than 40 different gangliosides.

❖ Glycolipids

Chemical Structure of Glycolipid molecules





1. Galactocerebrosides
contain sugar galactose. They are neutral glycolipid (uncharged)

2. Gangliosides
contain oligosaccharides as sugar and sialic acid residues (one or more) which give gangliosides negative charge (-).

Different cell membranes contains various types of lipids

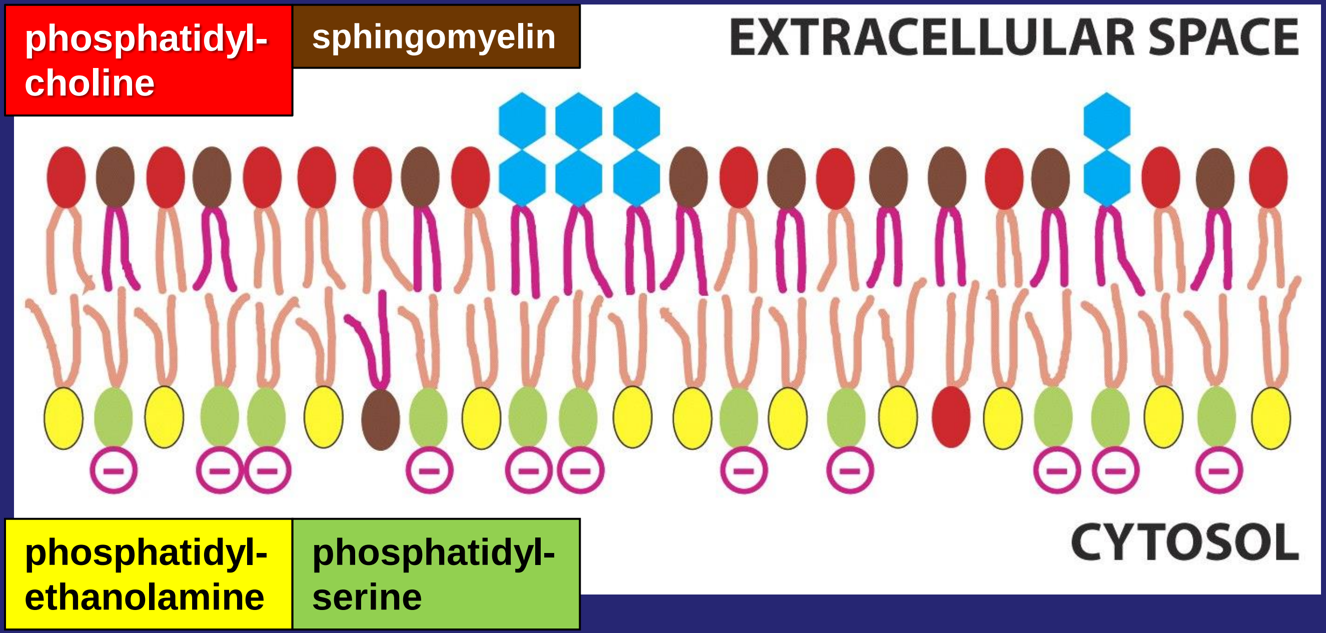
Table 10–1 Approximate Lipid Compositions of Different Cell Membranes

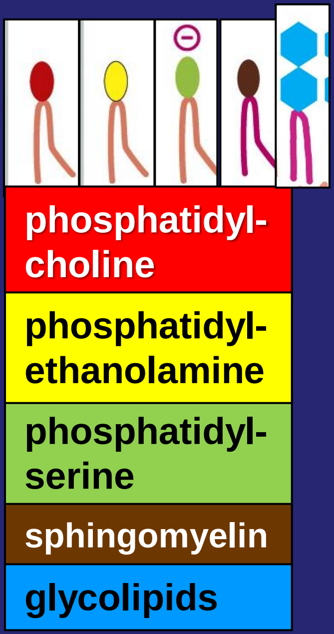
	PERCENTAGE OF TOTAL LIPID BY WEIGHT					
LIPID	LIVER CELL PLASMA MEMBRANE	RED BLOOD CELL PLASMA MEMBRANE	MYELIN	MITOCHONDRION (INNER AND OUTER MEMBRANES)	ENDOPLASMIC RETICULUM	*E. COLI* BACTERIUM
Cholesterol	17	23	22	3	6	0
Phosphatidylethanolamine	7	18	15	28	17	70
Phosphatidylserine	4	7	9	2	5	trace
Phosphatidylcholine	24	17	10	44	40	0
Sphingomyelin	19	18	8	0	5	0
Glycolipids	7	3	28	trace	trace	0
Others	22	13	8	23	27	30

Red circle mark the largely represented type of lipid in given type of cell membrane.

Asymmetry of the Lipid Bilayer

The lipid composition of the two monolayers of the lipid bilayer are **strikingly different.**





Cholesterol (not shown) is distributed roughly equally in both monolayers

Asymmetry of the Lipid Bilayer

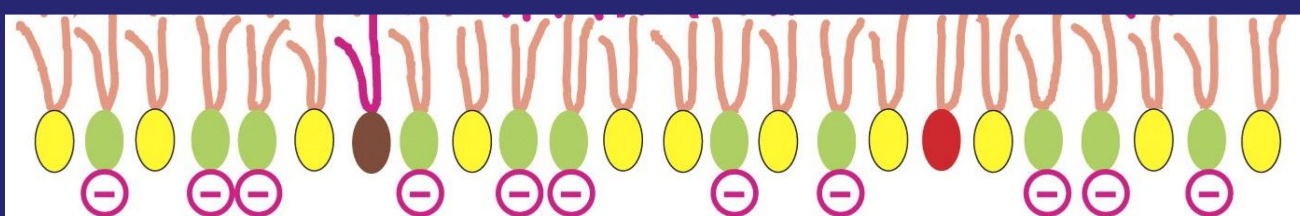
OUTER MONOLAYER **(touch extracellular space)**

Almost all of the phospholipid molecules contain **CHOLINE chain** in their molecules ***(= phospatidyl-choline + sphingomyeline)***

INNER MONOLAYER **(touch cytosol)**

Almost all of the phospholipid molecules contain **terminal primary amino group** in their molecules

(= phosphatidyl-ethanolamin + phosphatidyl-serin)



-

has negative charge

The inner monolayer is negative charged, but outer monolayer is neutral

Asymmetry of the Lipid Bilayer

Lipid asymmetry is functionally important especially in signaling pathways (converting extracellular signals into intracellular signals).

On the cytosolic face of the plasma membrane (inner monolayer) are

- specific proteins proteinkinase *C (PKC), phospholipase C*
- specific lipid head groups *phosphatidylinositol*
- specific lipid kinases *phosphoinositide 3-kinase (PI3-kinase)*

Membrane Proteins

Each type of cell membrane have characteristic functional properties

The membrane's specific tasks perform proteins in cell membrane, therefore there are various types of proteins

The amount of proteins in cell membrane differ

- in myelin membrane proteins consist less than 27% of the membrane mass
- in membranes of mitochondria a total of 75 % of the mass are proteins

Membrane proteins are

- **Transmembrane proteins**

  They extend through the lipid bilayer

  On either side is the part of their mass

- **Proteins located entirely in the one side of membrane**

  Proteins are anchored in the internal or external side of membrane

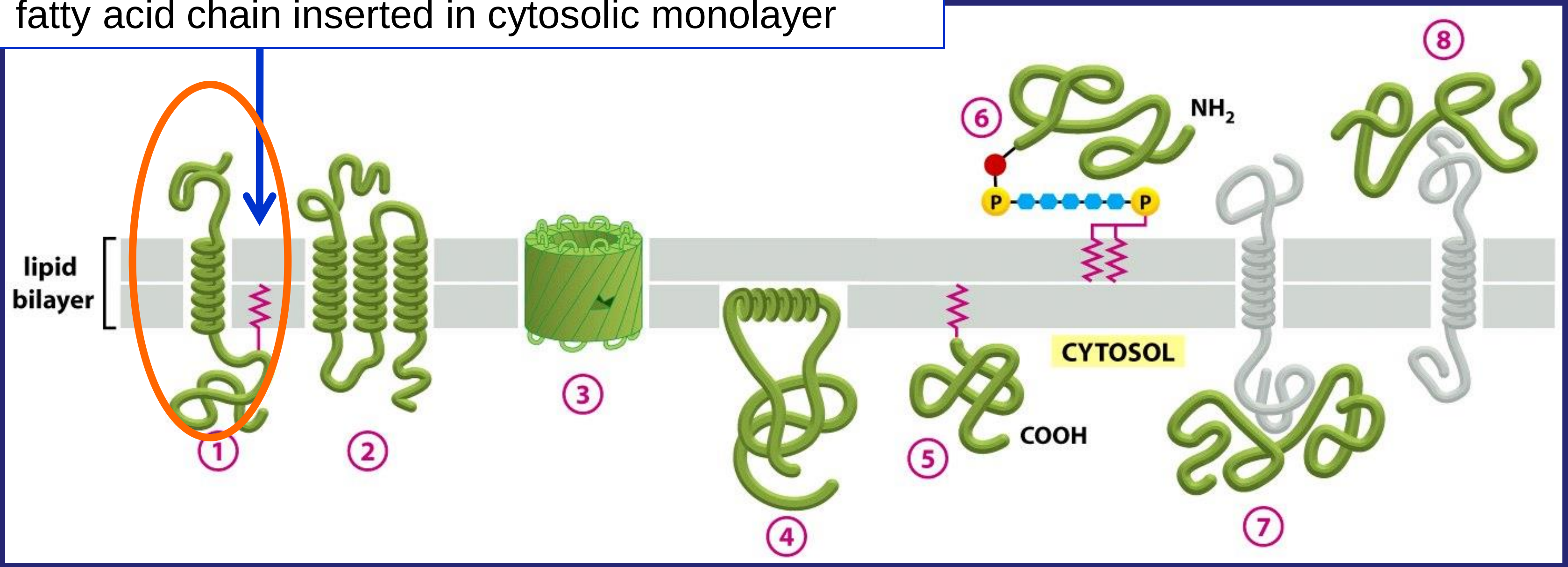
❖ Transmembrane proteins

They are amphiphilic, having **hydrophobic** and **hydrophilic** regions

hydrophilic	hydrophobic
are exposed to water on either side of the membrane	pass through the membrane and interact with the hydrophobic tails of the lipid molecules in the bilayer

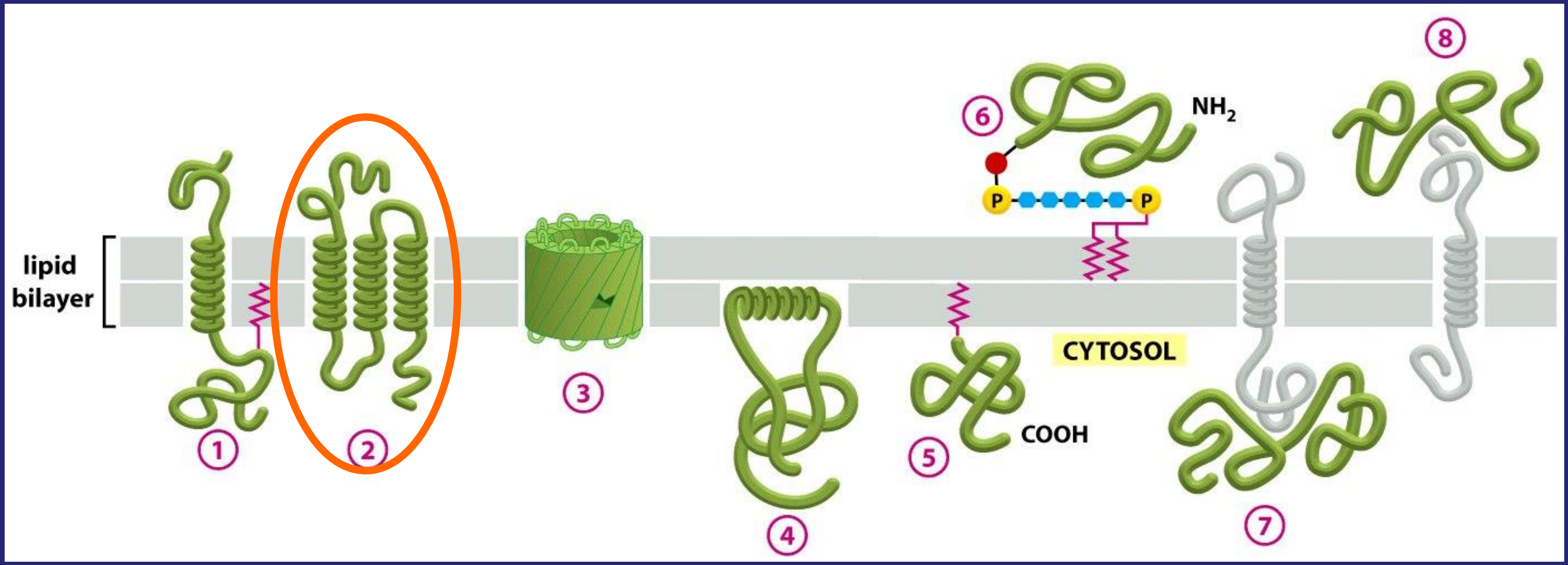
This picture shows the **different ways** in which the membrane proteins can associate with the membrane

some of these proteins are covalently attached to fatty acid chain inserted in cytosolic monolayer



① **Most transmembrane proteins** are throught to extend across the bilayer as **single α helix** **= single-pass transmembrane proteins**

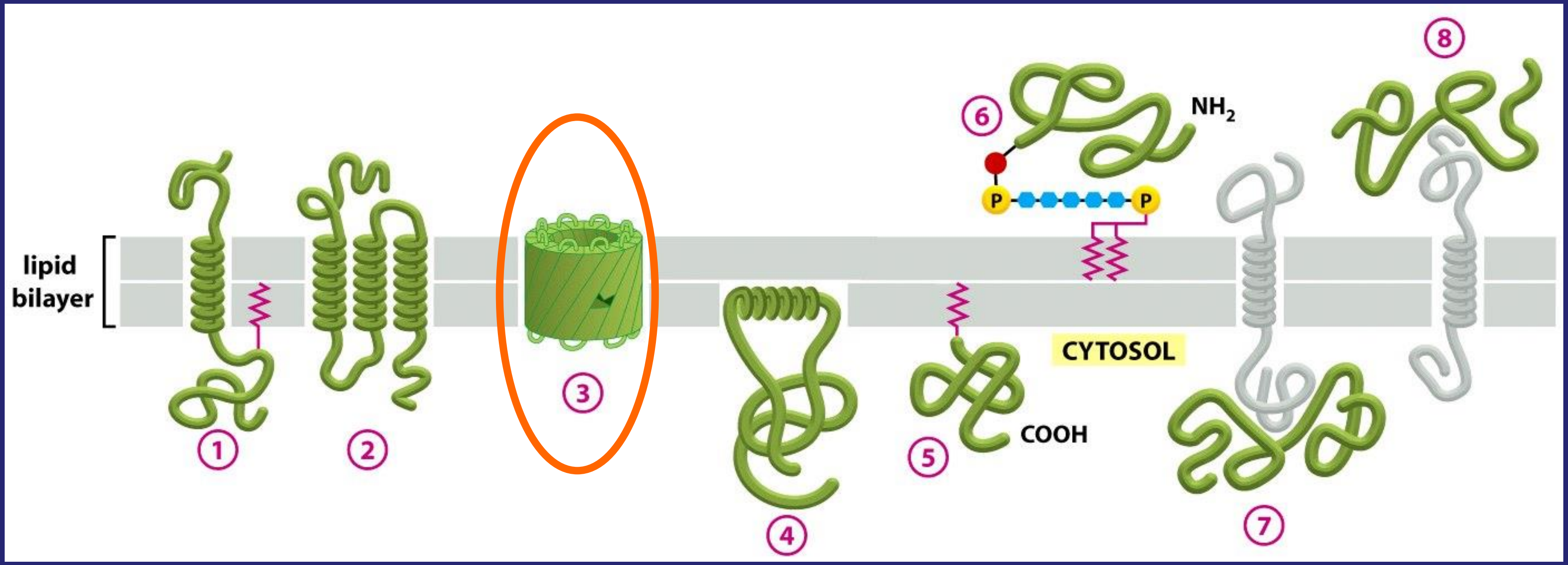
This picture shows the **different ways** in which the membrane proteins can associate with the membrane



② **…or** as **multiple α helices**

= multipass transmembrane proteins

This picture shows the **different ways** in which the membrane proteins can associate with the membrane



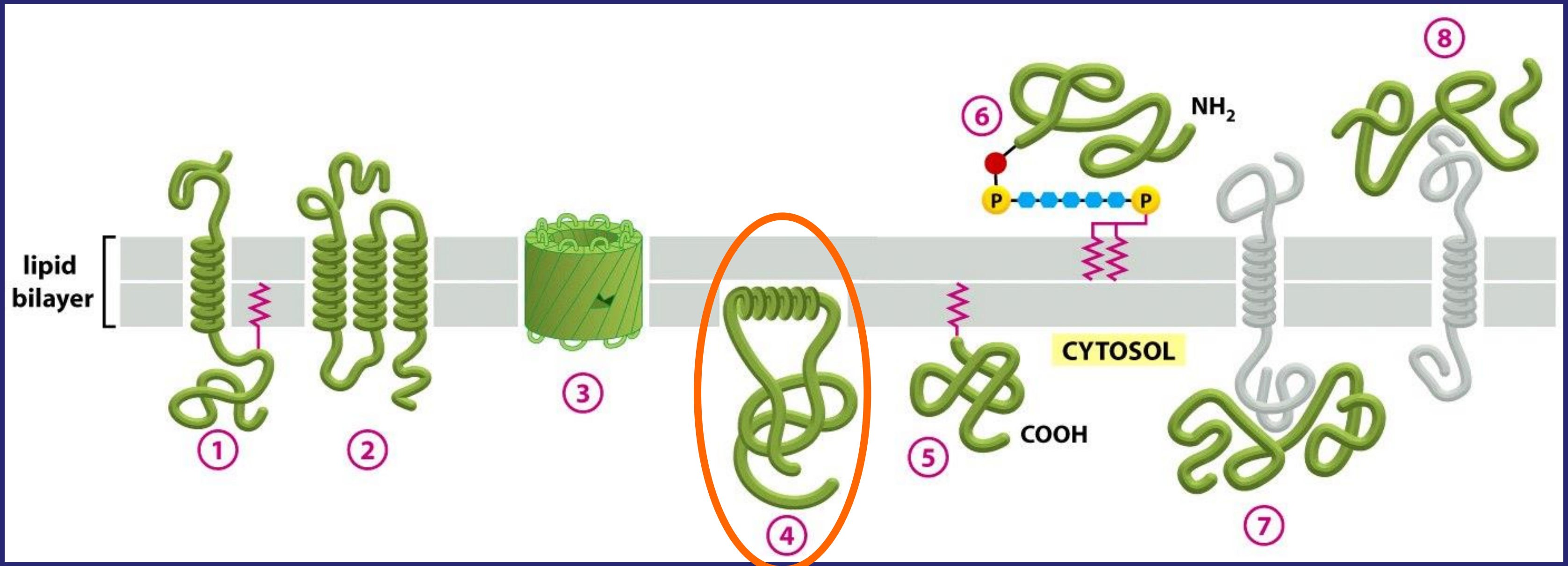
③ **Other transmembrane proteins** extend across the bilayer as a **rolled–up β sheet (β barrel)**

❖Proteins located entirely in the one side of membrane (internal or external side).

They are attached to the lipid chain, phosphadityl-inositole group of phospholipids or to the other transmembrane protein.

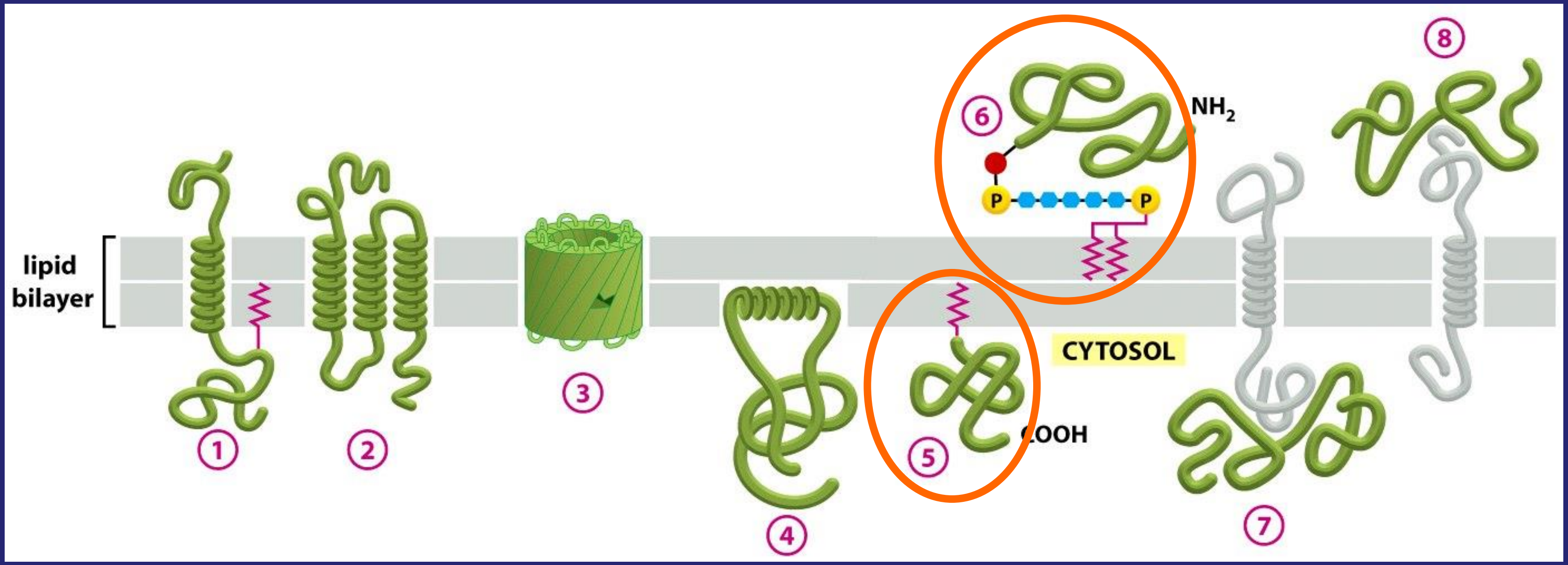
Sometimes these proteins (enzymes, signaling proteins) are anchored by GPI (glyco phosphatidyl-inositol) anchor into correct place of cytosolic side of the membrane.

This picture shows the **different ways** in which the membrane proteins can associate with the membrane



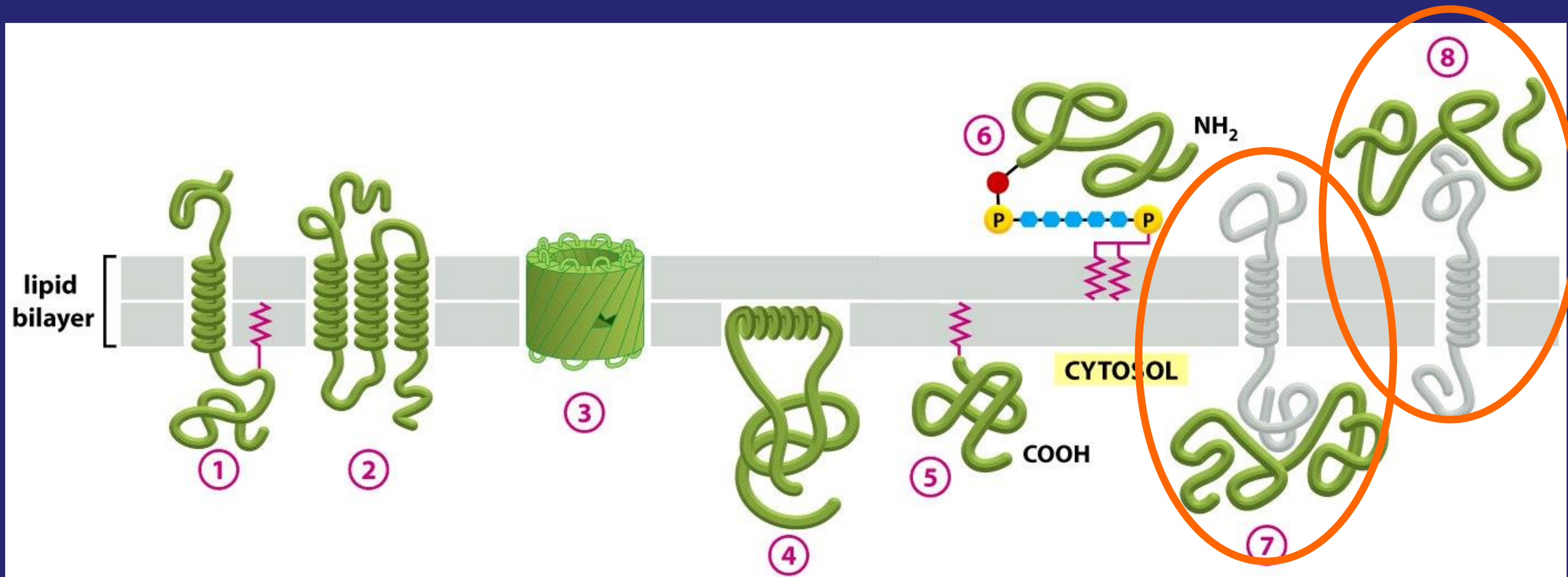
④ **Other membrane proteins** exposed at only one side of the membrane **-** some of these are **anchored to the cytosolic surface by an amphiphilic α helix**

This picture shows the **different ways** in which the membrane proteins can associate with the membrane



⑤ **Others are attached** to the bilayer only (specifically) **by a covalent bond with lipid chain or fatty acid chain or a prenyl group <u>or</u> via a oligosaccharide linker to PI** (phosphatidyl-inositol) **– called GPI** (glyco-PI) **anchor** ⑥

This picture shows the **different ways** in which the membrane proteins can associate with the membrane



⑦ ⑧ Many proteins are attached to the membrane only by noncovalent interactions with other membrane proteins

❖ Functions of membrane proteins

Transmembrane proteins can functions as

❖ **Cell surface receptors** (e.g. GPCR = G protein coupled receptors)

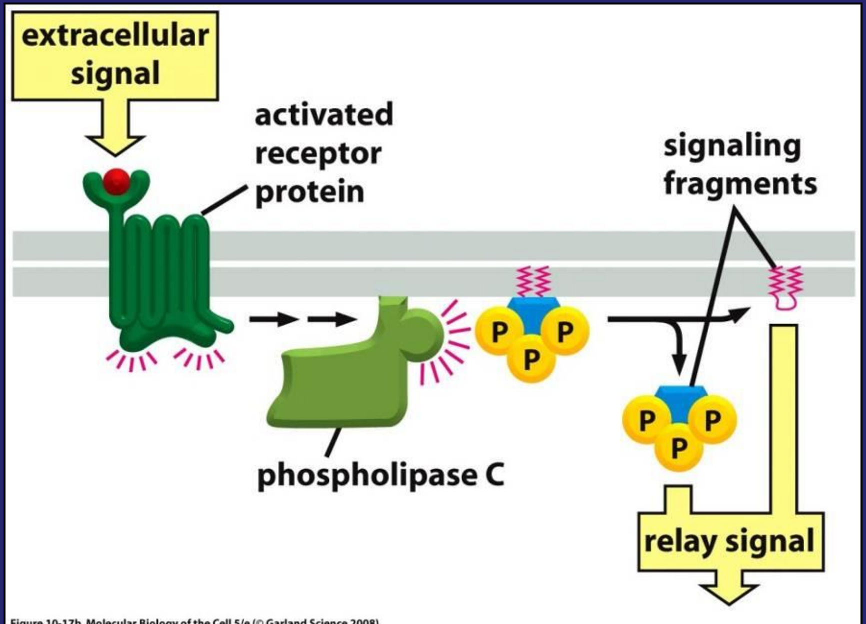


Figure 10-17b Molecular Biology of the Cell 5/e (© Garland Science 2008)

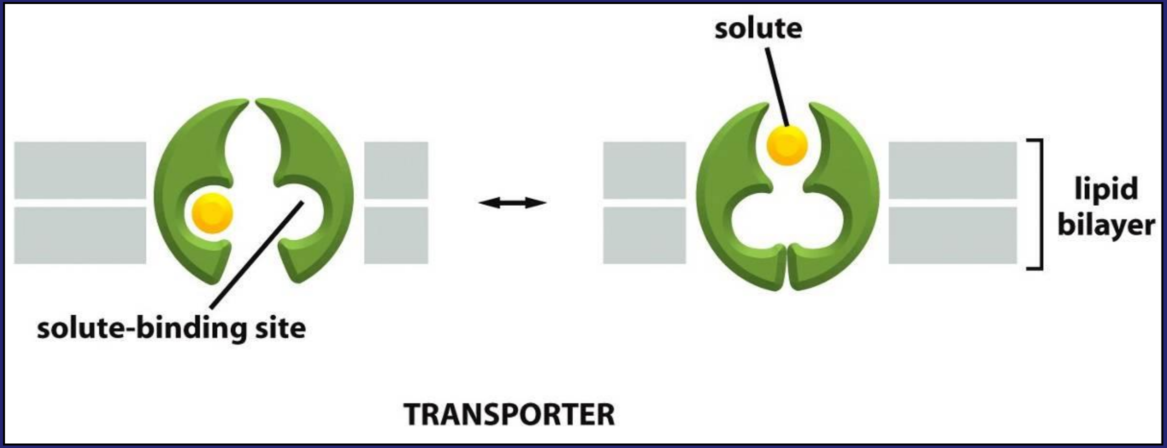
The signal molecule in the extracellular side binds on the extracellular part of receptor protein.
This binding generate intracellular signal on the opposite side of the plasma membrane.

❖ Functions of membrane proteins

Transmembrane proteins

❖ **Transporters** (carriers or permeases)

Transporters bind the specific solute and undergo a series of conformational changes to transfer the bound solute across the membrane.

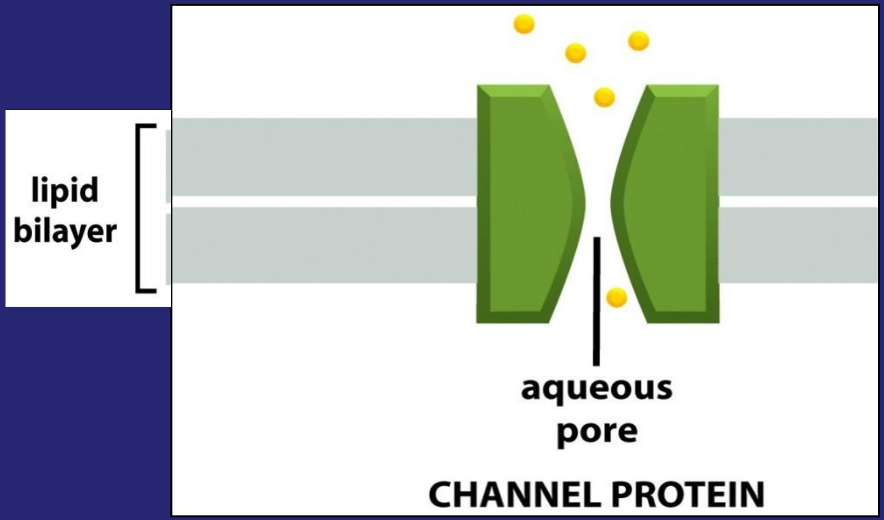


❖ Functions of membrane proteins

<u>Transmembrane proteins</u>

❖ **Channels** (inorganic ions)

Channel proteins form a water-filled pore across the bilayer through which specific inorganic ions can diffuse.



❖ Functions of membrane proteins

Proteins, which are only on one side of the lipid bilayer

These proteins are often associated exclusively with either the lipid monolayer or a protein domain on that side.

- ❖ **Intracellular signalling molecules**

  (proteins of Src family, Ras, Raf proteins,…)
- ❖ **Enzymes**

  (proteinkinases, adenylylcyclases, phospholipases)

Transmembrane protein always has a unique orientation in the membrane

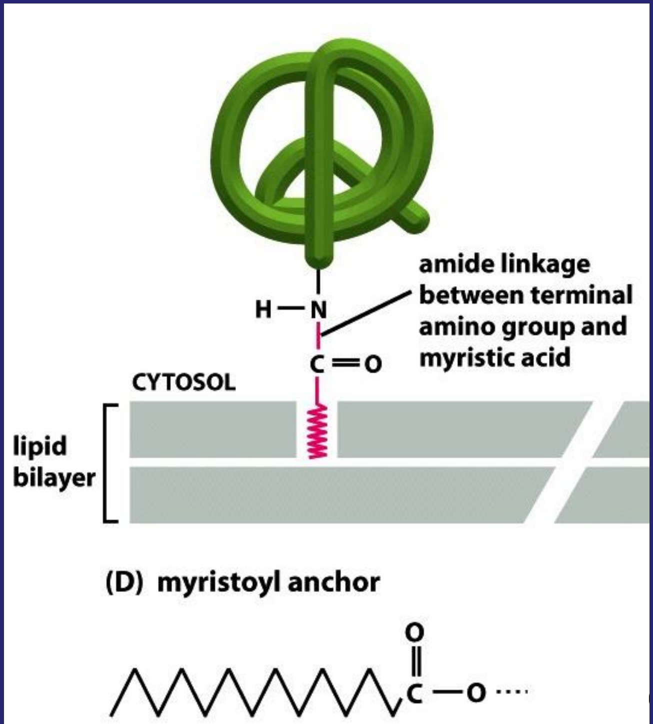
In order to membrane protein is attached to fatty acid chain or a prenyl group. The covalent attachment of certain type of lipid can help to localise a protein to a membrane after its synthesis in the cytosol.

The lipid anchors are:

Myristoyl anchor, Palmitoyl anchor, Farnesyl anchor

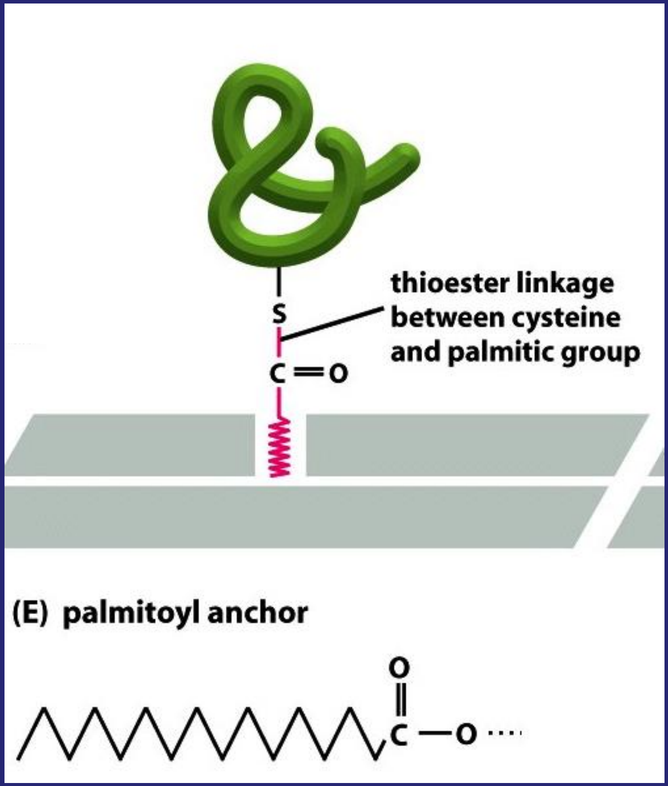
1) Myristoyl anchor

A fatty acid chain (myristic acid) is attached via an amide linkage to an N-terminal glycine

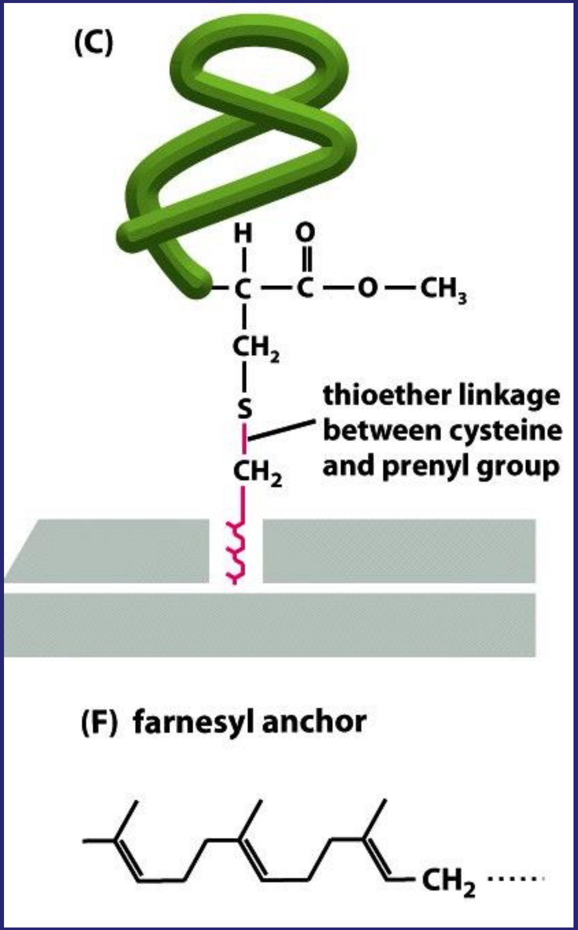


2) Palmitoyl anchor

A fatty acid chain (palmitic acid) is attached via a thioester linkage to a cysteine



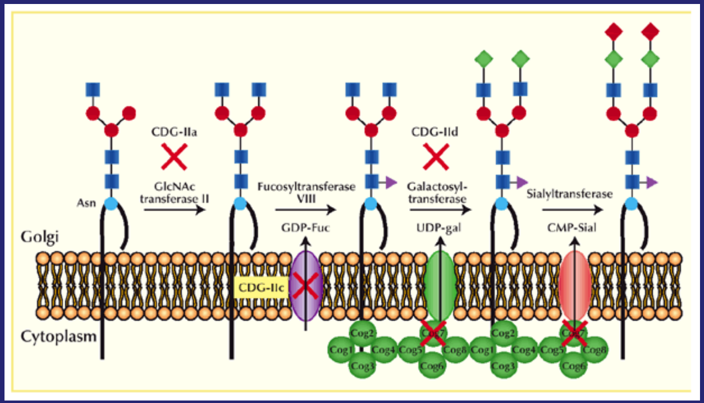
3) Farnesyl anchor



A prenyl group (either farnesyl or longer geranylgeranyl group) is attached via a thioether linkage to a cysteine residue

Many of the membrane proteins are glycosylated

Because most trans membrane proteins in animal cells are glycosylated*, <u>carbohydrates extensively coat the surface </u>of all eukaryotic cells.



*The sugar residues are added in the lumen of the ER and the Golgi apparatus.

1. The Plasma Membrane, the Lipid Bilayer

Summary

Biological membranes consist of a continuous double layer of lipid molecules in which membrane proteins are embedded

The lipid bilayer is fluid – The membrane lipid molecules are amphiphilic and they are able to diffuse rapidly within their own monolayer.

1. <u>The Plasma Membrane, the Lipid Bilayer</u>

Summary

Cells contain 500-1000 different lipid species – there are three major classes of membrane lipids – phospholipids, cholesterol and glycolipids.

The lipid composition of the inner and outer monolayers a different, reflecting the different functions.

Plasma membrane lipid bilayer play an important part in cell signalling *(see lecture Principles of cell communication – signaling pathways)*