Structure of the Plasma Membrane Lecture-3

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Structure of plasma membrane

Proteins in plasma membrane

Types of membrane proteins

Integral proteins

- They are firmly associated with plasma membrane.

- They can either be trans membrane proteins i.e. Spanning the total thickness of the membrane or found associated with only one of the monolayers.

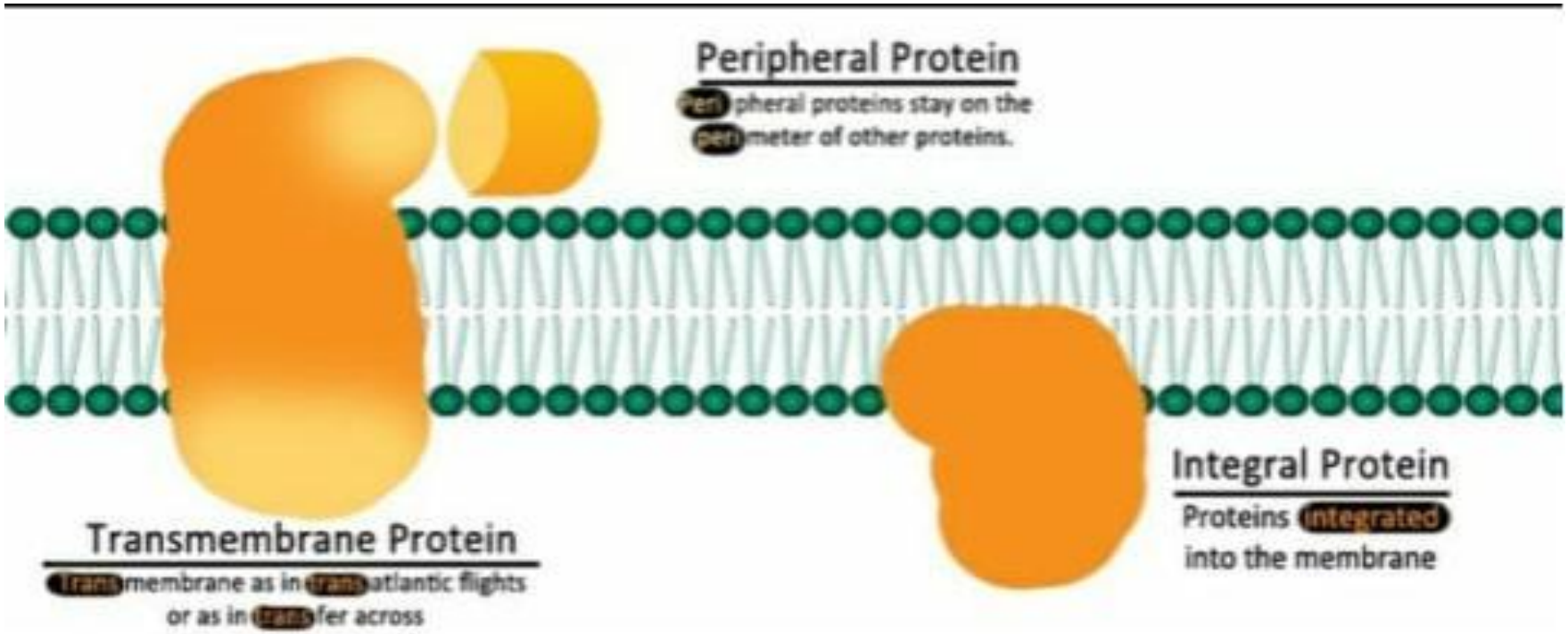
- They are associated with the membrane mainly by hydrophobic interactions but can also be found using covalent bonds.

Peripheral proteins

- They are found on the surface of the monolayers.

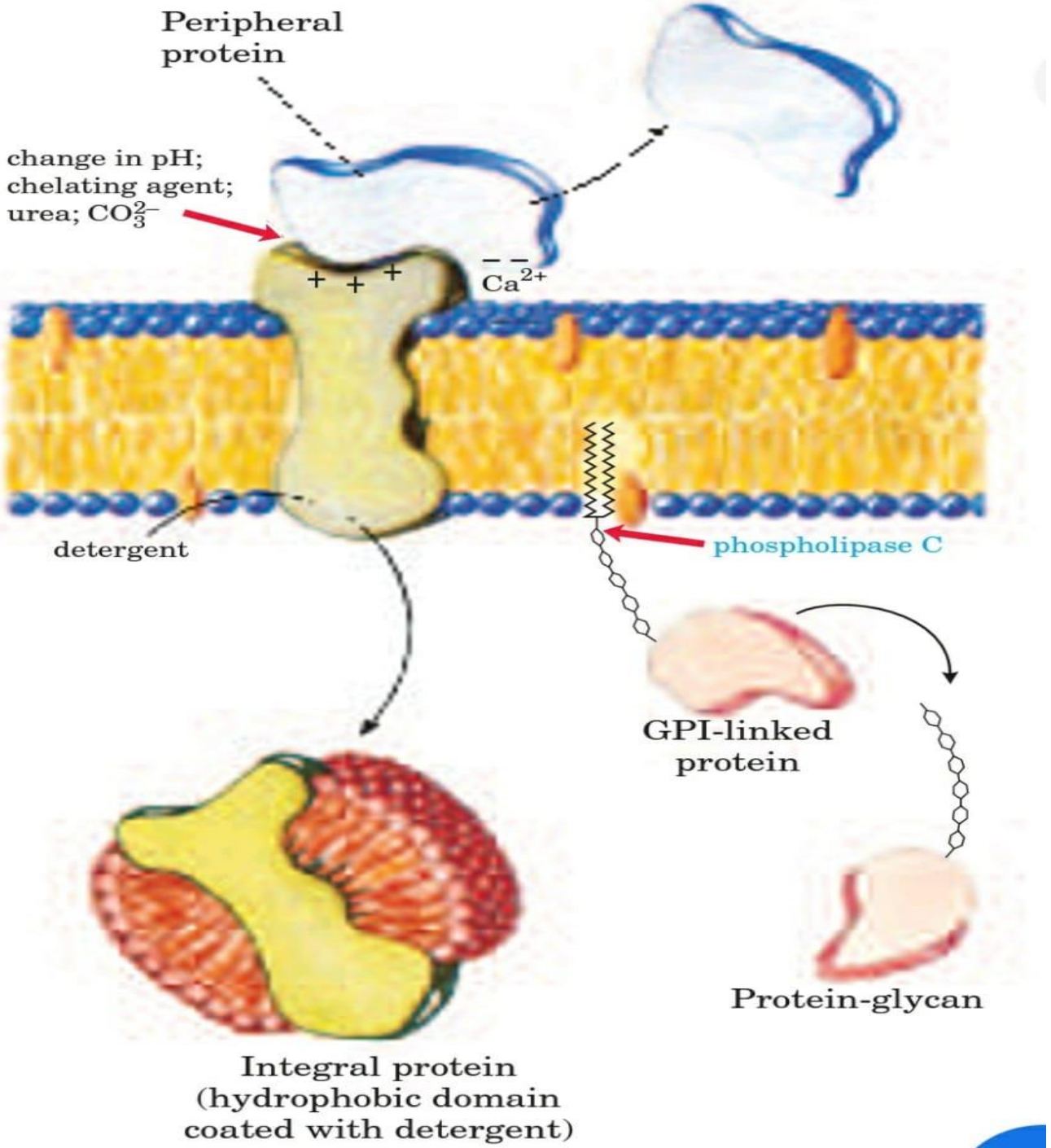
- They are associated with the membrane by electrostatic interactions and hydrogen bonds.

- These interactions are formed with hydrophilic domains of integral membrane and with the polar head group of membrane lipids.



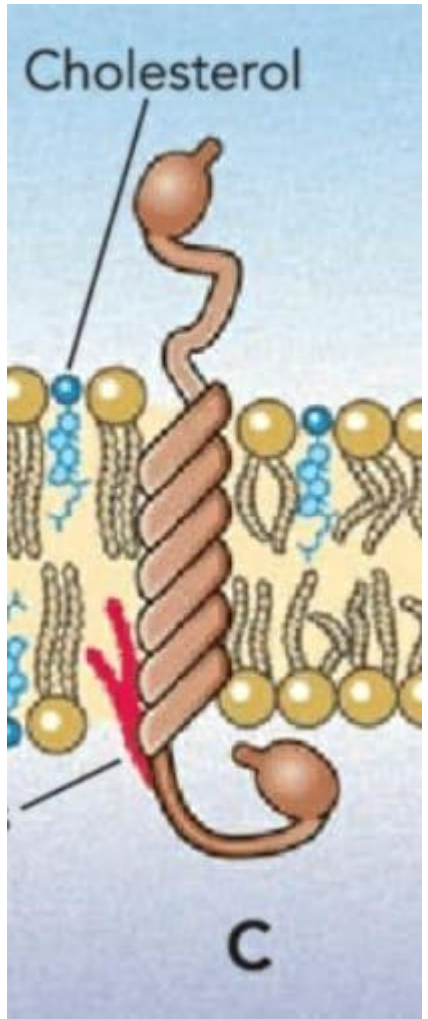
Removing proteins from membrane

- For this basic requirement is to disturb the interactions that are holding the protein in the membrane.
- For integral membrane proteins that are held by hydrophobic interactions, agents that disturb these interactions are used. These include detergents, organic solvents and denaturants.
- If integral membrane protein is held by some covalent interaction then enzymes that can cleave such interactions are used. E.g. Phospholipases such as phospholipase C.
- For peripheral proteins agents that disturb the electrostatic interactions and hydrogen bonds are used.
- These agents include carbonate solution at high pH or sodium chloride solution or urea solution

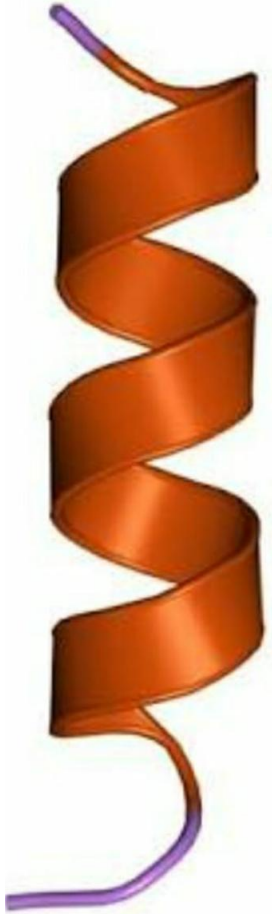

Peripheral protein
change in pH; chelating agent; urea; CO_3^{2-}
Ca^{2+}
detergent
phospholipase C
GPI-linked protein
Protein-glycan
Integral protein (hydrophobic domain coated with detergent)

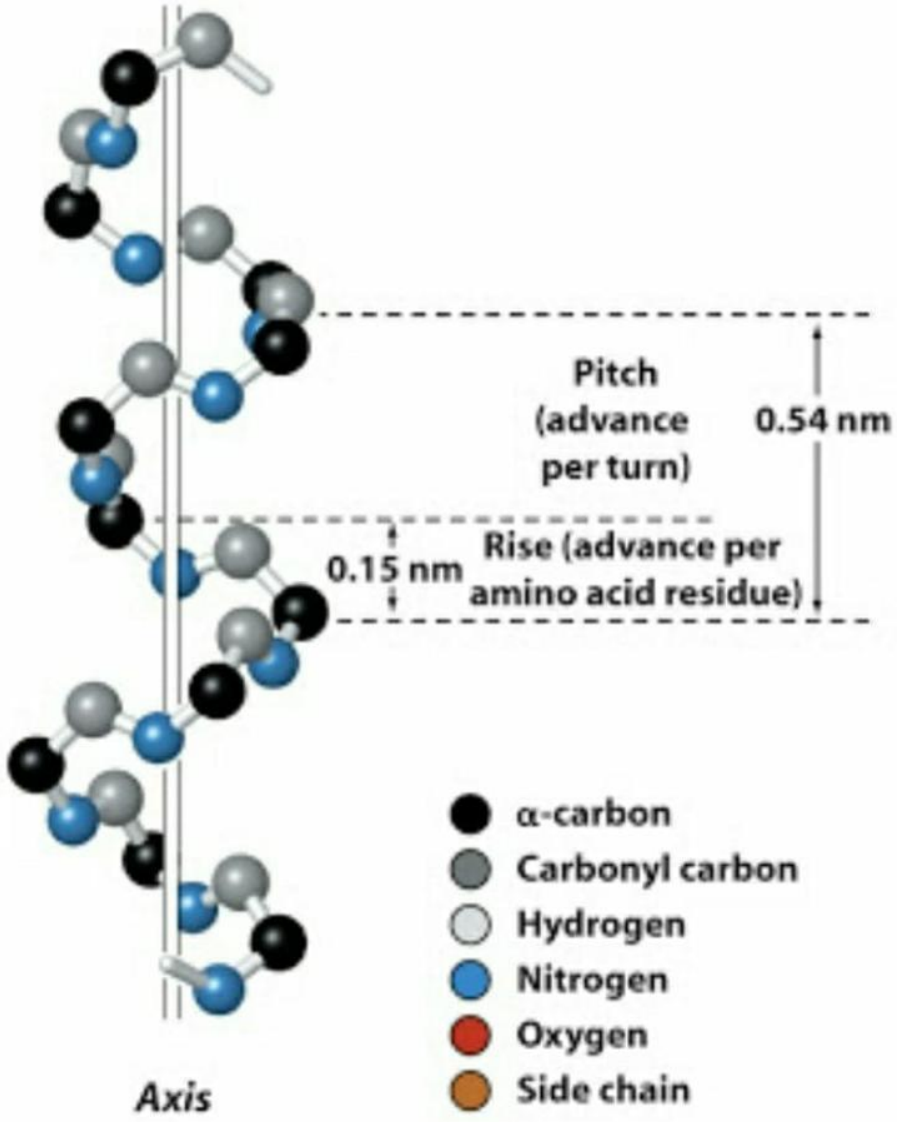
Integral membrane proteins that are transmembrane

- They span the total thickness of the bilayer.
- Their transmembrane region can have either alpha helix or beta sheets.
- Those having alpha helix are more common.
- A single transmembrane alpha helix is about 20 amino acids long.
- The adjoining figure shows the transmembrane protein with a single alpha helix.



Why 20 amino acids?





Alpha helix in plasma membrane is like spring and should be imagined like this rather than like jalebi.

Question: Thickness of the plasma membrane is 3 nm and rise of alpha helix per amino acid is 0.15 nm. Then calculate the number of amino acids needed in alpha helix to completely cross the plasma membrane.

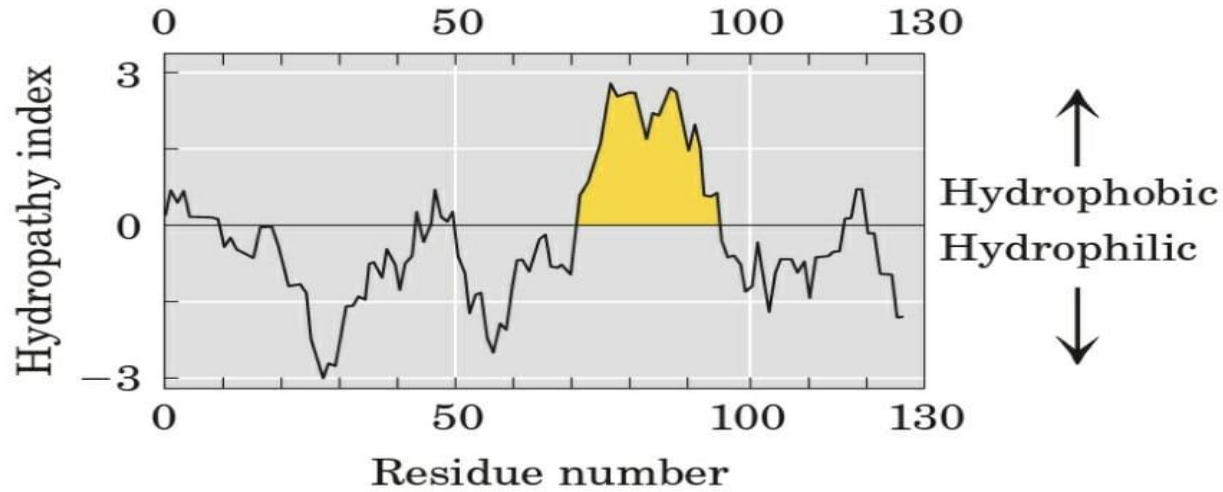
How to find transmembrane region in a given protein?

- To find this we plot hydropathy index for the side chain of each amino acid.

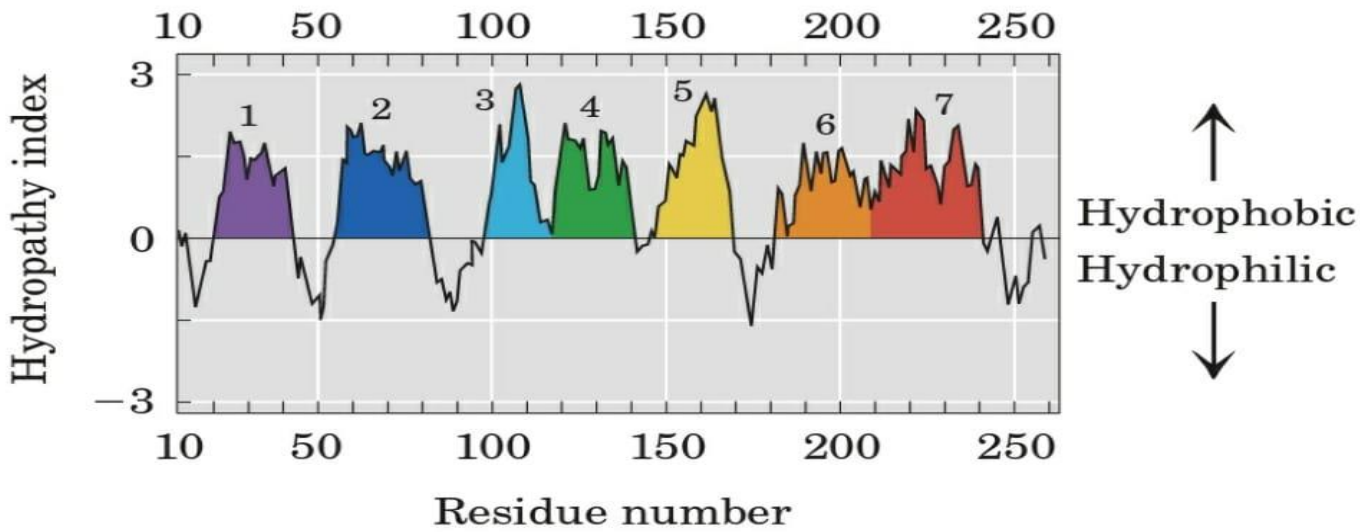
- Free energy change while transfer of amino acid side chain from hydrophobic solvent into water is measured.
- It is highly exergonic for polar and charged side chains while highly endergonic for hydrophobic side chains.

- When we plot this for entire protein sequence we have hydropathy index.

- If we find a stretch of hydrophobic amino acids that is at least 20 amino acids long then such region is likely to be transmembrane.



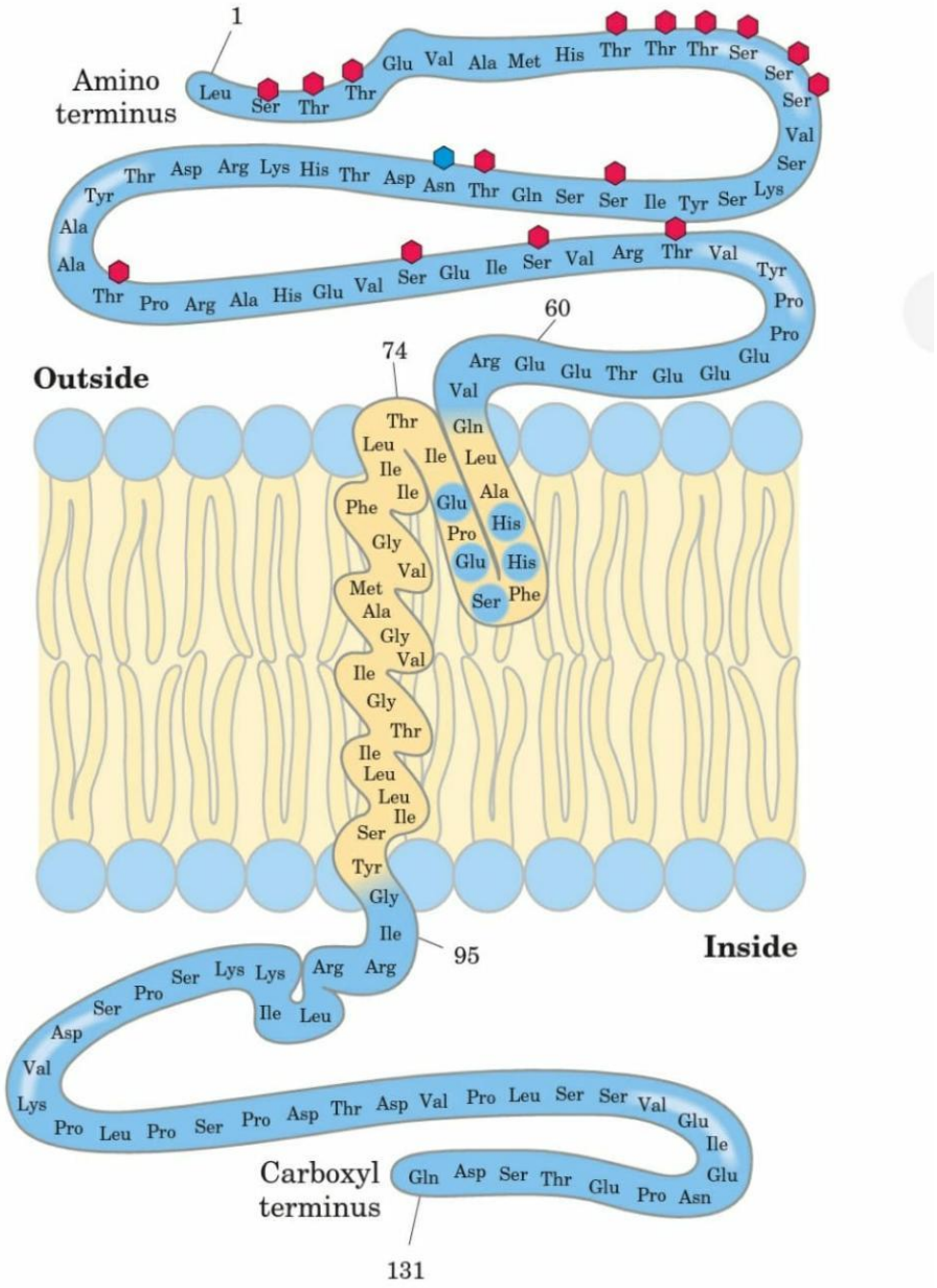
(a) Glycophorin



(b) Bacteriorhodopsin

Glycophorin and membrane topology

- Glycophorin is found in RBC membrane and is example of transmembrane protein with a single transmembrane region.
- This transmembrane region contains alpha helix conformation.
- Another common example of membrane protein with alpha helical transmembrane regions is Bacteriorhodopsin. It has 7 transmembrane alpha helices.
- Glycophorin is a commonly used model for study of membrane protein topology.
- Membrane protein topology refers to protein localisation relative to lipid bilayer.



For this we use reagents that react with protein chains but can not cross the bilayer.

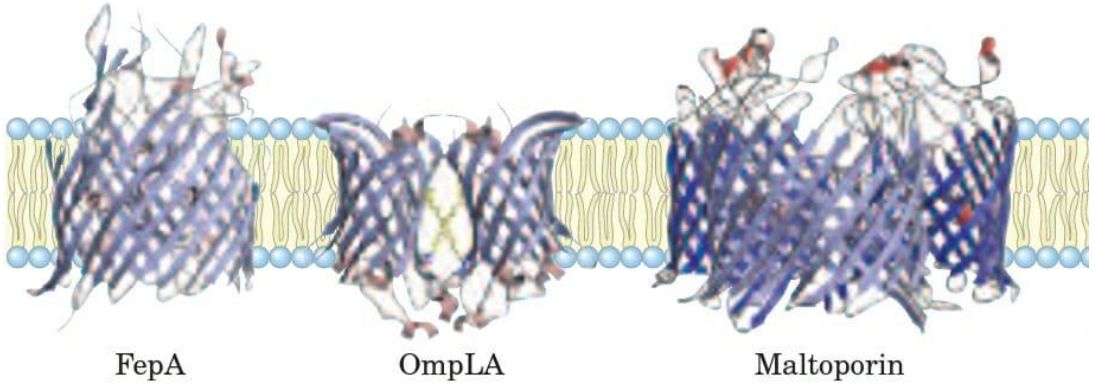
E.g. Enzymes like trypsin that cleave the protein side chain but can't cross the membrane.

Such experiments have revealed that it spans the plasma membrane and it's amino terminal is on the outer surface because only this is cleaved by trypsin.

So by extension carboxyl terminal protrudes in the cytosolic region.

Other examples of transmembrane proteins

- Some proteins also have beta sheets forming barrel like structures that are part of transmembrane region
- Examples: Porins, in Outer membrane of gram negative bacteria such as E.coli
- Other examples are shown below in the figure



Thank you