Chem 452 - Lecture 8
Lipids and Cell Membranes
111116

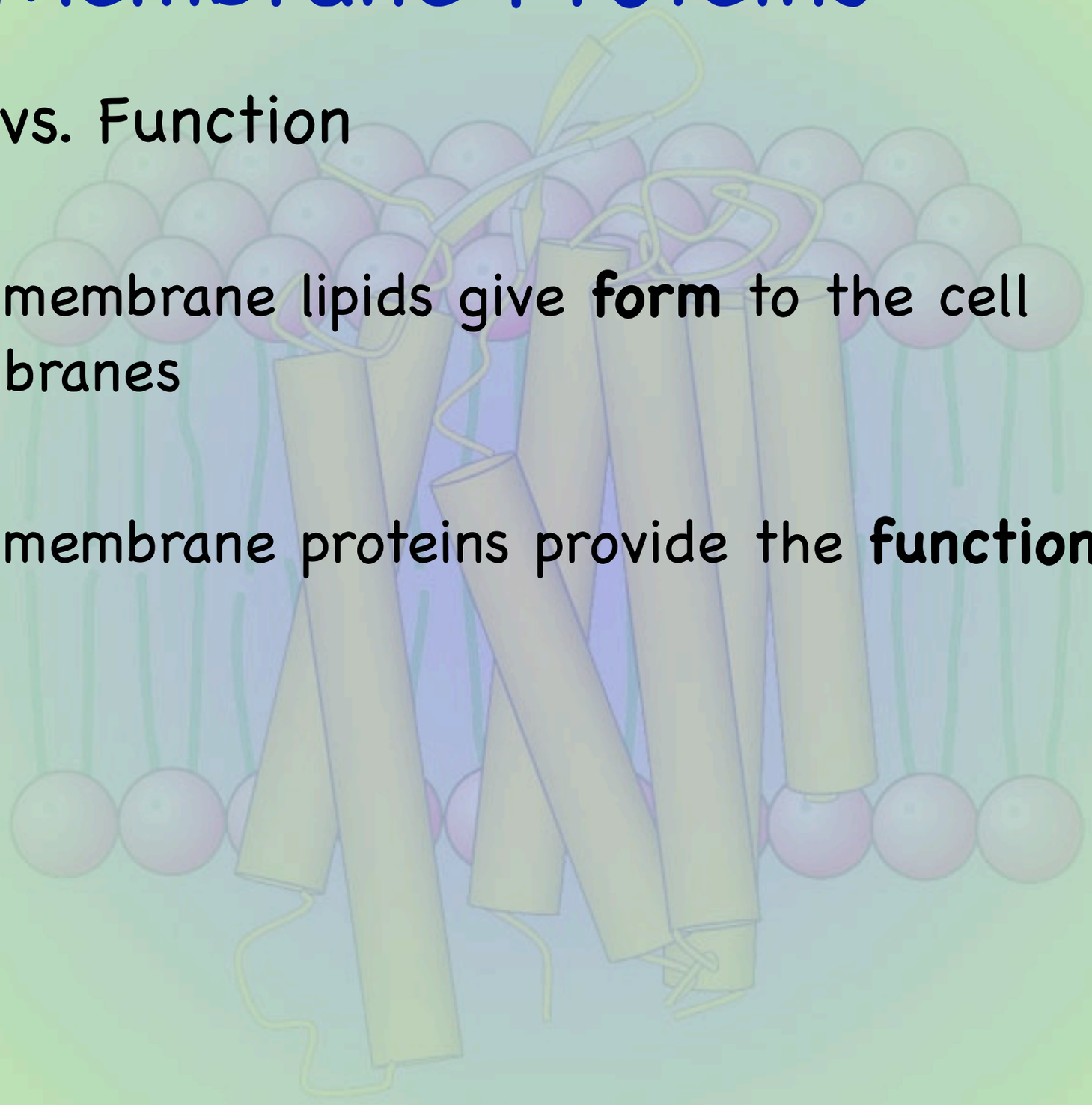
Like carbohydrates, lipids are one of the four major classes of biomolecules, which also include the proteins, carbohydrates and nucleic acids. Lipids are grouped not according to a chemical structure, as is the case for the other four classes, but rather they are grouped according to a physical property. 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**

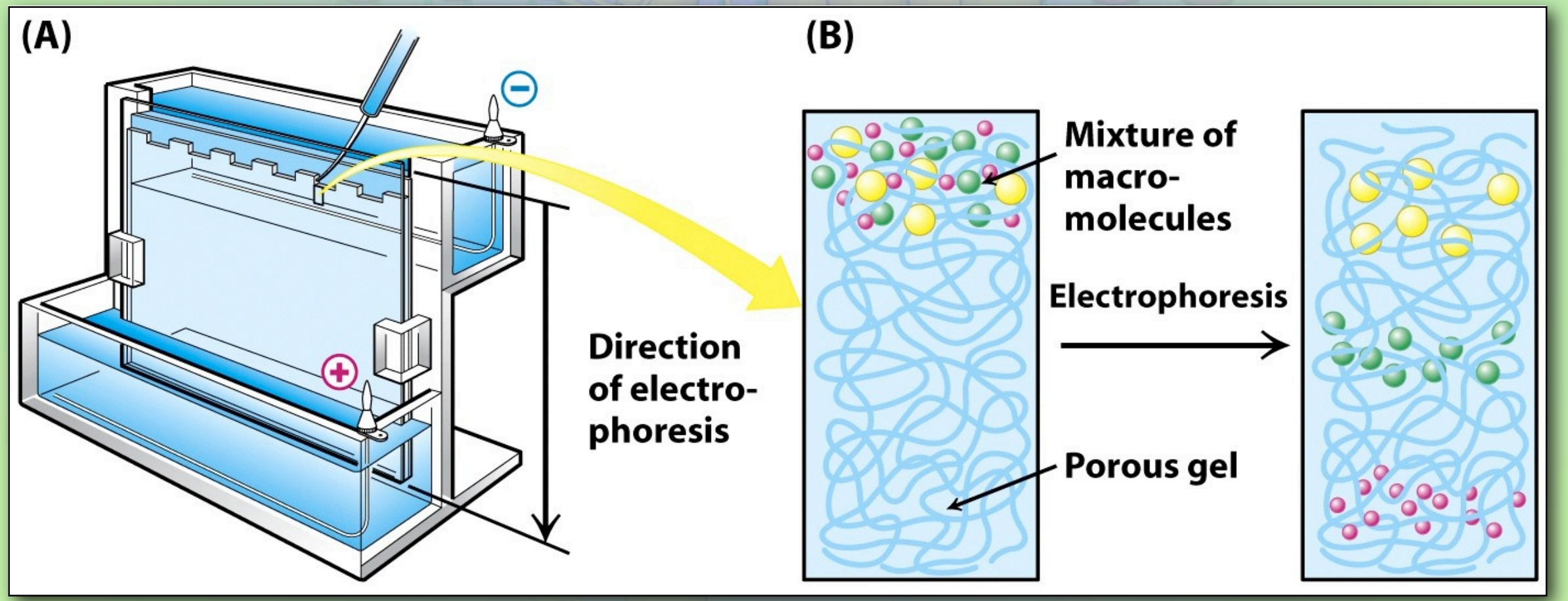


Cell Membrane Proteins

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

Cell Membrane Proteins

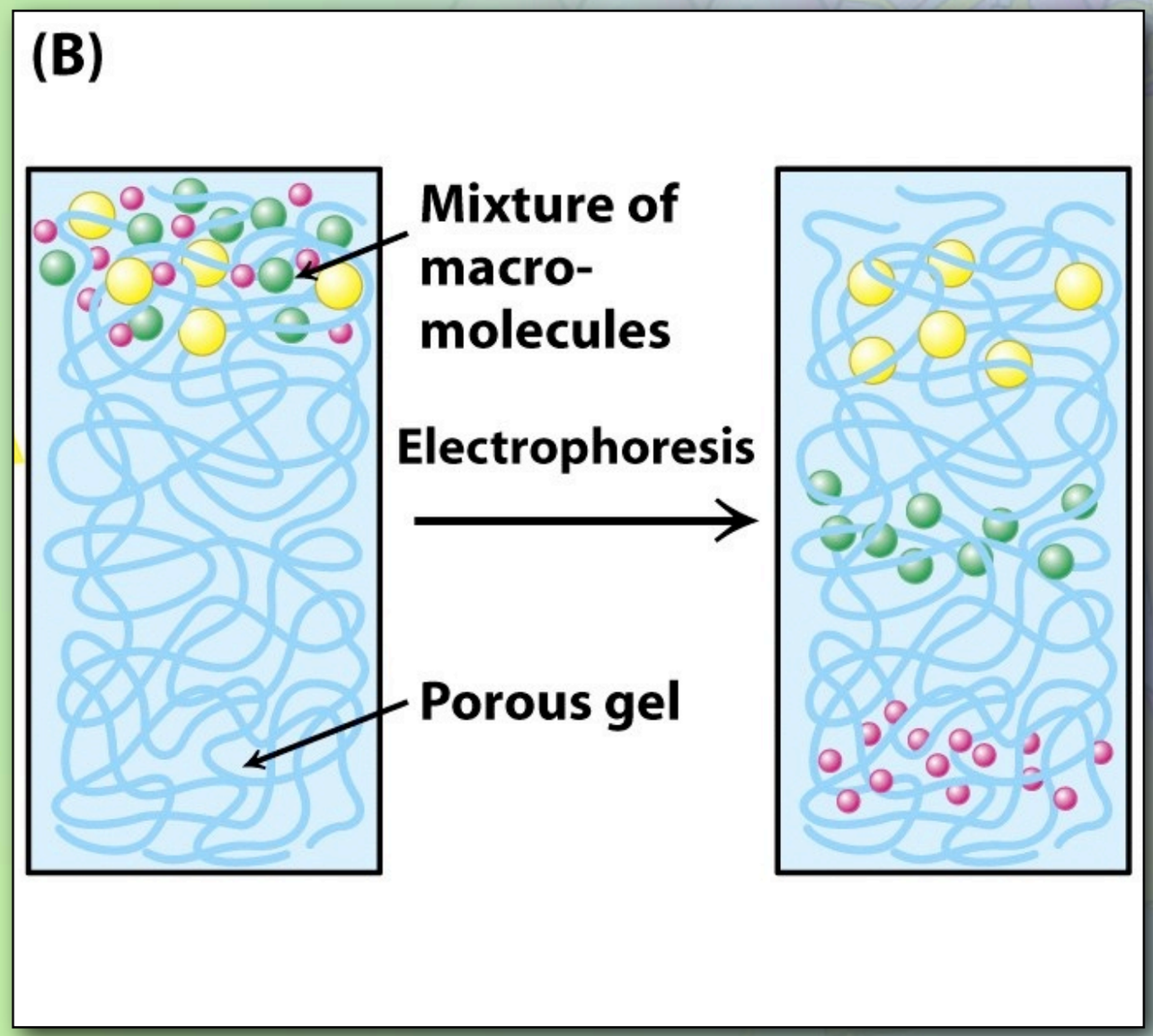
- Different membranes contain different proteins.
  - They can visualized using SDS-Polyacrylamide electrophoresis.

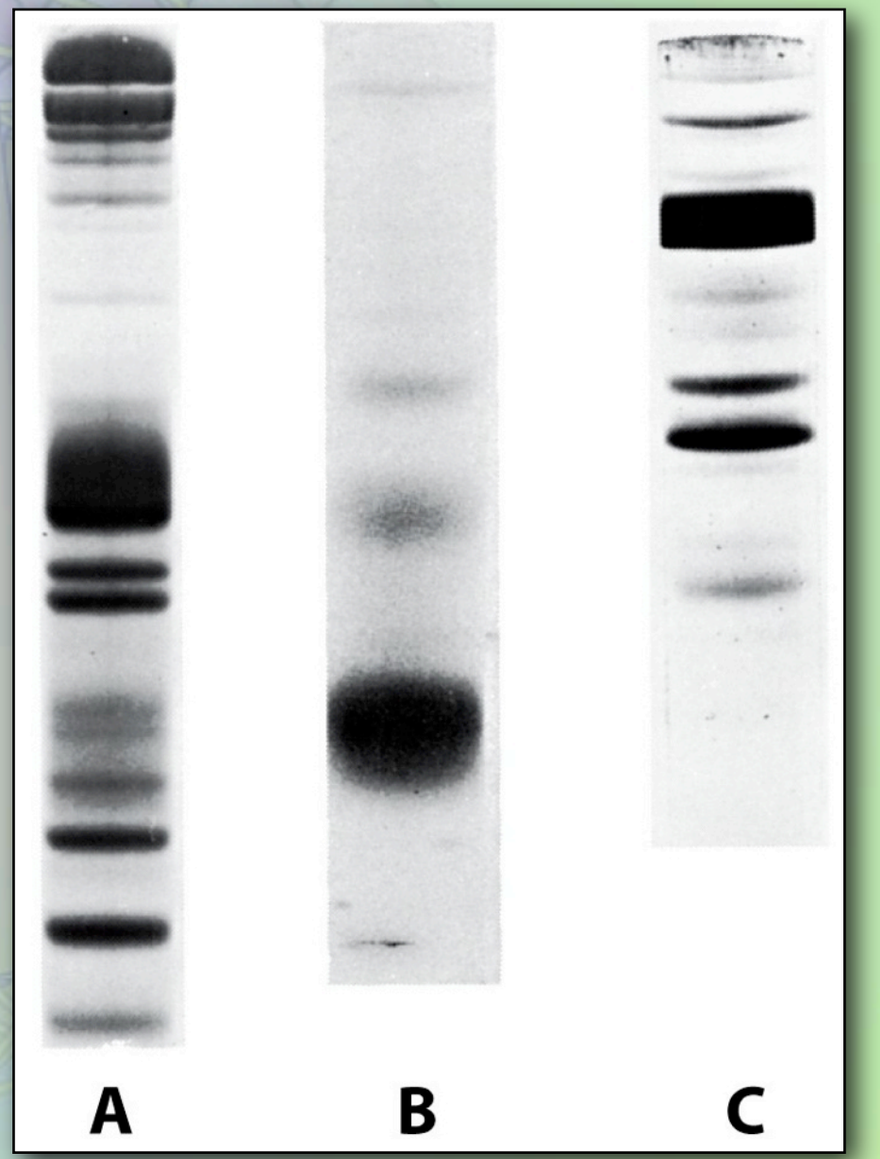


(Chapter 3, pp.71-75)

Cell Membrane Proteins

- Different membranes contain different proteins





Cell Membrane Proteins

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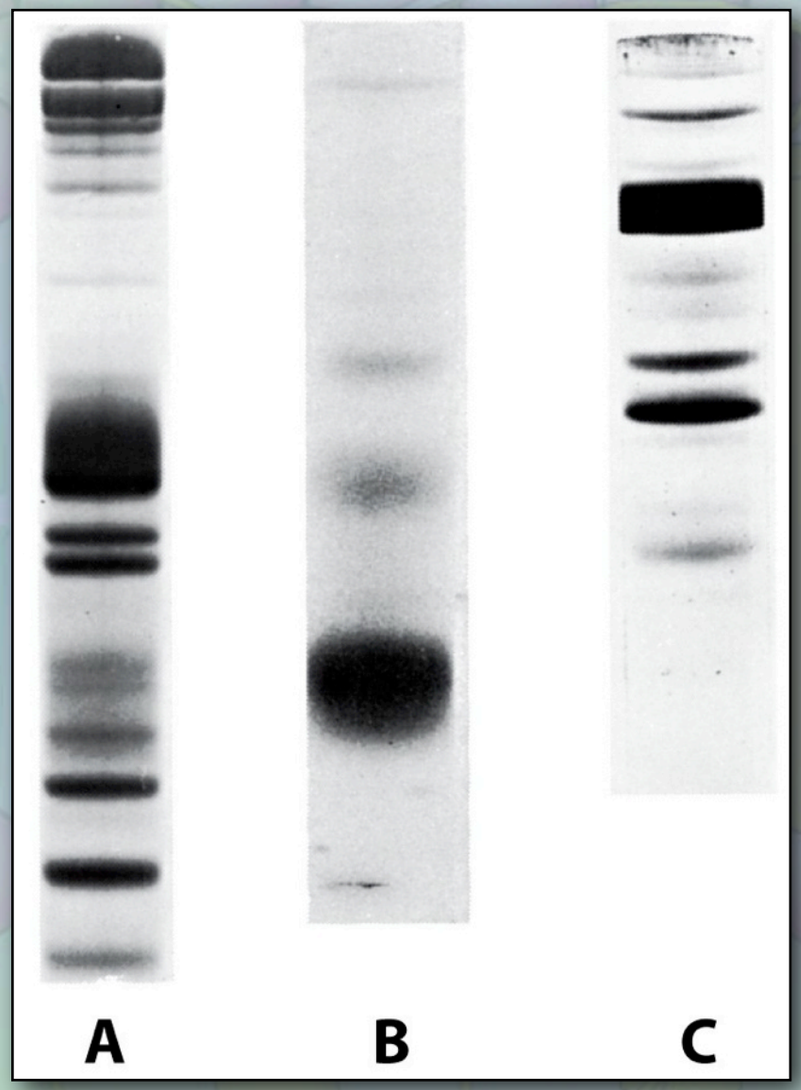


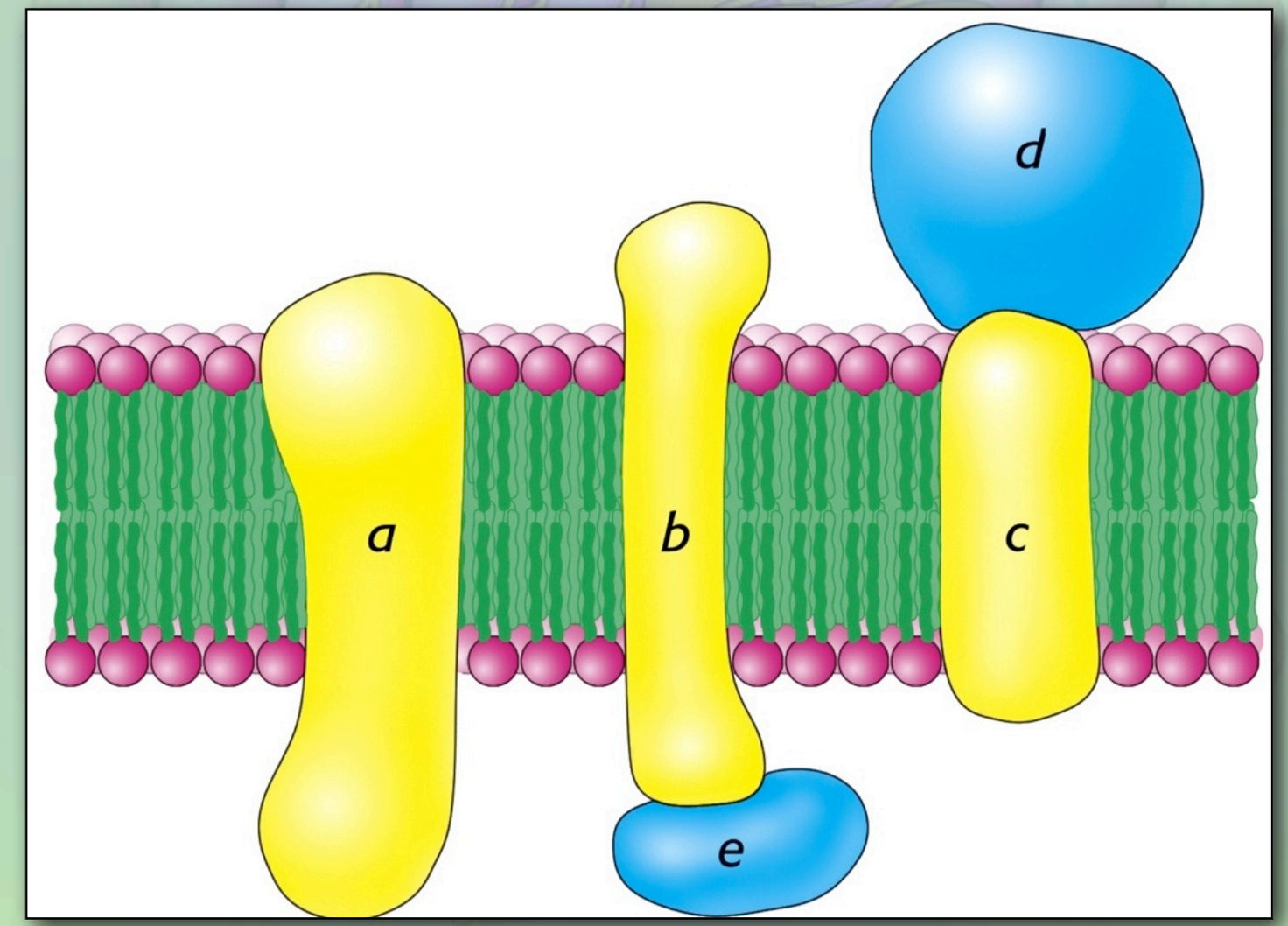
RBC plasma membrane

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

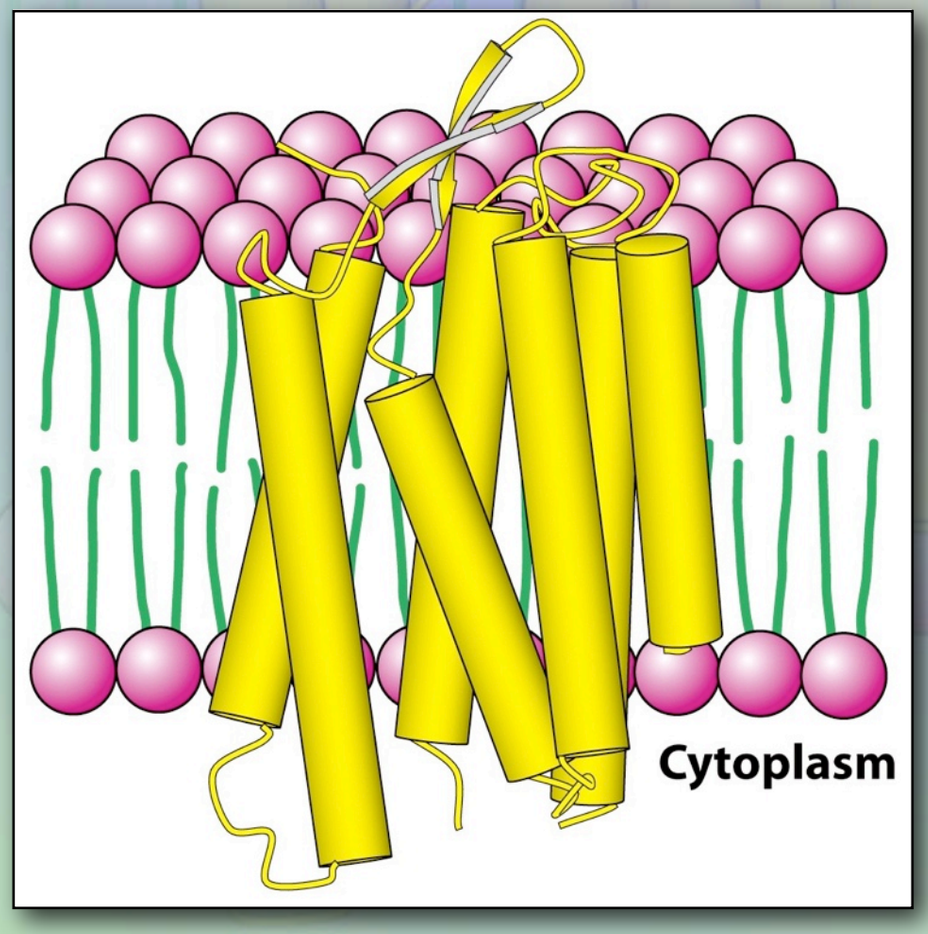
  - Bacteriorhodopsin (pump)

  - 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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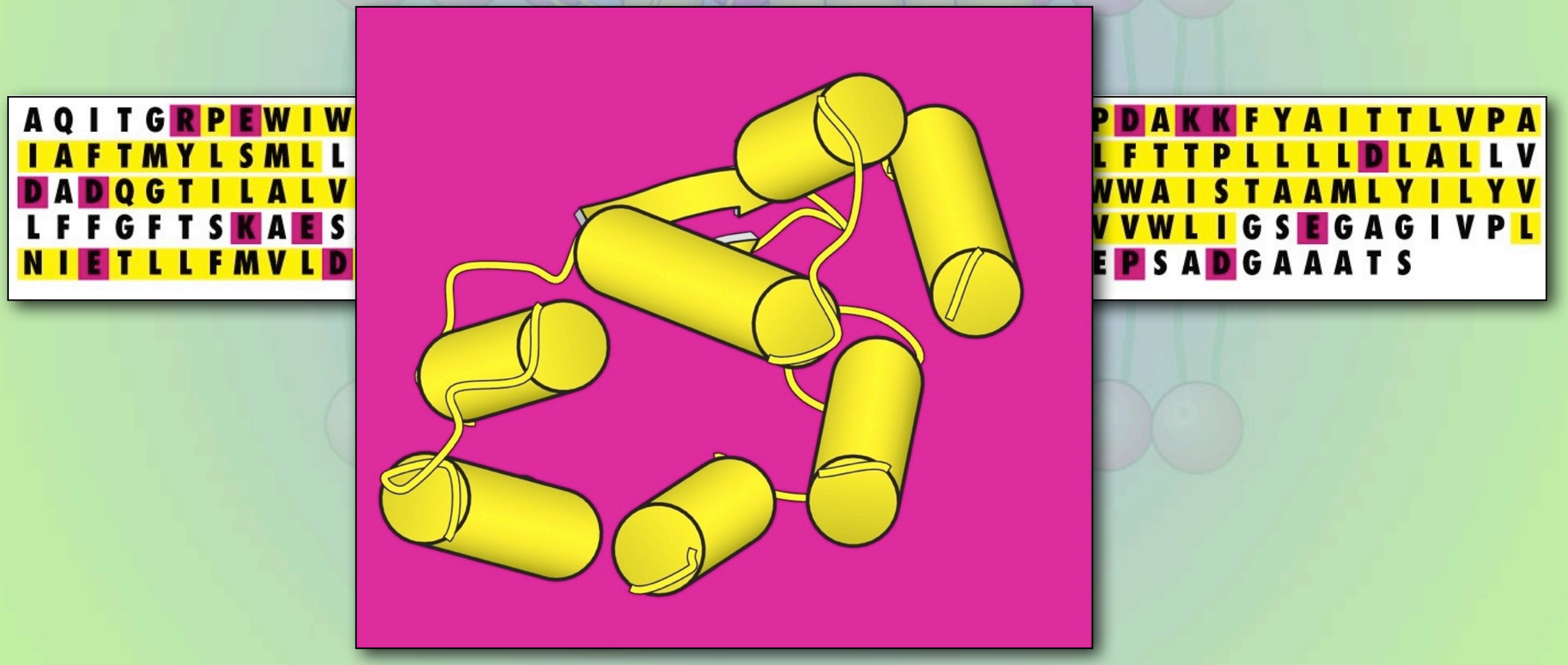

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Cell Membrane Proteins

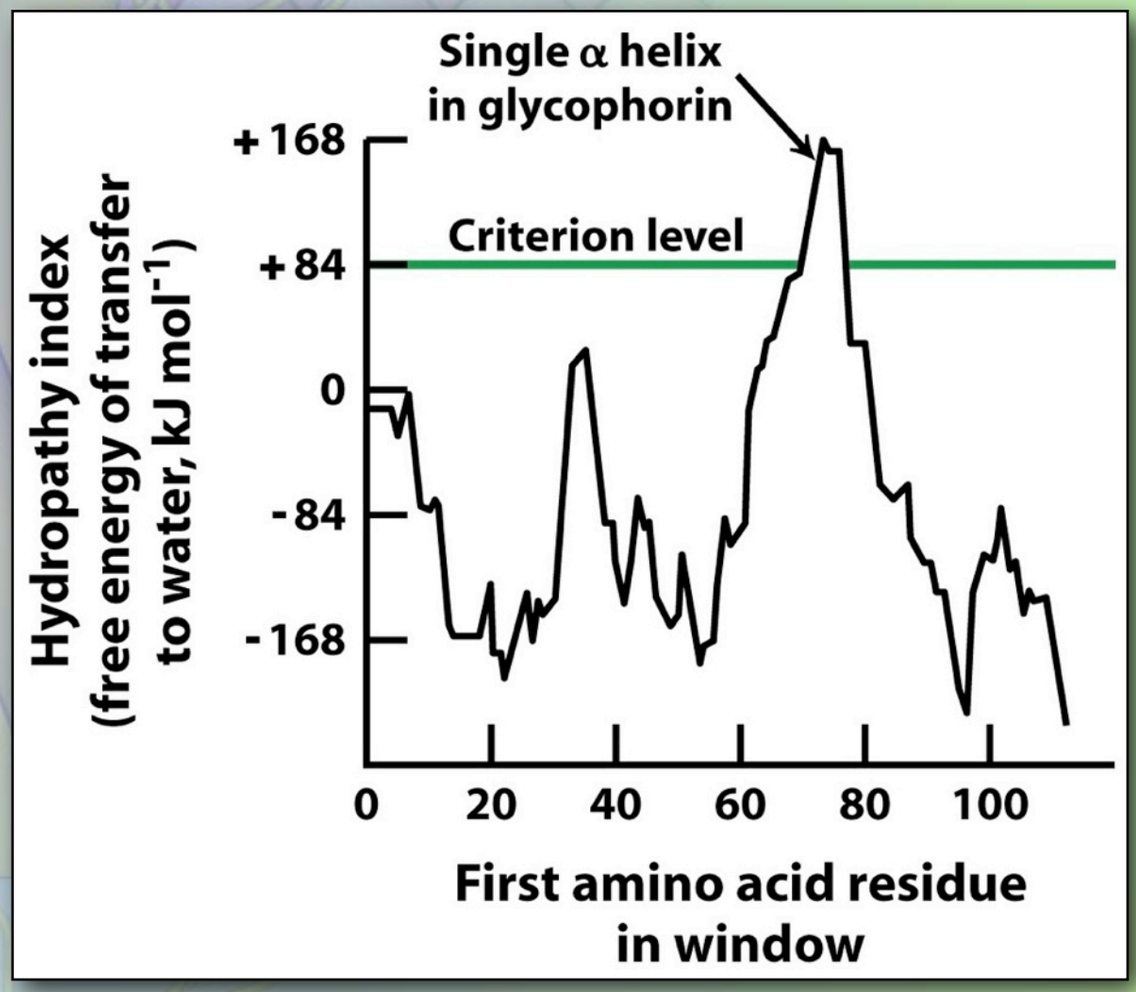
- Hydropathy plots are used to look for membrane spanning α-helicies

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

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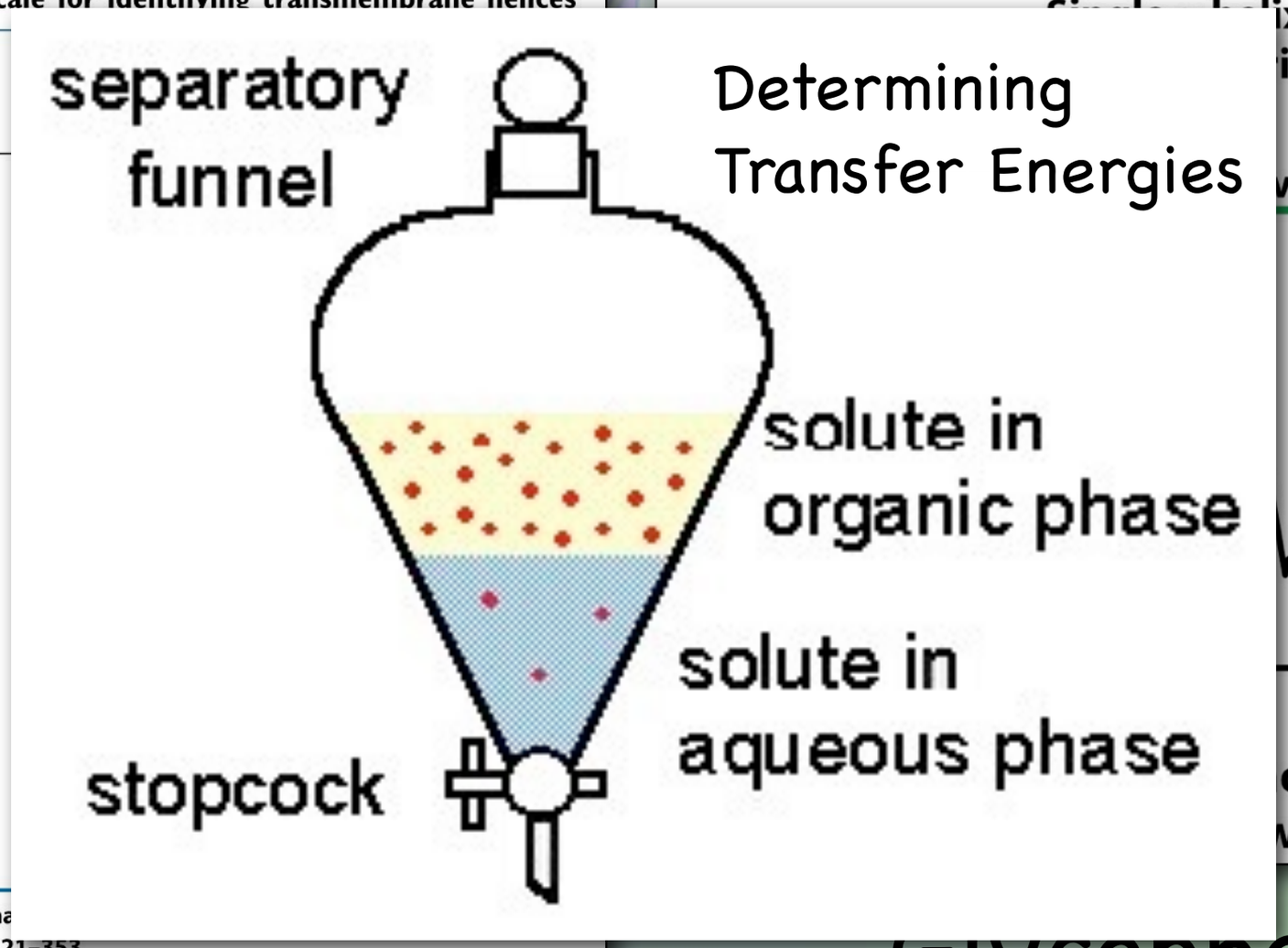

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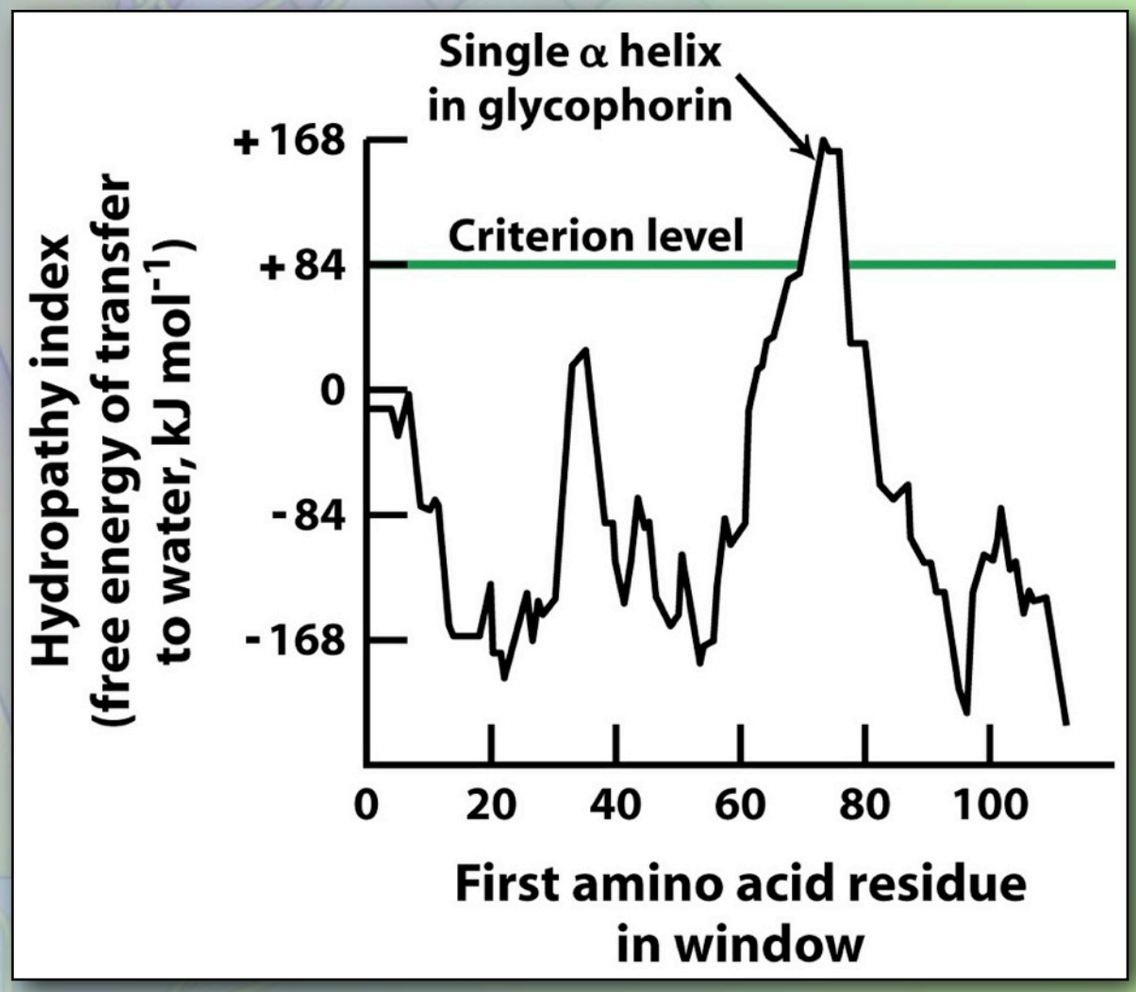

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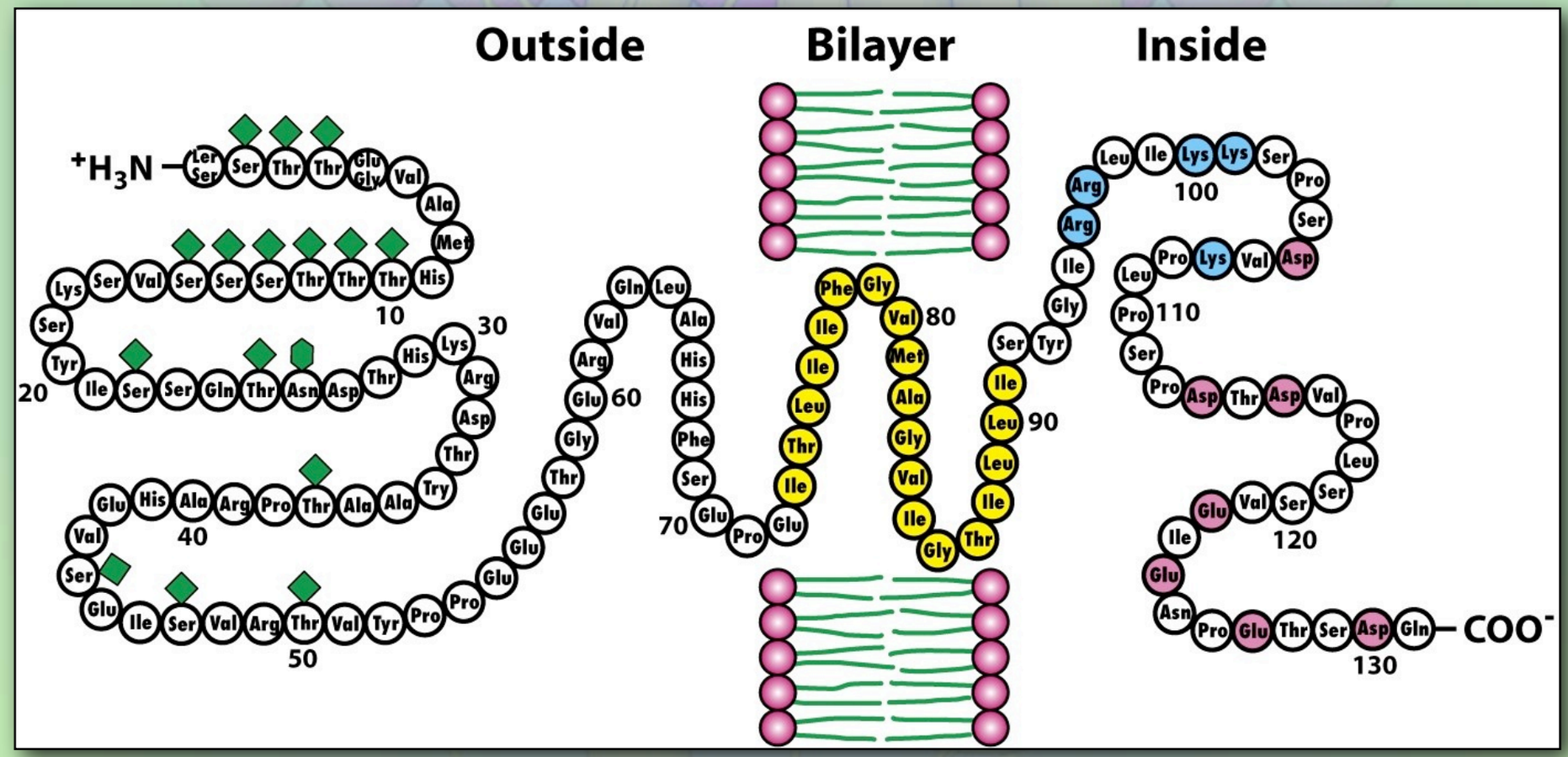

Glycophorin

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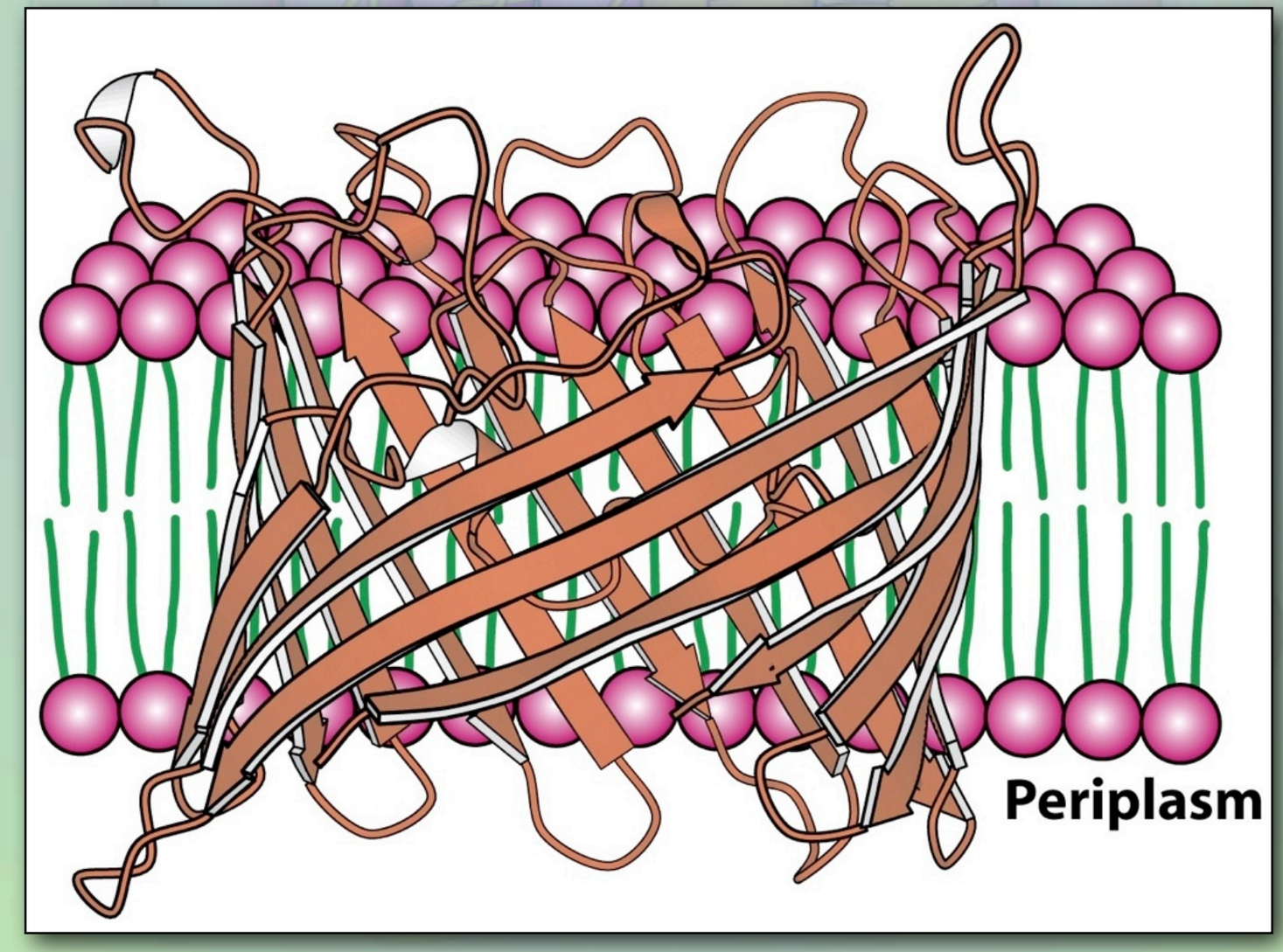

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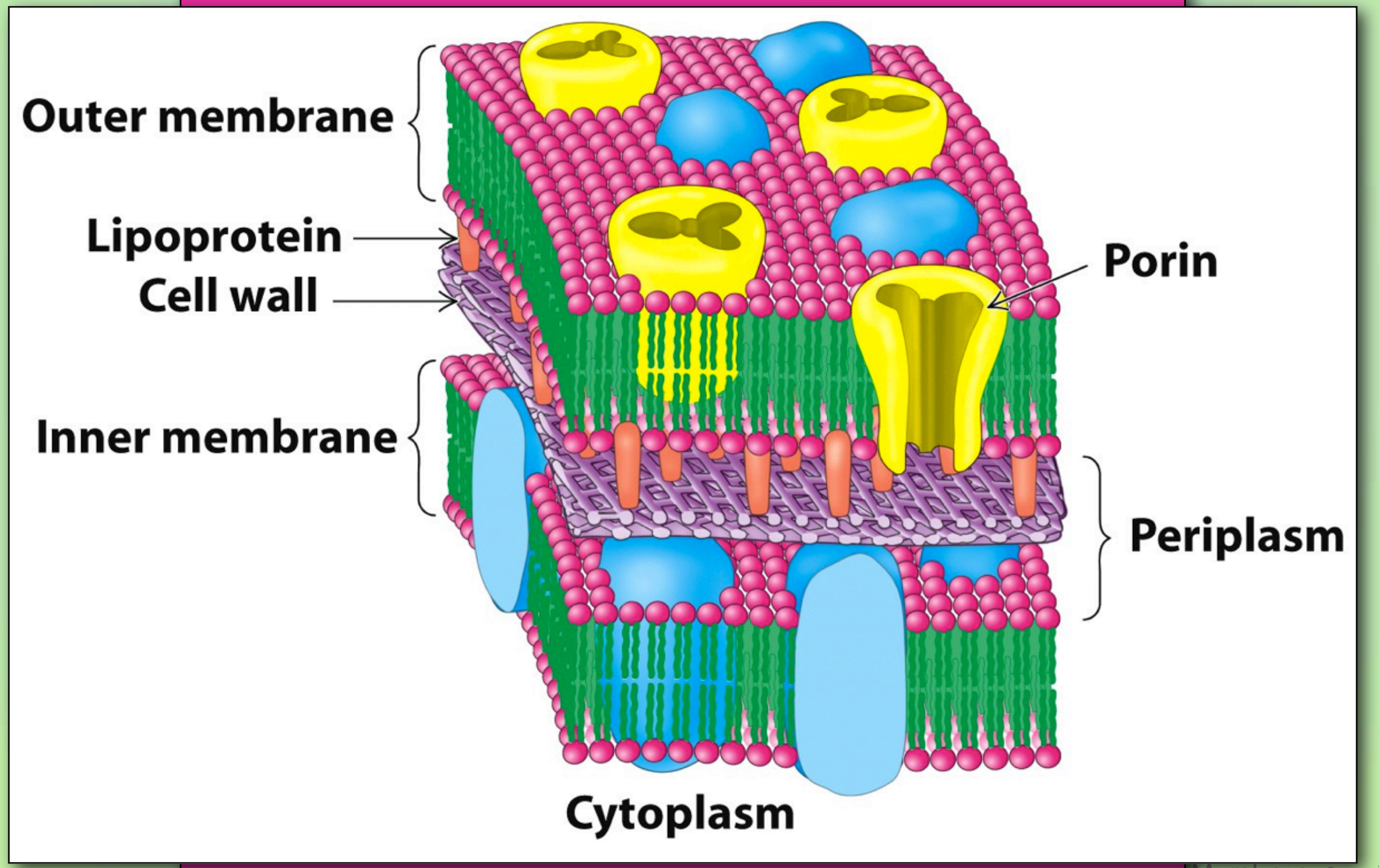

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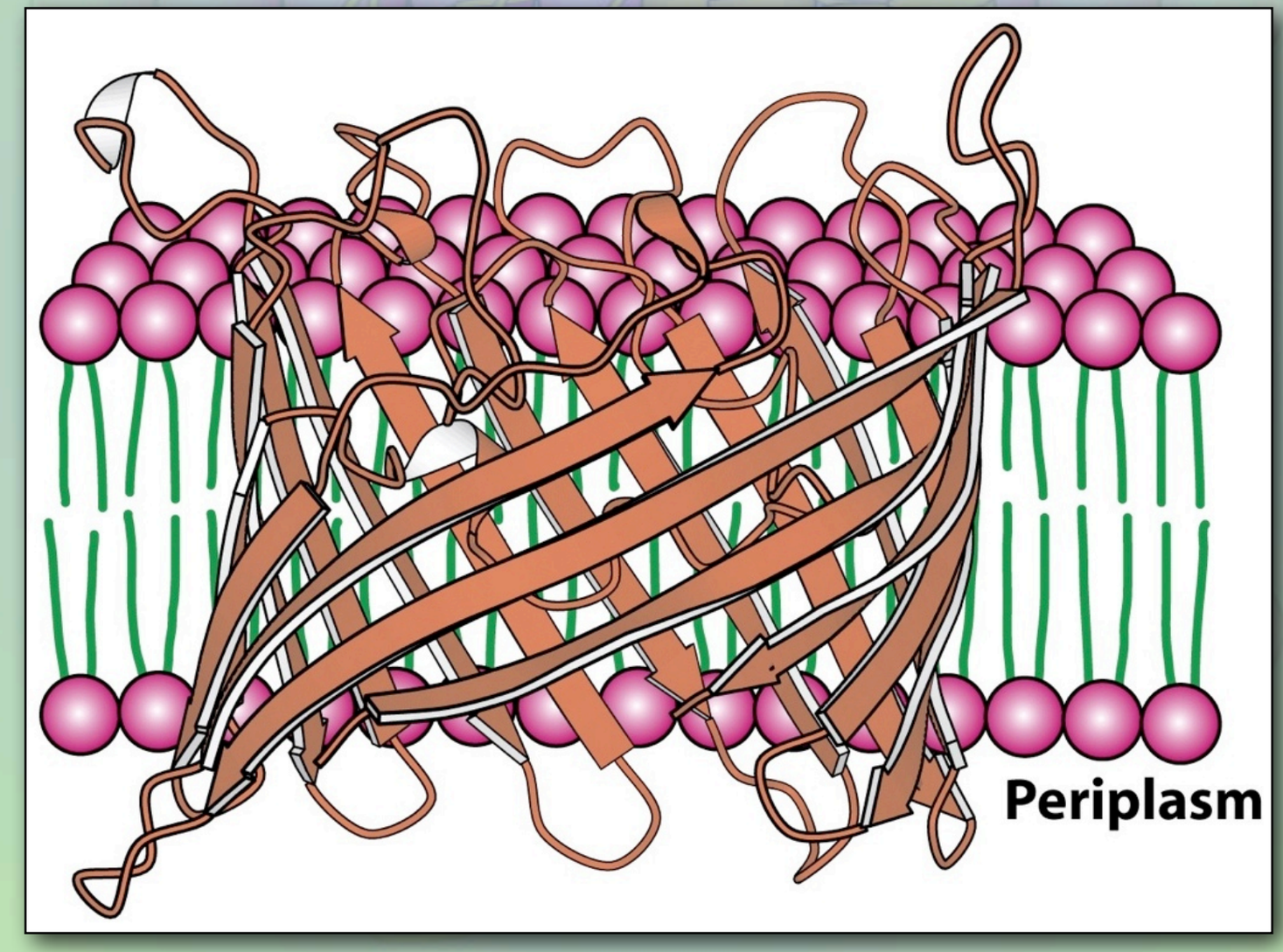

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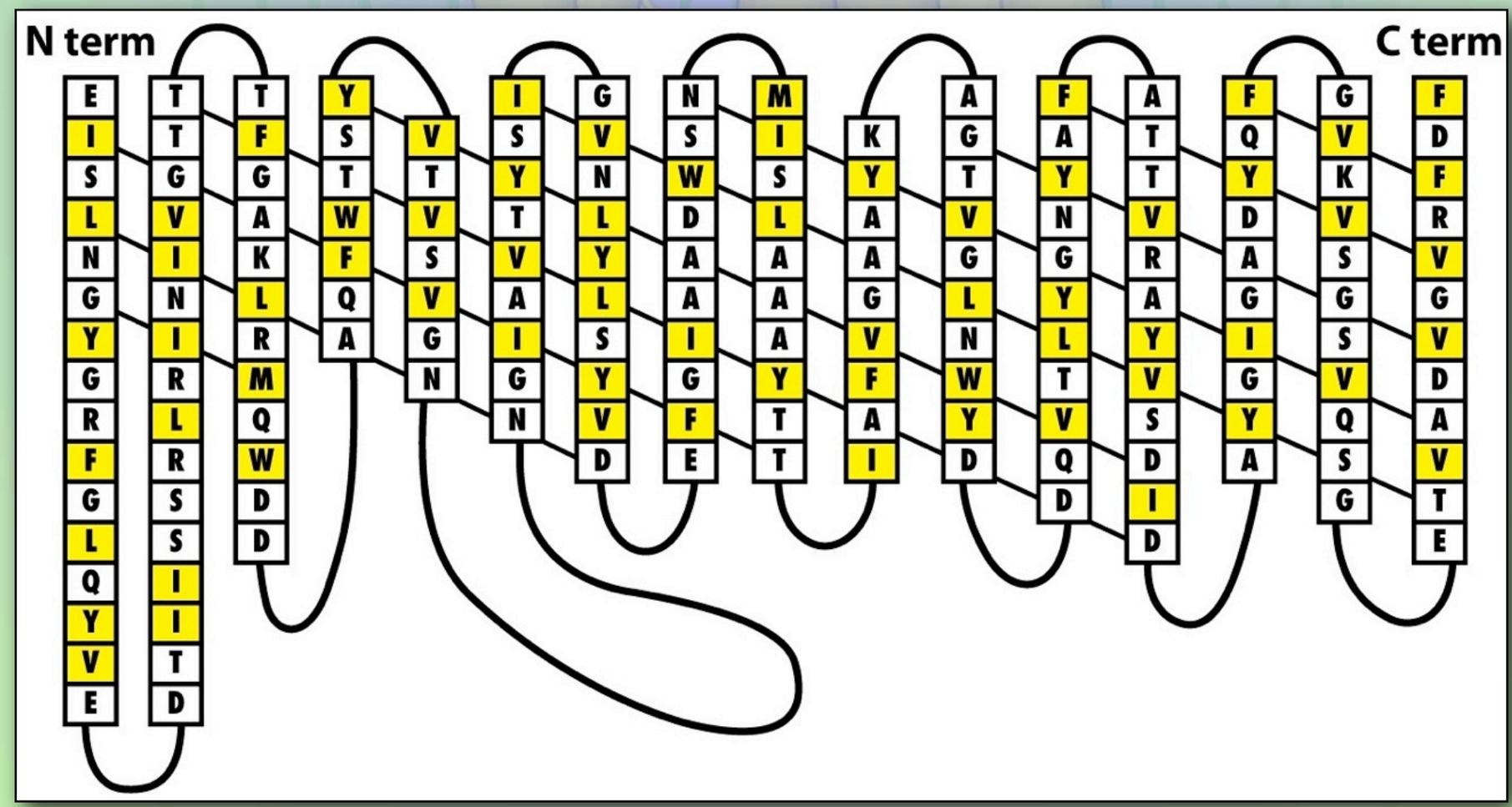

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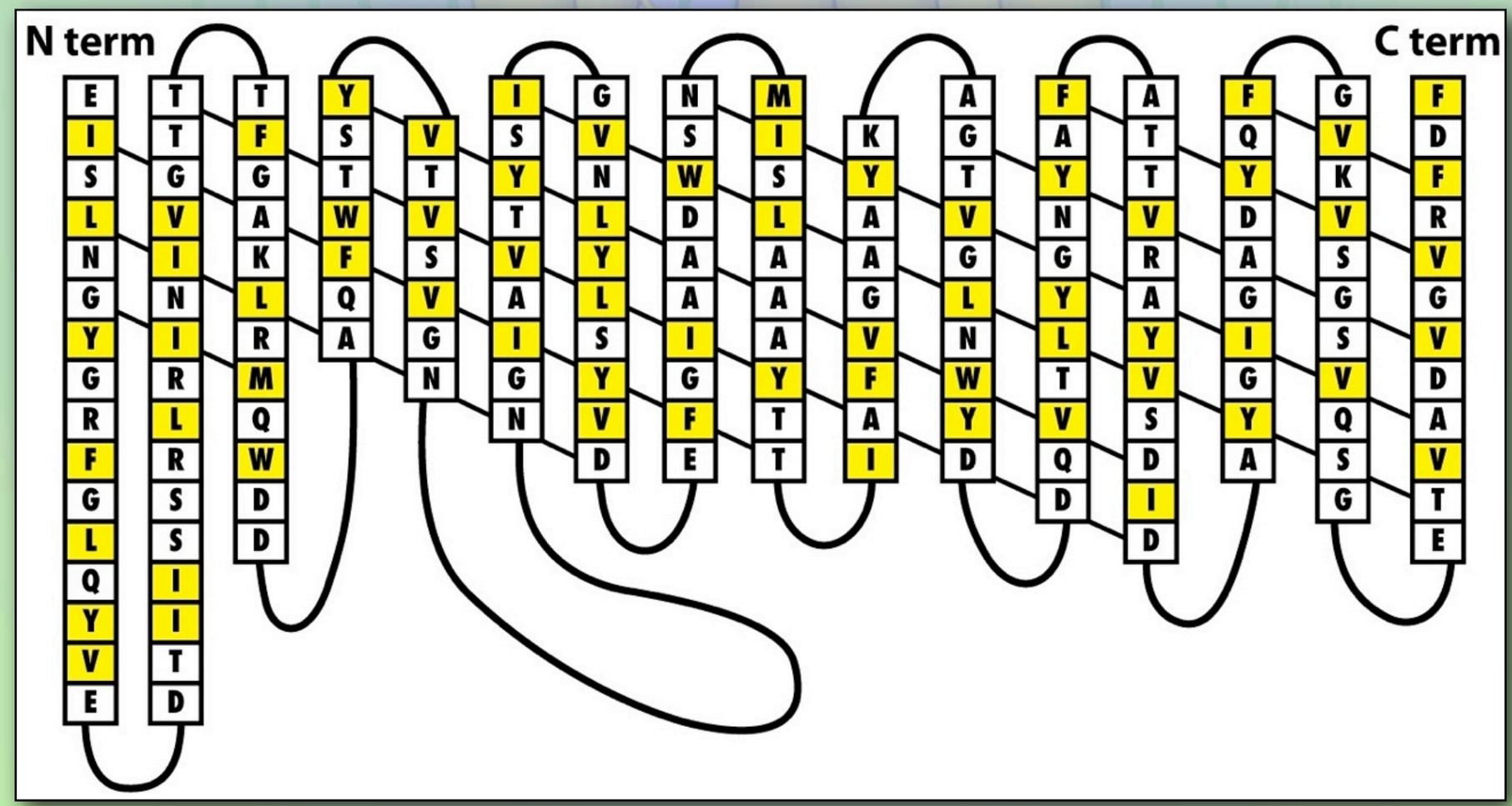

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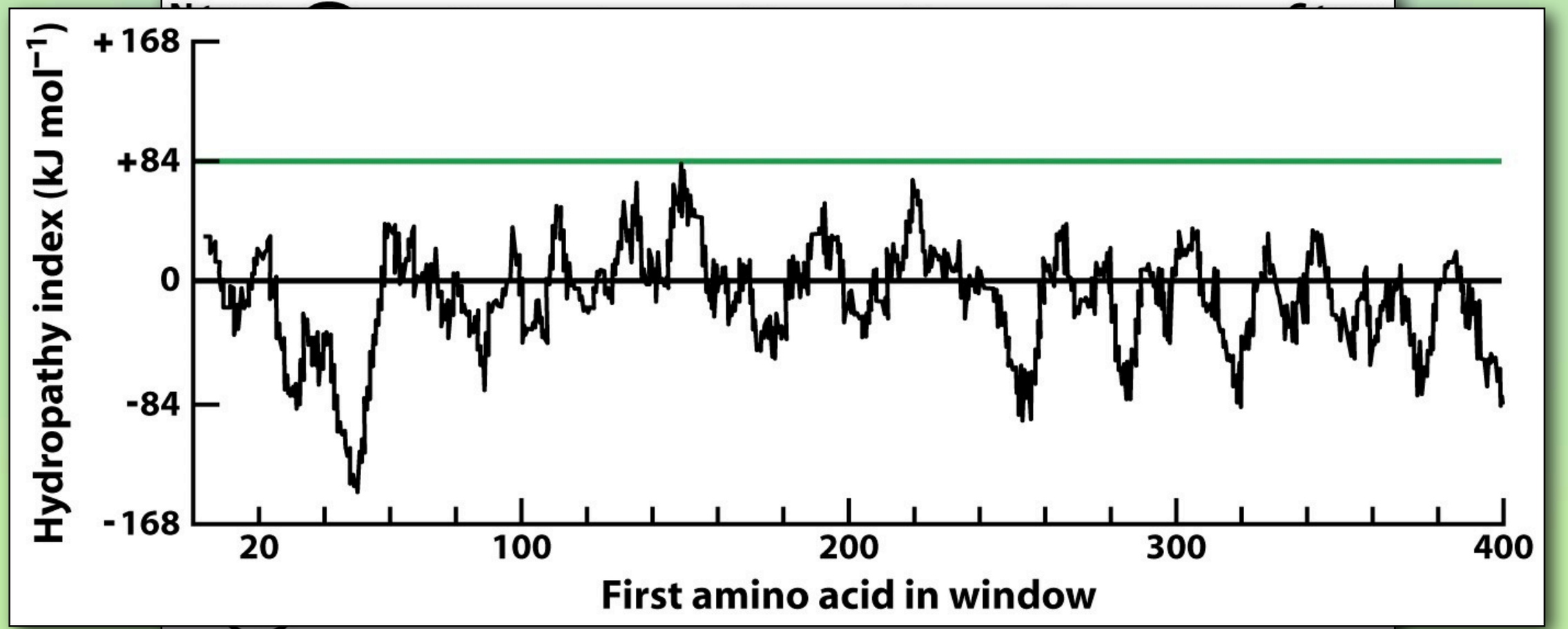

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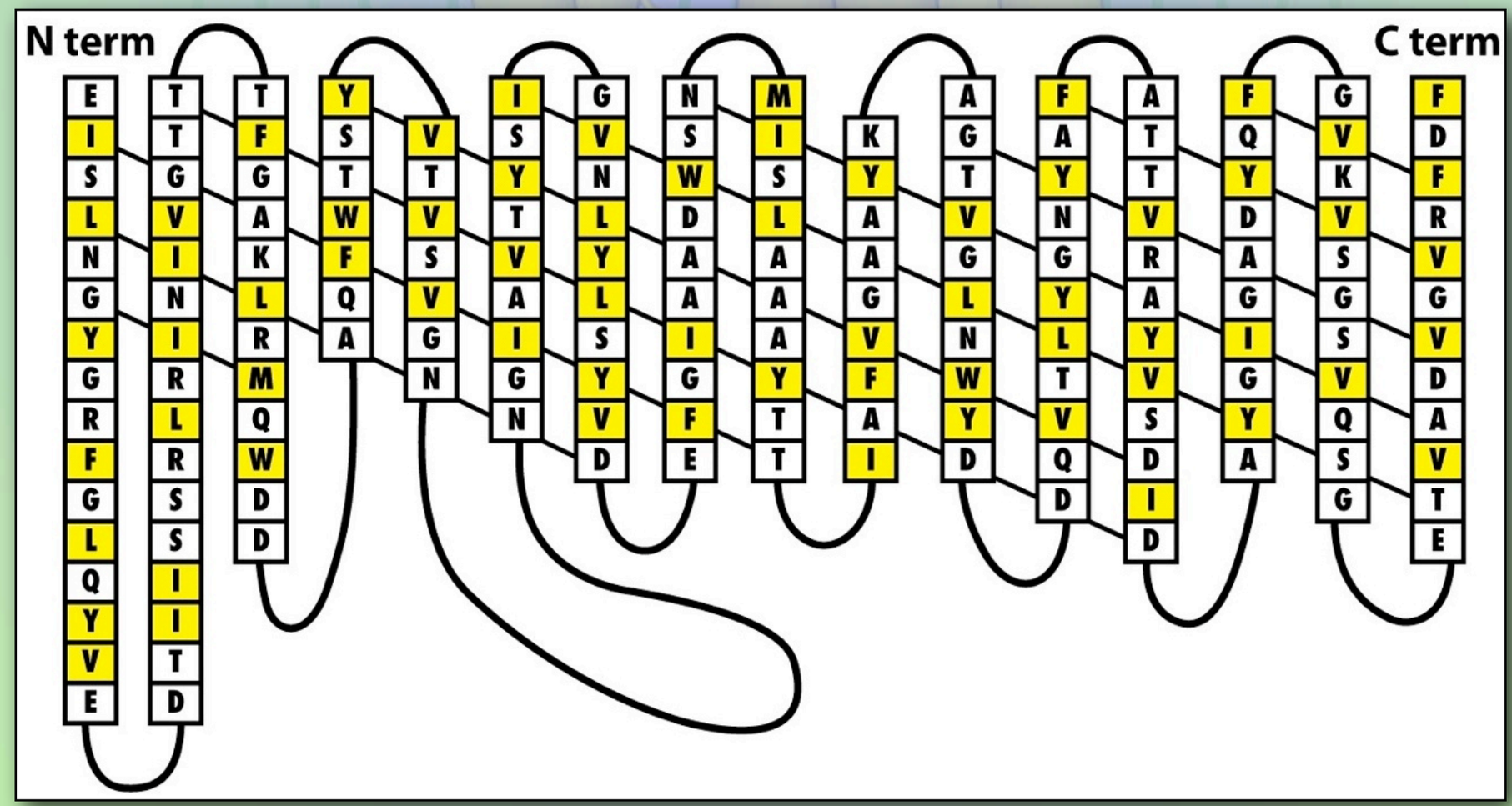

Cell Membrane Proteins

- Three examples of integral membrane proteins
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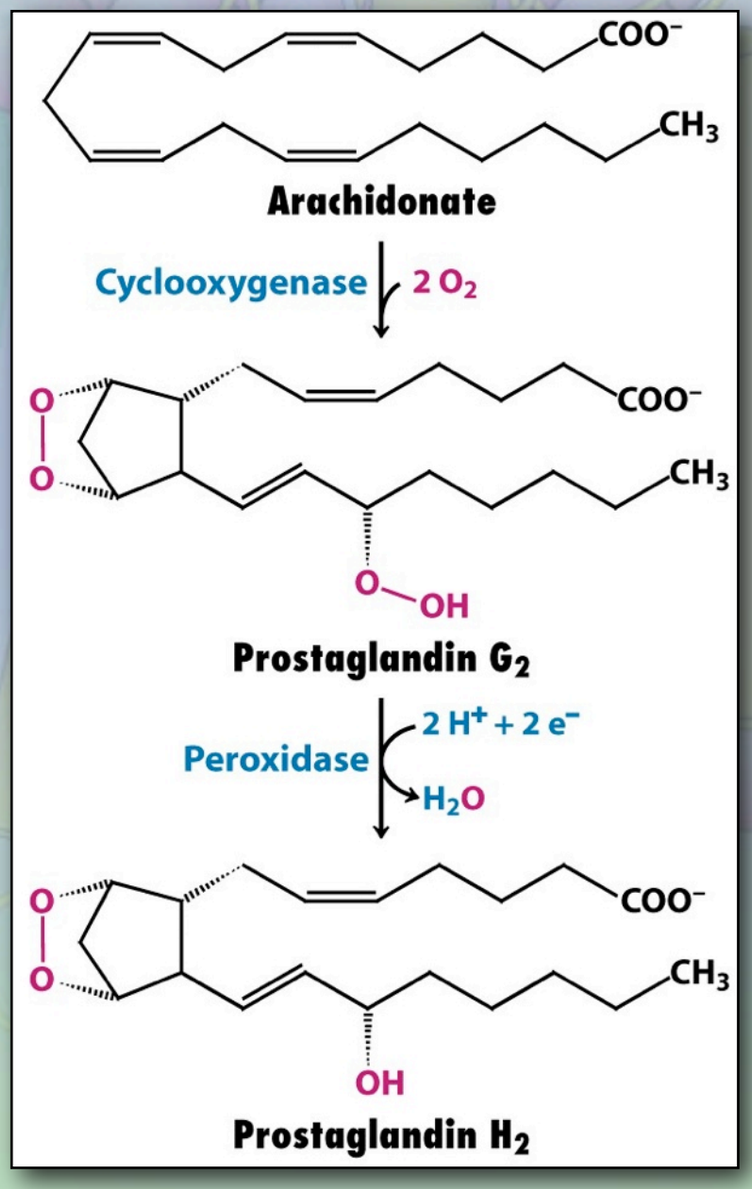

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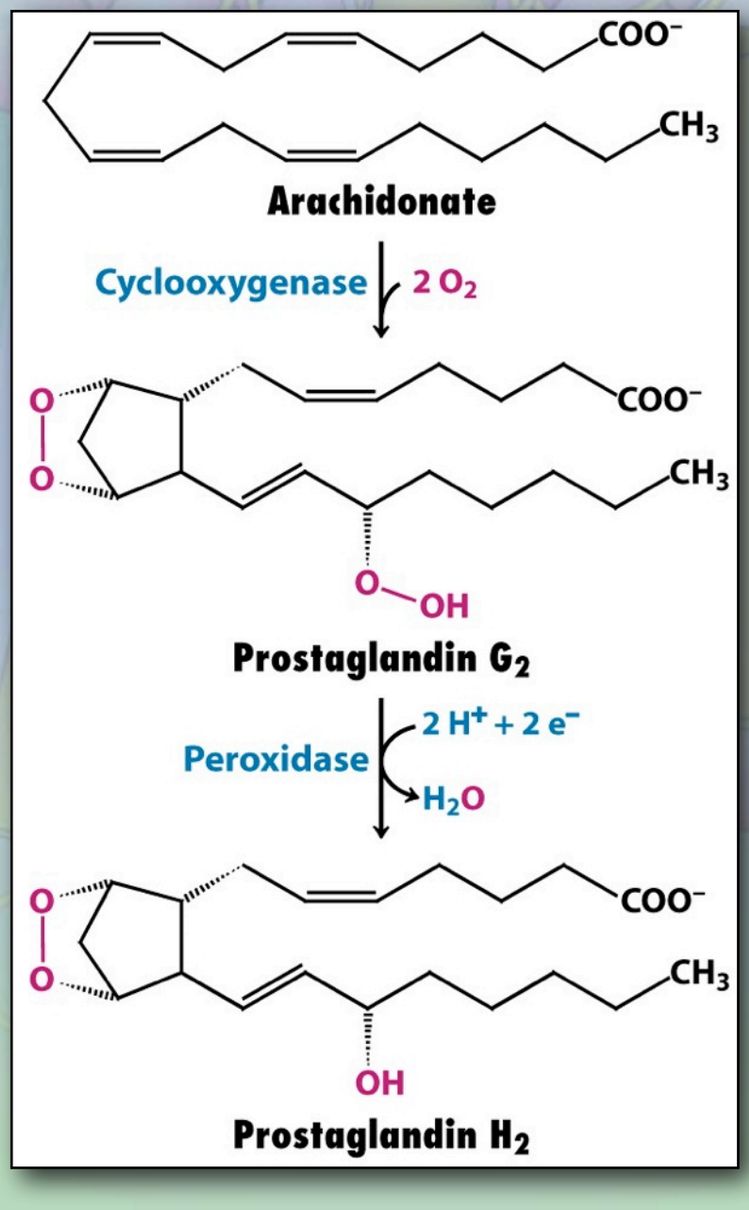

Promotes inflammation and modulates gastric acid secretion

Cell Membrane Proteins

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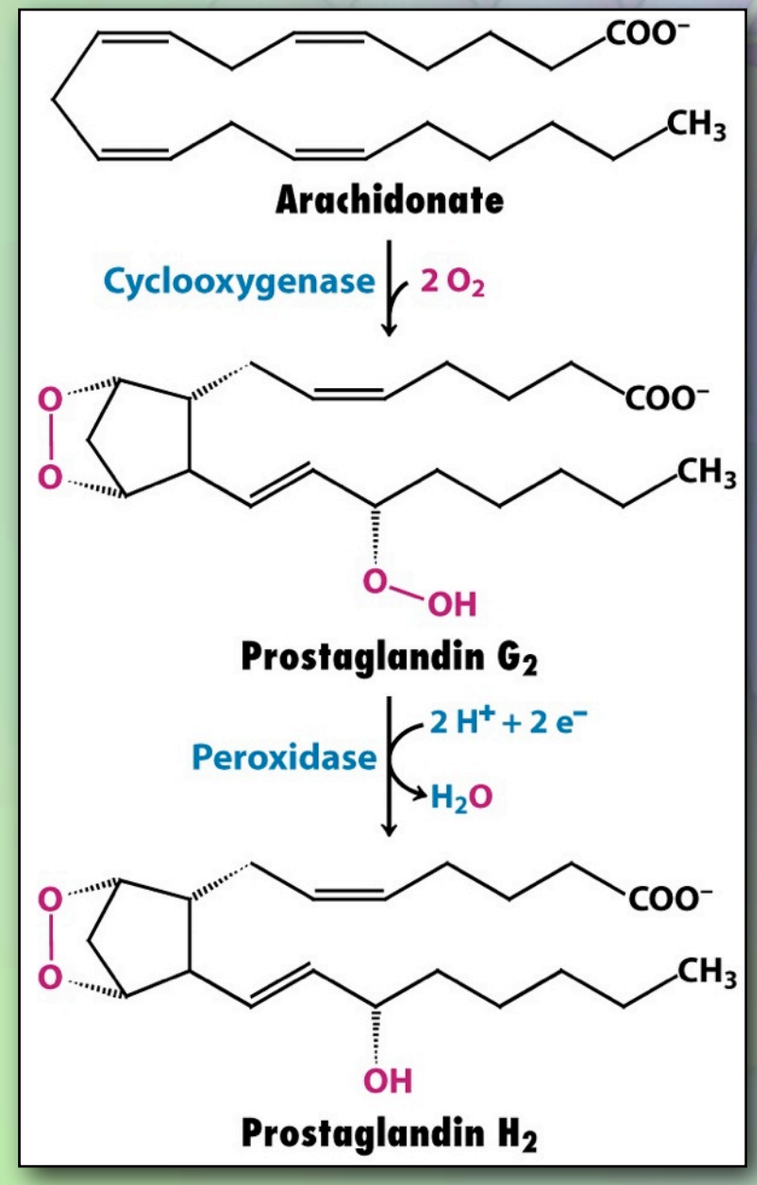

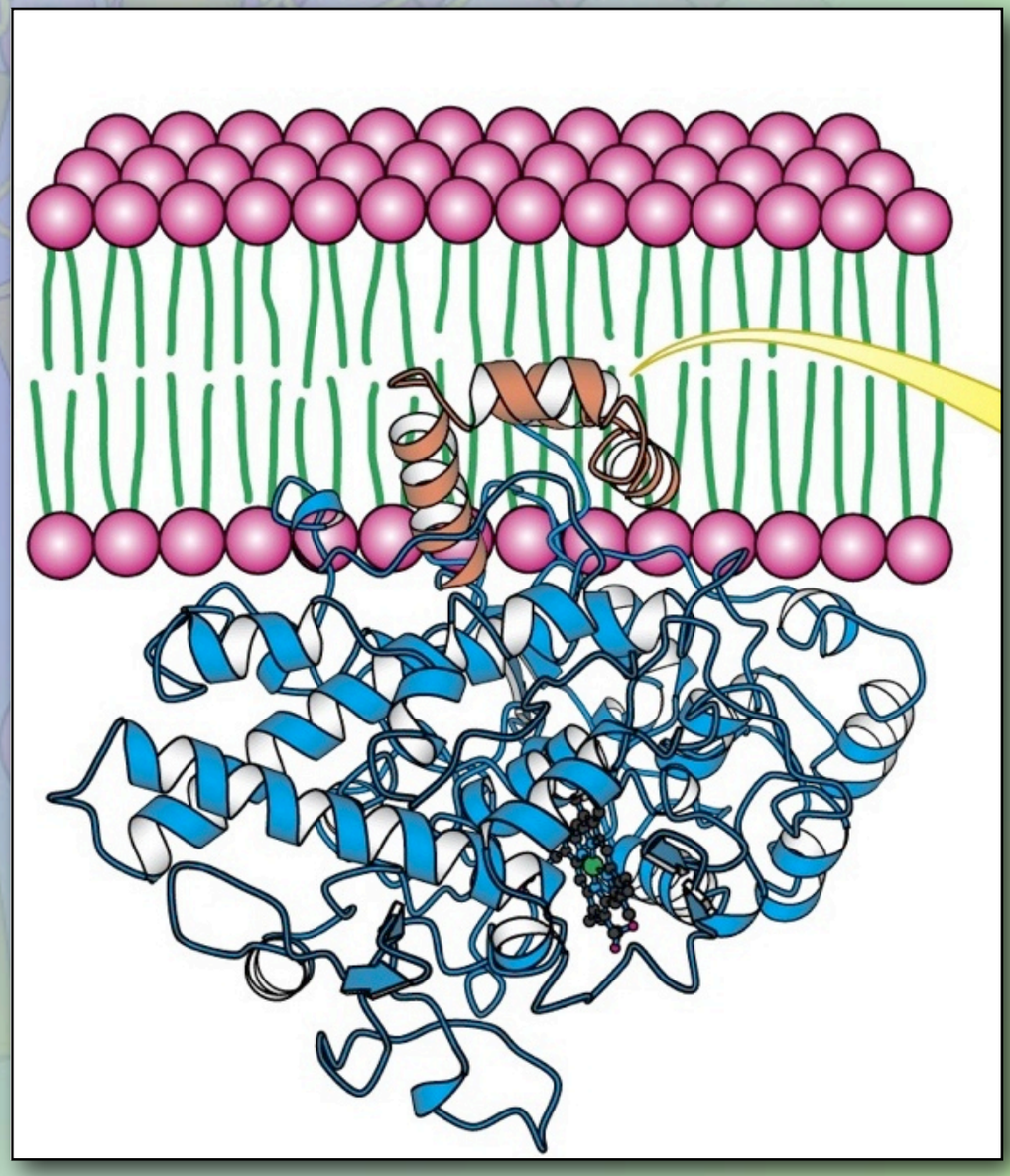

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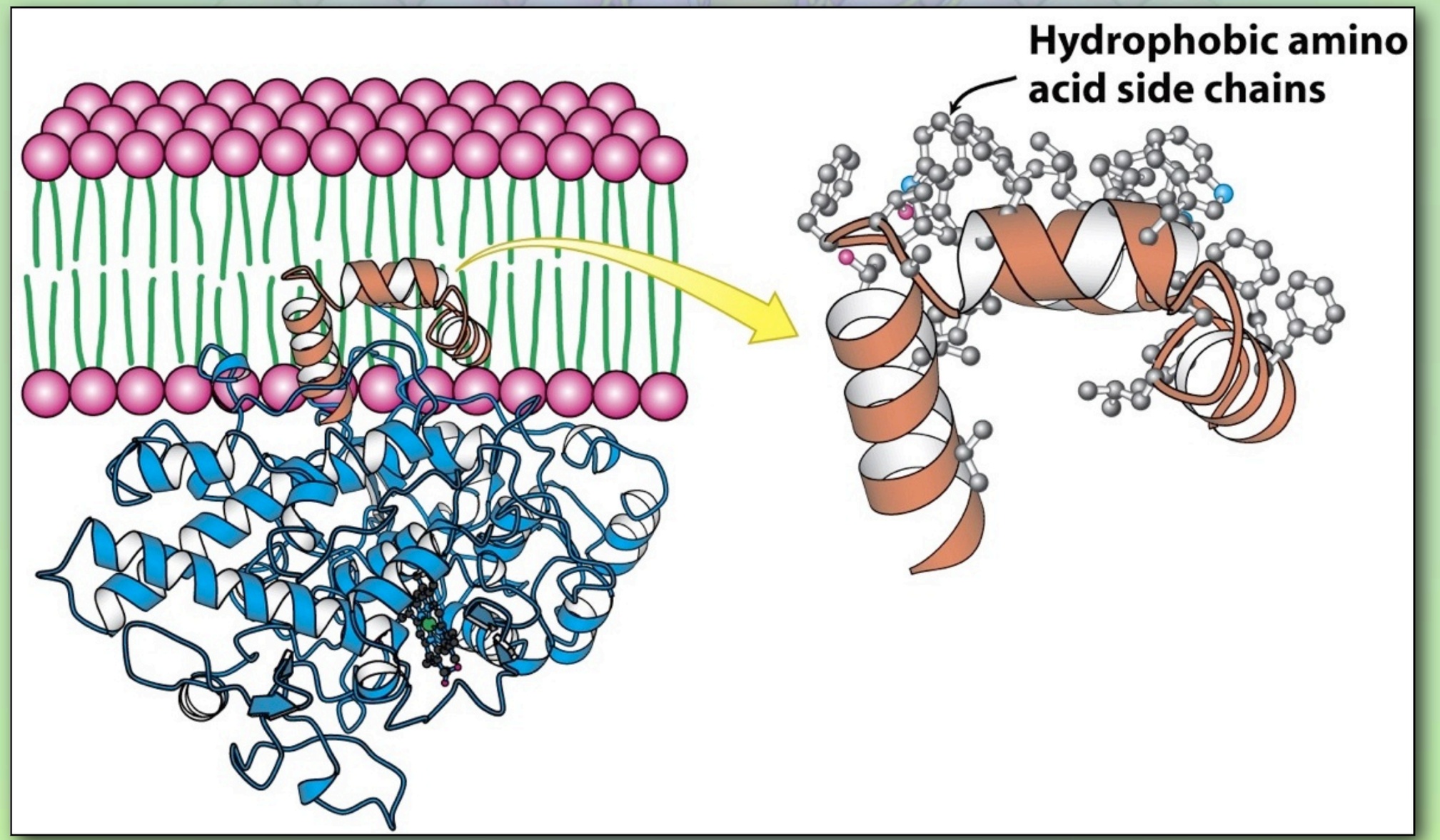
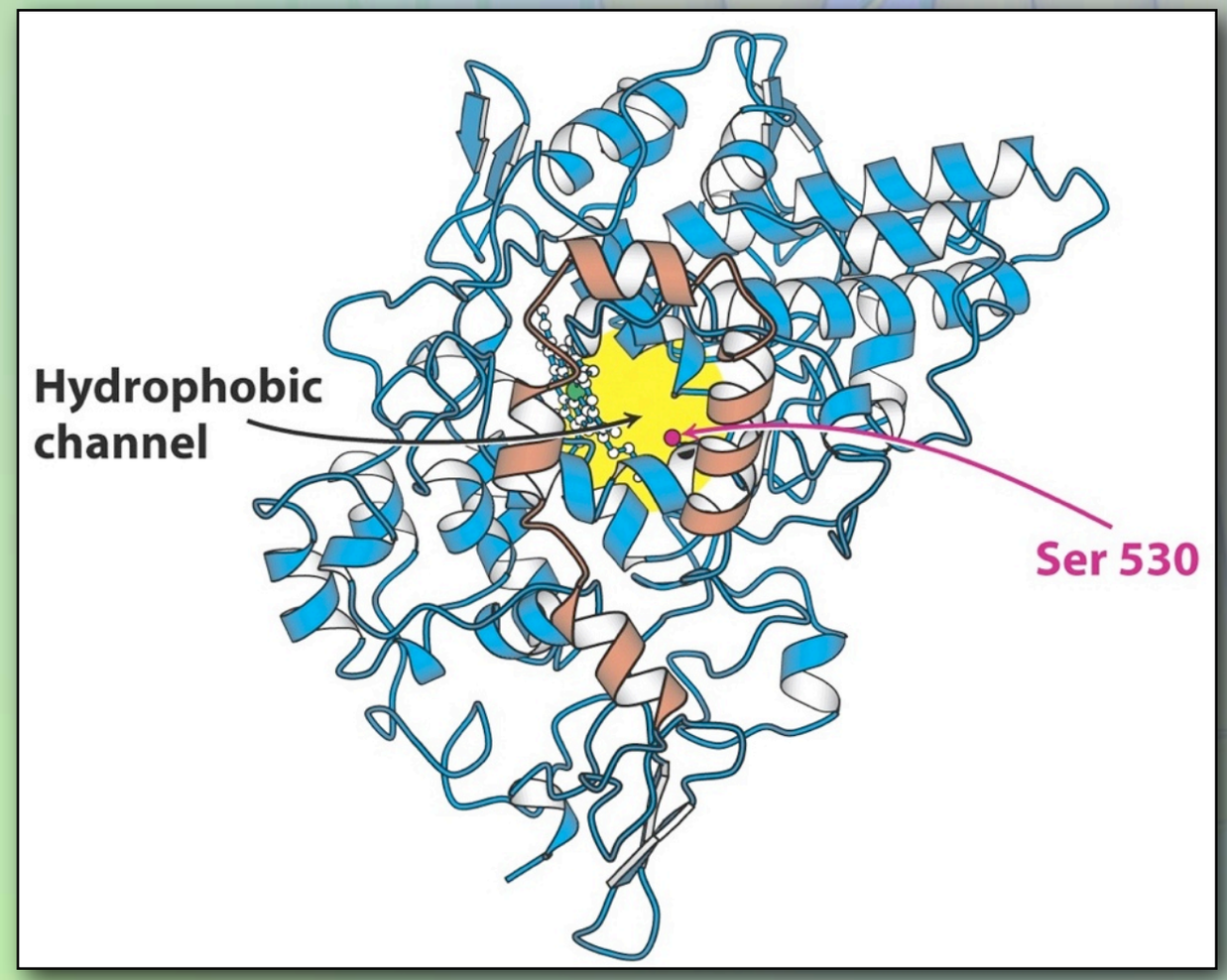
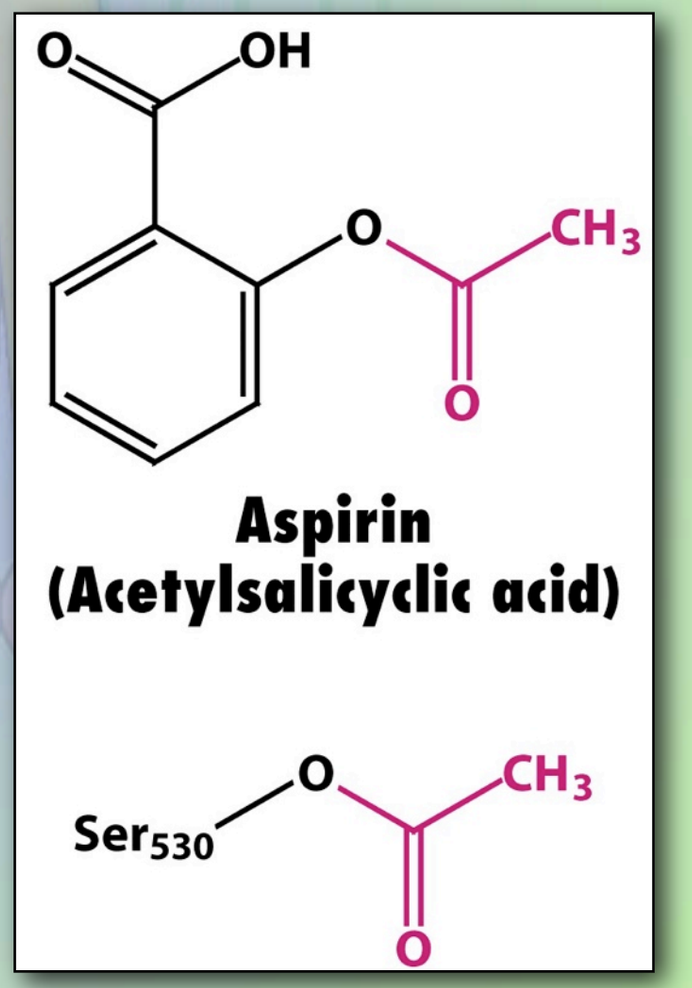


Cell Membrane Proteins

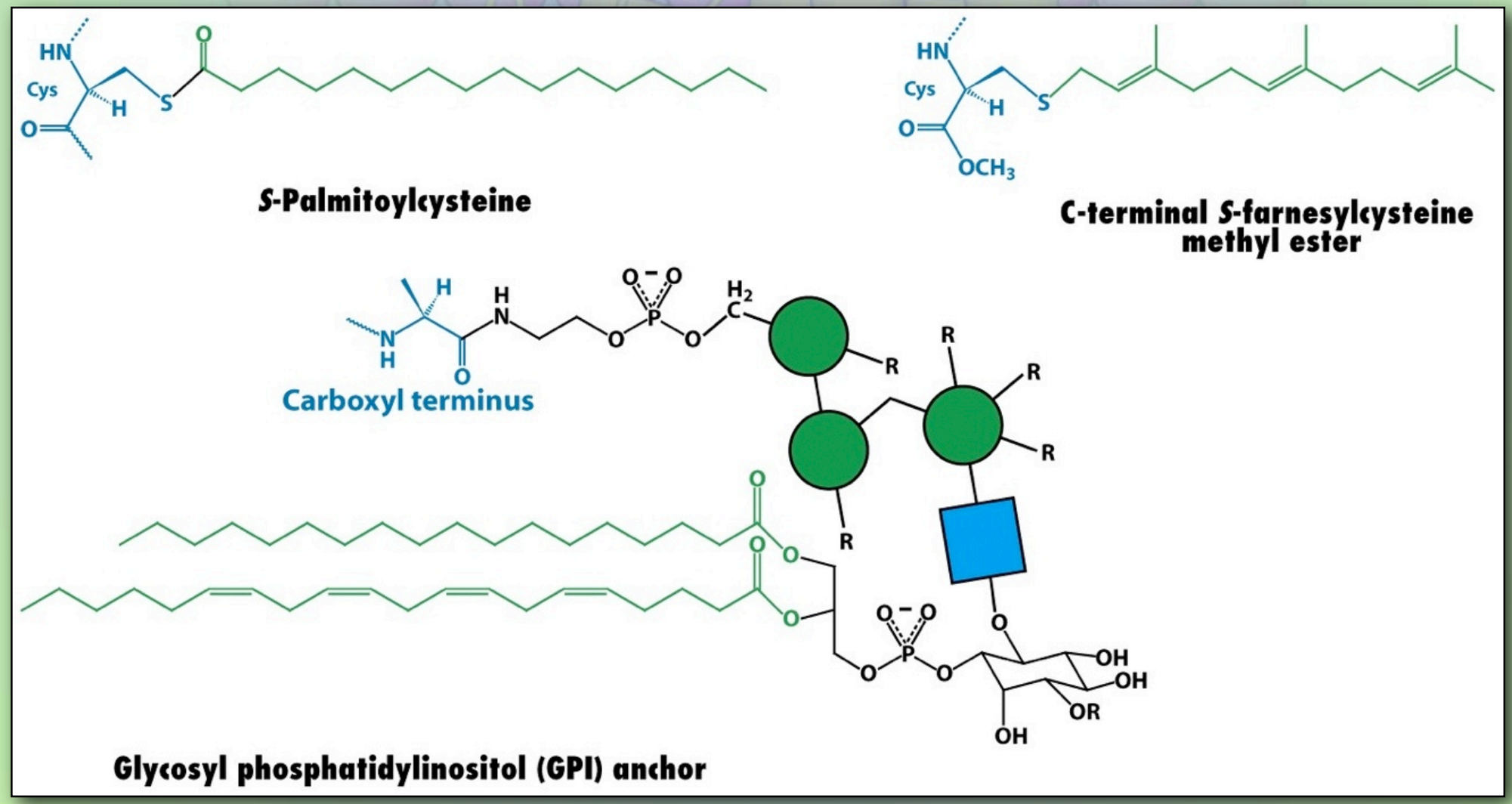
- Three examples of integral membrane proteins
  - Prostaglandin H_2 synthase-1 (Enzyme)
    - Inhibited by COX inhibitors (NSAID)





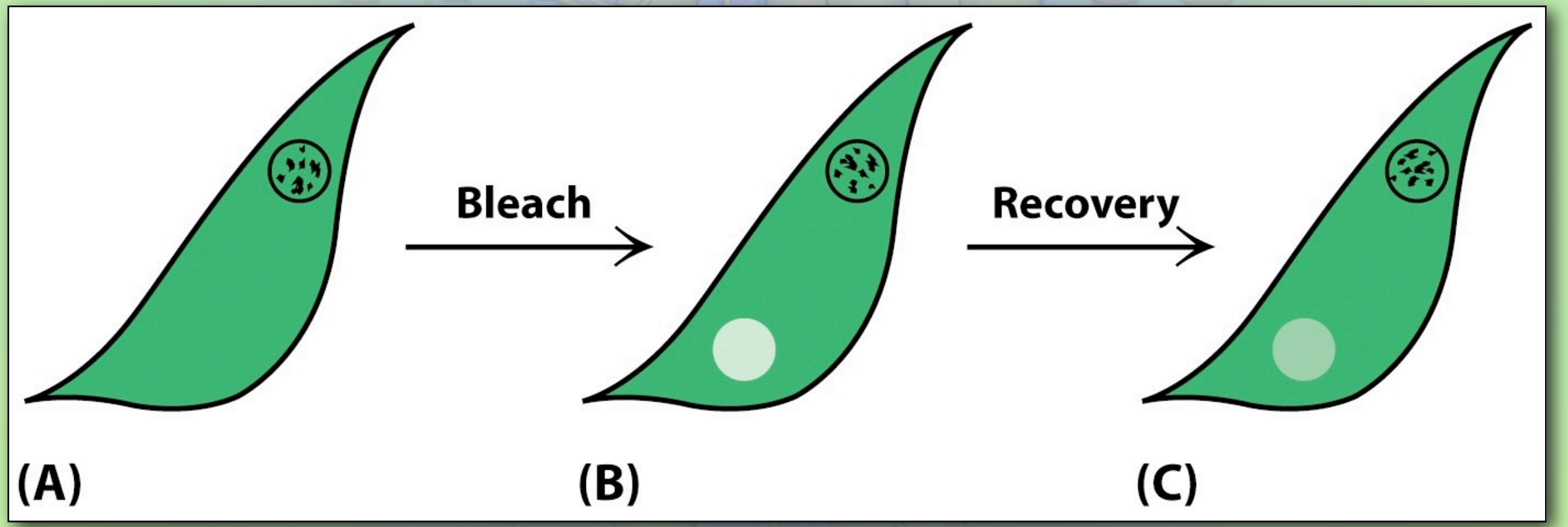
Cell Membrane Proteins

- 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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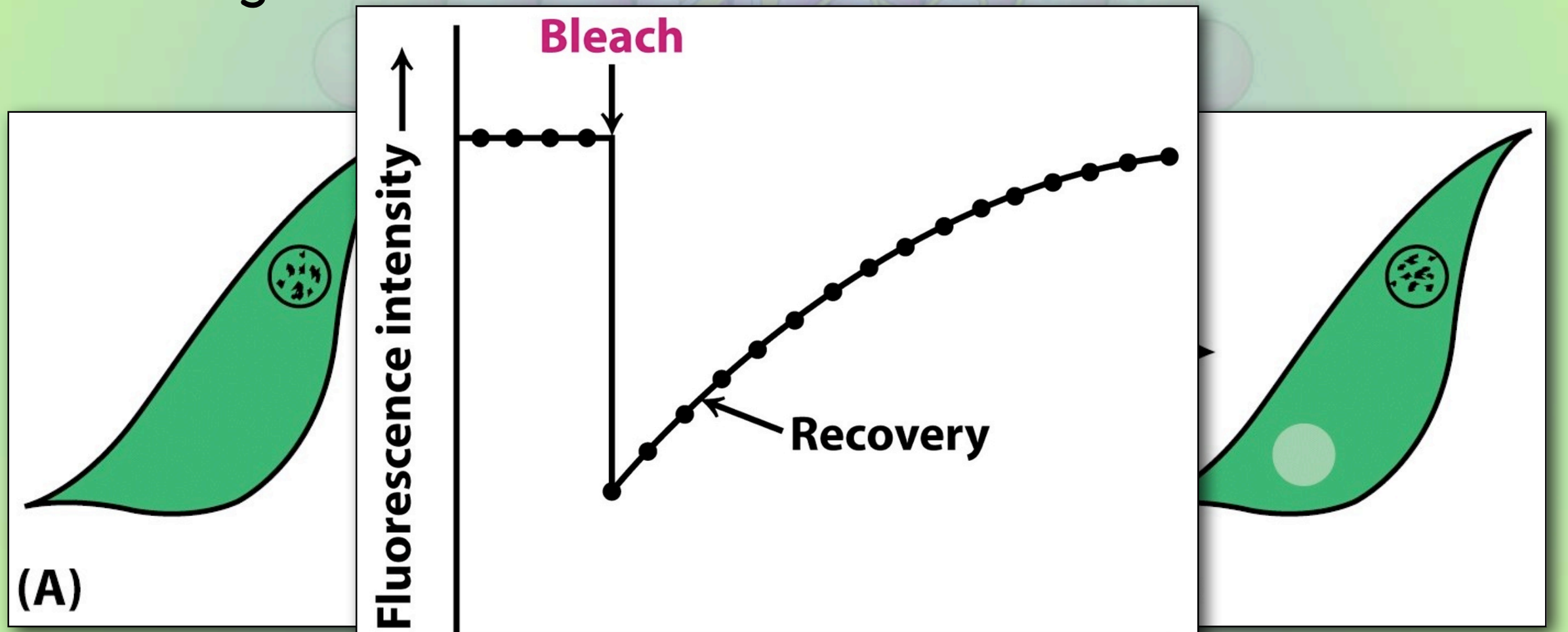

$$S = (4Dt)^{1/2}$$

Cell Membrane Proteins

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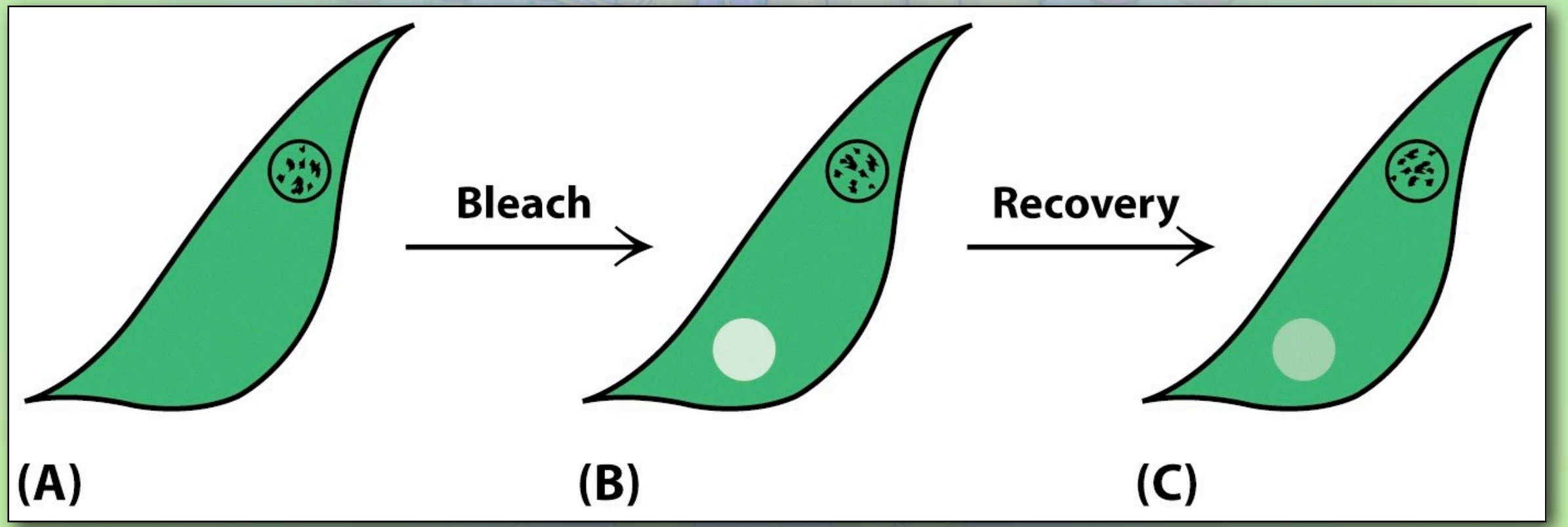
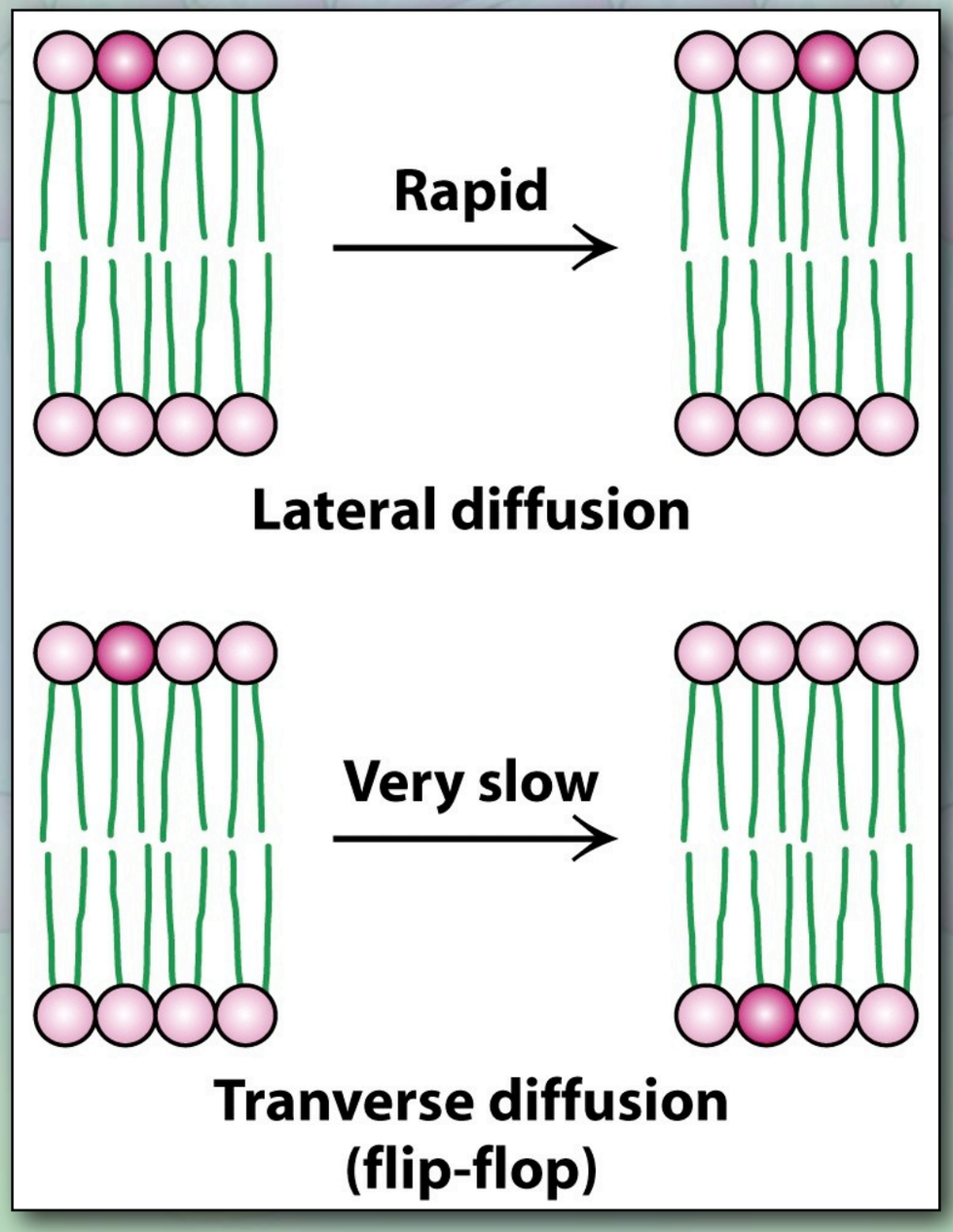


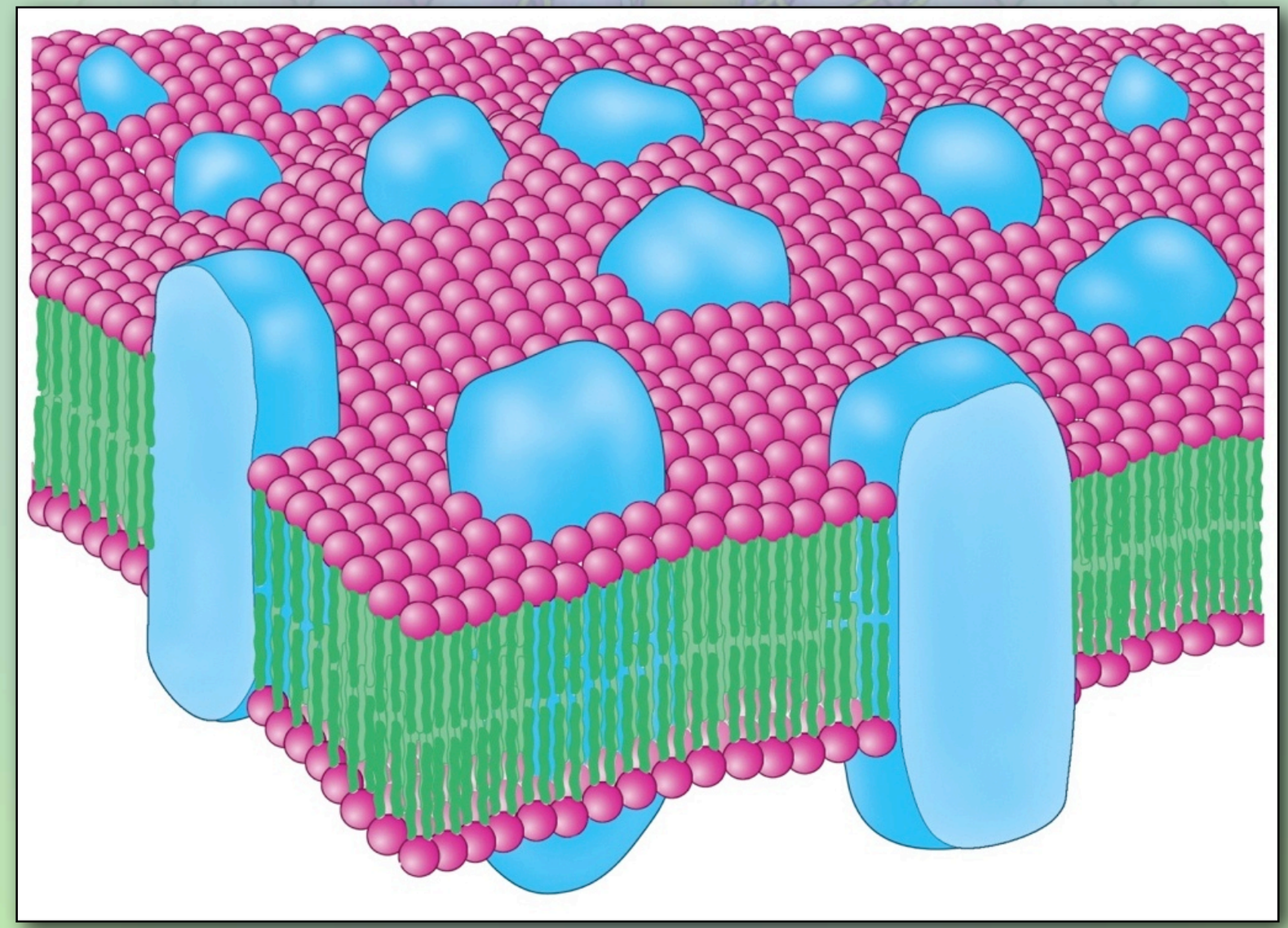
Cell Membrane Proteins

- Transverse diffusion is very slow.



Cell Membrane Proteins

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



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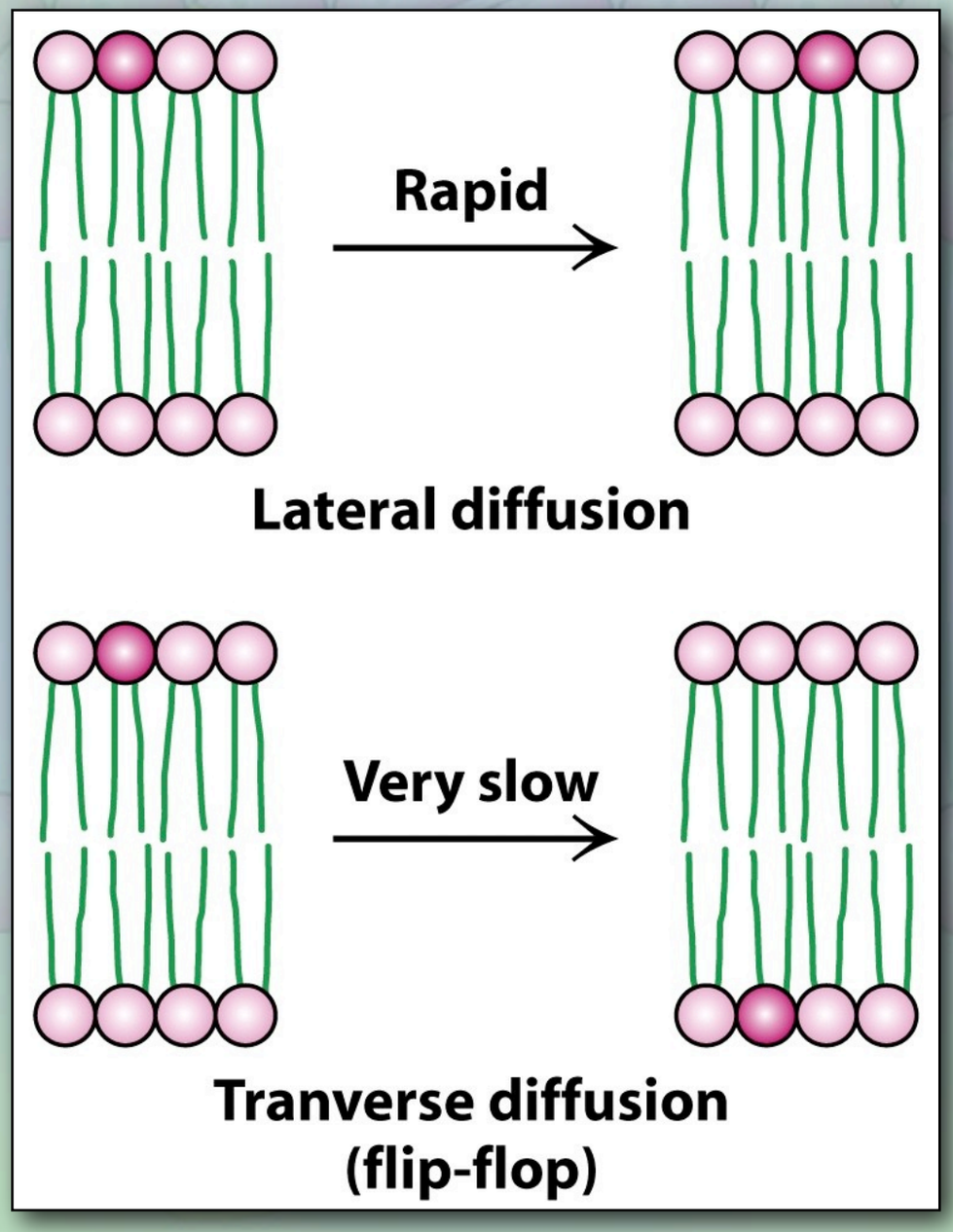

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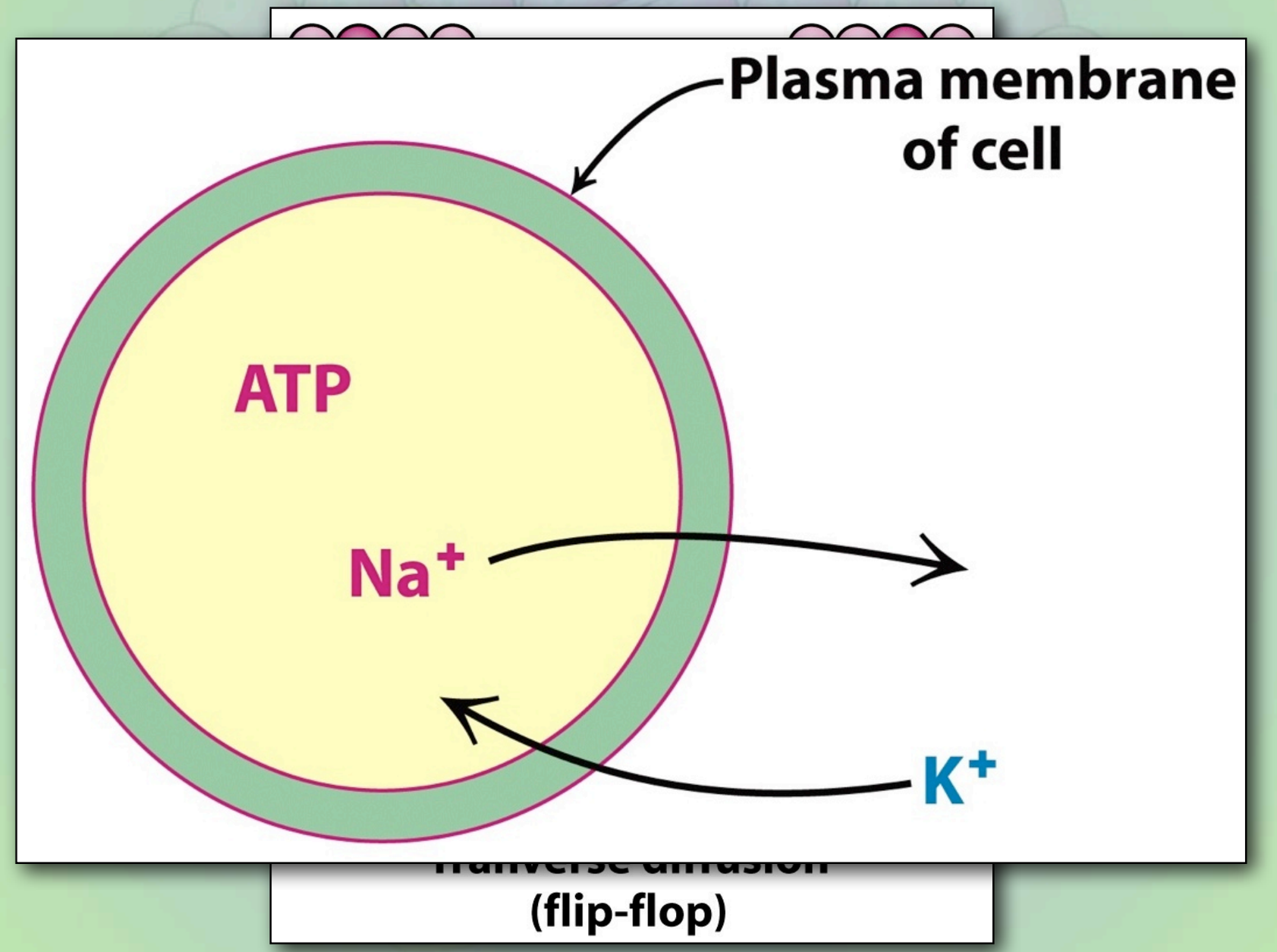

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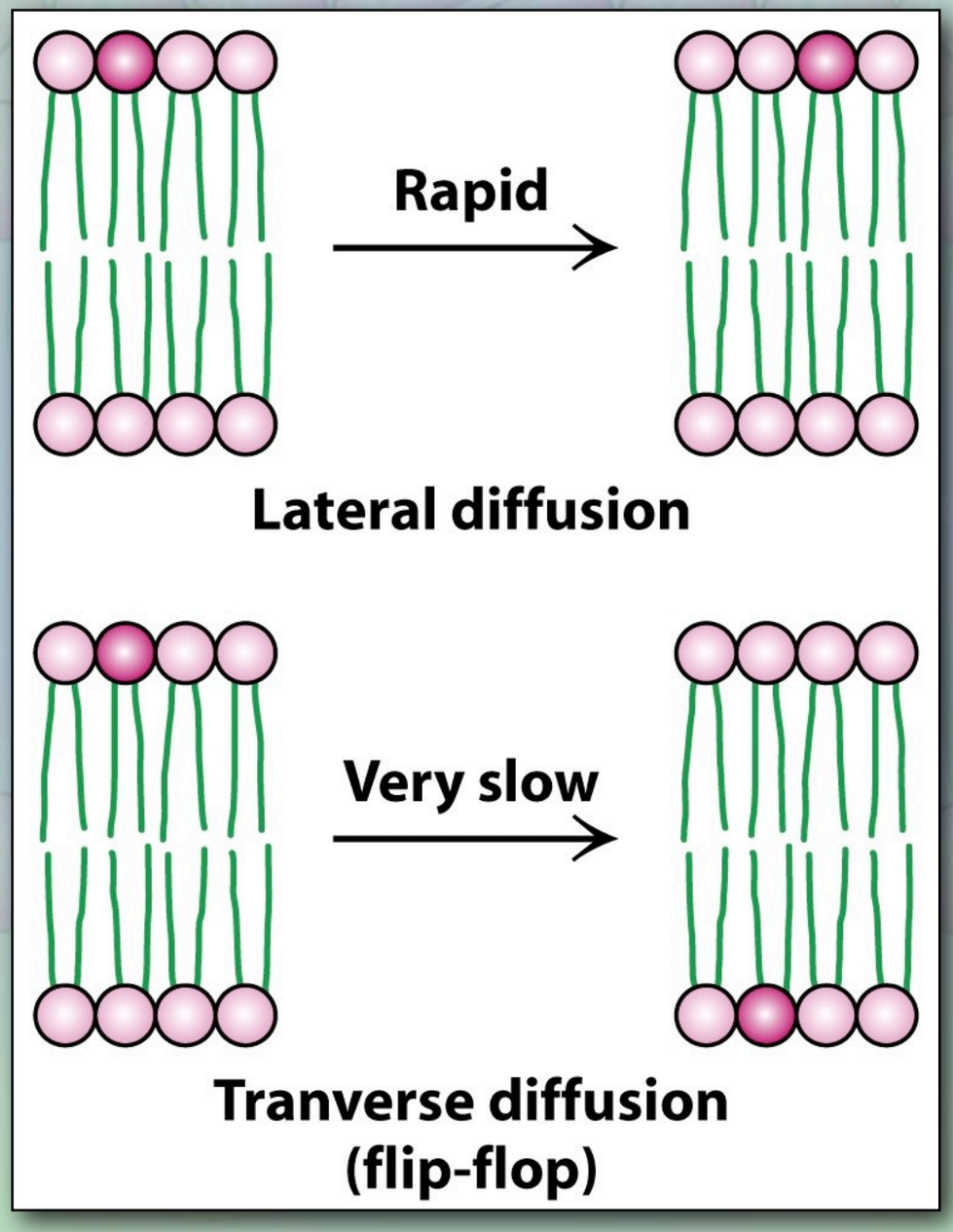
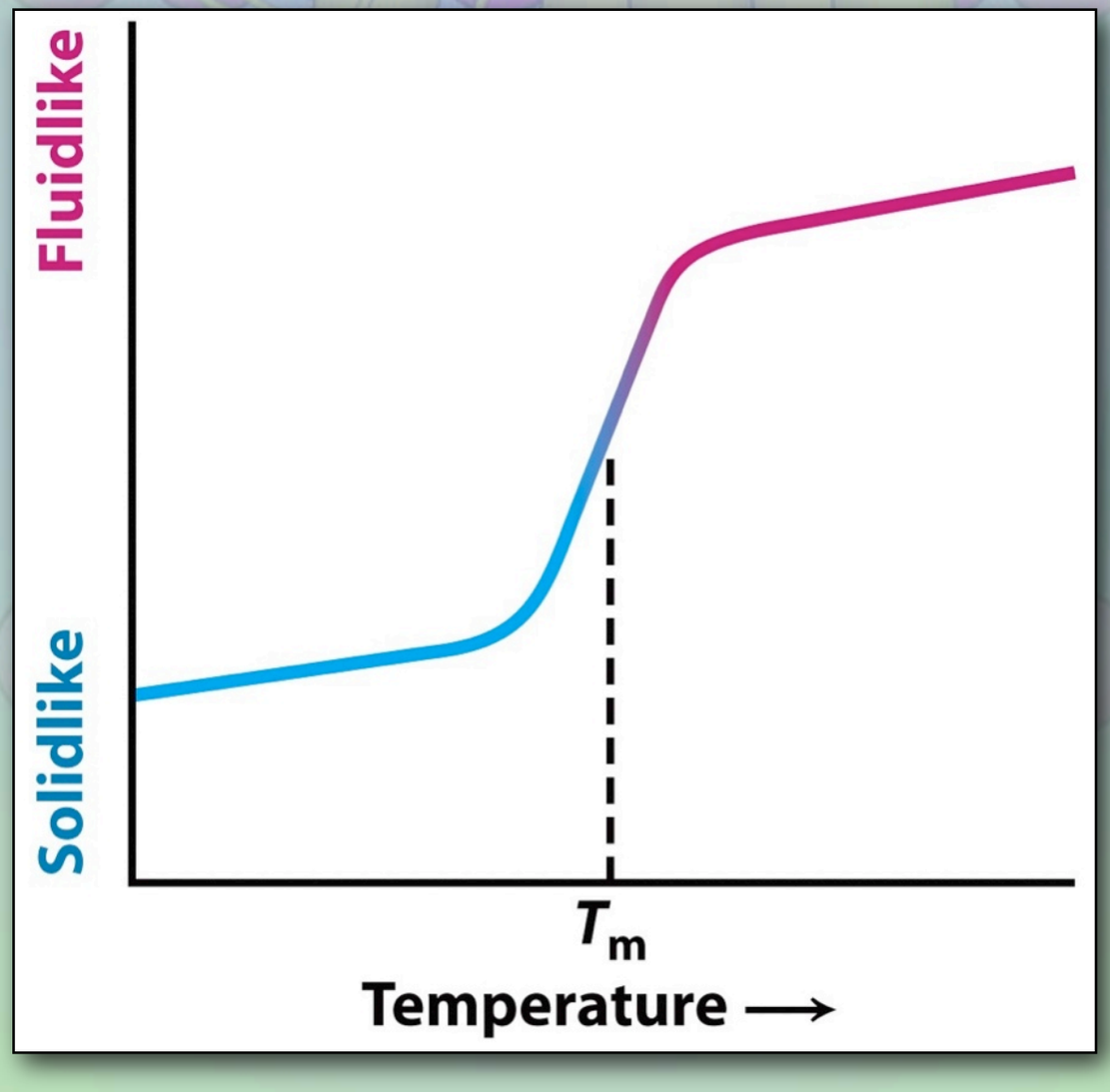


Cell Membrane Proteins

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



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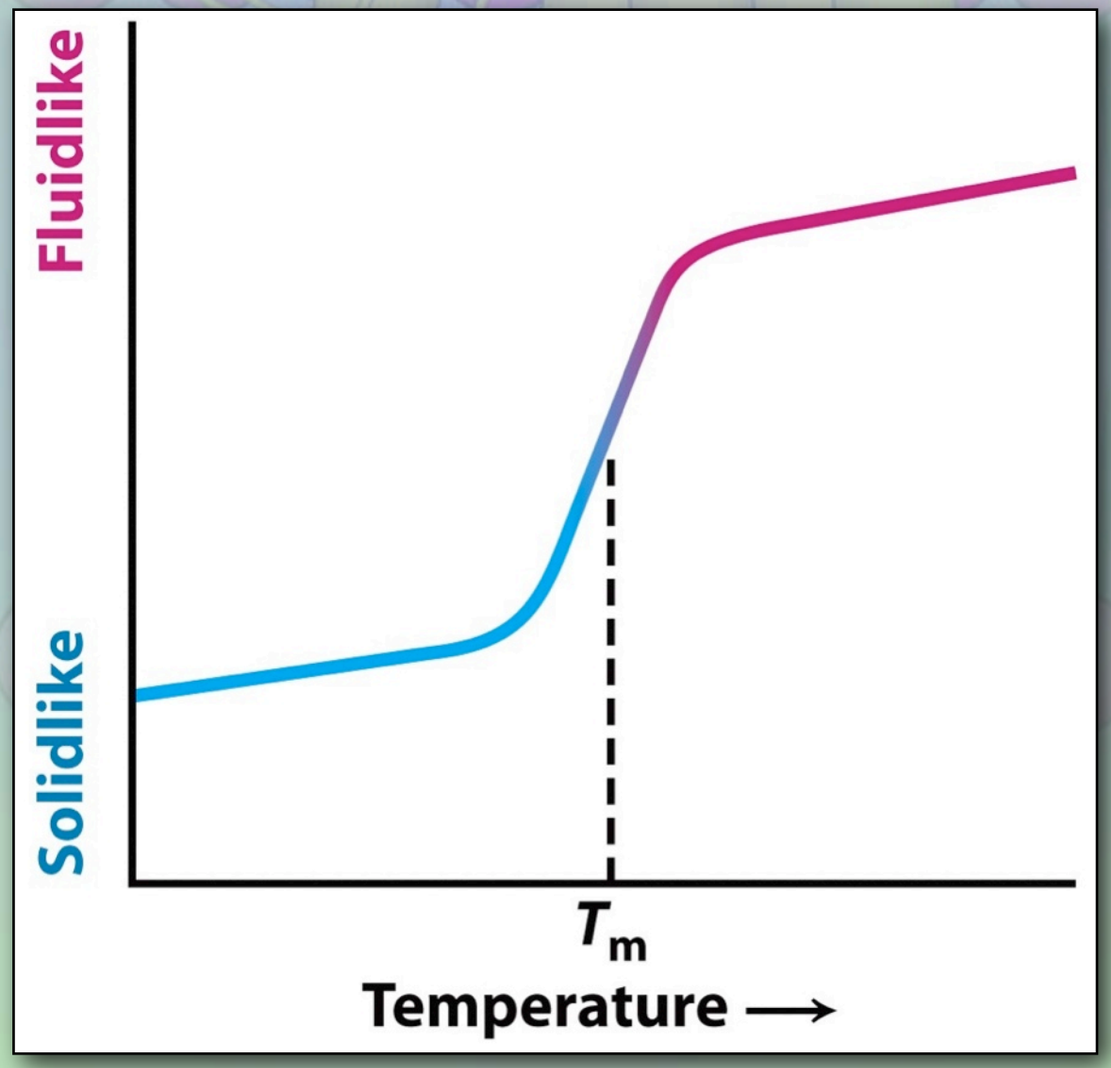

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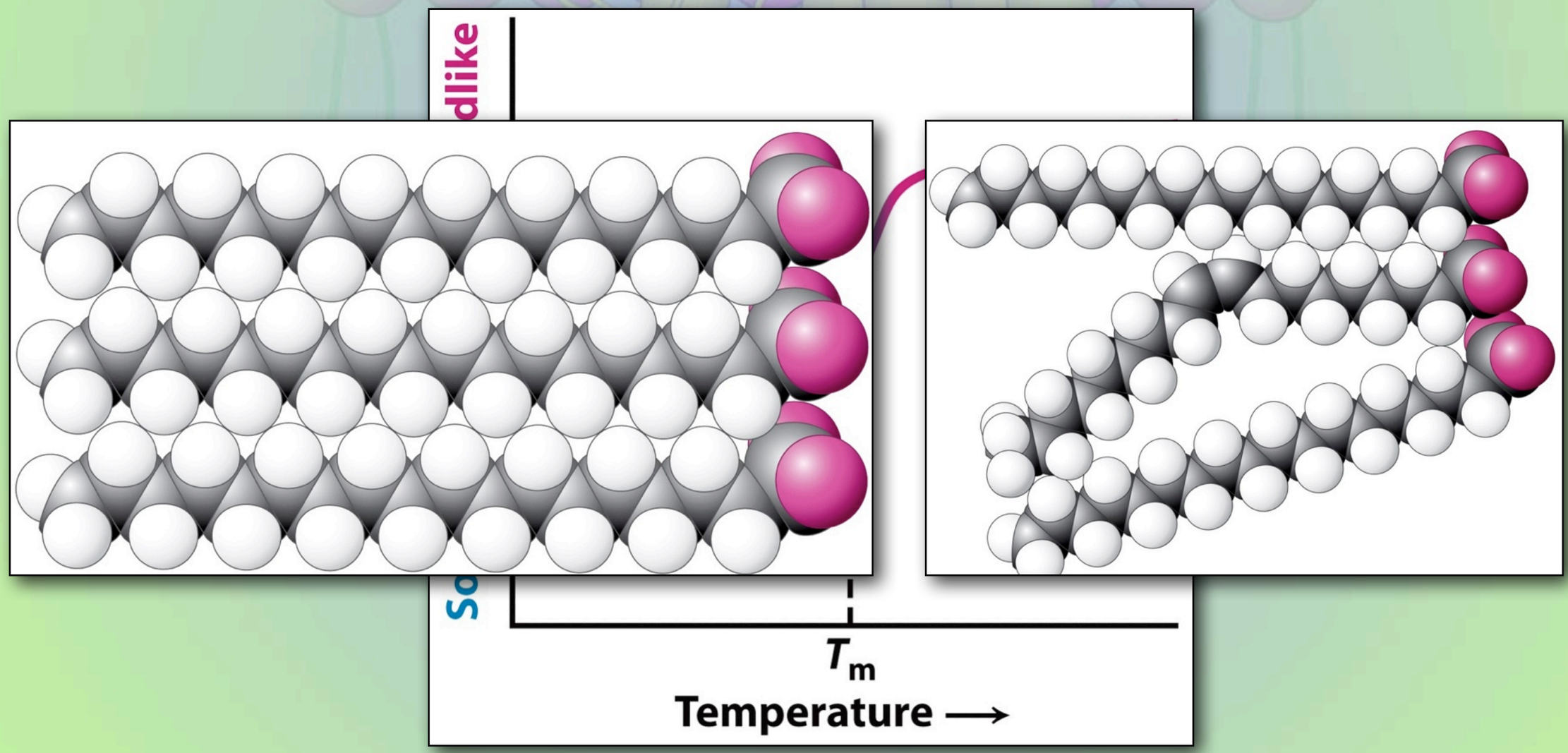

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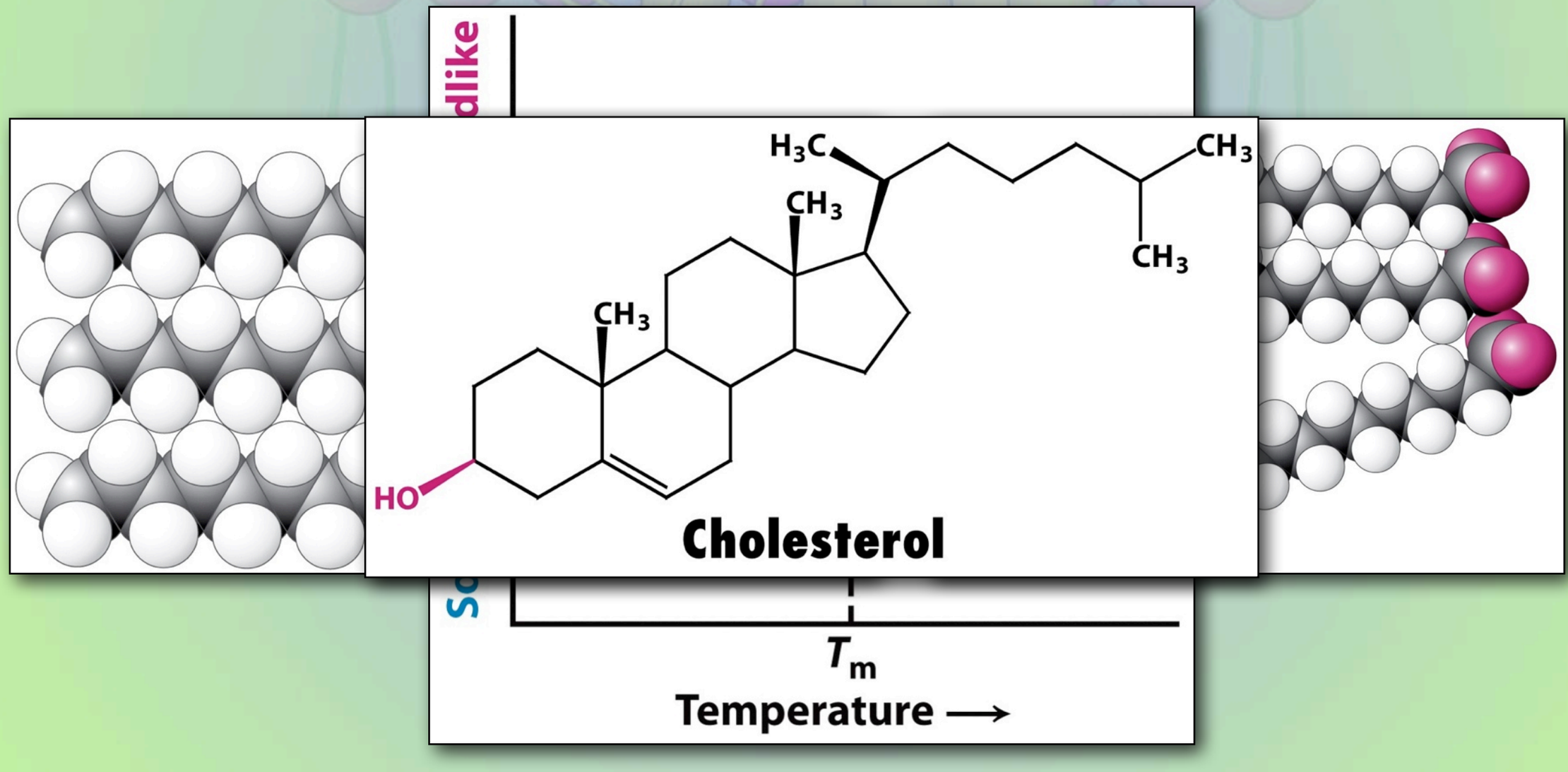

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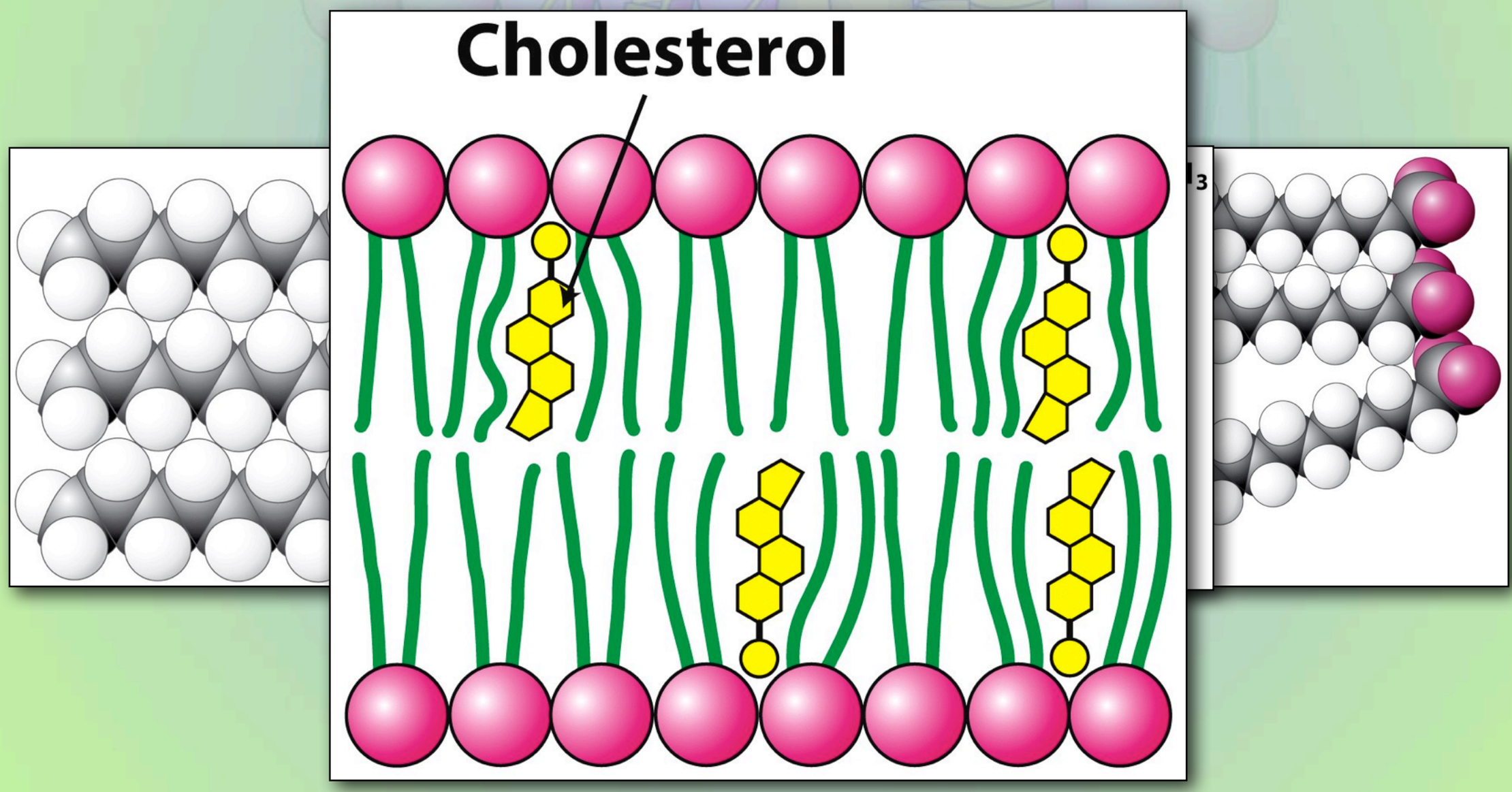

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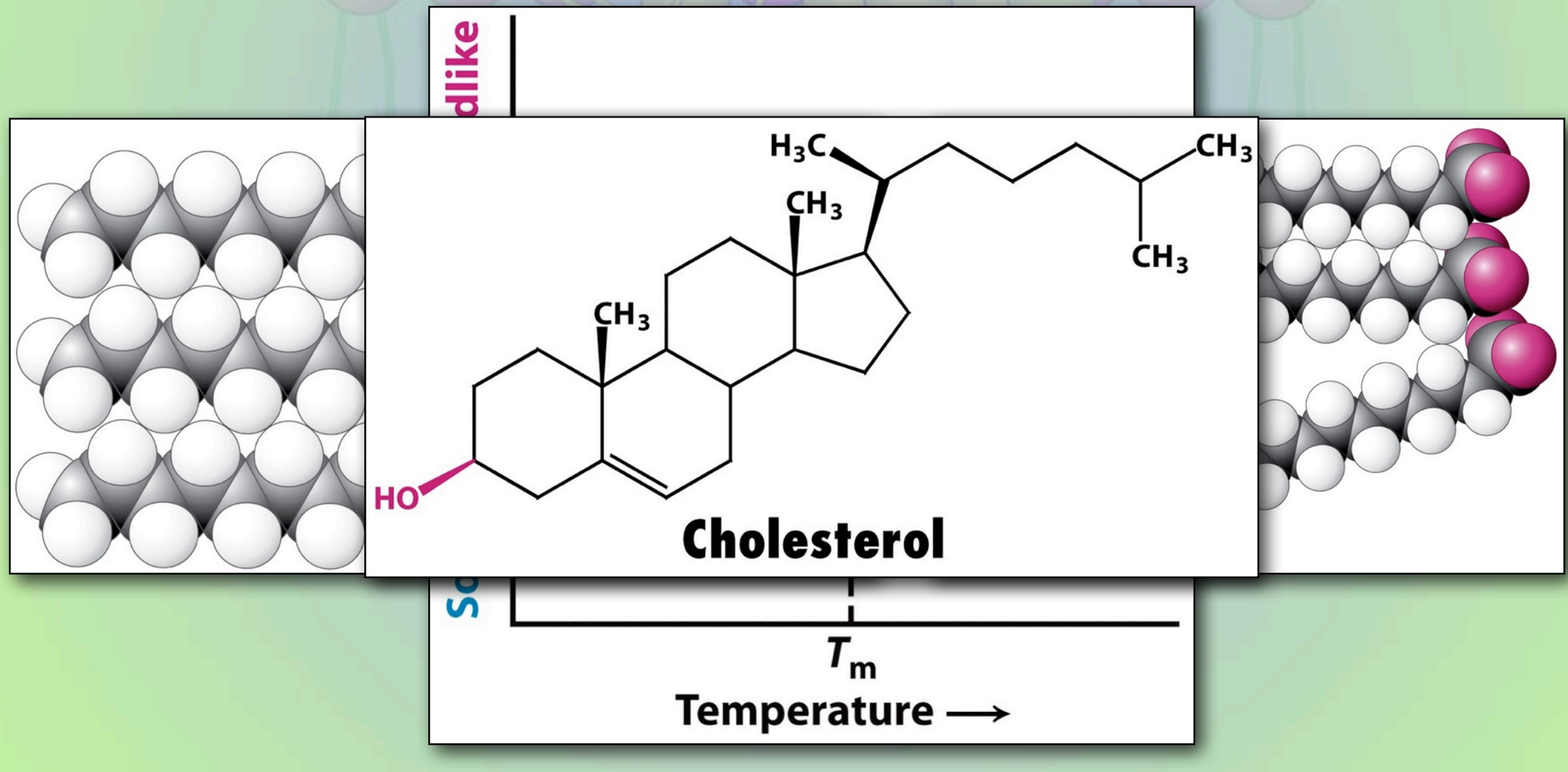

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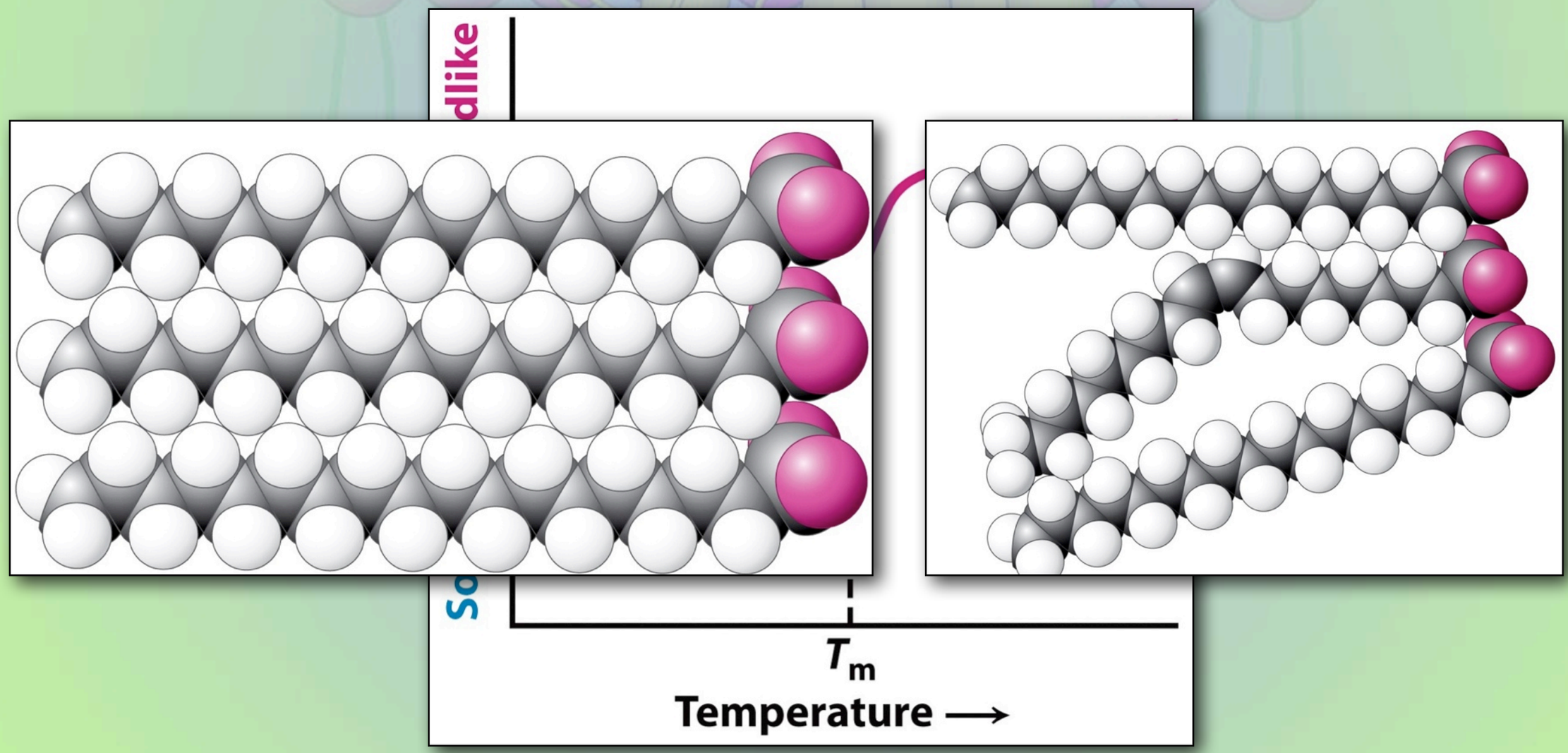

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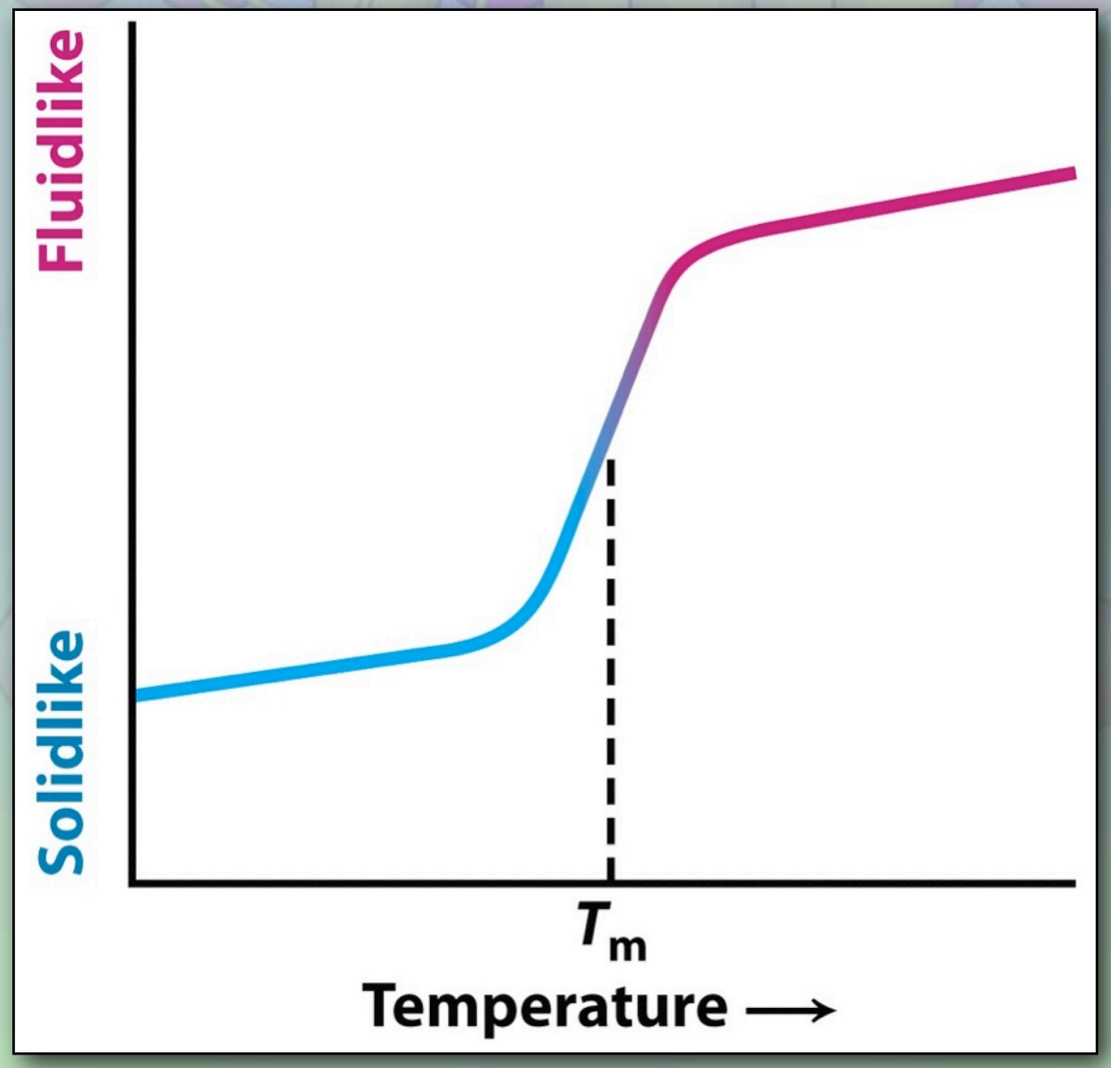
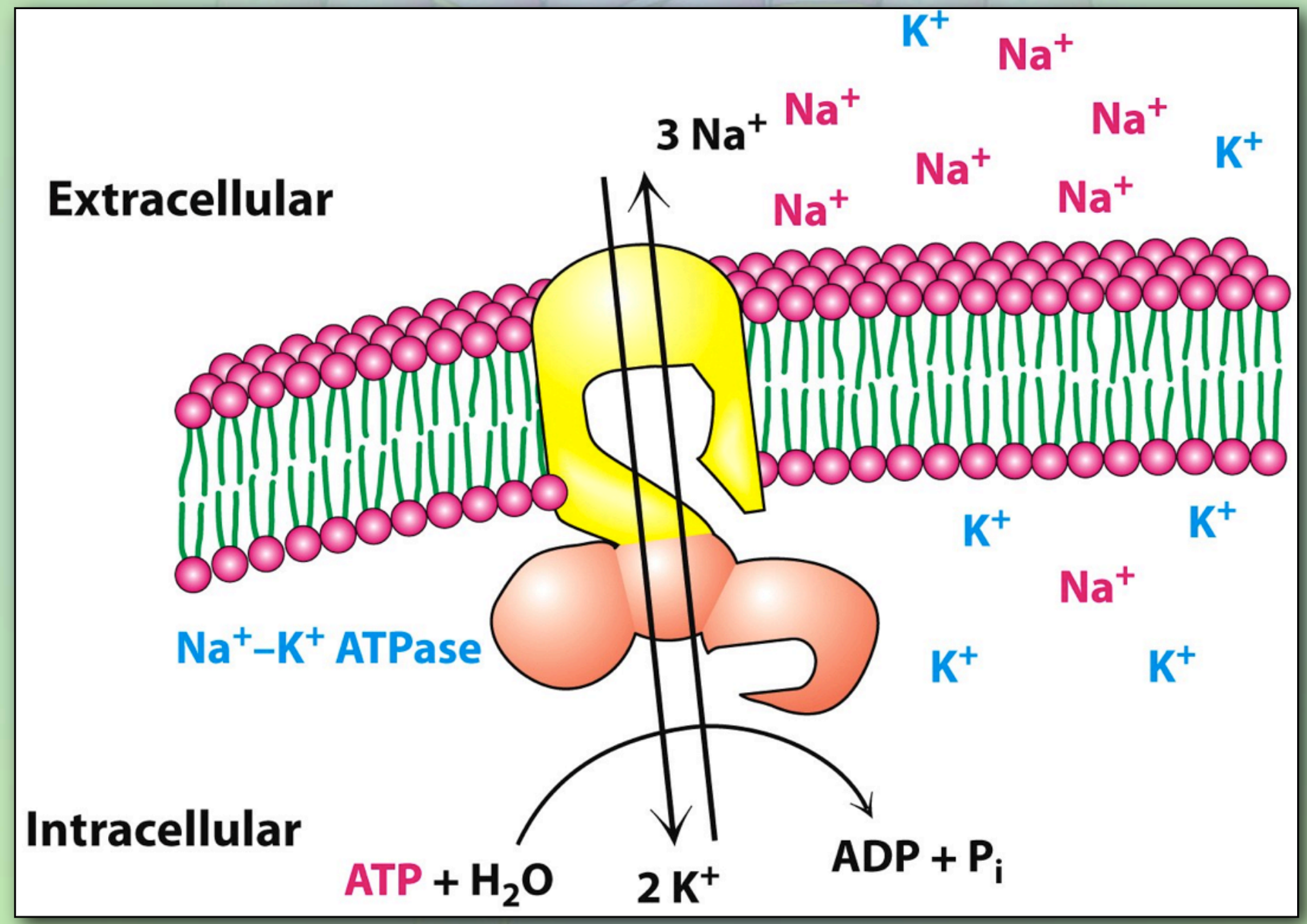


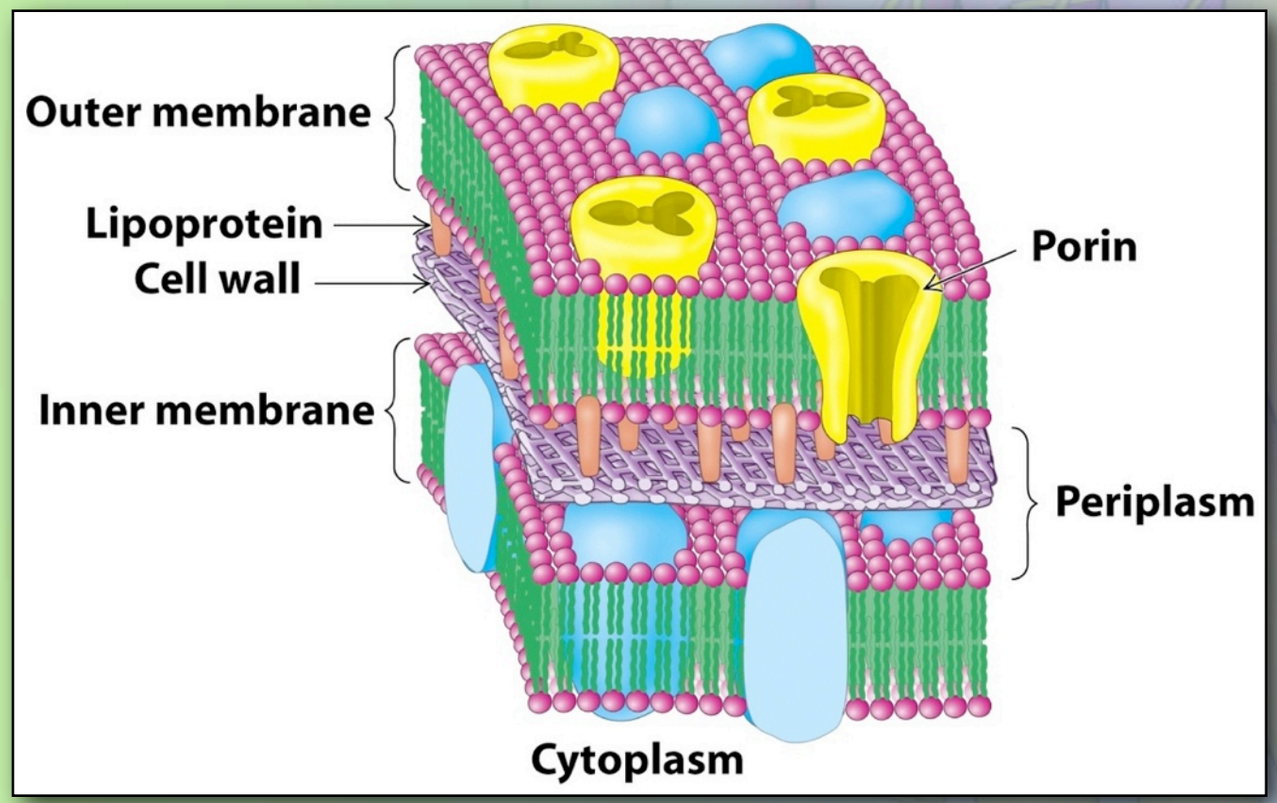
Cell Membrane Proteins

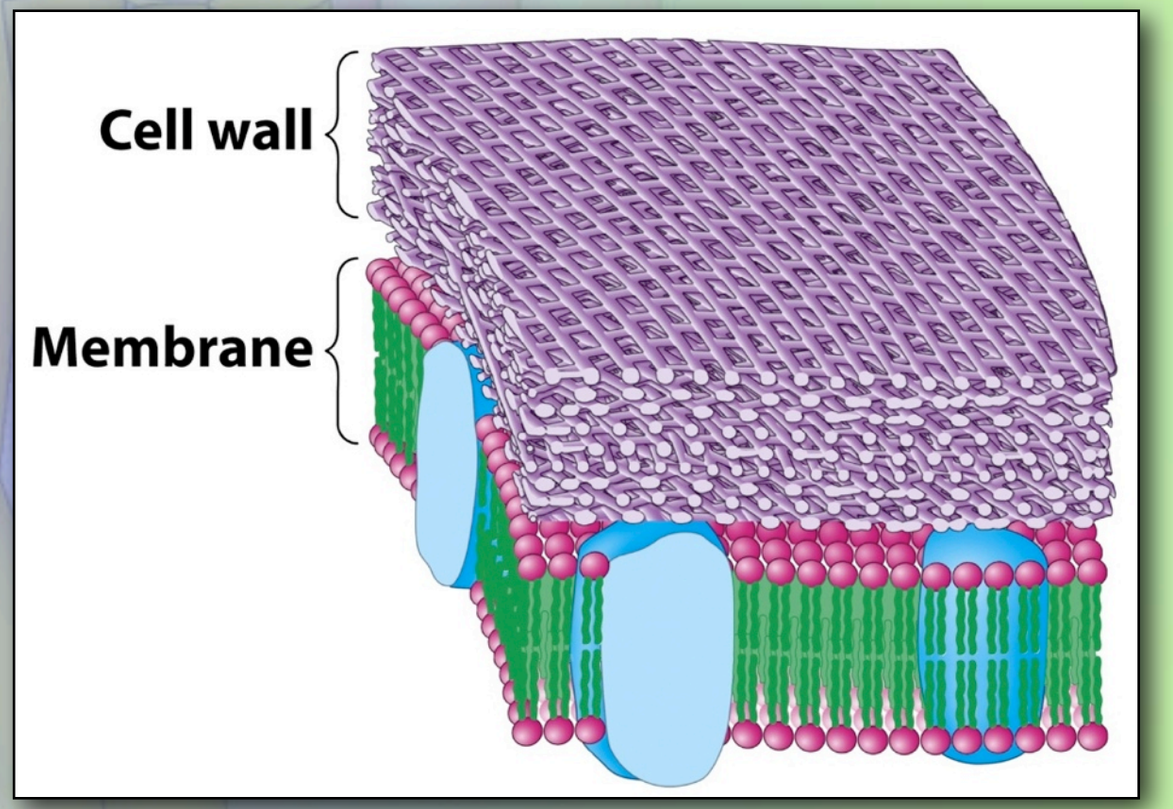
- Membranes are asymmetric



Cell Membrane Proteins

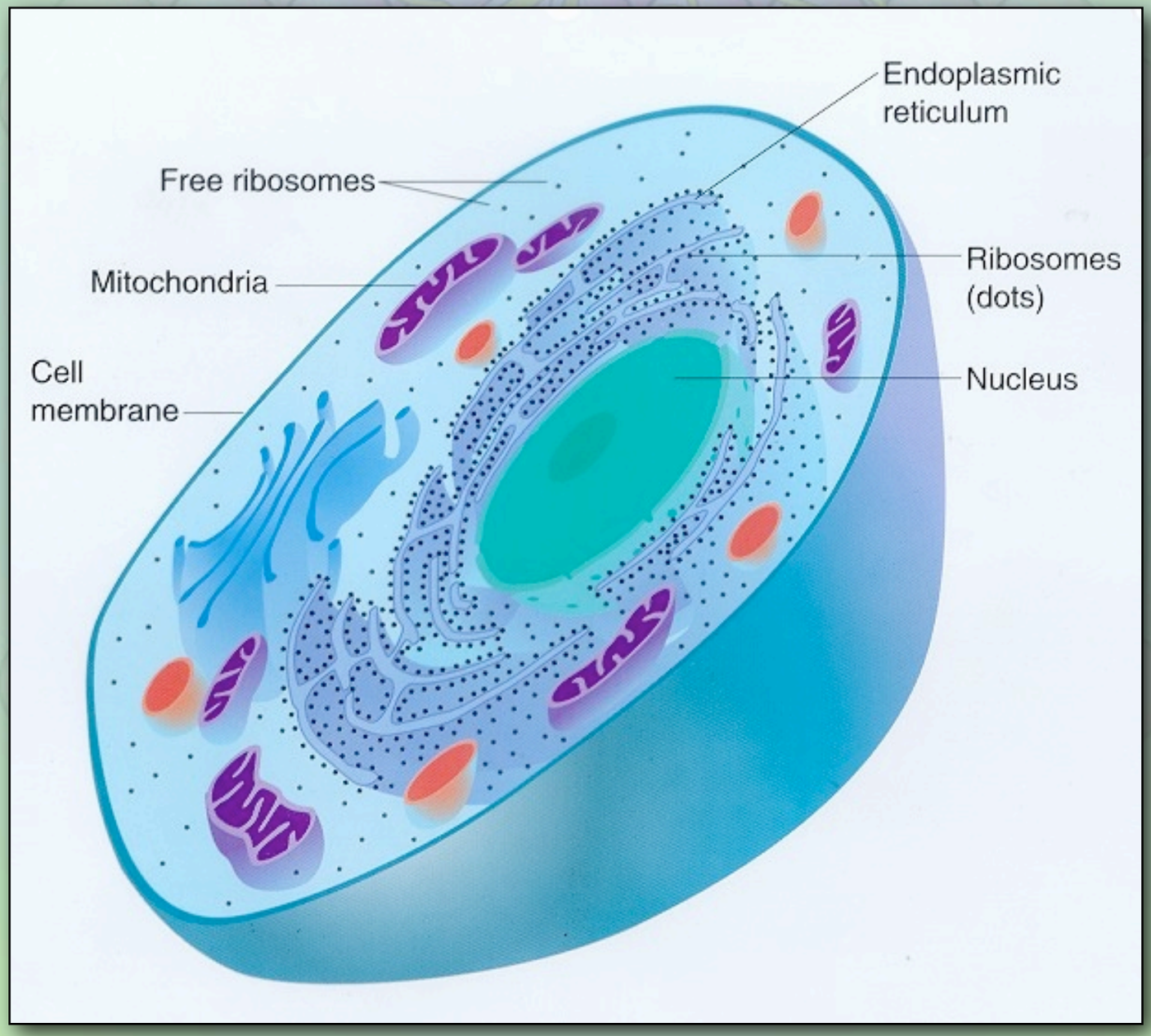
- Bacterial cells





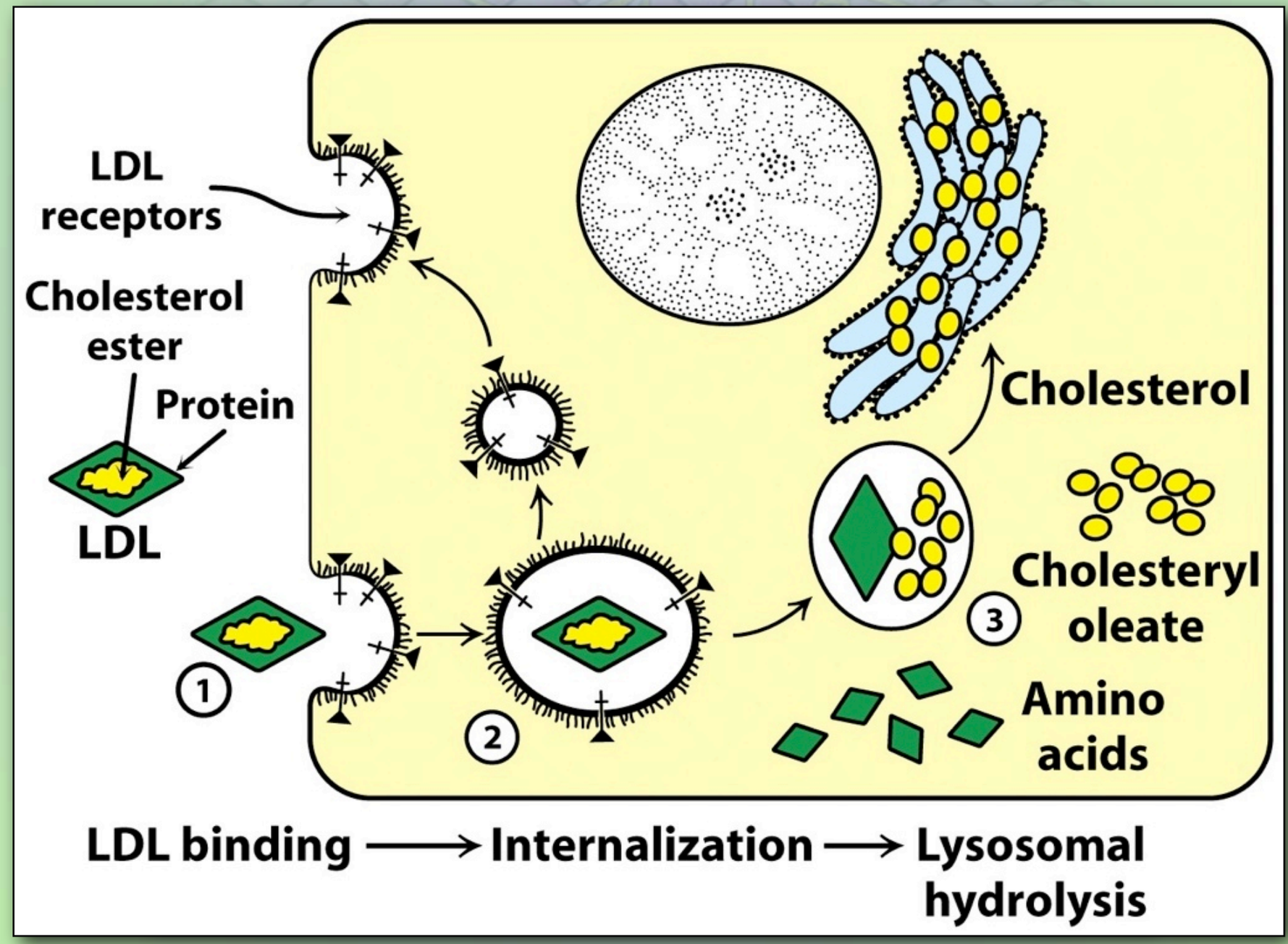
Cell Membrane Proteins

- Eukaryotic cells



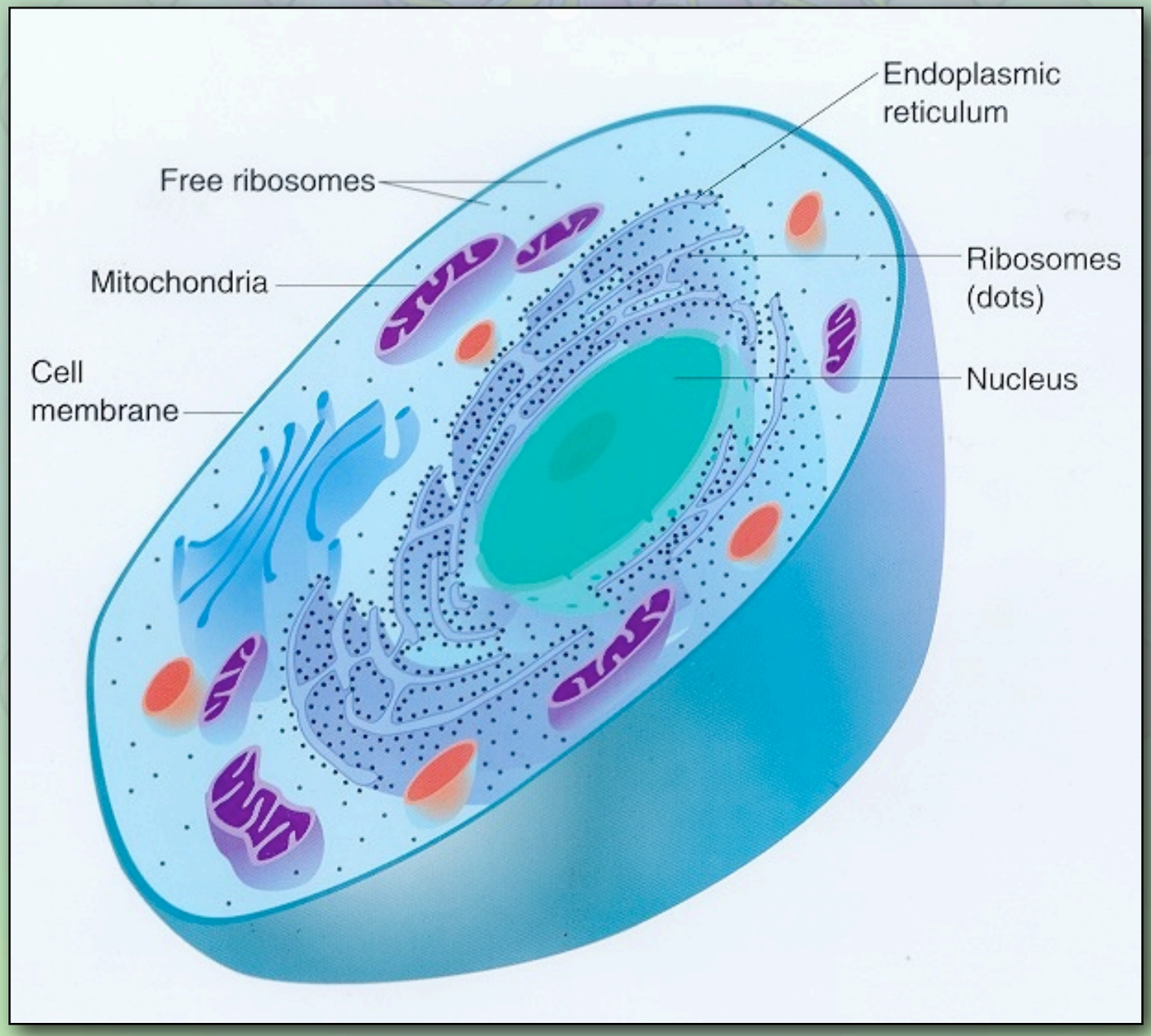
Cell Membrane Proteins

- Eukaryotic cells



Cell Membrane Proteins

- Eukaryotic cells



Next up

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