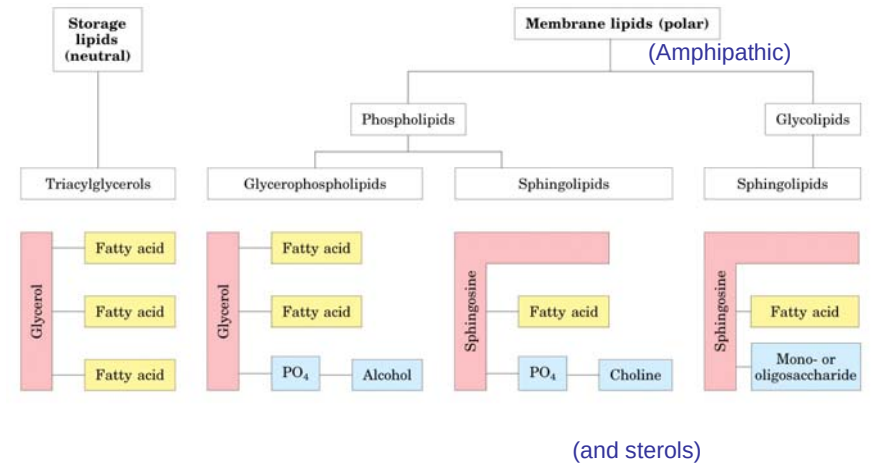


Biological Membranes

- **Proteins** associated with a **lipid** bilayer matrix
- **Functions:**
 - Define external boundary of cell
 - Regulate molecular traffic across
 - Divide internal space into compartments; segregate processes and components
 - Organize complex reaction sequences
 - Energy conservation
 - Cell to cell communication

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1



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Phospholipids form the core of lipid bilayer structure

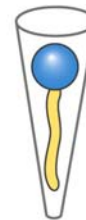
table 12-1

	Components (% by weight)			Sterol type	Other lipids
	Protein	Phospholipid	Sterol		
Human myelin sheath	30	30	19	Cholesterol	Galactolipids, plasmalogens
Mouse liver	45	27	25	Cholesterol	—
Maize leaf	47	26	7	Sitosterol	Galactolipids
Yeast	52	7	4	Ergosterol	Triacylglycerols, steryl esters
Paramecium (ciliated protist)	56	40	4	Stigmasterol	—
E. coli	75	25	0	—	—

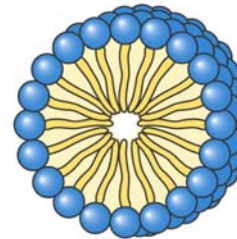
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Fatty acid aggregates



Individual units are wedge-shaped (cross-section of head greater than that of side chain)



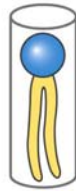
Micelle
(a)

(What's the difference between a soap and a detergent?)

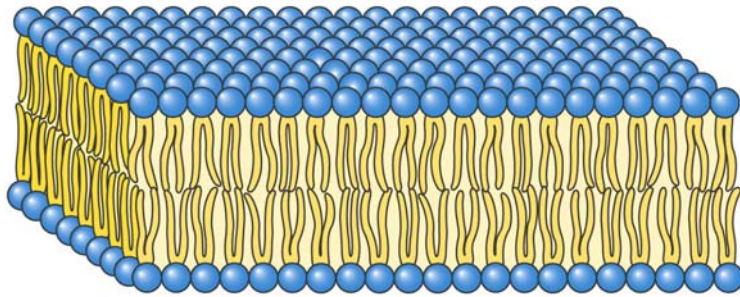
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Phospholipid aggregates

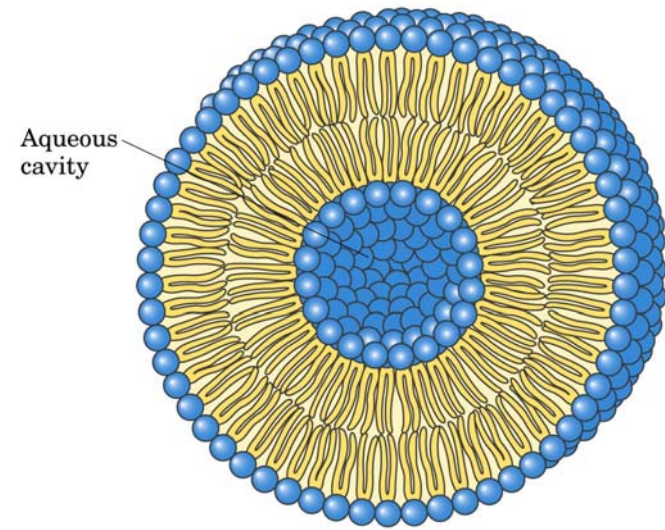


Individual units are cylindrical (cross-section of head equals that of side chain)



**Bilayer
(b)**

5



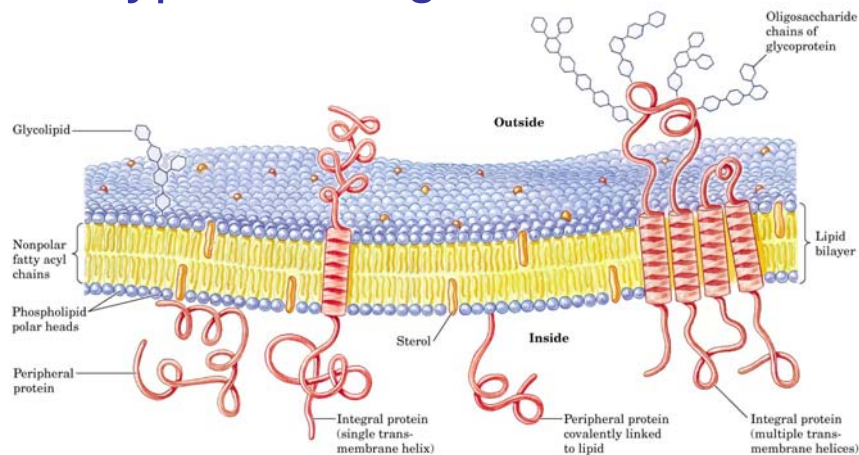
Aqueous cavity

**Liposome
(c)**

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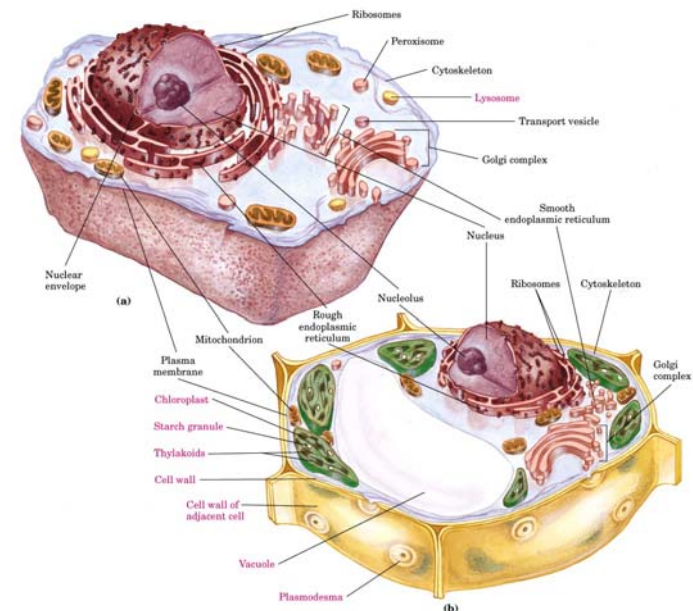
A typical biological membrane



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Compartmentalization

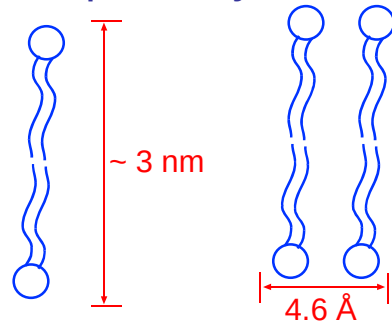


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Properties of phospholipid bilayers

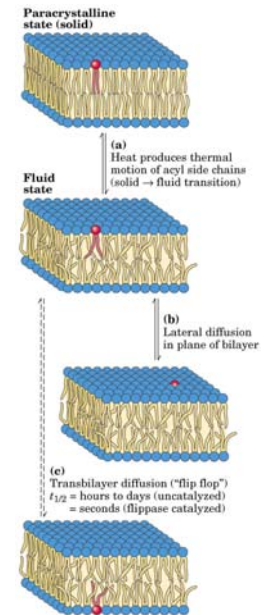
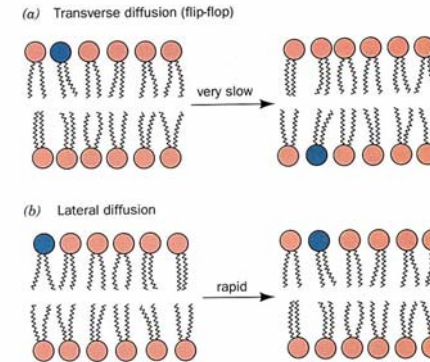
- Components
- Thickness/spacing
- Permeability
- “two-dimensional fluid”
- Fluidity determined by temperature and lipid composition



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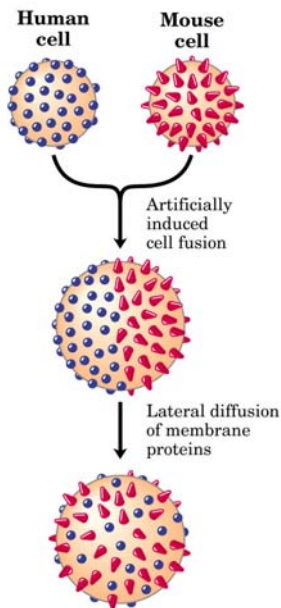
9

Lateral and transverse diffusion of phospholipids



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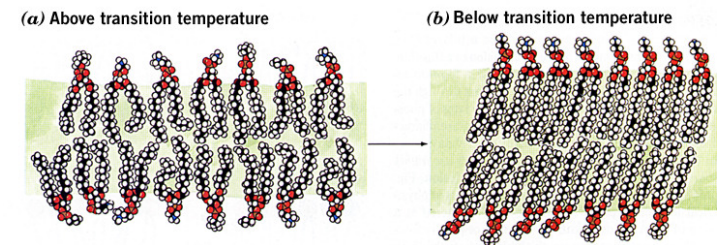
10



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Order-disorder transition



Liquid-crystalline bilayer (para) crystalline bilayer

Rapid motion

Little motion

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table 12-2

Fatty Acid Composition of *E. coli* Cells Cultured at Different Temperatures

	Percentage of total fatty acids*			
	10 °C	20 °C	30 °C	40 °C
Myristic acid (14:0)	4	4	4	8
Palmitic acid (16:0)	18	25	29	48
Palmitoleic acid (16:1)	26	24	23	9
Oleic acid (18:1)	38	34	30	12
Hydroxymyristic acid	13	10	10	8
Ratio of unsaturated to saturated†	2.9	2.0	1.6	0.38

Source: Data from Marr, A.G. & Ingraham, J.L. (1962) Effect of temperature on the composition of fatty acids in *Escherichia coli*. *J. Bacteriol.* **84**, 1260.

*The exact fatty acid composition depends not only on growth temperature but on growth stage and growth medium composition.

†Calculated as the total percentage of 16:1 plus 18:1 divided by the total percentage of 14:0 plus 16:0. Hydroxymyristic acid was omitted from this calculation.

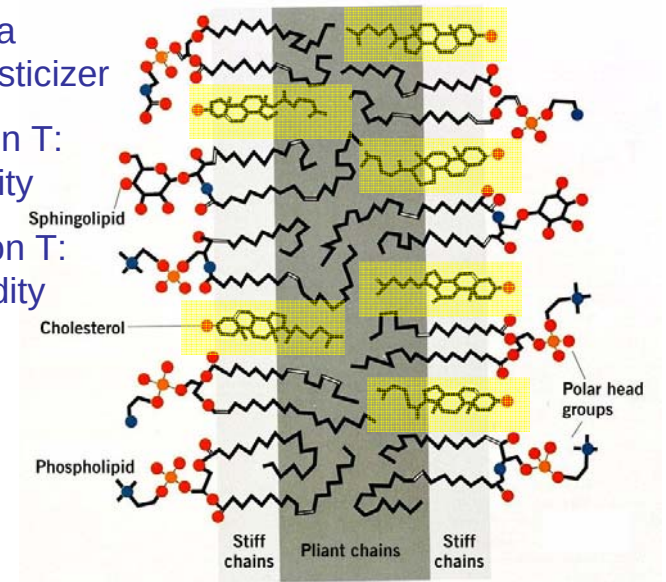
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Cholesterol is a membrane plasticizer

Below transition T:
increases fluidity

Above transition T:
decreases fluidity



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table 12-1

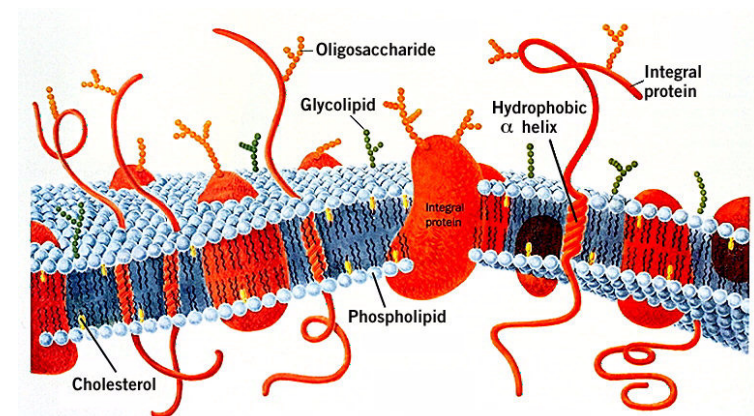
Major Components of Plasma Membranes in Various Organisms

	Components (% by weight)				
	Protein	Phospholipid	Sterol	Sterol type	Other lipids
Human myelin sheath	30	30	19	Cholesterol	Galactolipids, plasmalogens
Mouse liver	45	27	25	Cholesterol	—
Maize leaf	47	26	7	Sitosterol	Galactolipids
Yeast	52	7	4	Ergosterol	Triacylglycerols, steryl esters
<i>Paramecium</i> (ciliated protist)	56	40	4	Stigmasterol	—
<i>E. coli</i>	75	25	0	—	—

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Membrane proteins

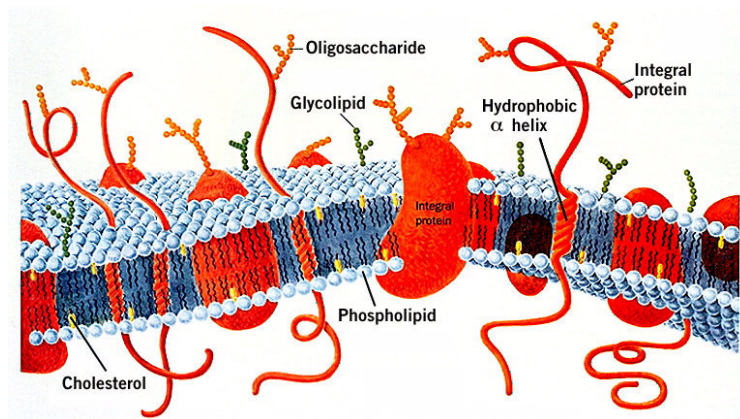


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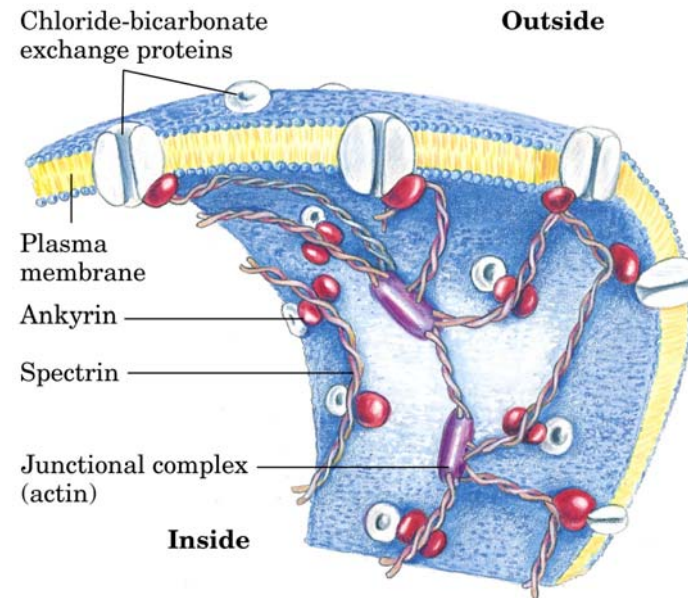
Fluid mosaic model for membrane structure

- Integral membrane proteins: icebergs floating in a 2-dimensional sea. Proteins are free to diffuse laterally, if not tied down



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Some proteins are tethered or anchored in place

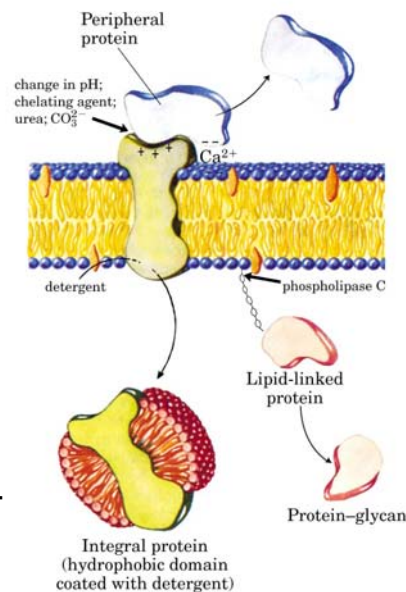


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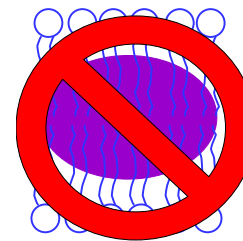
Membrane proteins

- Integral (intrinsic):** tightly bound to (imbedded in) membrane by hydrophobic forces
- Peripheral (extrinsic):** dissociate from membrane with mild conditions
- Lipid-linked:** covalent AA-lipid bond



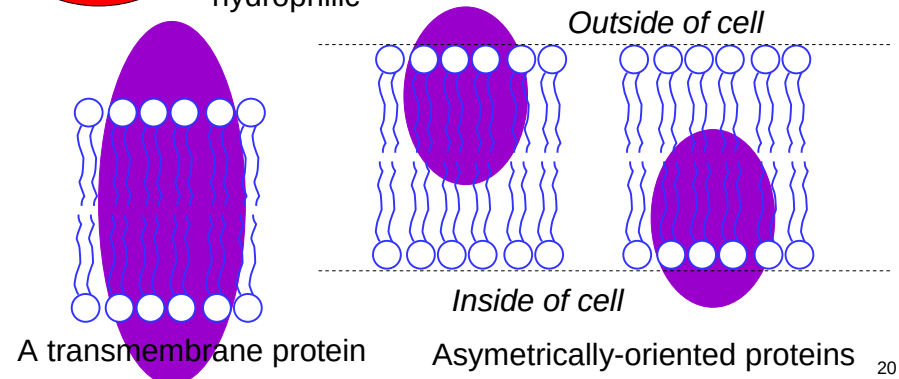
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Possible orientations of integral membrane proteins



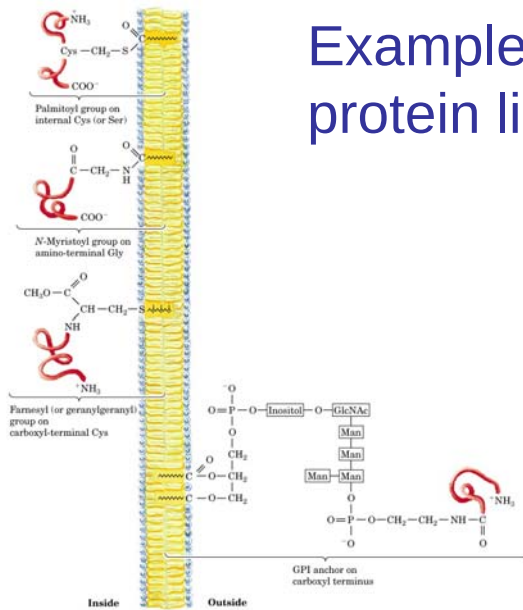
No membrane protein has been found to be completely embedded in a membrane

Membrane proteins are amphipathic: portion in membrane is hydrophobic, portion outside is hydrophilic



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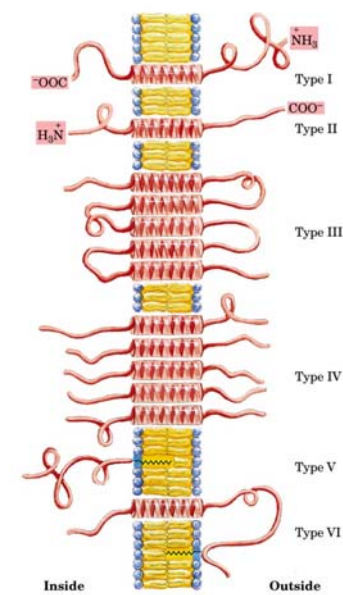
20



Examples of lipid-protein linkages

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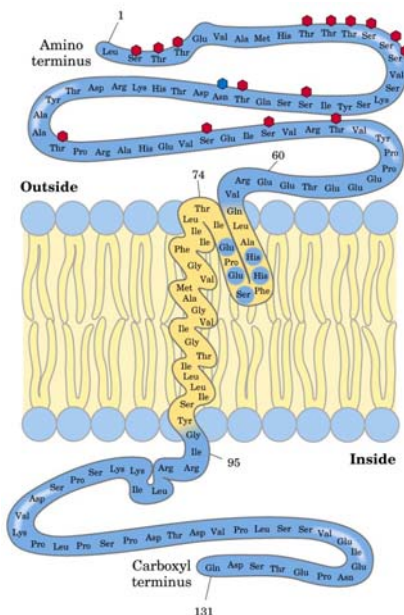
Transmembrane proteins can span the lipid bilayer one or more times

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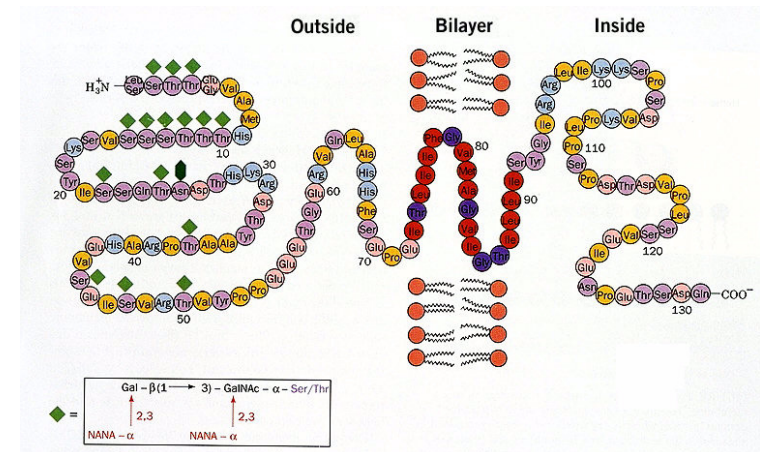
A transmembrane protein spanning the membrane only once

- Glycophorin A, an erythrocyte protein
- Note asymmetric orientation, and glycosylation on outer side
- Three domains:
 - N-term. (outside)
 - 19 residue spanning
 - C-terminal inside



23

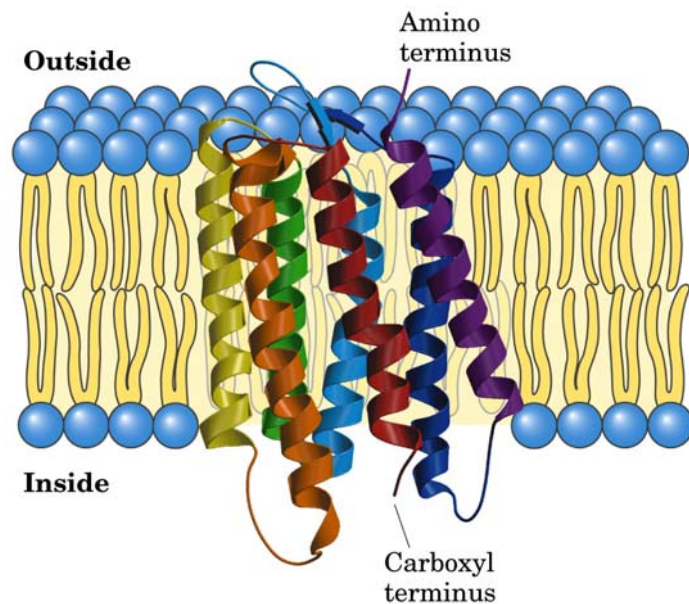
Another representation of glycophorin A



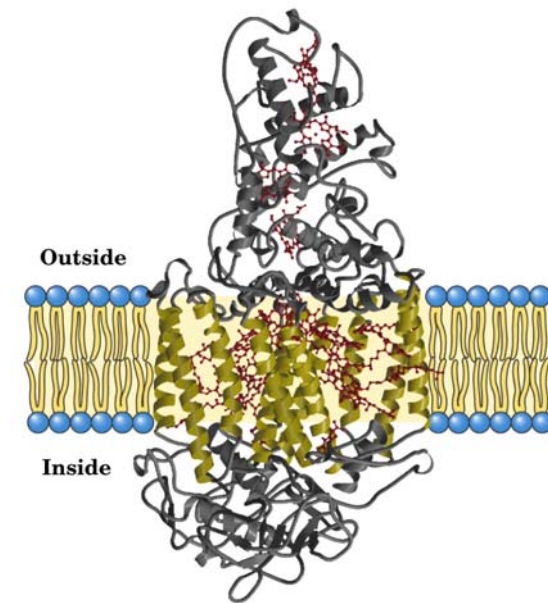
If glycosylation occurs, it will usually be only on the outer side of the protein

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Predicting membrane spanning domains from amino acid sequence information:
“Hydropathy plots”

- Polypeptides in lipid bilayers fold into α -helices or β -sheets
- Nonpolar side chains in helix or sheet stabilize 2° structure via interactions with lipids
- Residue hydrophobicity: ΔG° , going from a nonpolar solvent $\rightarrow$ H₂O
- Sum of free energies for transferring a sequence of AAs from nonpolar solvent $\rightarrow$ H₂O = “hydropathy index”

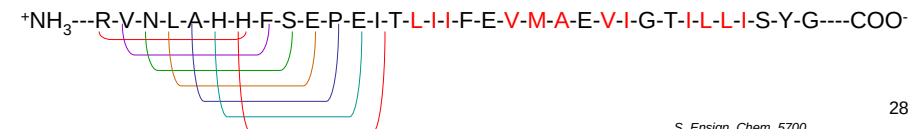
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Calculating protein hydropathy

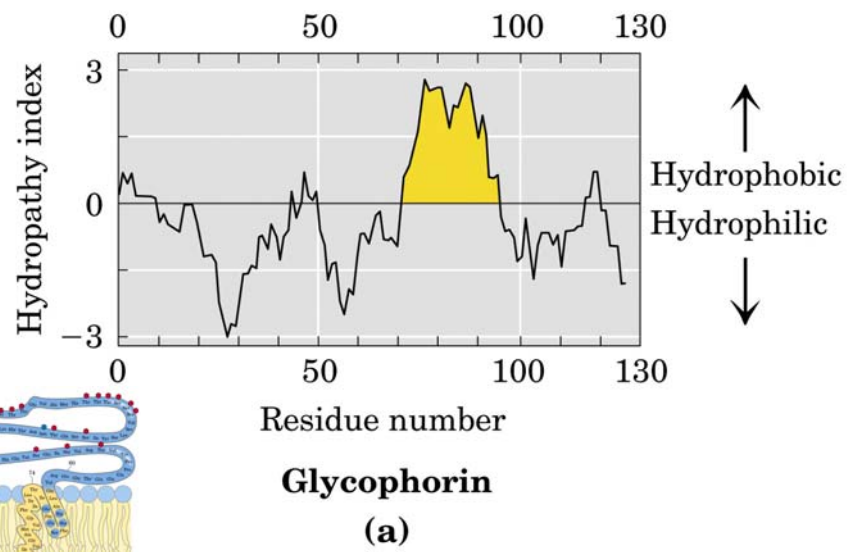
- Start at N-terminus
- Sum ΔG° hydrophobicity values for the first 7 residue stretch (segment 1)
- Shift one residue to right and sum the ΔG° hydrophobicity values for the next 7 AA stretch
- Continue for entire peptide
- Plot hydropathy index for each segment vs. sequence #

Segment 7 ΔG° 7-13
Segment 6 ΔG° 6-12
Segment 5 ΔG° 5-11
Segment 4 ΔG° 4-10
Segment 3 ΔG° 3-9
Segment 2 ΔG° 2-8
Segment 1 ΔG° 1-7



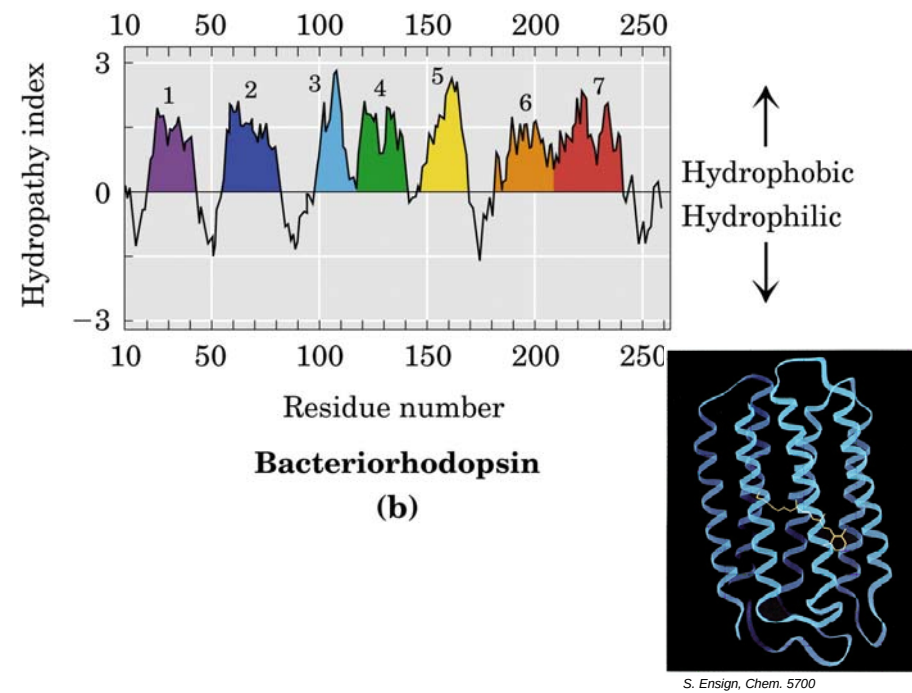
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