# Chem 452 - Lecture 8
# Lipids and Cell Membranes
# 111116

Like carbohydrates, lipids are one of the four major classes of biomolecules, which also include the proteins, carbohydrates and nucleic acids. Lipids are grouped not according to a chemical structure, as is the case for the other four classes, but rather they are grouped according to a physical property. Lipids comprise the molecules in a cell that can be extracted into non-polar solvents, which means they are non-polar, hydrophobic molecules. We will see that this does not mean that they do not contain hydrophilic functional groups, but all lipids molecules do contain large, hydrophobic regions. With cells being made up of largely water, this produces some very interesting and important cellular structure, not the least of which are the cell membranes.

## Cell Membrane Proteins

- Form vs. Function
  - The membrane lipids give **form** to the cell membranes
  - The membrane proteins provide the **function**



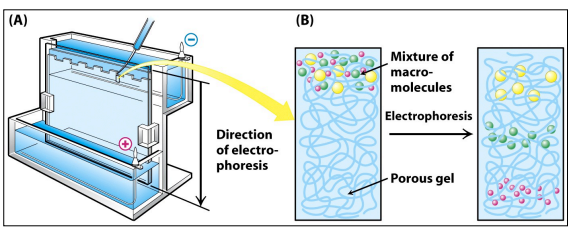
## Cell Membrane Proteins

- Membrane proteins function as
  - Pumps (Chapter 13)
  - Channels (Chapter 13)
  - Signal transducers (Chapter 14)
  - Energy transducers (Chapter 18 & 19)



## Cell Membrane Proteins

- Different membranes contain different proteins.
  - They can visualized using SDS-Polyacrylamide electrophoresis.




(Chapter 3, pp.71-75)

# Cell Membrane Proteins

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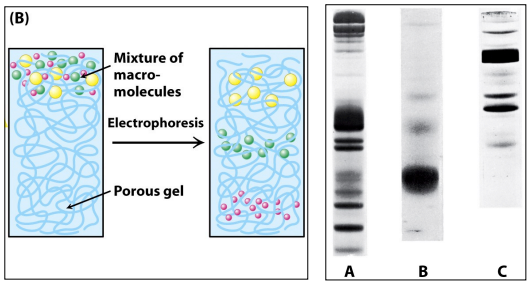







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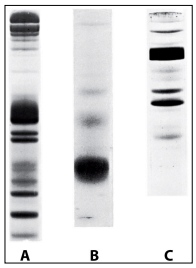



RBC plasma membrane

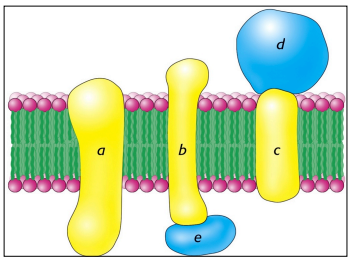
retinal rod cell photoreceptor membrane

muscle cell sarcoplasmic membrane



# Cell Membrane Proteins

- Proteins can associate with membranes in different ways.



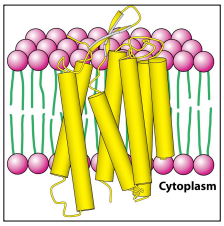



# Cell Membrane Proteins

- Proteins can associate with membranes in different ways.
- We will look a three different examples
  - Bacteriorhodopsin (pump)
  - Porin (channel)
  - Prostaglandin $H_2$ synthase-1 (enzyme)

# Cell Membrane Proteins

- Three examples of integral membrane proteins
  - Archaeal Bacteriorhodopsin (Pump)
  - Uses light energy to transport ions across the membrane.






# Cell Membrane Proteins

- Three examples of integral membrane proteins
  - Bacteriorhodopsin (7 α-helical bundle)
    - There are 7 non-polar stretches of amino-acids.

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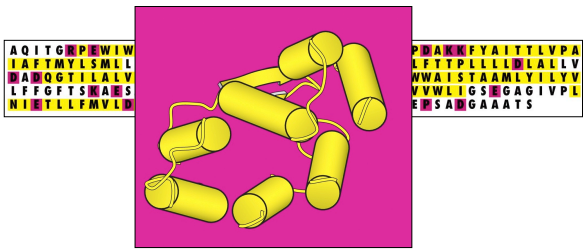



# Cell Membrane Proteins

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  - Bacteriorhodopsin (7 α-helical bundle)
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# Cell Membrane Proteins

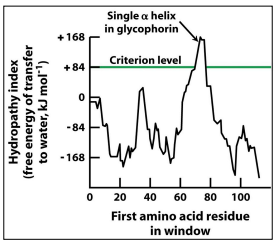
- Hydropathy plots are used to look for membrane spanning α-helicies

**Table 12.2 Polarity scale for identifying transmembrane helices**

| Amino acid residue | Transfer free energy in kJ mol$^{-1}$ (kcal mol$^{-1}$) |
|---|---|
| Phe | 15.5 (3.7) |
| Met | 14.3 (3.4) |
| Ile | 13.0 (3.1) |
| Leu | 11.8 (2.8) |
| Val | 10.9 (2.6) |
| Cys | 8.4 (2.0) |
| Trp | 8.0 (1.9) |
| Ala | 6.7 (1.6) |
| Thr | 5.0 (1.2) |
| Gly | 4.2 (1.0) |
| Ser | 2.5 (0.6) |
| Pro | −0.8 (−0.2) |
| Tyr | −2.9 (−0.7) |
| His | −12.6 (−3.0) |
| Gln | −17.2 (−4.1) |
| Asn | −20.2 (−4.8) |
| Glu | −34.4 (−8.2) |
| Lys | −37.0 (−8.8) |
| Asp | −38.6 (−9.2) |
| Arg | −51.7 (−12.3) |

Source: After D. M. Engelman, T. A. Steitz, and A. Goldman. *Annu. Rev. Biophys. Biophys. Chem.* 15(1986):321–353.

Note: The free energies are for the transfer of an amino acid residue in an α helix from the membrane interior (assumed to have a dielectric constant of 2) to water.




Glycophorin



# Cell Membrane Proteins

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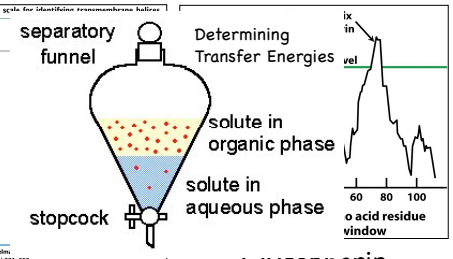


Glycopnorin



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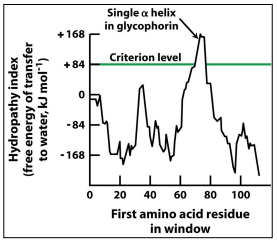


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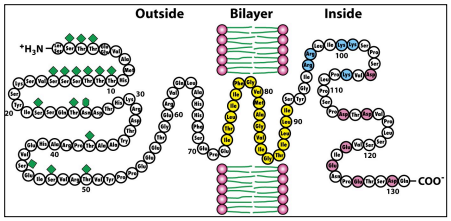
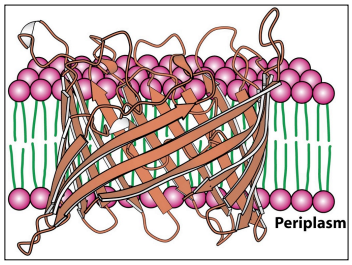



Glycophorin

## Cell Membrane Proteins

- Three examples of integral membrane proteins
  - Porin (Channel)






## Cell Membrane Proteins

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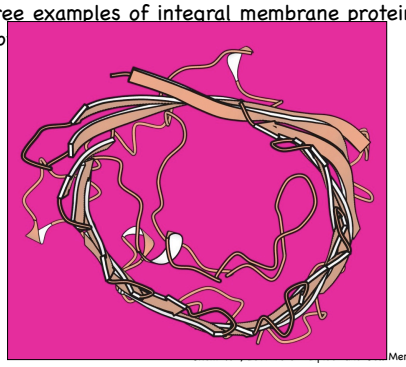



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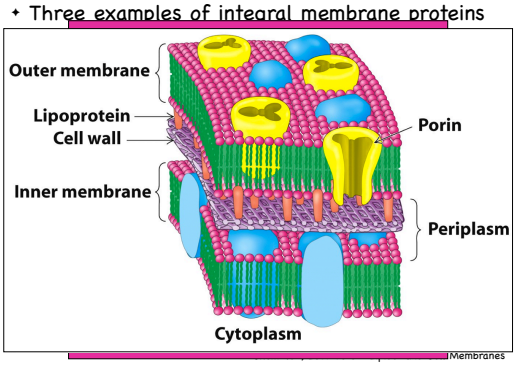




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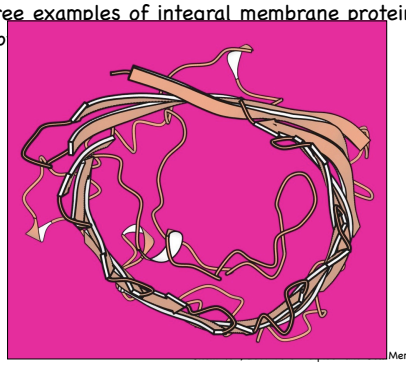

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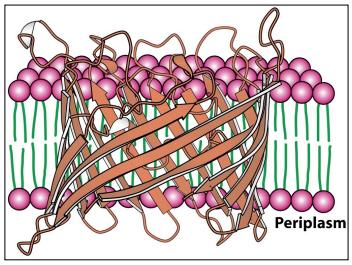




# Cell Membrane Proteins

- Three examples of integral membrane proteins
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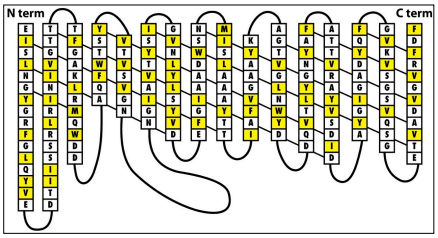
    - Sequence alternates between polar and non-polar amino acid residues



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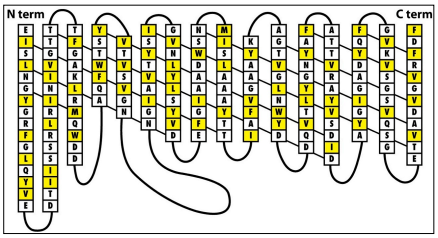




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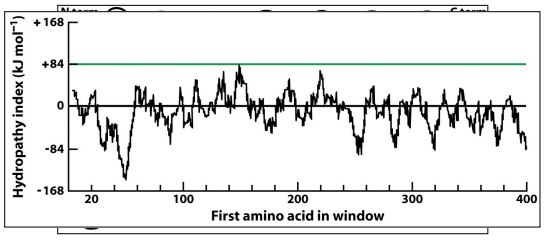

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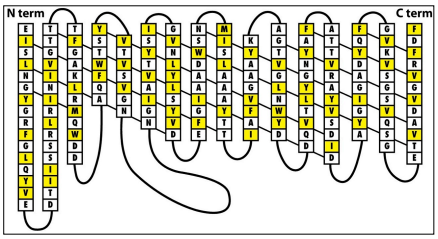




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- Three examples of integral membrane proteins
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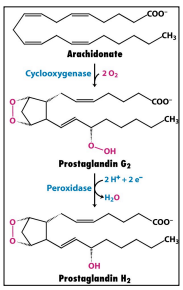




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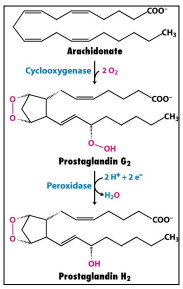


Promotes inflammation and modulates gastric acid secretion



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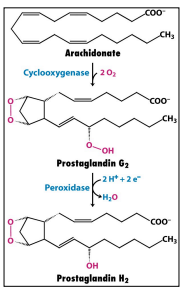


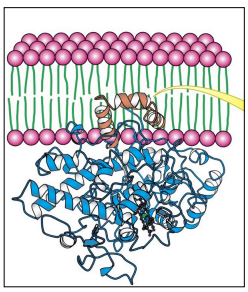

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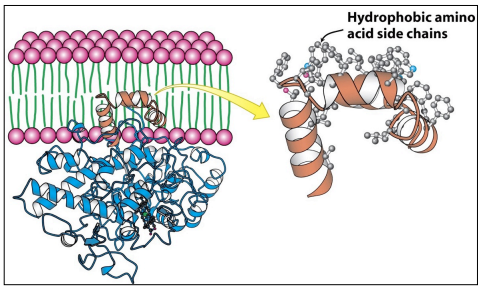
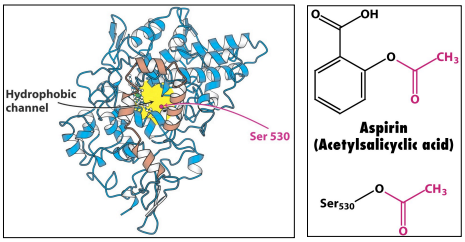





# Cell Membrane Proteins

- Three examples of integral membrane proteins
  - Prostaglandin $H_2$ synthase-1 (Enzyme)
    - Inhibited by COX inhibitors (NSAID)



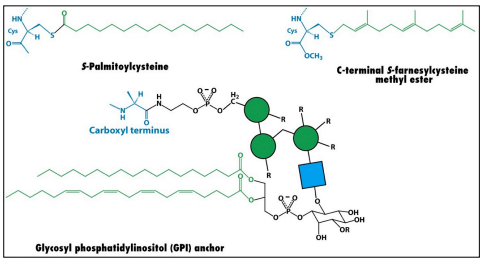






# Cell Membrane Proteins

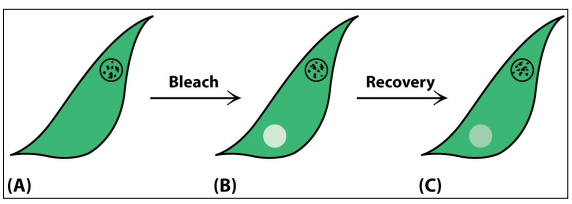
- Peripheral proteins are often have hydrophobic lipids attached to them.






# Cell Membrane Proteins

- Lateral Diffusion in membranes can have a wide range of values.



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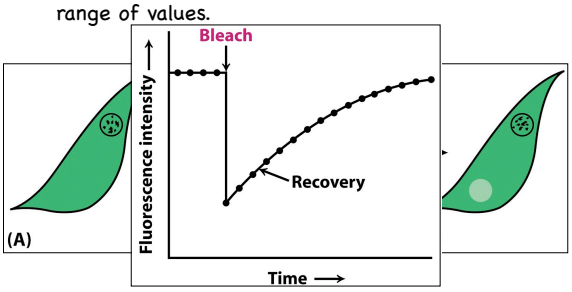


$$S = (4Dt)^{1/2}$$



# Cell Membrane Proteins

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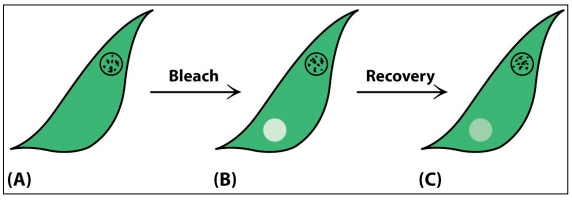
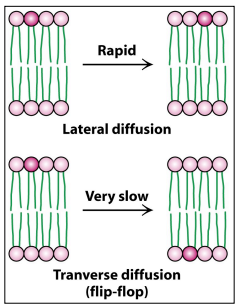





# Cell Membrane Proteins

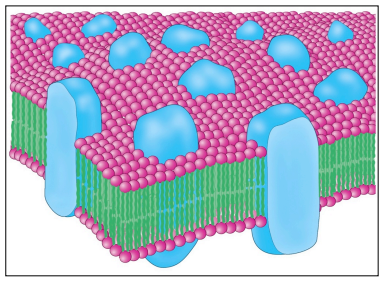
- Transverse diffusion is very slow.






# Cell Membrane Proteins

- Fluid Mosaic Model of Singer and Nicolson (1972).



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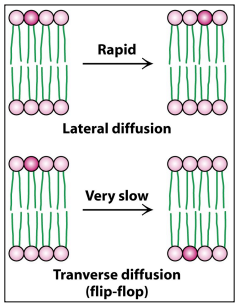




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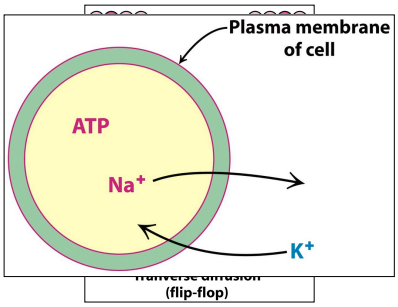




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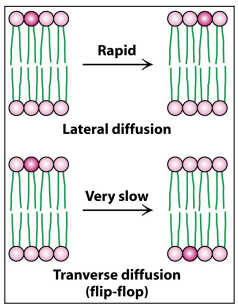
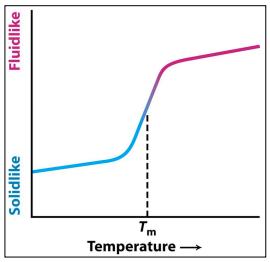





## Cell Membrane Proteins

- Membrane fluidity is modulated by
  - Fatty acid composition
  - Cholesterol (animals)



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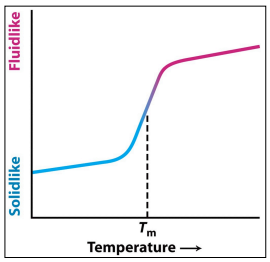




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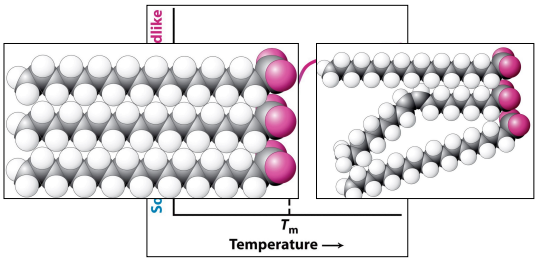




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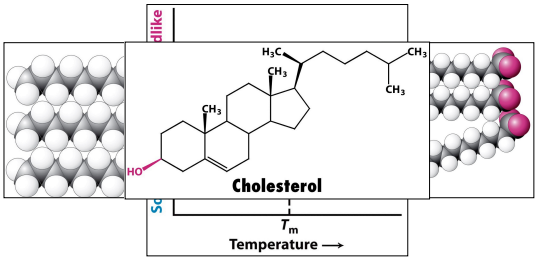




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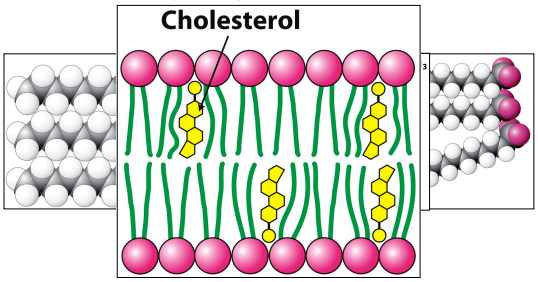

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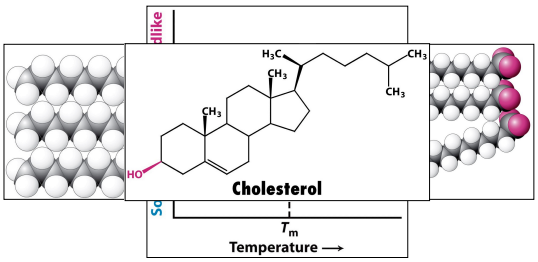




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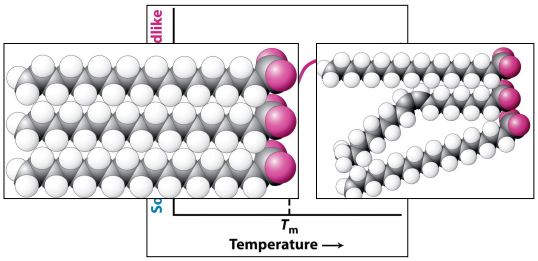




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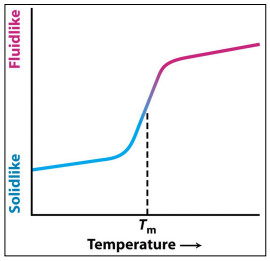
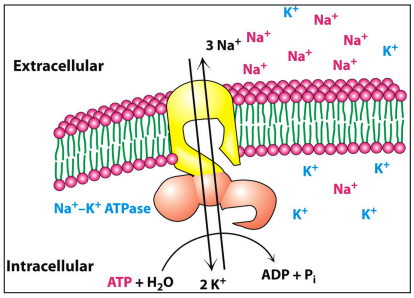




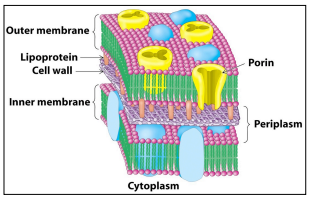

# Cell Membrane Proteins

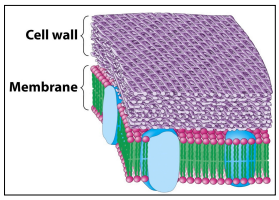
- Membranes are asymmetric



# Cell Membrane Proteins

- Bacterial cells

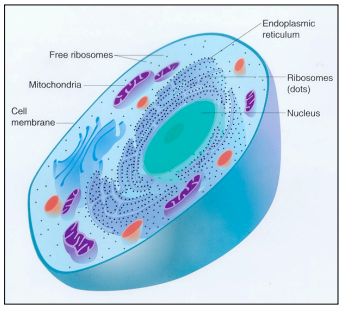





# Cell Membrane Proteins

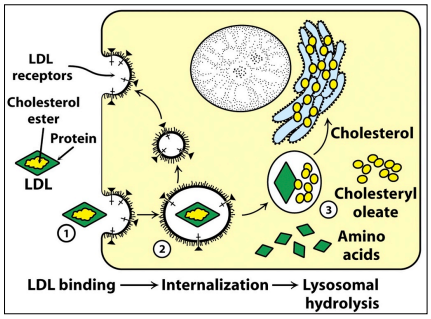
- Eukaryotic cells






# Cell Membrane Proteins

- Eukaryotic cells



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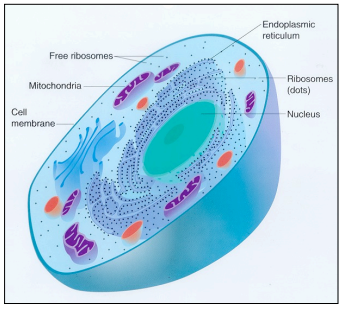

# Next up

- Unit V, Lecture 9 - Membrane Channels and Pumps. (Chapter 13)