RNDr. Ivana Fellnerová, Ph.D.
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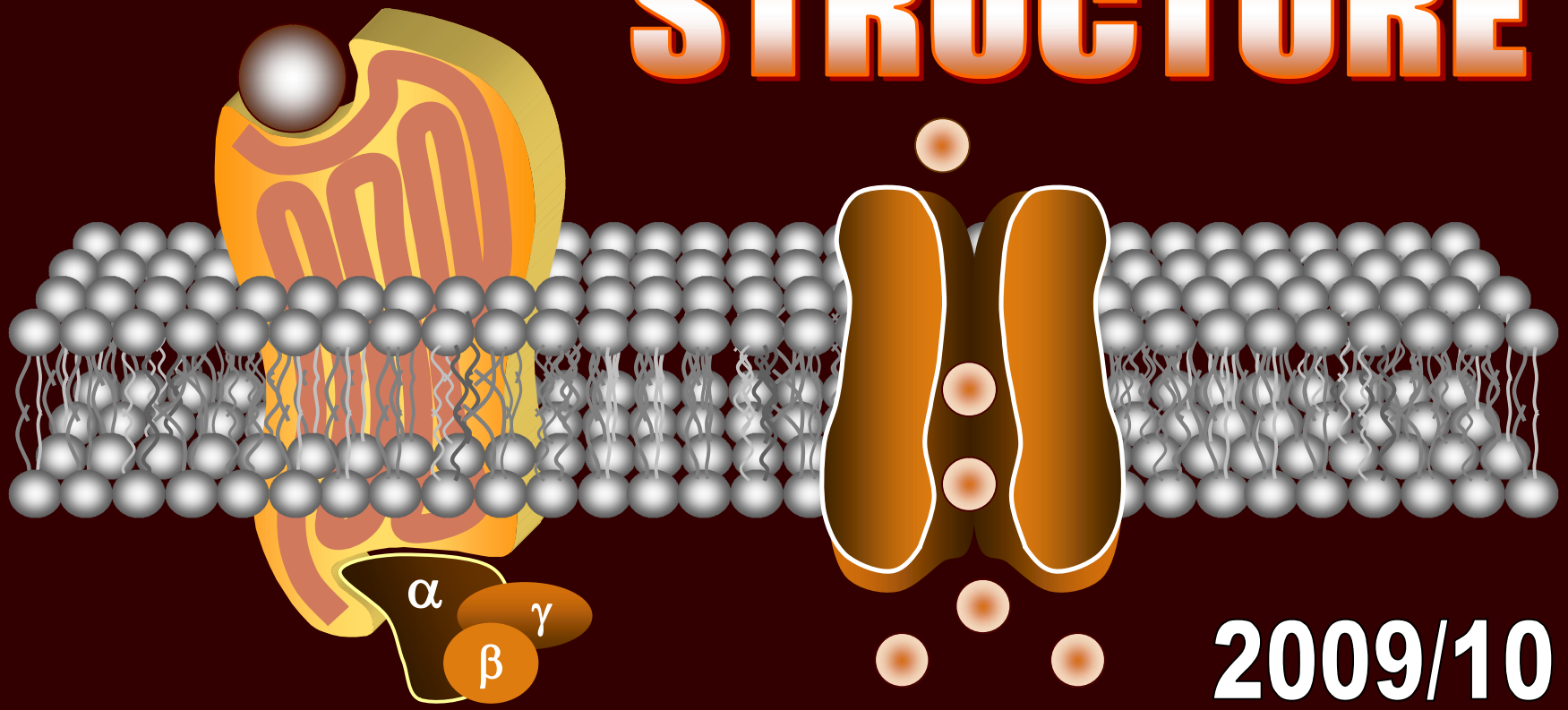
1. Plasma membrane: STRUCTURE



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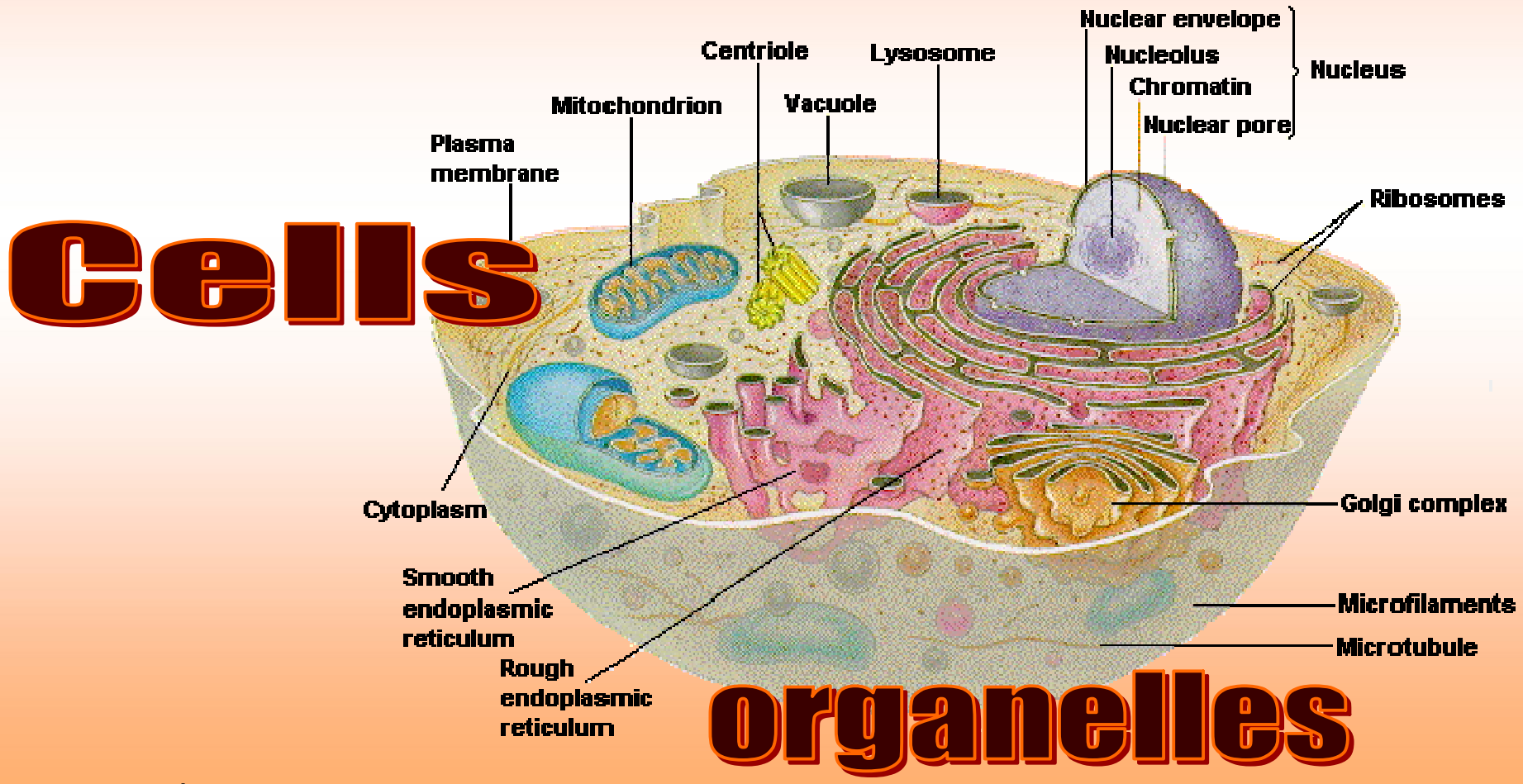
Biomembranes

- Boundary that separates a living cells from its extracellular environment
- Constitutes many of the subcellular organelles in eukaryotic cells



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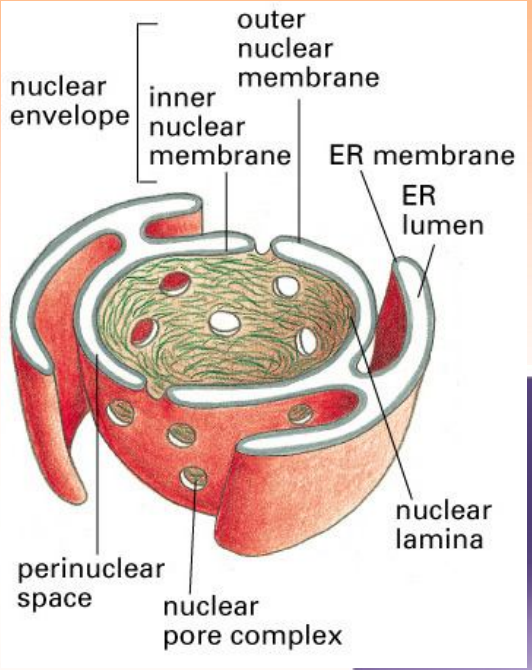
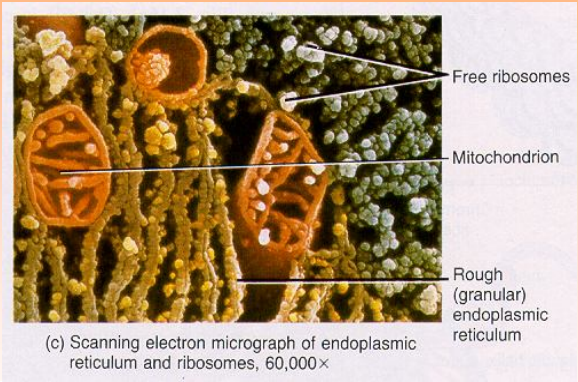
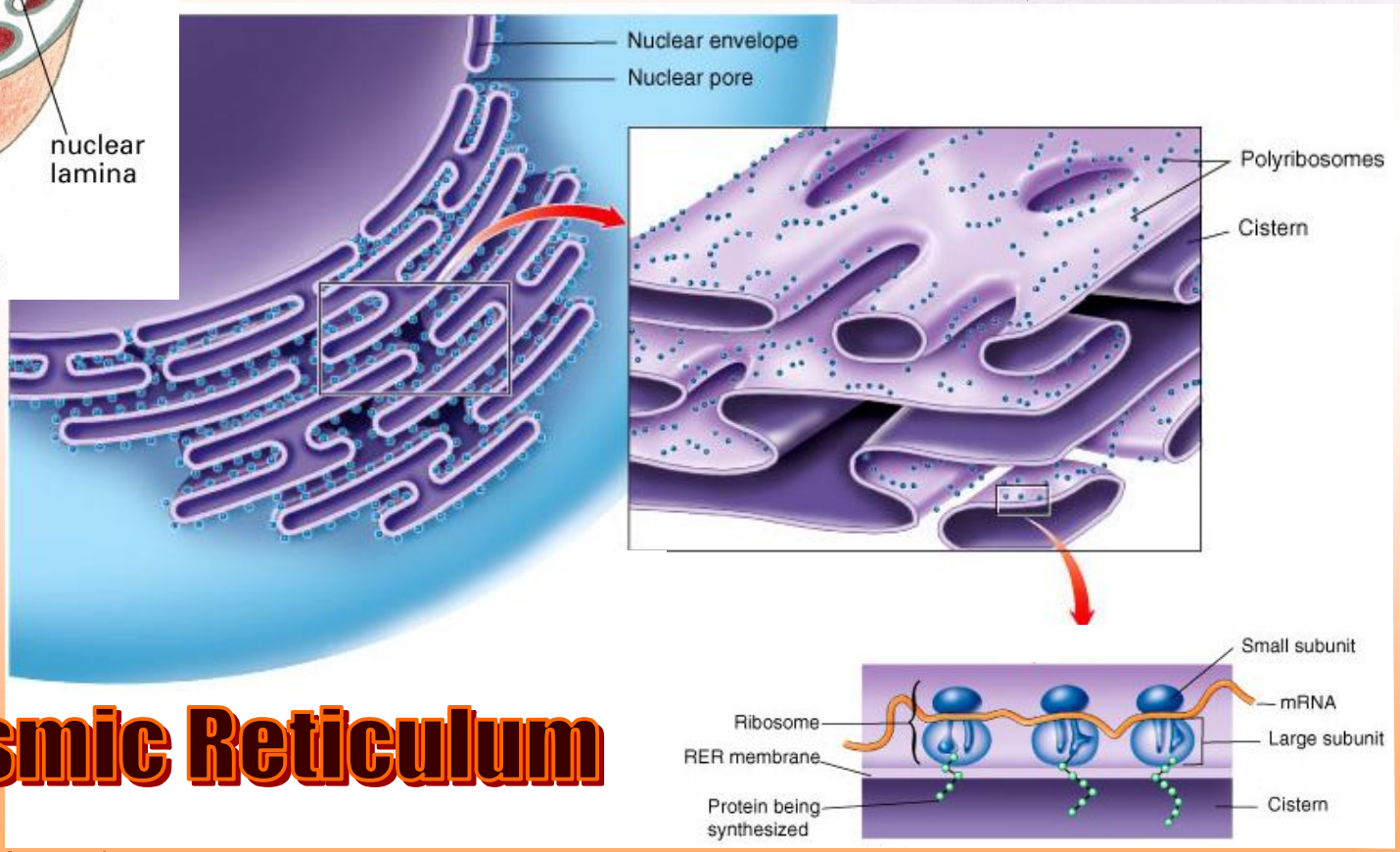
Nucleus – Rough Endoplasmic Reticulum





(c) Scanning electron micrograph of endoplasmic reticulum and ribosomes, 60,000×



Rough Endoplasmic Reticulum

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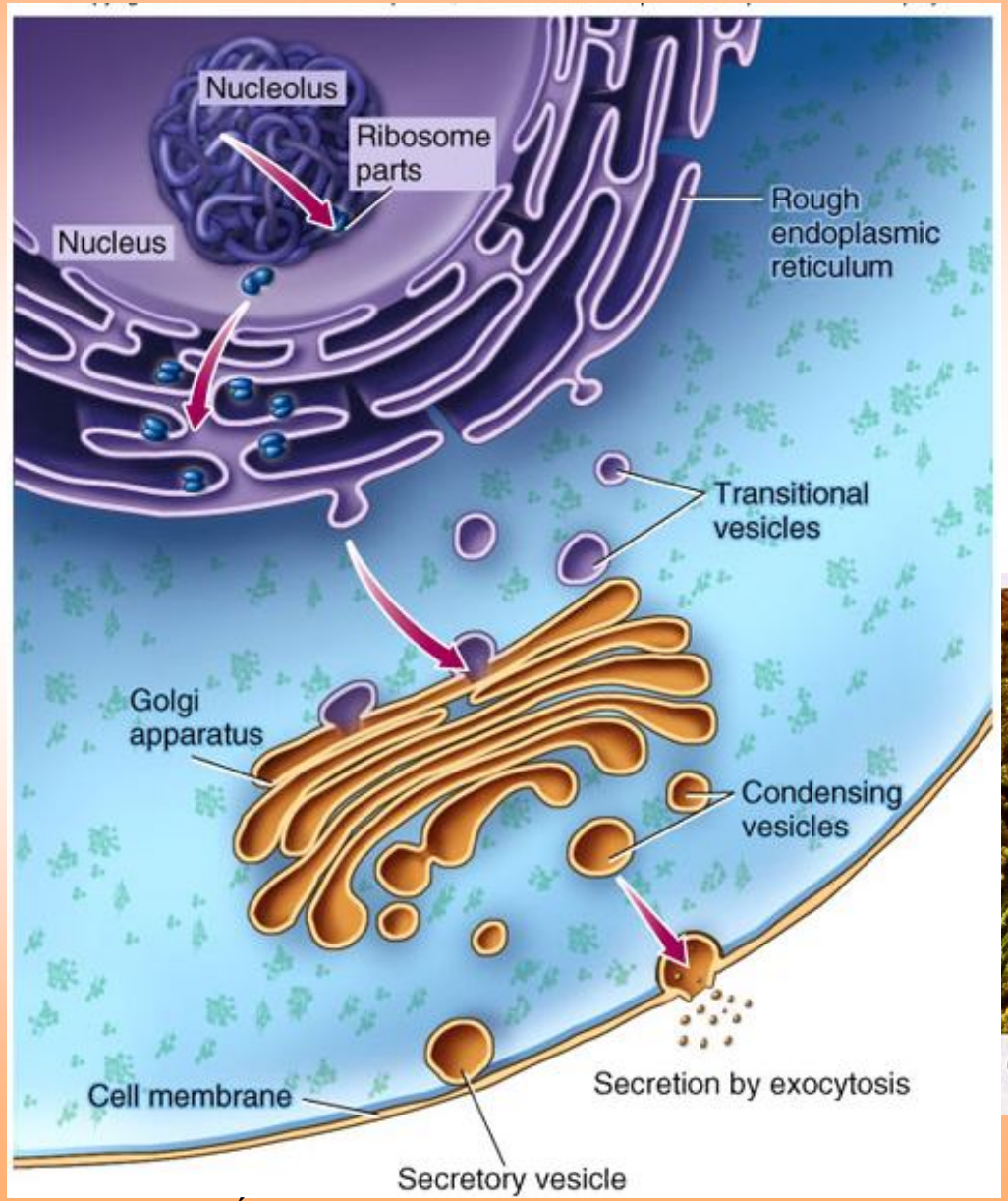
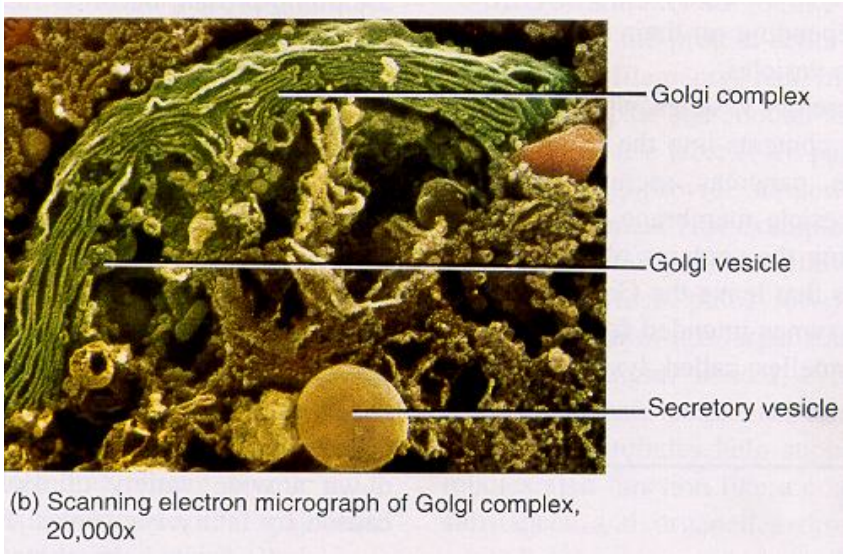
Golgi Complex



Golgi Complex



(b) Scanning electron micrograph of Golgi complex, 20,000x

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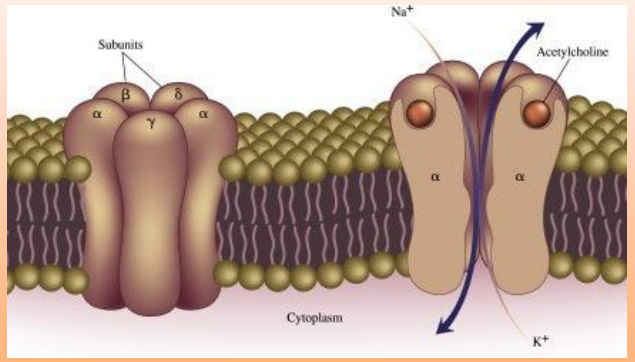
Basic membrane function

Physical barrier

Cell membrane separates the inside of the cell from the surrounding extracellular fluid
Allows selective communication between the intracellular and extracellular compartments

Specific functions of the membrane

The proteins found in the cell membrane serve a variety of functions:



RECEPTORS:
Recognize hormones or other regulatory molecules

PROTEIN TRANSPORTERS:
Control selective transport of molecules across the cell membrane

ENZYME:
Control of chemical reactions in the cell membrane

CELL MARKERS (antigens):
Identify the blood and tissue type of an individual

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Biomembrane structure

Particular biomembranes differ in proportion of individual components
but
there is the main basic rule about membrane structure

All biomembranes are build up on the same basic principles

3 classes of biochemical compounds

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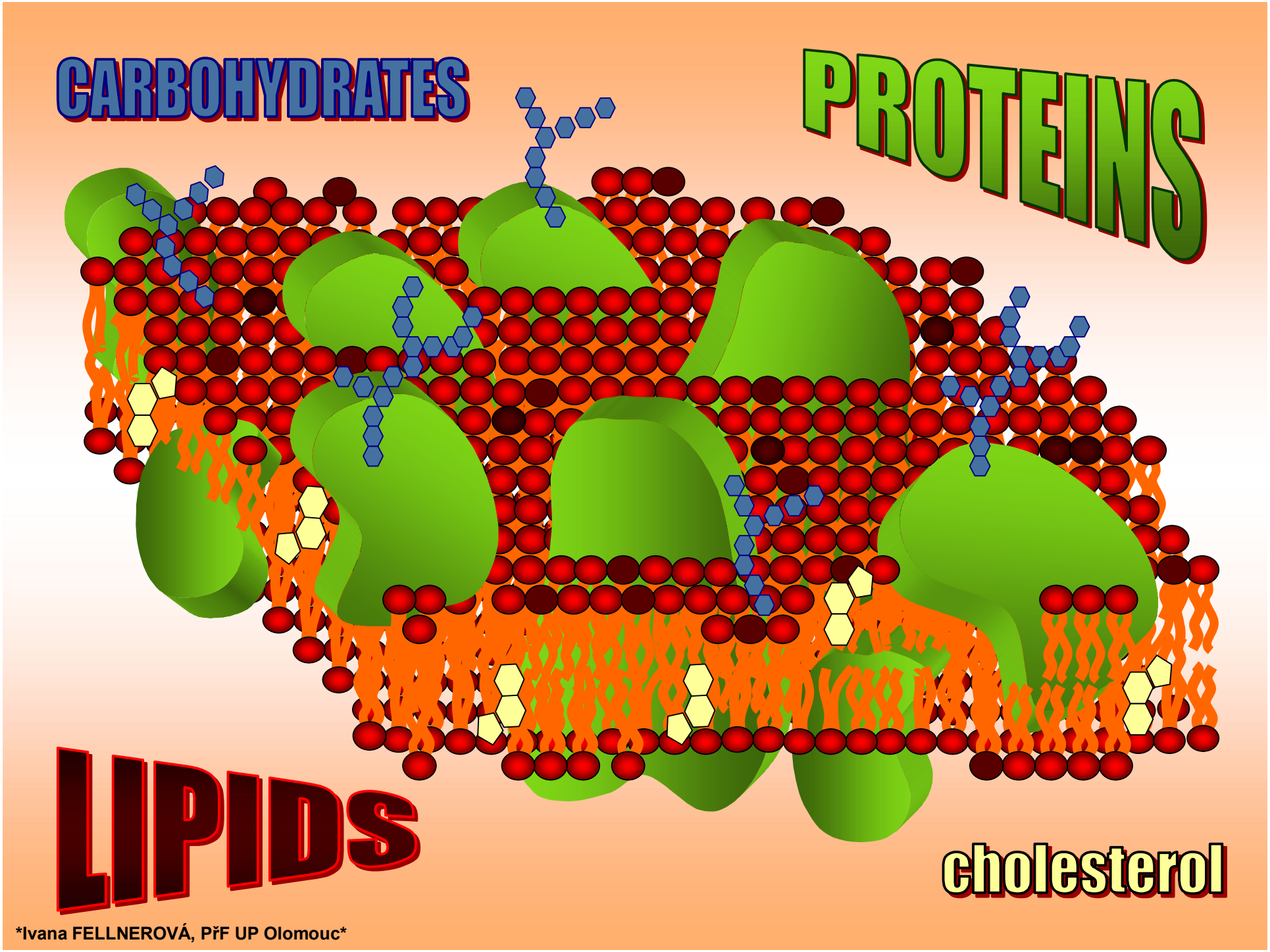

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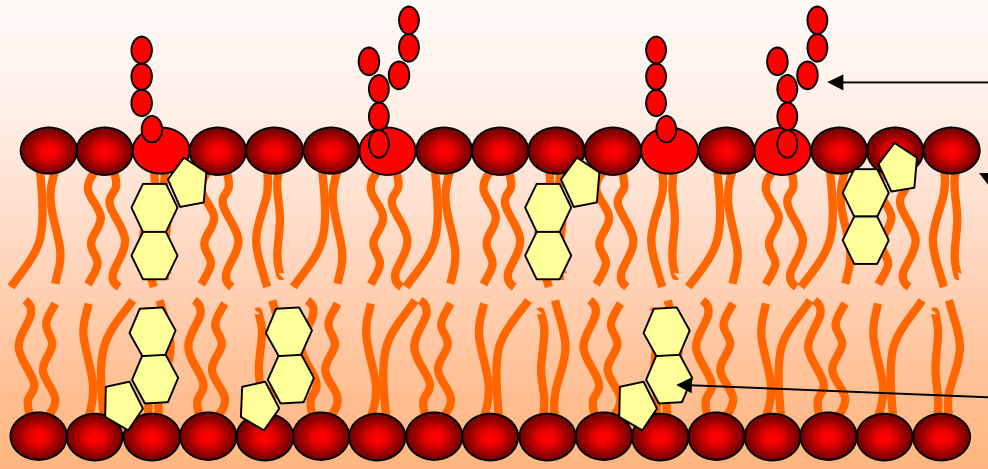
LIPIDS in cell membrane

- Lipids provide the basic structure of the biological membrane backbone – continuous double layer
- A lipid‘s double layer provides an effective barrier to passage of many materials between two aqueous environments [intracellular and extracellular]

Main groups of the membrane lipids:



Glycolipids:
Derivates of lipids (lipid+carbohydrate)

Phospholipids:
Lipids derived from 3-carbon alcohol (most abundant membrane lipids)

Cholesterol:
Steroid lipids

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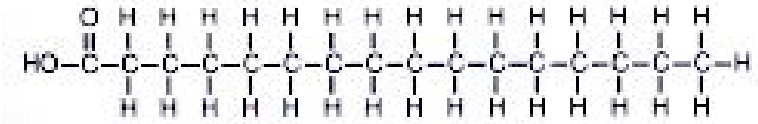
Lipid's general features

- Lipids are a very **heterogenic group** of biological molecules

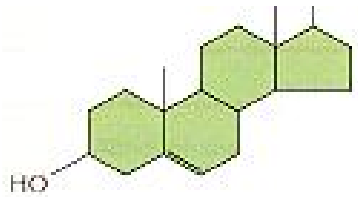
- What's common for all of them?

  Lipids are **insoluble in the water** and soluble in fat and organic solvents such as benzene

- Lipids derived from **triacylglycerol** contain long **hydrocarbon chains.**



- **Steroid lipids** contain multiple linked **aromatic rings.**



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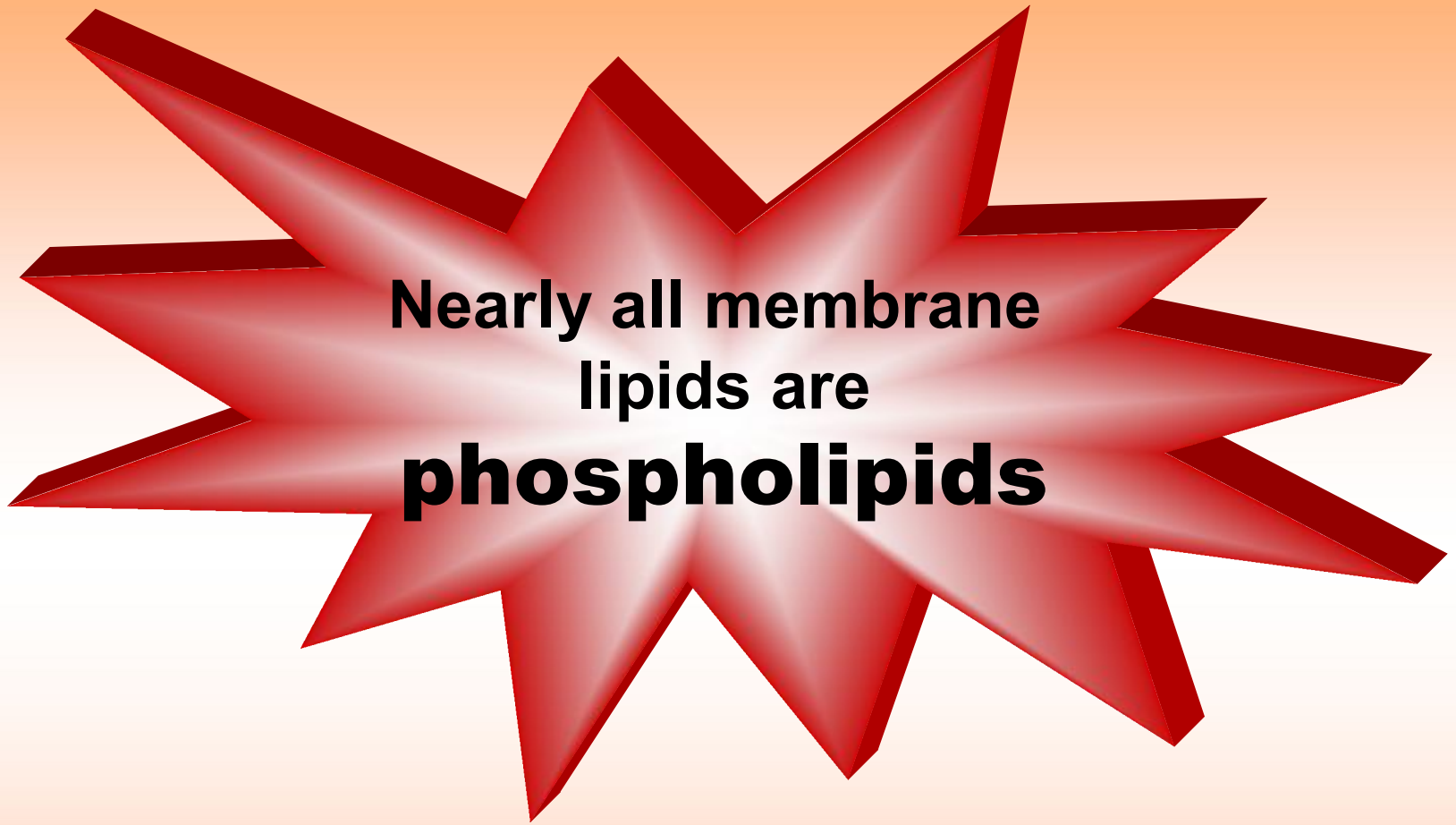

Phospholipids belong to the category of lipids derived from 3-carbon alcohol

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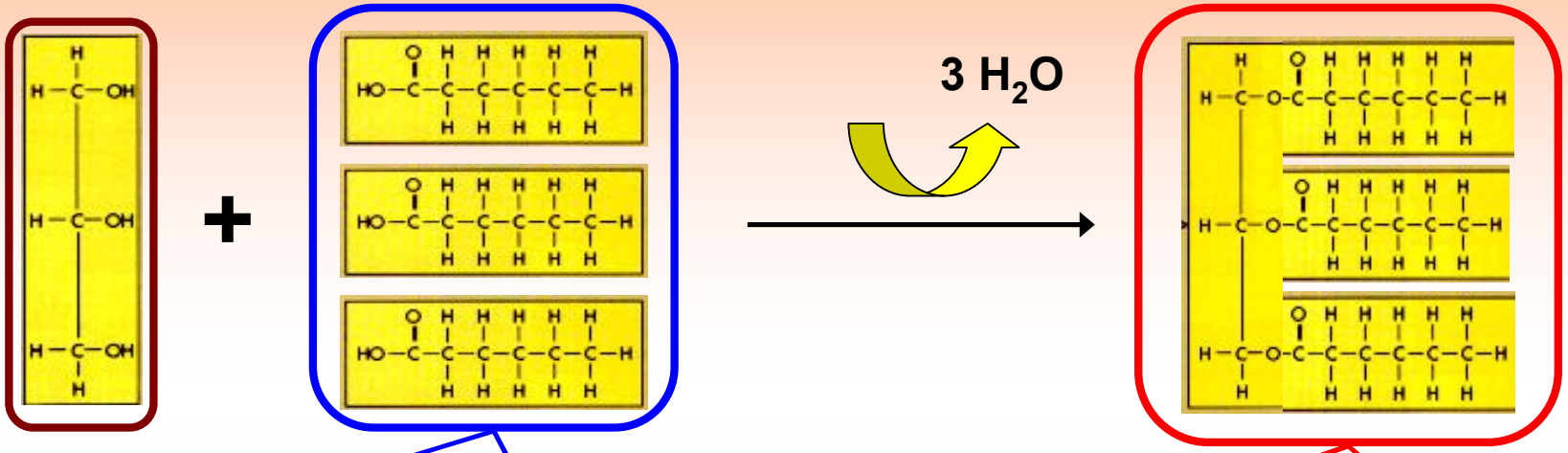
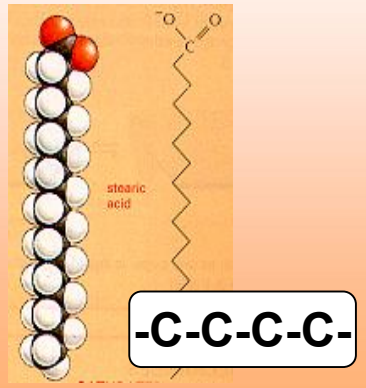
Lipids derived from glycerol

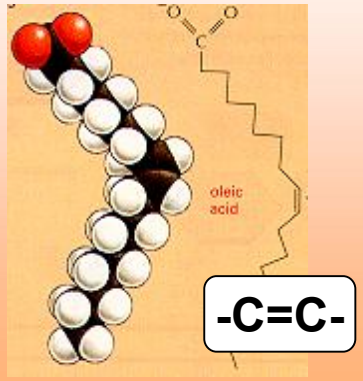
Glycerol and **3 fatty acids** form together molecules of **triacylglycerol** :



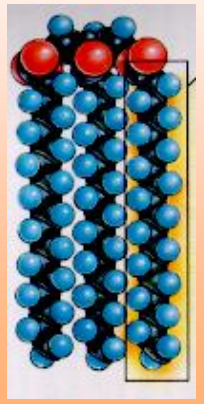
Saturate fatty acids



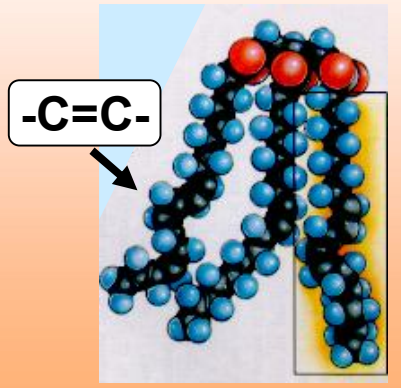
Unsaturated fatty acids



Saturate triacylglycerol



Unsaturate triacylglycerol



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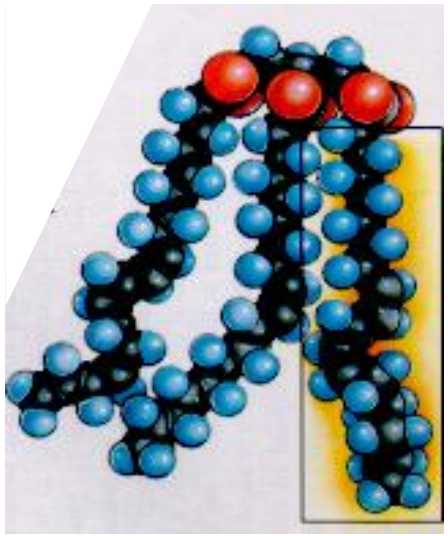
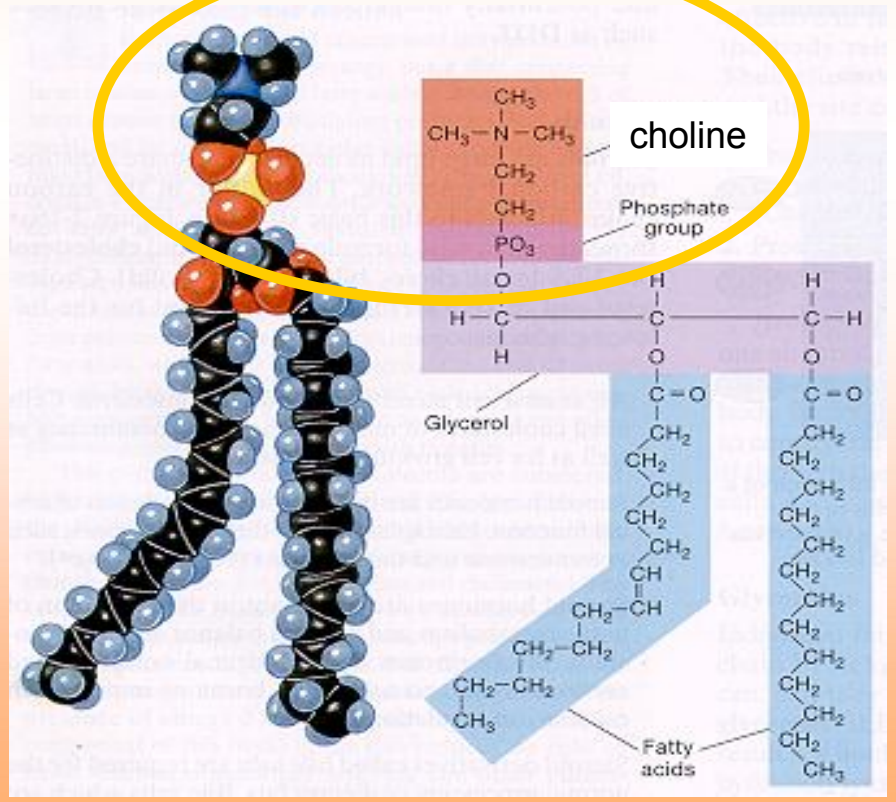
Lipids derived from glycerol

TRIACYLGLYCEROL



Fatty acid
in triacylglycerol
can be substituted
by a different molecule

In **phospholipids** two of –OH groups in glycerol are linked to fatty acids, while the **third –OH group is linked to phosphoric acid PO_4^{3+}.**
The phosphate is further linked to one of a variety of small polar groups [alcohol, choline]



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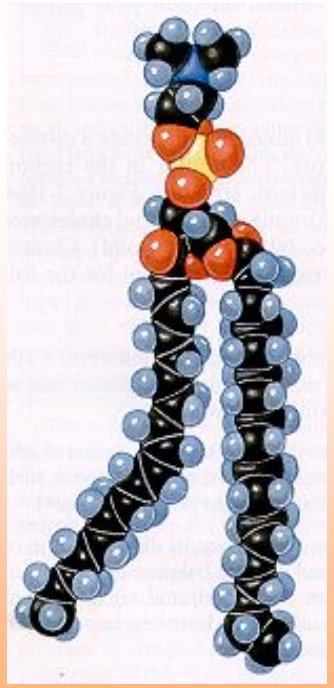
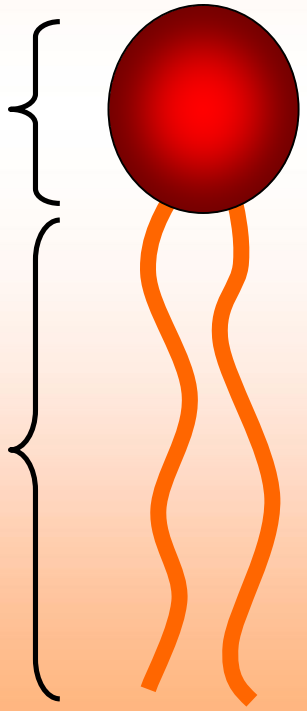
PHOSPHOLIPIDS: overview

- Most abundant membrane lipids. They form **membrane backbone**
- Contains **phosphate group** linked to other small polar molecule
- They are **amphipathic:** containing both **hydrophilic** and **hydrophobic** domain



Hydrophilic ("water lowing"),
polar, electrically charged region:
phosphate head

Hydrophobic ("water hating"),
nonpolar region:
fatty acids tails



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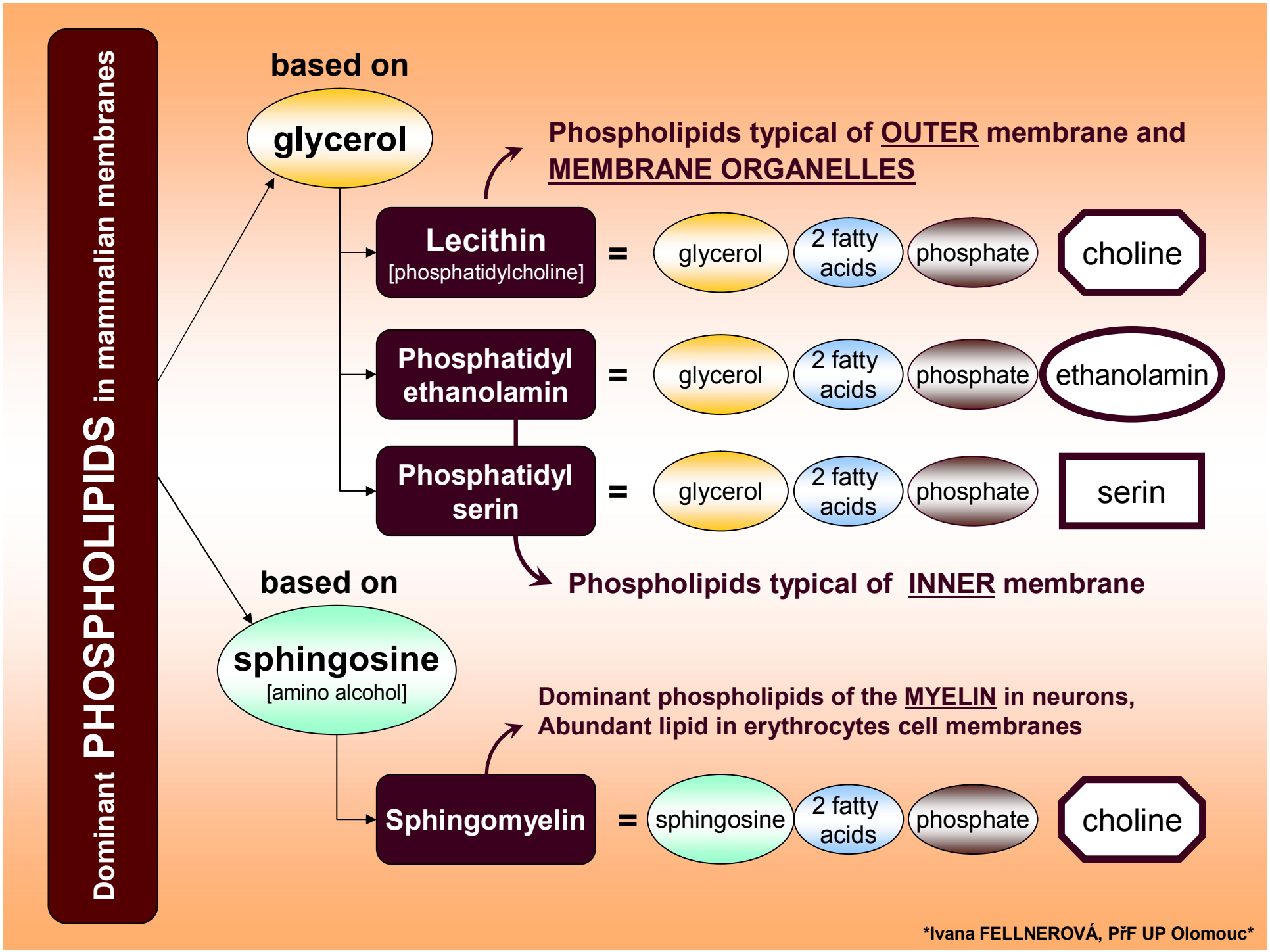
Dominant PHOSPHOLIPIDS in mammalian membranes
based on
glycerol
Phospholipids typical of OUTER membrane and MEMBRANE ORGANELLES
Lecithin
[phosphatidylcholine]
=
glycerol
2 fatty acids
phosphate
choline
Phosphatidyl ethanolamin
=
glycerol
2 fatty acids
phosphate
ethanolamin
Phosphatidyl serin
=
glycerol
2 fatty acids
phosphate
serin
Phospholipids typical of INNER membrane
based on
sphingosine
[amino alcohol]
Dominant phospholipids of the MYELIN in neurons,
Abundant lipid in erythrocytes cell membranes
Sphingomyelin
=
sphingosine
2 fatty acids
phosphate
choline
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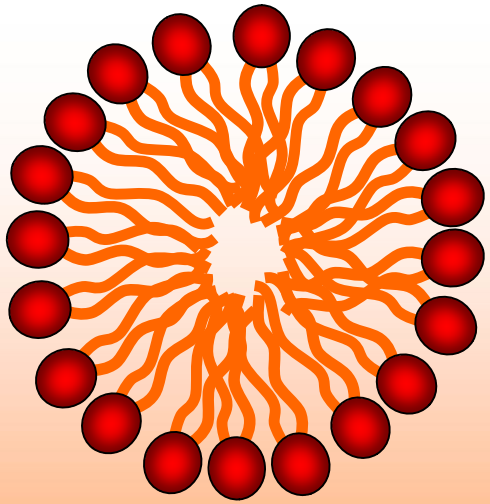
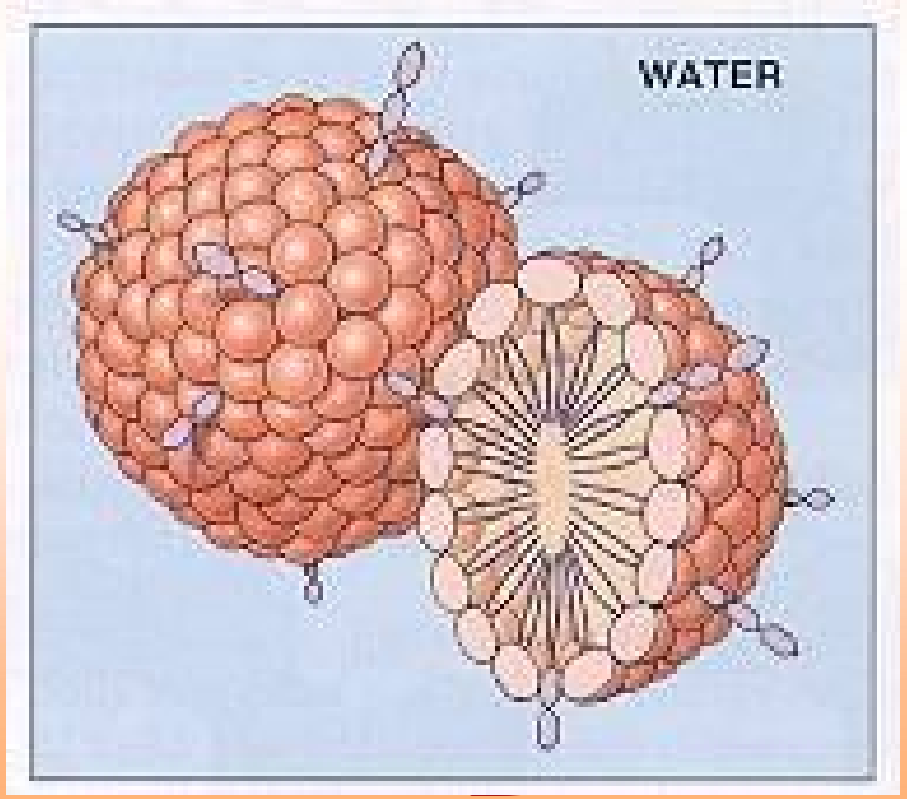
PHOSPHOLIPIS and water

Phospholipids spontaneously associate with one another to exclude water from contact with the hydrophobic region of the lipid molecule.

- Form **spherical micelles** with the hydrophobic fatty acids tails inside



MICELLES



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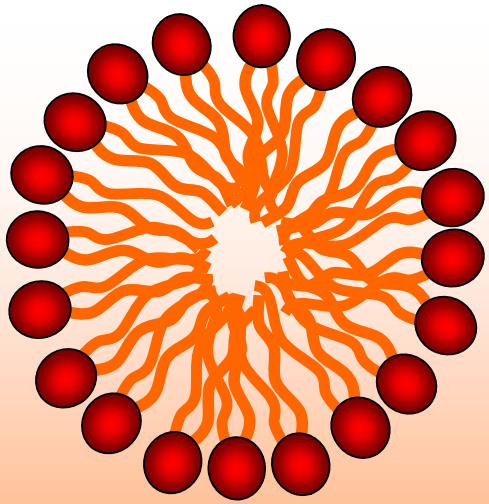
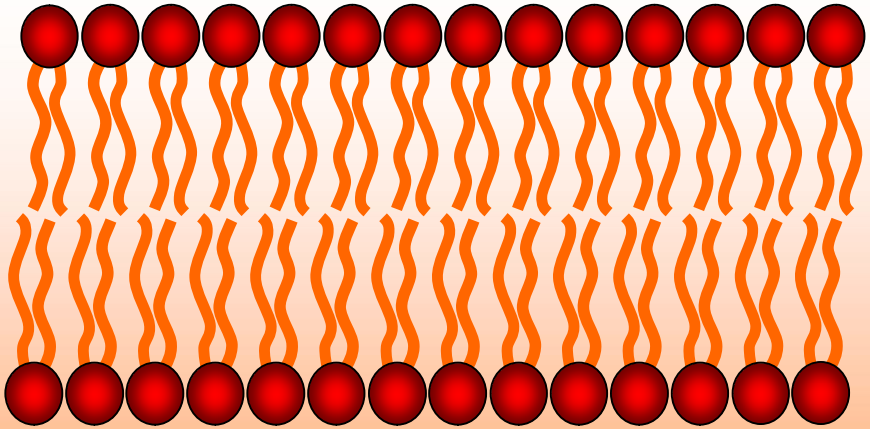


MICELLES

- **Form bimolecular sheets - bilayers, with hydrophobic fatty acid tails pointing toward each other and the polar regions facing the outside.**



bilayer

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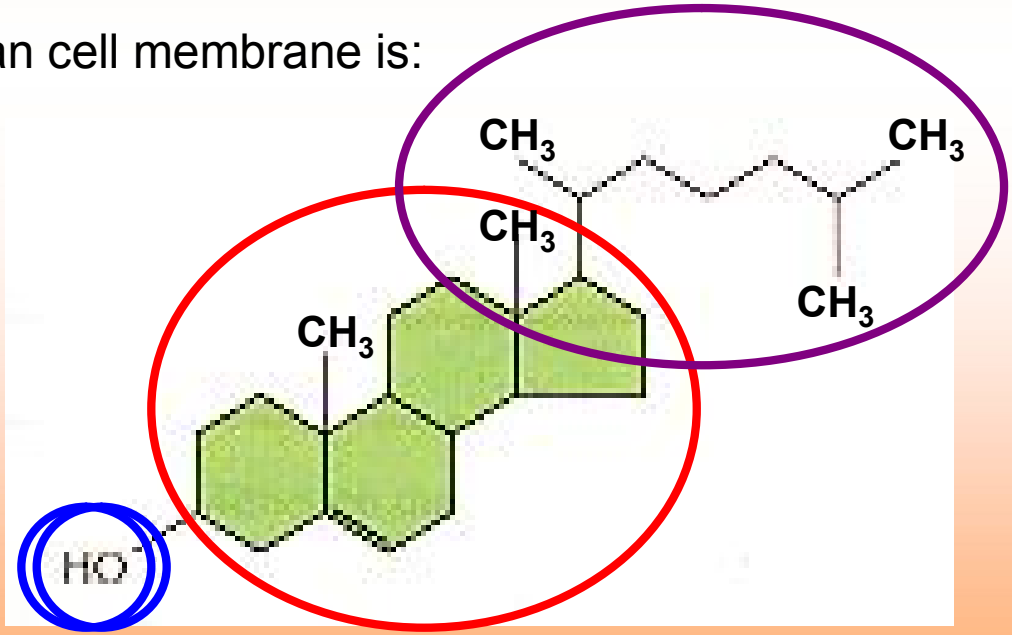
2. Steroid lipids in the membrane:

Structure of steroids

- multiple linked **aromatic rings**
- **hydroxyl** [phenol] **group**
- the hydrocarbon part is **hydrophobic**
- hydroxyl group is **hydrophilic**

The typical steroid of the mammalian cell membrane is:

Cholesterol



- ❖Enhance the permeability barrier properties of the lipid bilayer
- ❖Makes lipid bilayer less deformable
- ❖Prevent hydrocarbon chains from coming together
- ❖Key regulator of membrane fluidity

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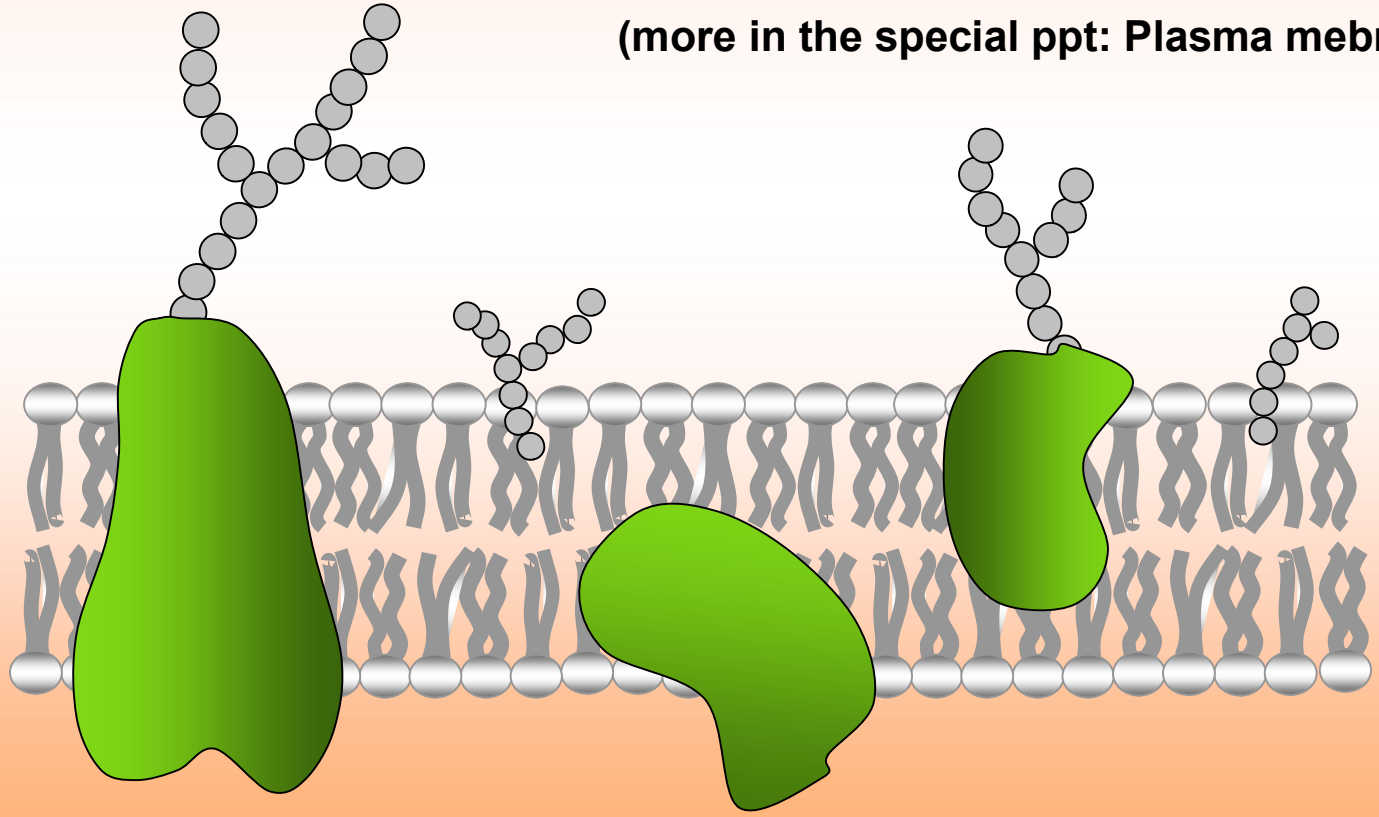
PROTEINS in plasma membranes

Protein performs most of the specific functions of the membrane

(more in the special ppt: Plasma mebrane: function)



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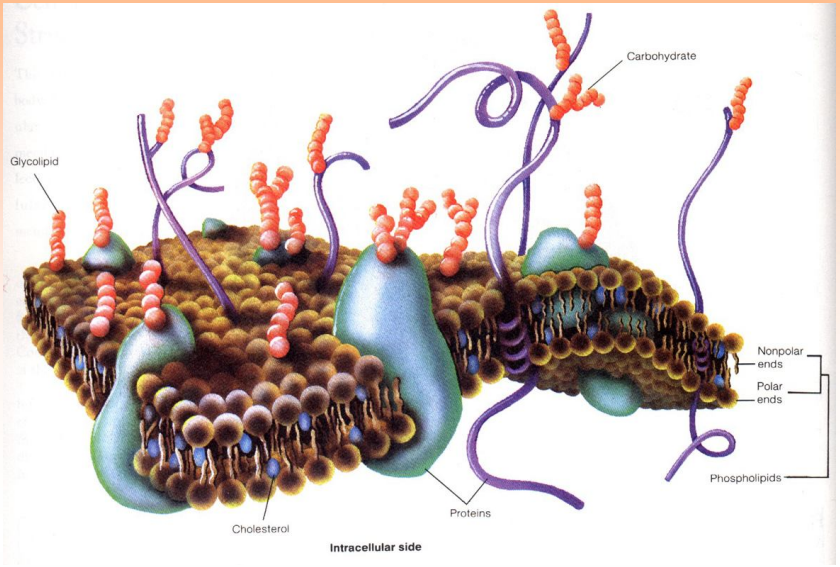
MEMBRANE PROTEIN: overview

- Constitute about **50% of the mass** of of typical plasma membrane in animals
- **Amounts** and **types** of proteins in membranes are **highly variable**



- **Integral (intrinsic) membrane proteins**
  Transmembrane (membrane spanning proteins) or membrane assiciated proteins
- **Periferal (extrinsic) membrane proteins**
  Protein attached to other integral protein or linked to polar region of membrane lipids
- Protein performs most of the **specific functions** of the membrane; gives each type of membrane its characteristic functional properties
  (**Receptors**, **Transporters**, **Structure support, Enzymes, Cell markers**)

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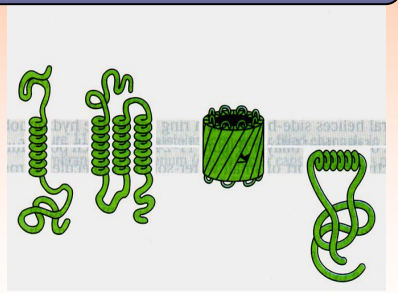
Clasification of membrane protein according to structure

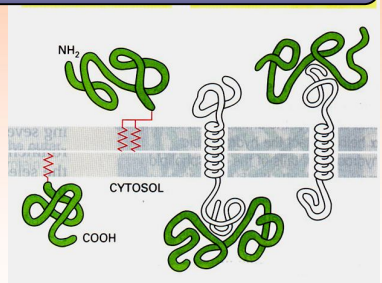
INTEGRAL [intrinsic] proteins

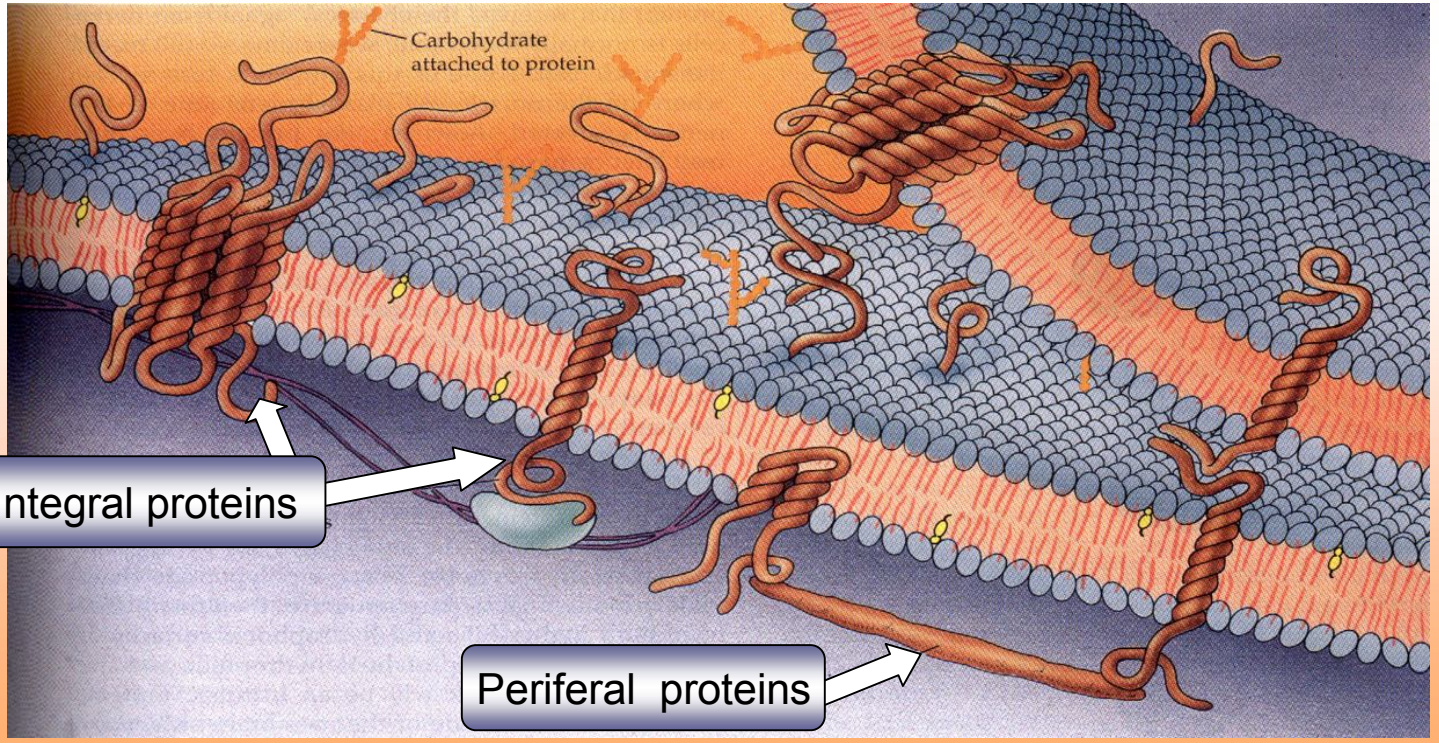
- Transmembrane [membrane spanning]
- Membrane associated [extend only partway]



PERIFERAL [extrinsic] proteins

- Protein attached to other integral protein
- Linked to polar regions of membrane lipid





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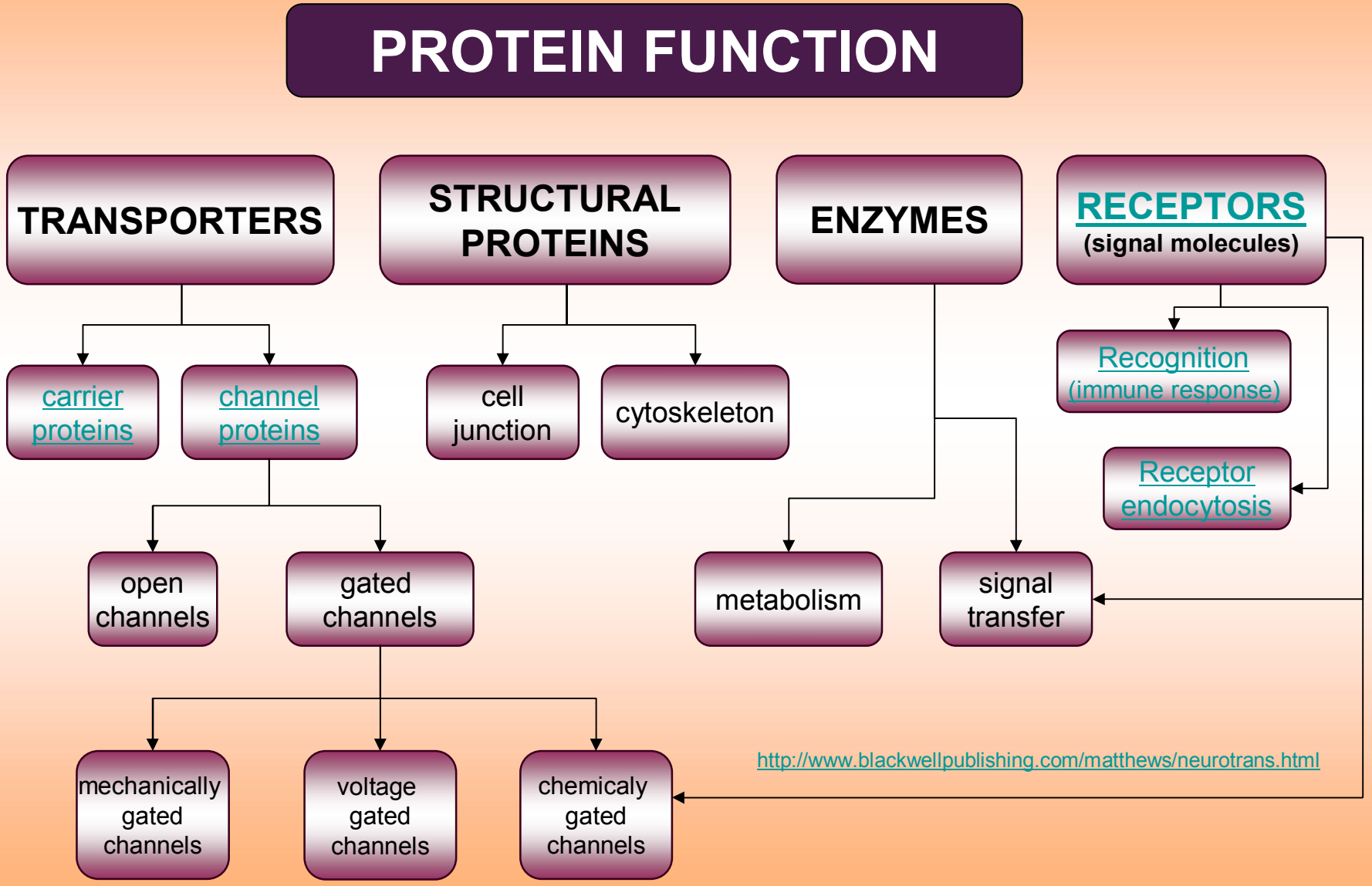
Functional types of the membrane proteins



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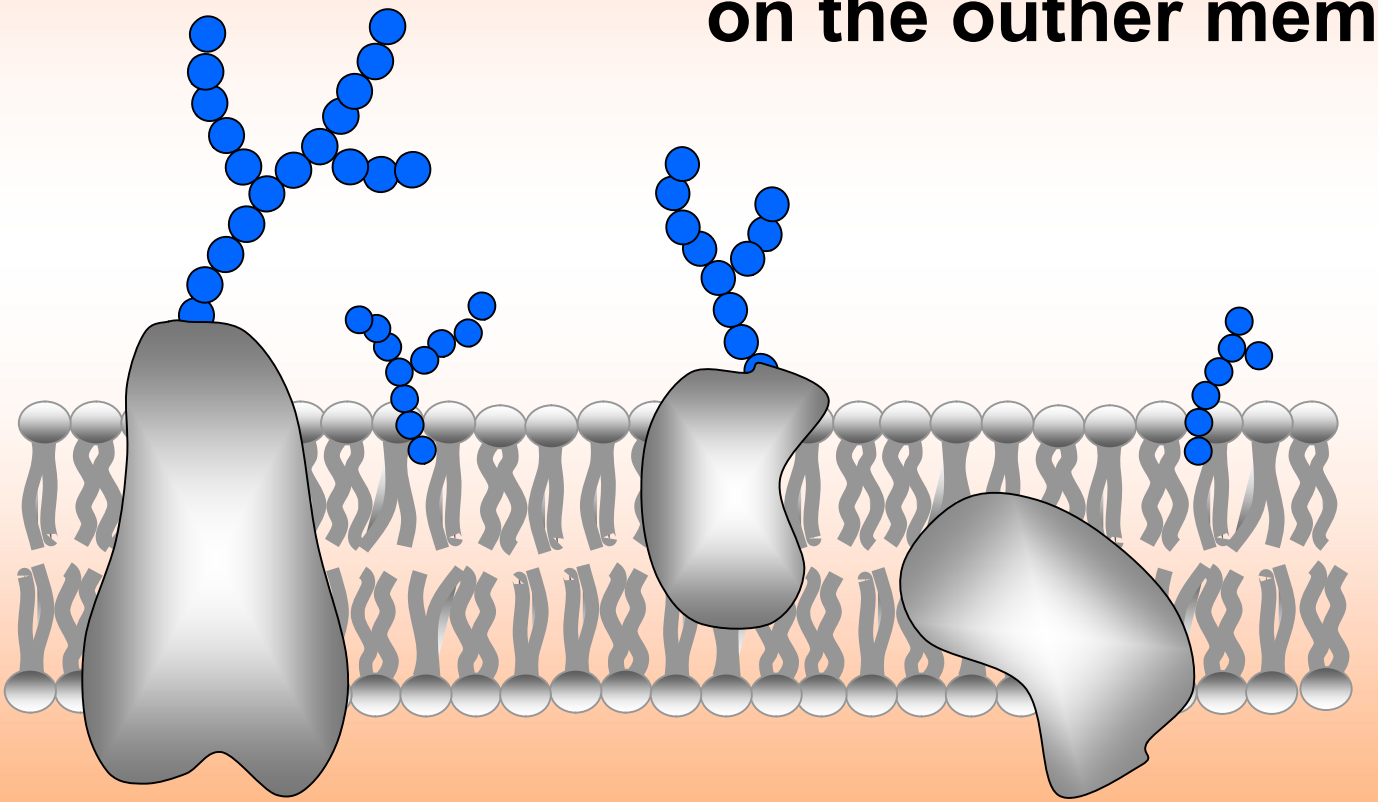
CARBOHYDRATES in plasma membranes

Protection and specific functions on the outher membrane



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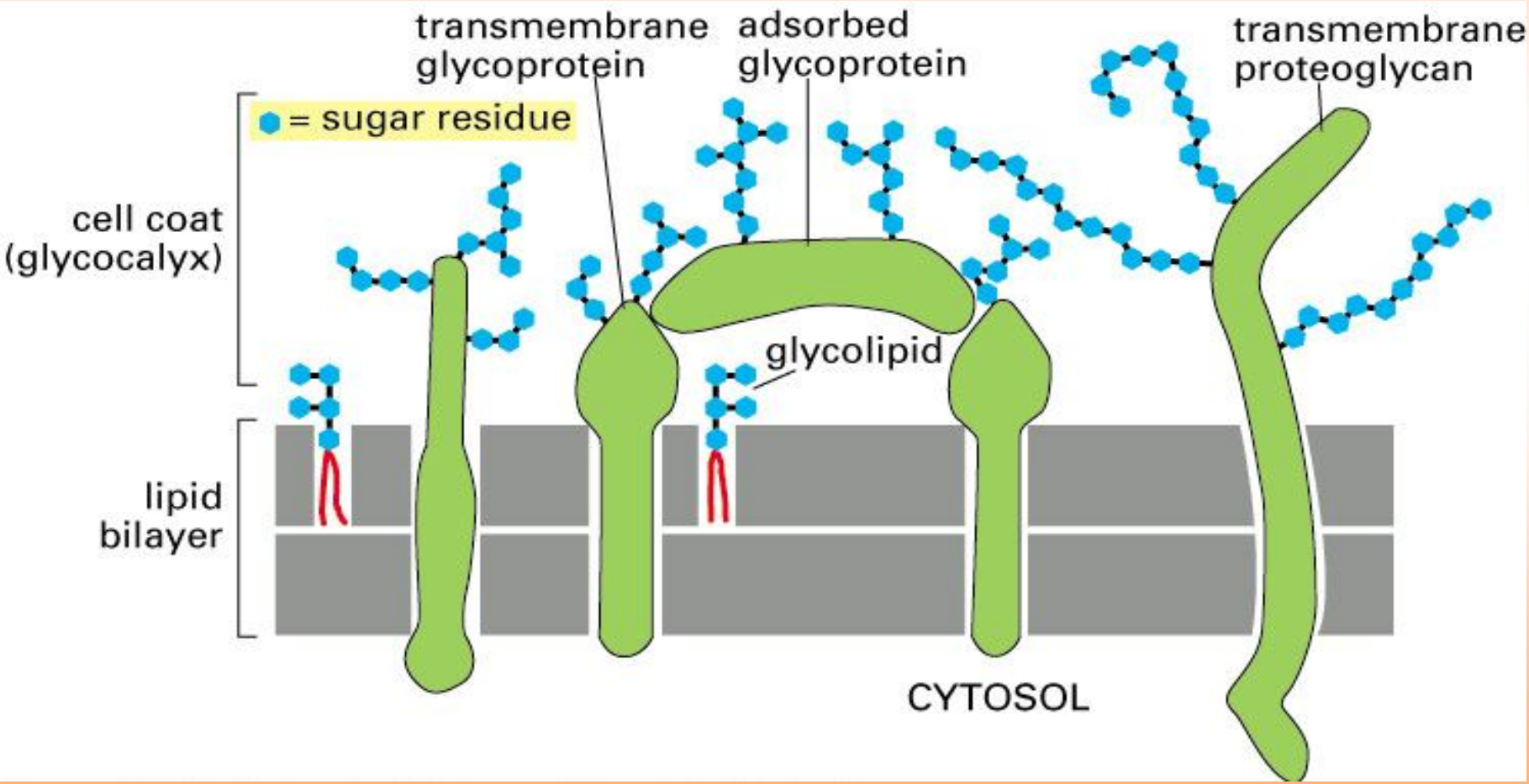
CARBOHYDRATES in plasma membrane

Carbohydrates are primarily attached to the outer surface of the membrane as glycoproteins and glycolipids.



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Glycocalyx

- Coating of molecules external to the cell wall, made of sugars and/or proteins
- 2 types
  - capsule - highly organized, tightly attached - thickest
  - slime layer - loosely organized and attached – thinnest
- Functions
  - attachment
  - inhibits killing by white blood cells
  - receptor

FUNCTION of membrane carbohydrates

PROTECTION

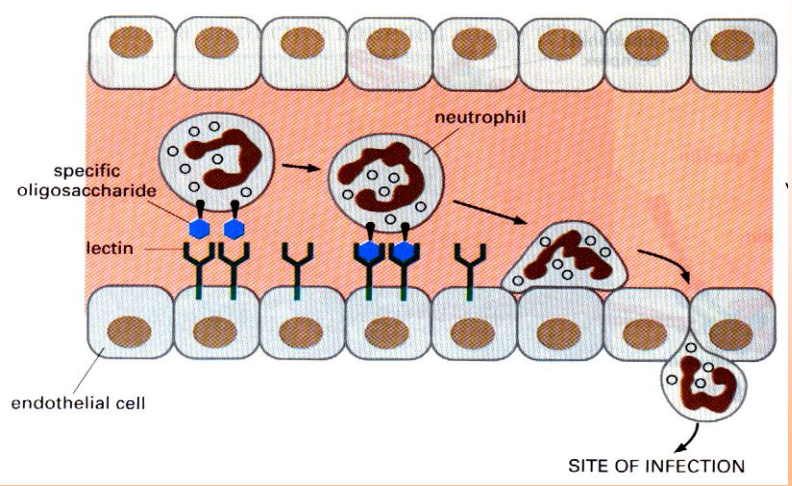
Carbohydrates protect the cell surface from mechanical and chemical damage [creating **glycocalyx** = cell carbohydrate rich coat]

ROLE IN "CELL – CELL" RECOGNITION

Particular oligosaccharide chains can be recognized by **lectins** [= carbohydrate binding proteins].

Lectins mediate a variety cell-cell adhesion processes

- sperm-egg interaction
- blood clotting
- lymphocyte recirculation
- inflammatory response



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MEMBRANE
as a fluid mosaic

- A membrane is **not a static sheet** of molecules locked rigidly in one place
- Membrane molecules are held together primarily by **weak hydrophobic interaction**
- Most lipids and some membrane proteins are **constantly in lateral motion**
- A biological membrane is in fact a **two dimensional liquid** of oriented lipids and globular proteins

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Membraine as a FLUID MOSAIC

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and some membrane proteins
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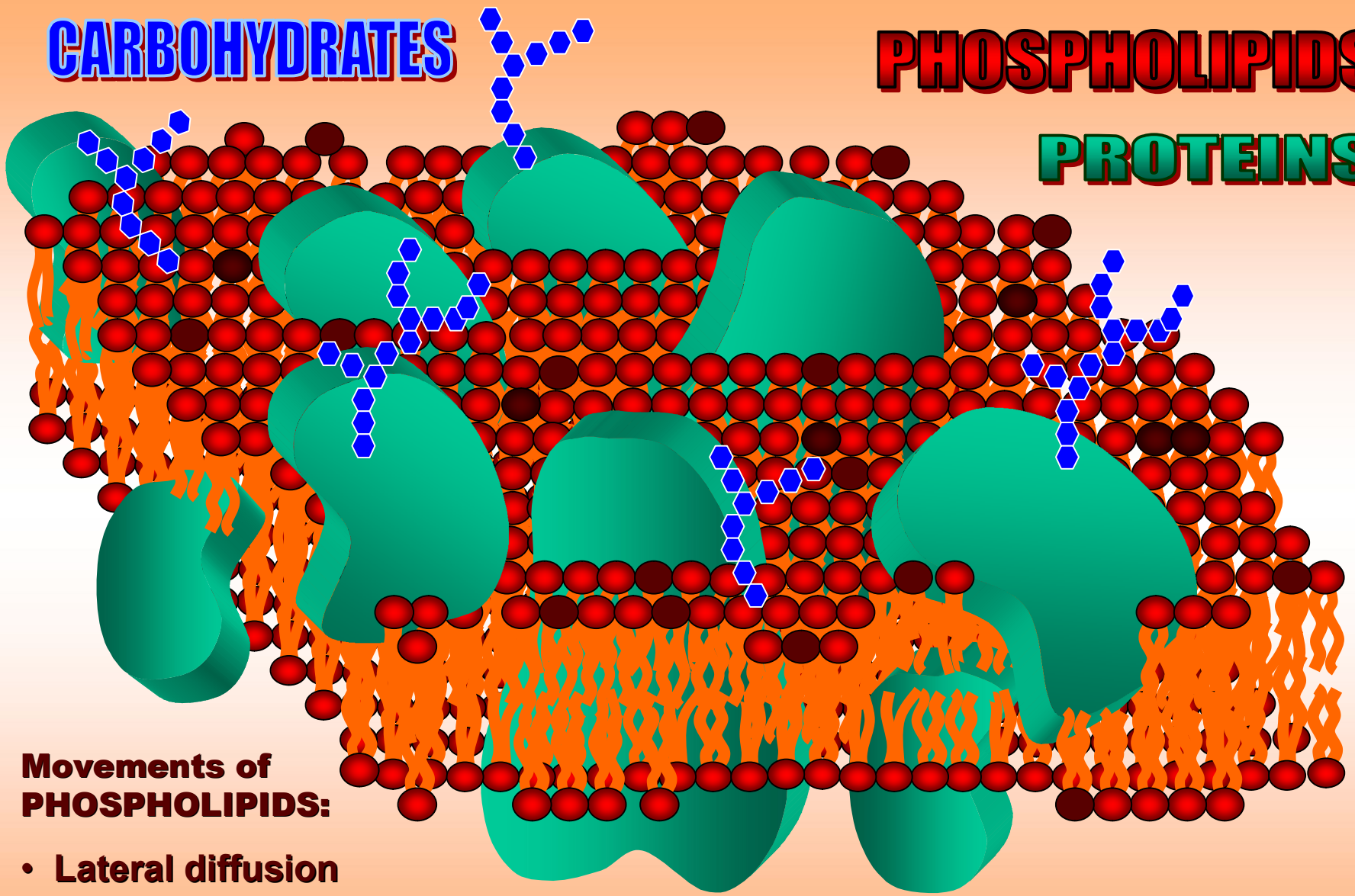

Movements of PHOSPHOLIPIDS:

- **Lateral diffusion**
- **Rotation** • **Bobbing**
- **„Flip-flop motion**

PROTEIN movements: migration synthesis, extinction

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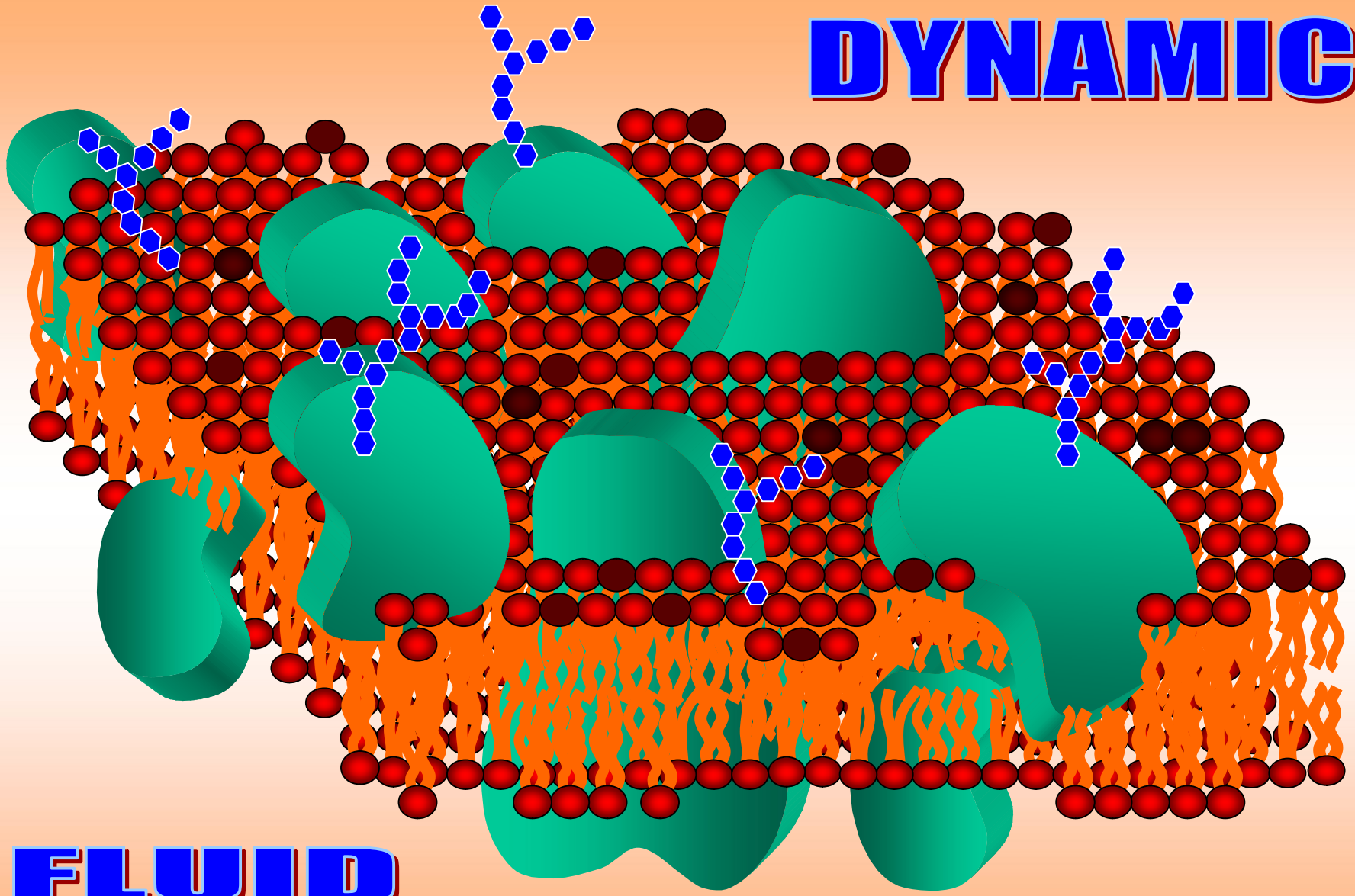
DYNAMIC



FLUID MODEL

In the lipid “lake”
float a variety of proteins

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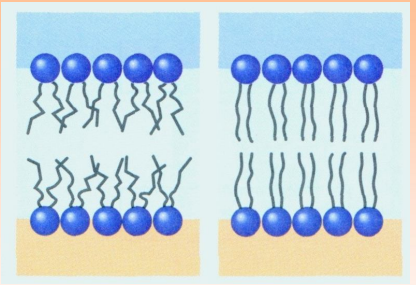
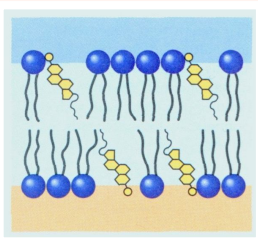
Factors influencing MEMBRANE FLUIDITY:

Composition:



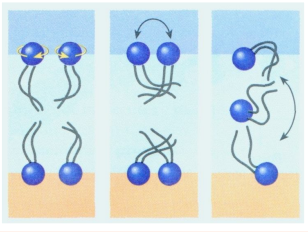
- number of **double bonds** and length of fatty acid chains: **Unsaturated phospholipids ↑ fluidity**
  Saturated phospolipids ↓ fluidity

- amount of **cholesterol**



Cholesterol ↓ fluidity

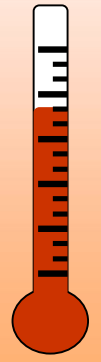
- phospholipids **movements**



Movements ↑ fluidity

Temperature:

"**Melting point**" is the critical temperature.
Below it membranes solidify. Fatty acids with short and unsaturated chains have lower melting points



Temperature ↑ fluidity

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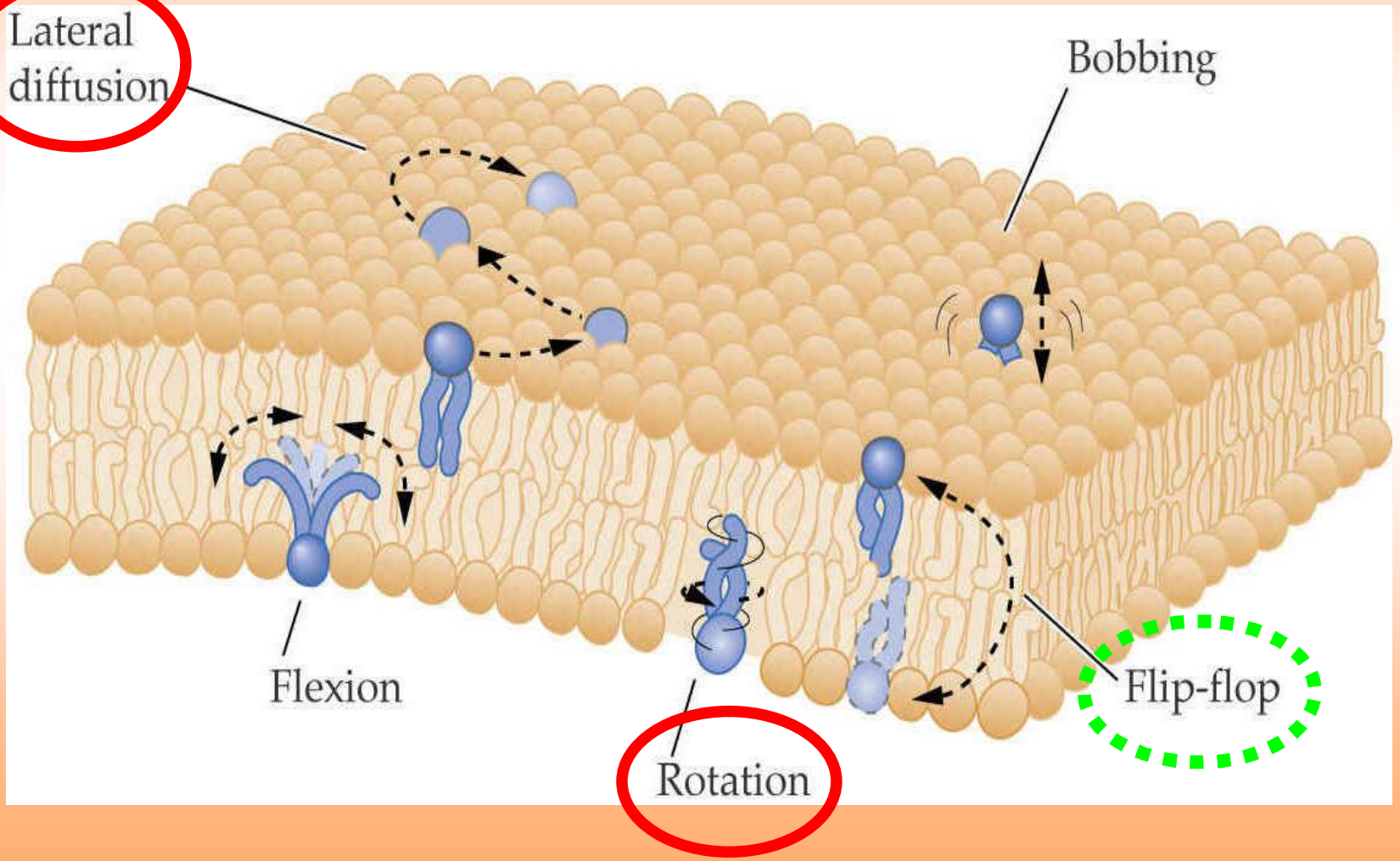
Phospholipid movements

The most common movements

Very rare movements



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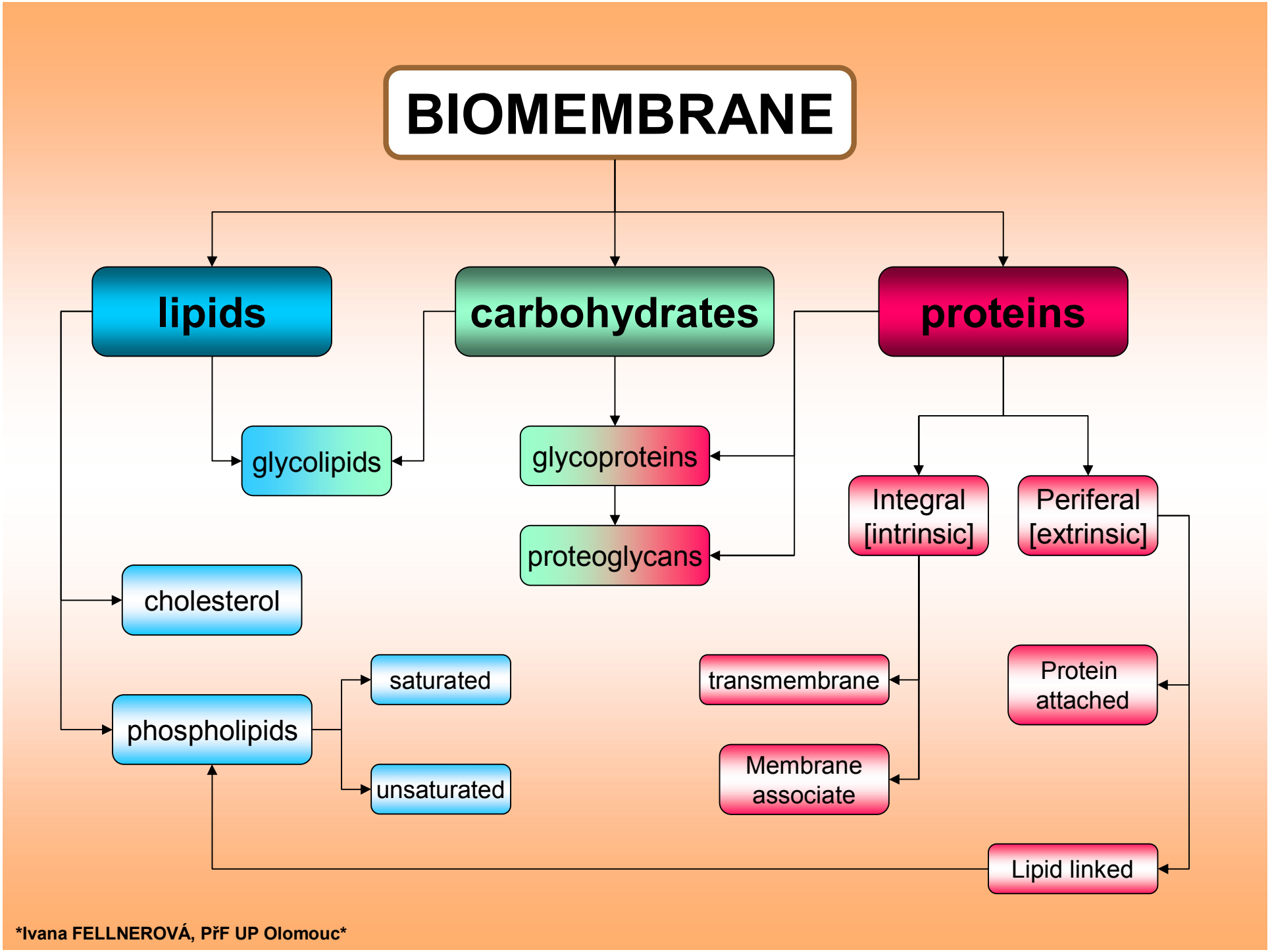

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