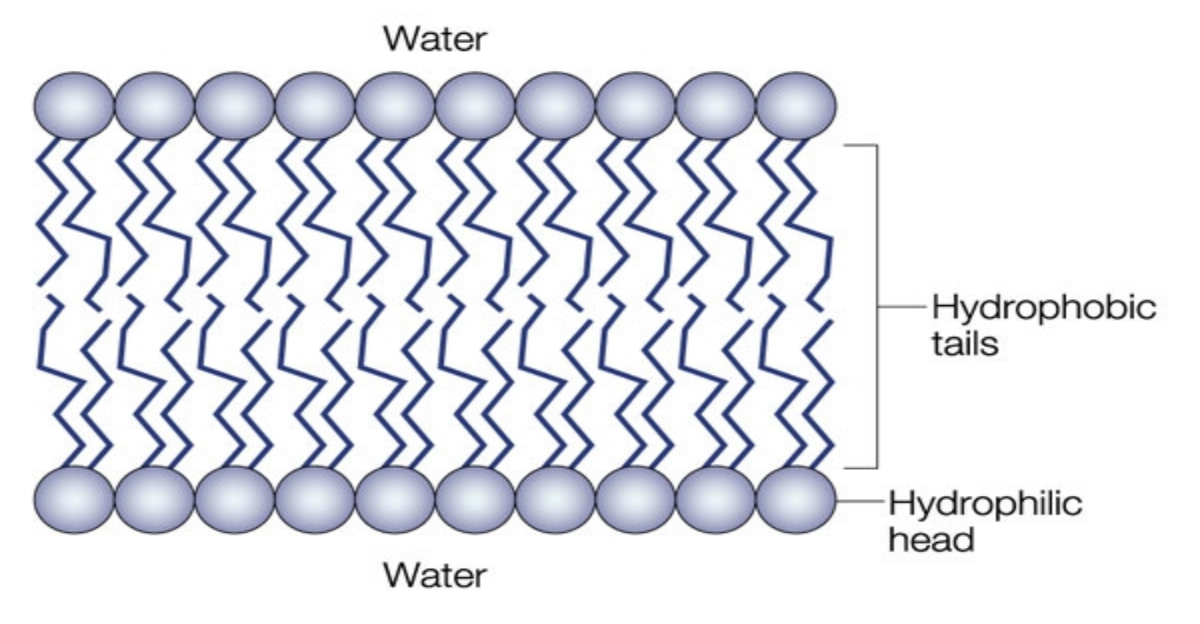
# Membranes 1

Steven E. Massey, Ph.D.
Assistant Professor
Department of Biology
University of Puerto Rico – Río Piedras

Office & Lab: NCN#343B
Tel: 787-764-0000 ext. 7798
E-mail: stevenemassey@gmail.com



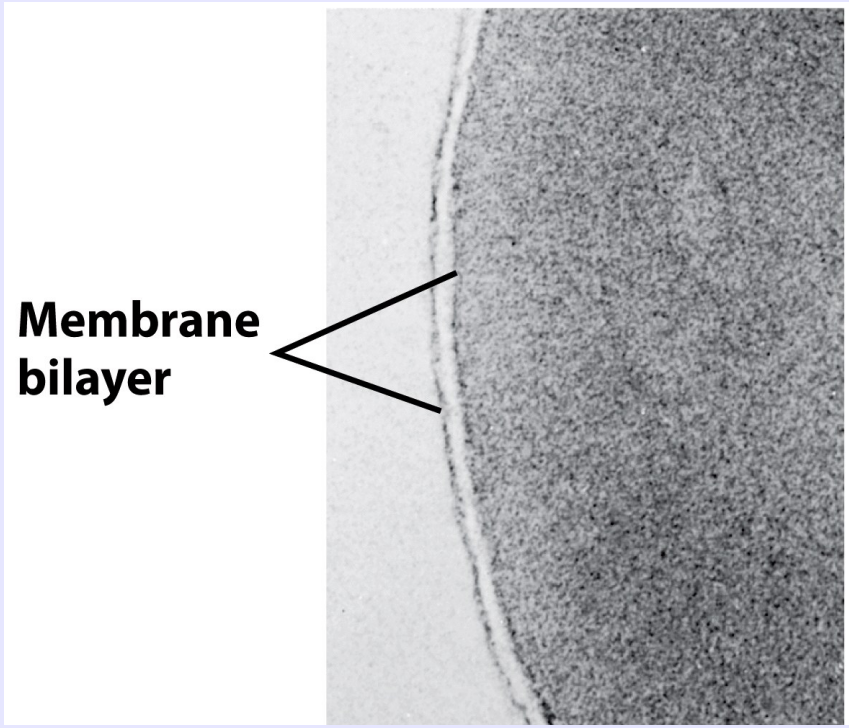
Membranes form cells and compartmentalize the components of the cell in eukaryotes. They are composed of lipids and form a bilayer

This bilayer is self assembling

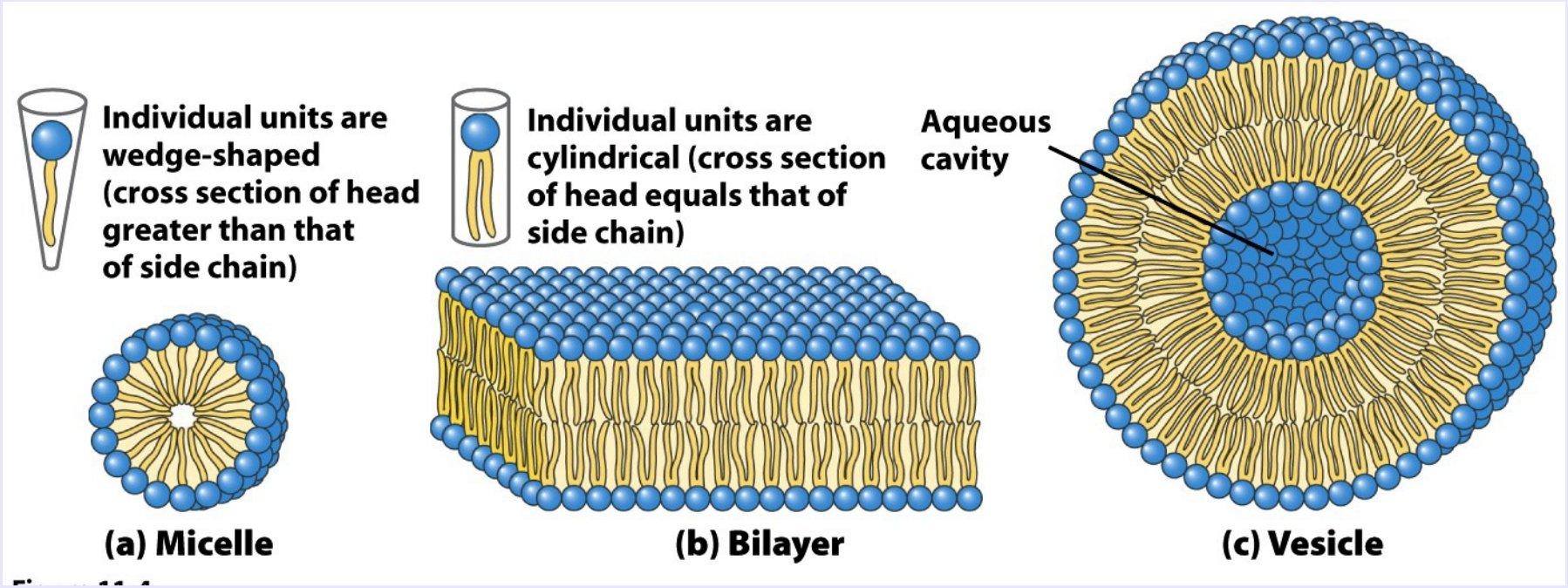
They are selectively permeable and flexible, allowing growth and movement, fusion and fission

Membranes are impermeable to polar compounds and permeable to nonpolar compounds

Transport across the membrane occurs using protein transporters



When phospholipids come into contact with water they will self assemble into various assemblages, depending on the conditions:



There is a commonly accepted idea that the first 'cells' emerged from the primordial soup and were self – assembling

This idea proposes that life is an emergent property

Emergence is defined as where the whole is greater than the sum of the parts or order out of disorder

Other emergent properties in biology include flocks of birds, schools of fish, human consciousness, bee hives, human society.....

Membranes have different compositions, depending on tissue type and subcellular organelle eg. the mitochondrial membrane is different from the cell membrane

Subcellular components may be isolated by differential centrifugation, otherwise known as subcellular fractionation

Membranes also differ in their protein composition

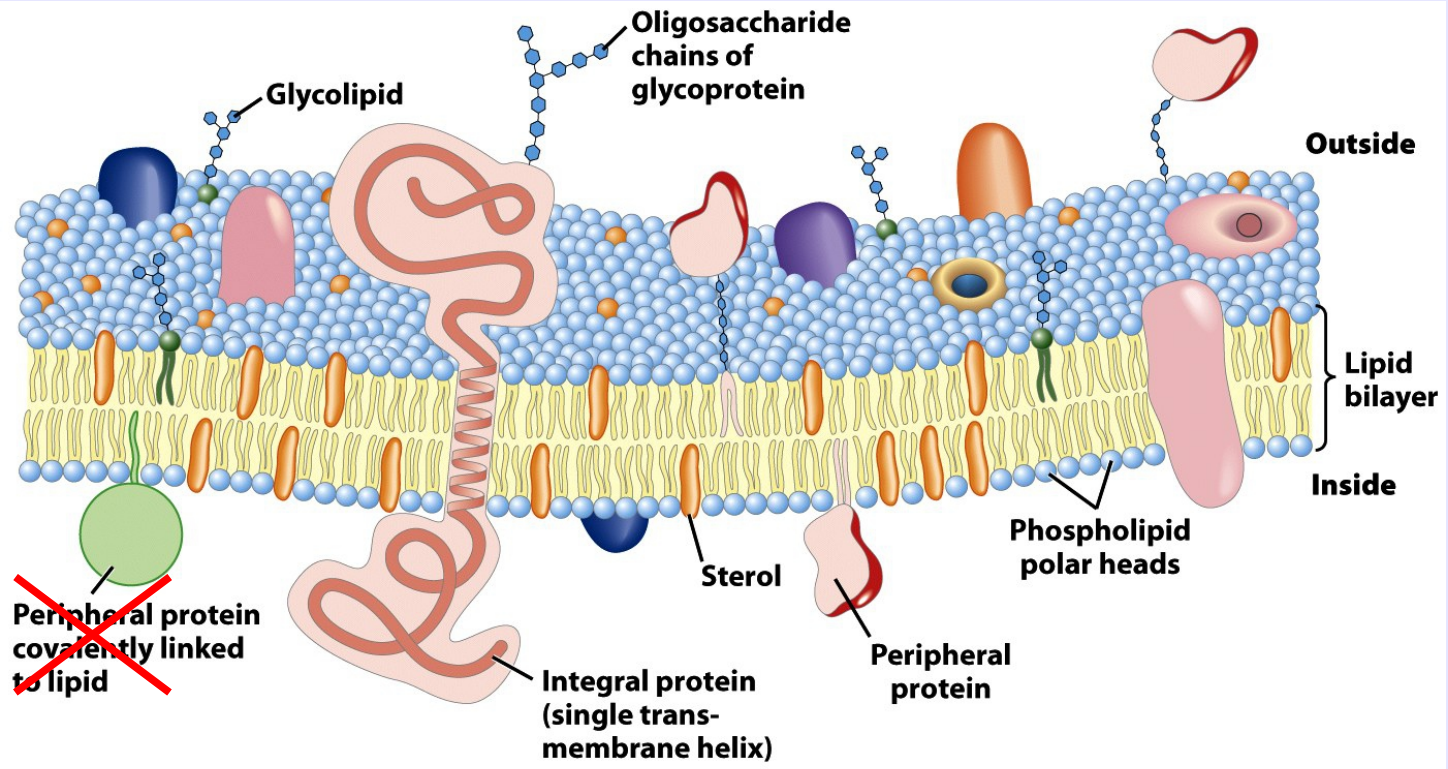
**TABLE 11–1 Major Components of Plasma Membranes in Various Organisms**

| | 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 |
| Paramecium (ciliated protist) | 56 | 40 | 4 | Stigmasterol | — |
| *E. coli* | 75 | 25 | 0 | — | — |

**Note:** Values do not add up to 100% in every case, because there are components other than protein, phospholipids, and sterol; plants, for example, have high levels of glycolipids.

The fluid mosaic model implies that the proteins move laterally

They are embedded in the lipid bilayer and are stabilized by hydrophobic interactions



Membrane proteins may be integral, peripheral or amphitropic

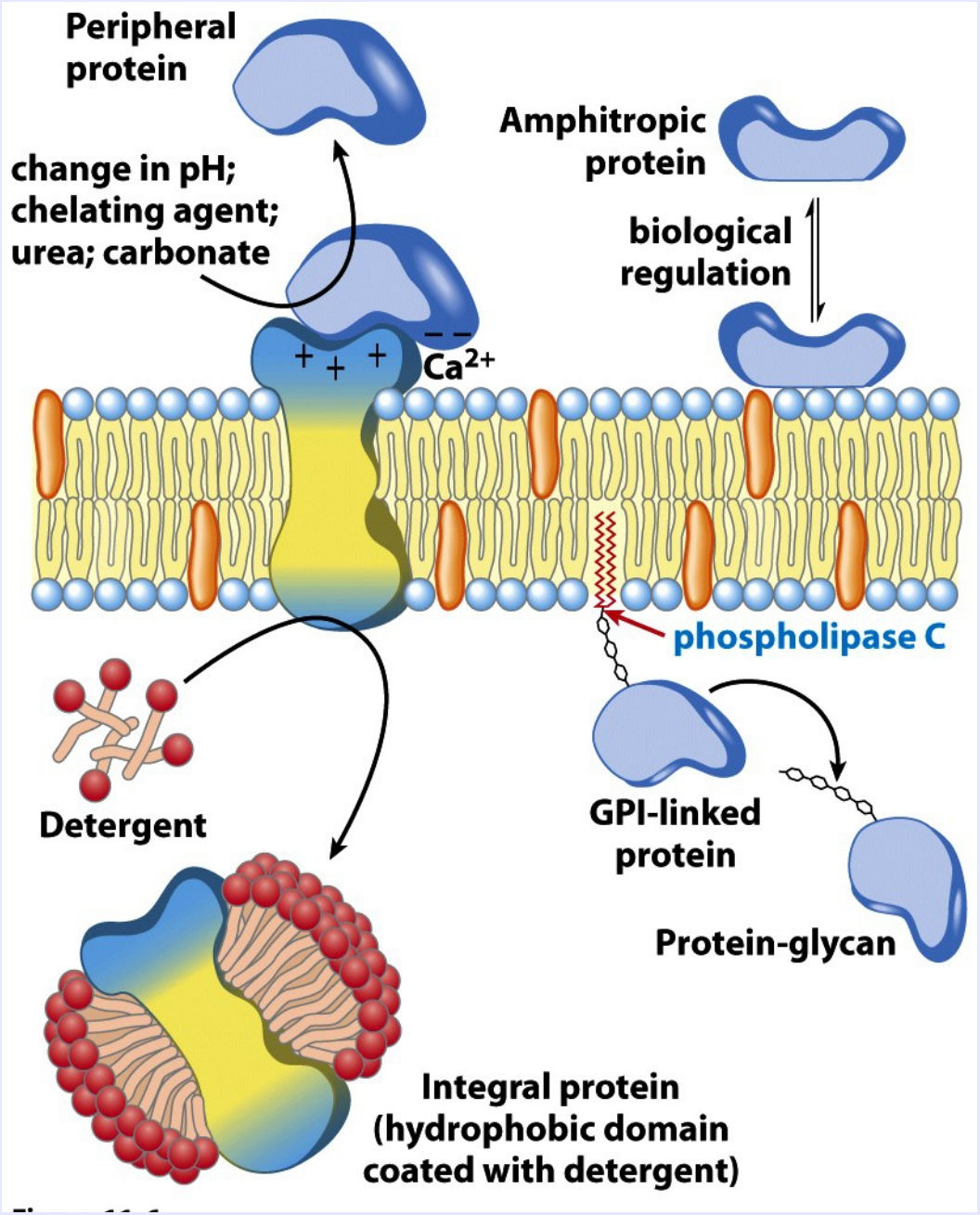
Integral membrane proteins have a hydrophobic component or have a covalent bond

Peripheral membrane proteins form electrostatic interactions and H bonds with the polar groups of membrane lipids

Amphitropic proteins are found in the cytosol and associated with membranes - may have a noncovalent interaction with a membrane protein or lipid, or lipids may be attached to the protein

The reversible association with the membrane may be regulated by phosphorylation or ligand binding

Integral, peripheral and amphitropic proteins

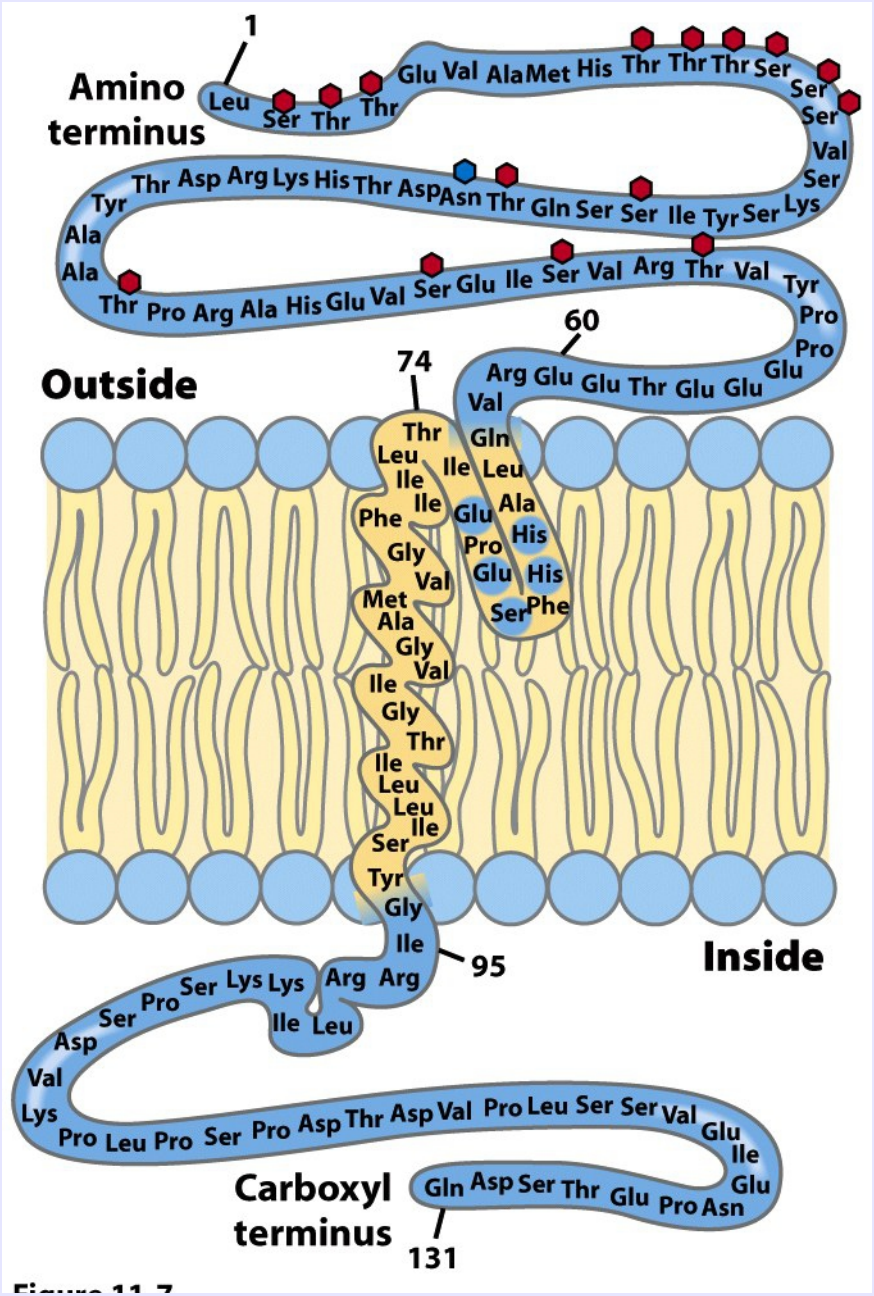


Many integral membrane proteins are transmembrane, going through the membrane

Glycophorin for example has a single transmembrane domain

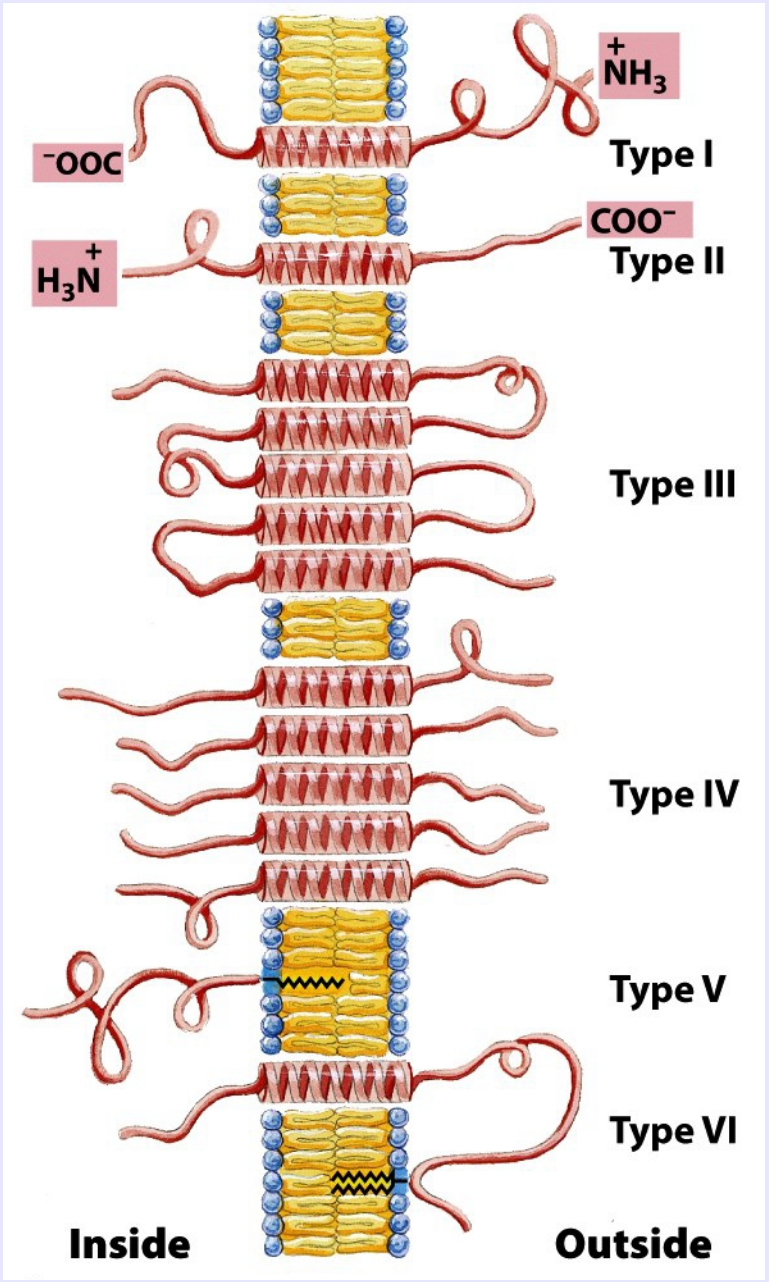
This region is made of hydrophobic residues

On the outer surface are oligosaccharides (red and blue hexagons on figure)



The different classes of integral membrane proteins

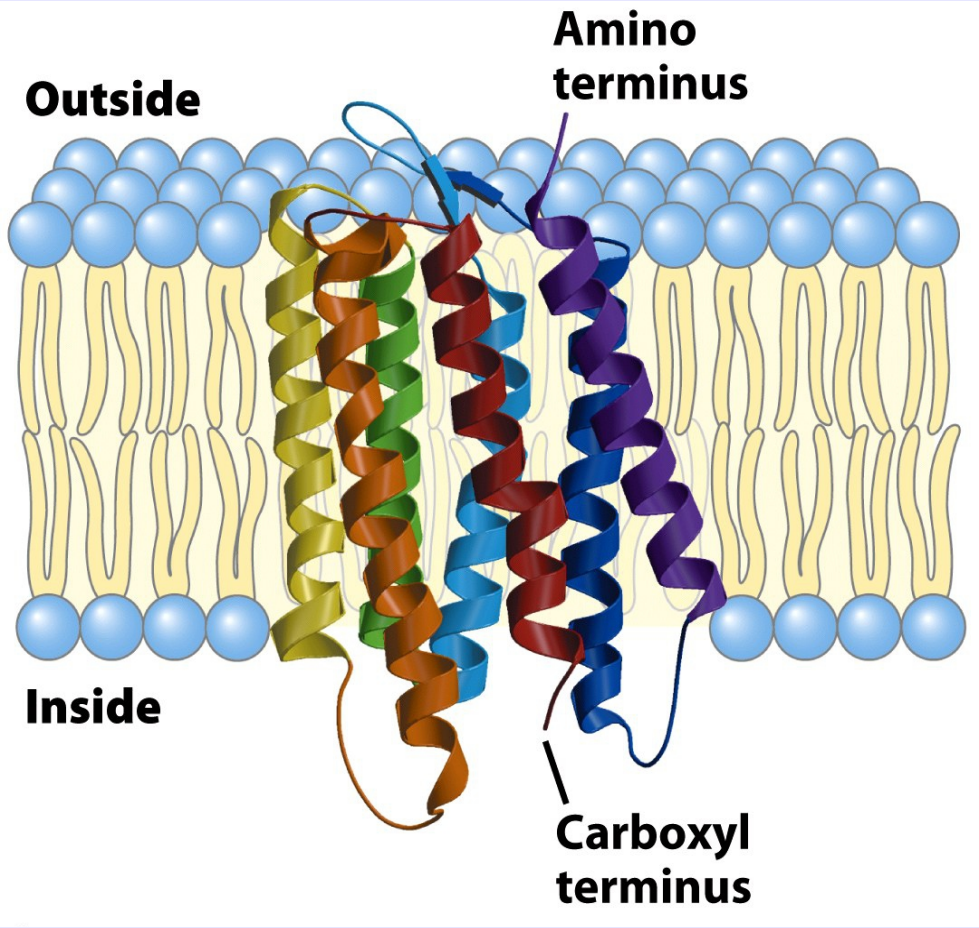
Type V and VI are held by covalent linkages to lipids



Bacteriorhodopsin is one of the best studied membrane proteins

It is a light driven proton pump found in archaea

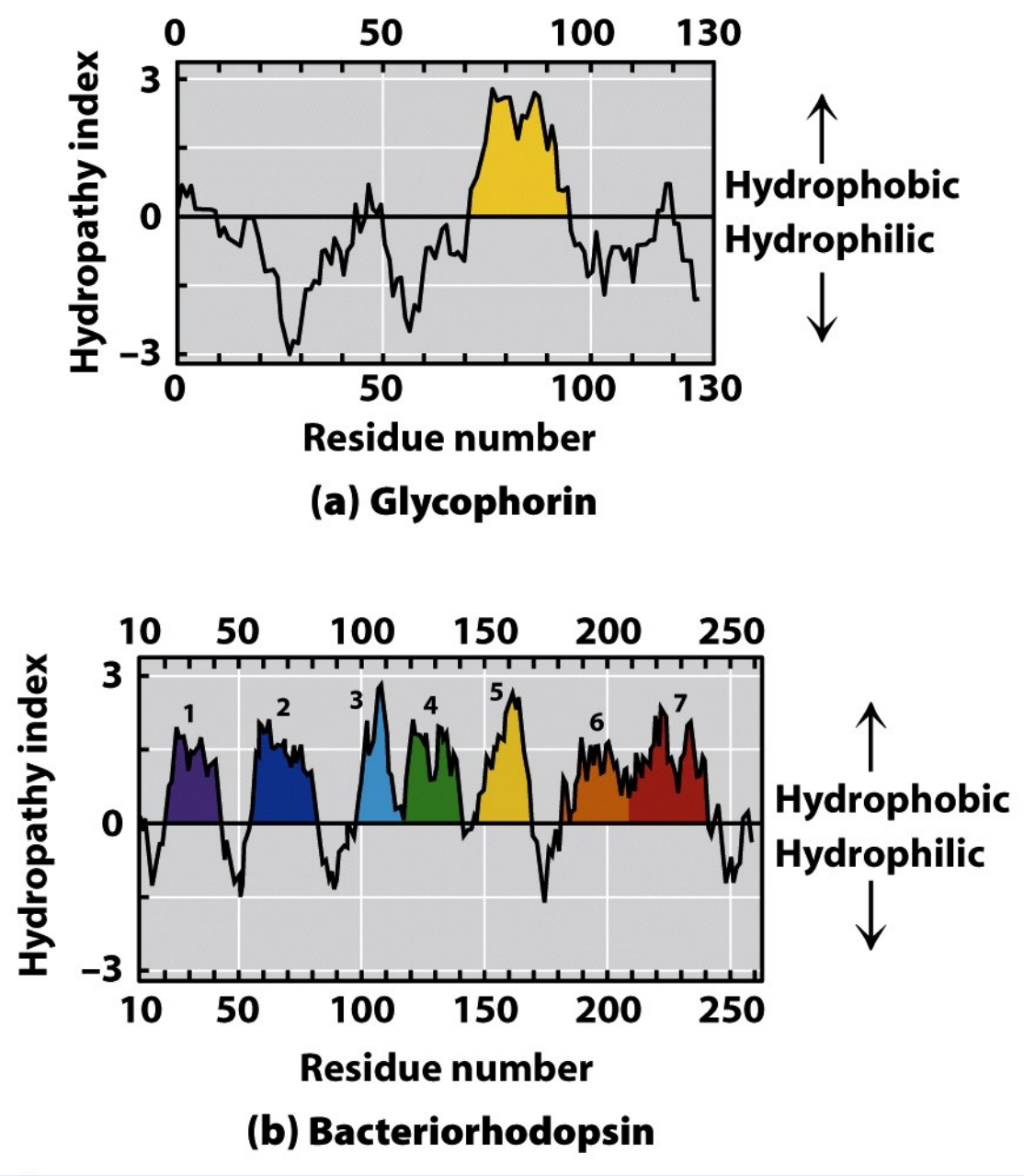
It has seven transmembrane alpha helices



Sequences can be used to prediction protein function – this is bioinformatics

A hydropathy plot can be used to predict the regions of the protein sequence that are transmembrane regions

The graph plots the hydrophobicity of an amino acid versus the amino acid number

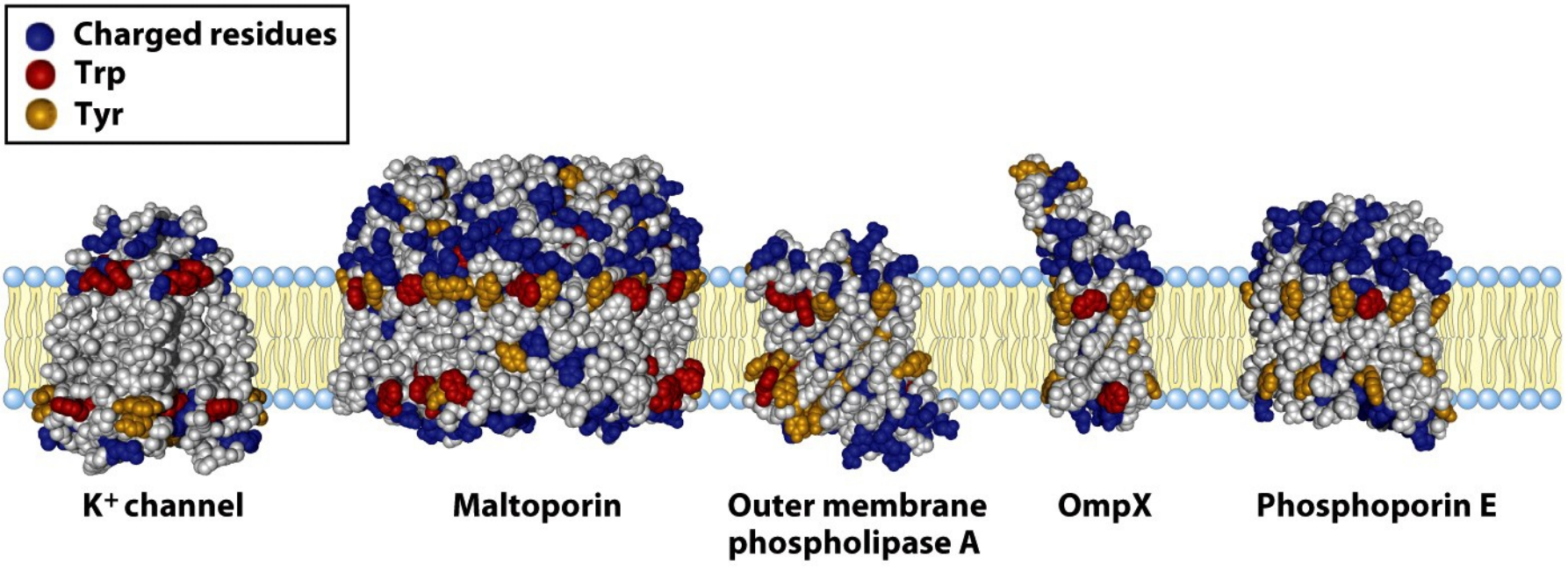


Charged residues tend to be on the surface of the membrane protein that is exposed to the aqueous environment

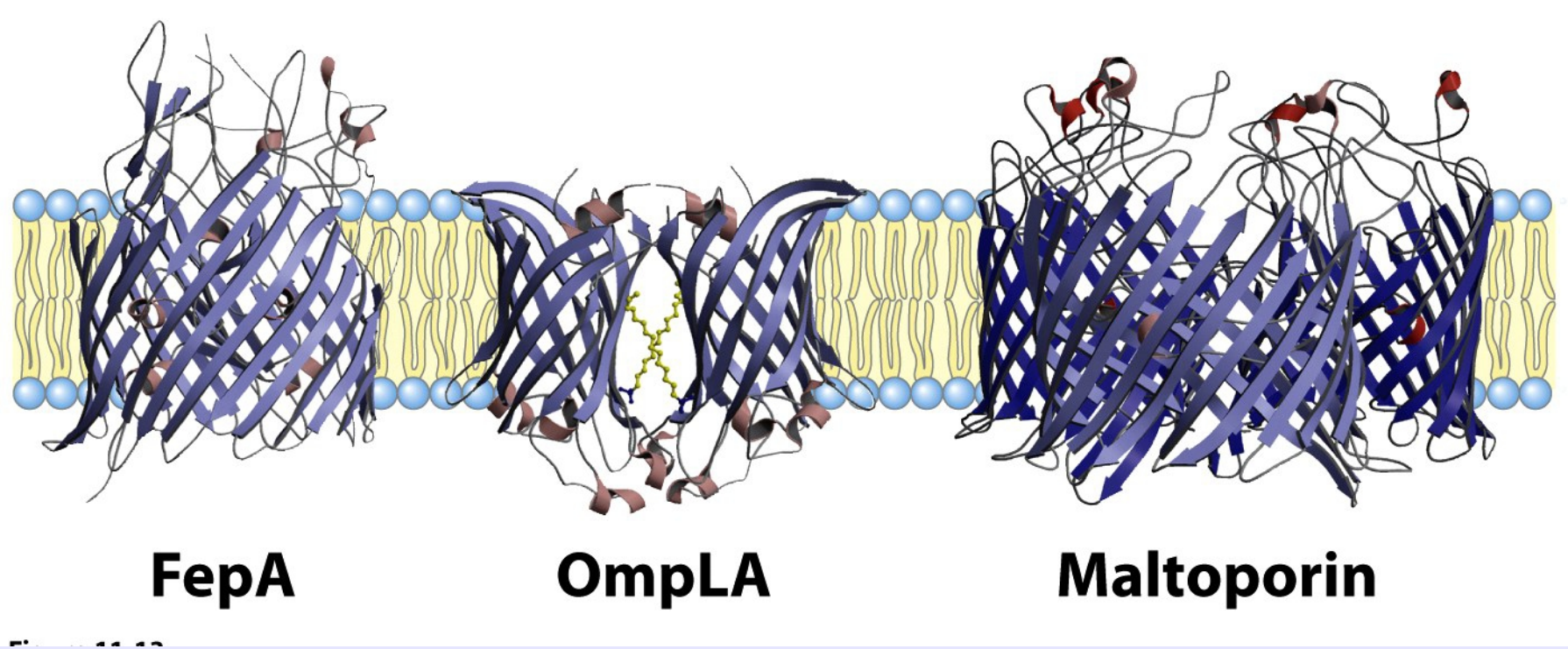
Positively charged residues tend to be on the cytoplasmic face of the membrane

This is the positive-inside rule

Distribution of residues in a range of membrane proteins



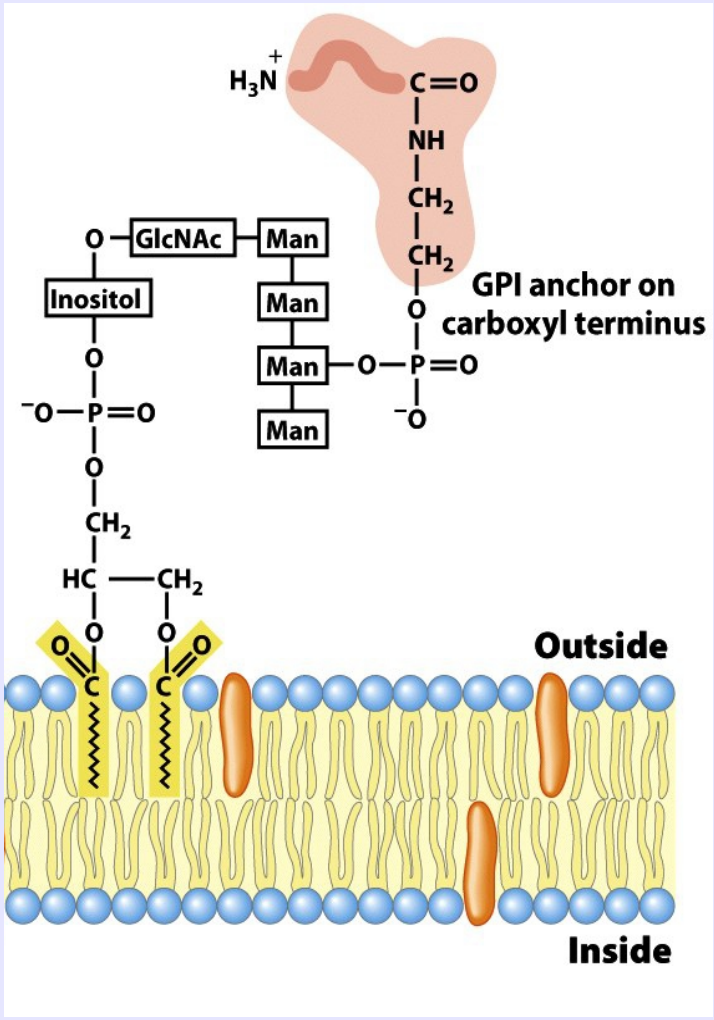
Transmembrane domains can also be composed of beta barrels



Proteins may be covalently attached to the membrane by covalently bonding to lipids

A glycosyl phosphatidylinositol (GPI) anchor is phosphatidylinositol attached to an oligosaccharide attached to phosphoethanolamine. The phosphoethanolamine is attached to the peptide chain

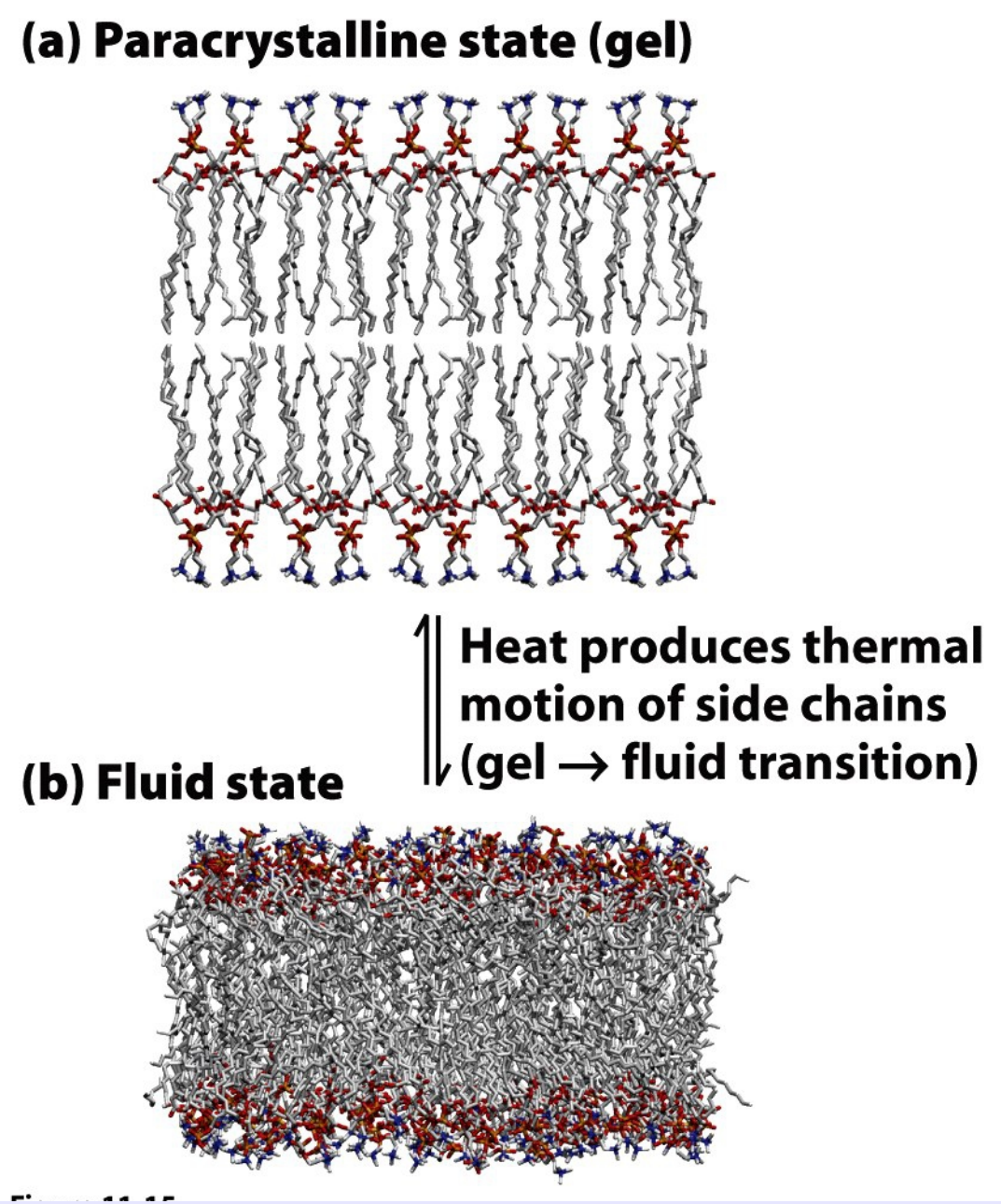
Man = mannose
GlcNAc = acetyl glucosamine



Heat can alter the state of the membrane

At low temperatures it will form a gel

At physiological temperatures it is in a fluid state



As a consequence, cells regulate their lipid composition according to temperature

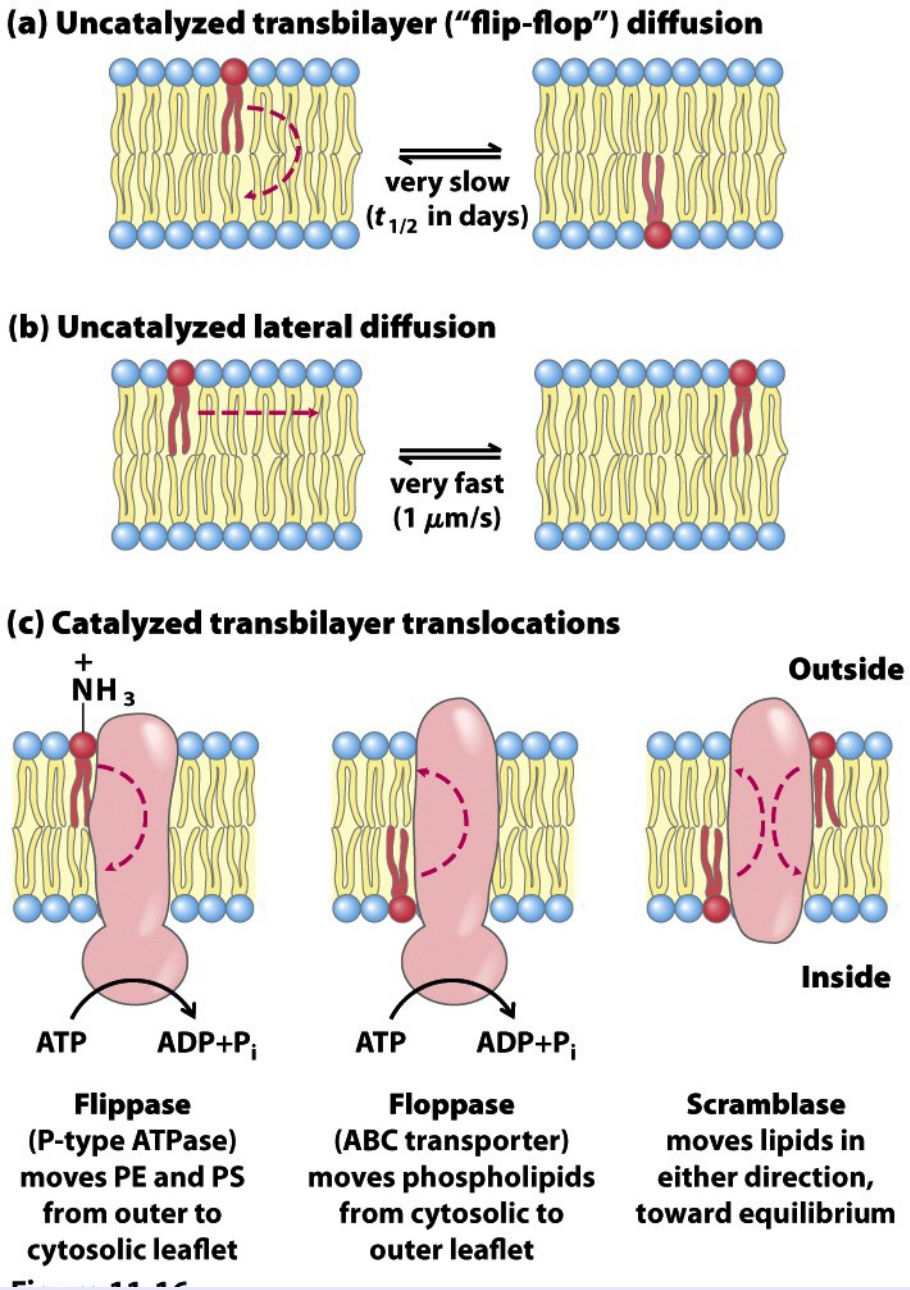
**TABLE 11–2 Fatty Acid Composition of *E. coli* Cells Cultured at Different Temperatures**

| | 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 |

Movement of a phospholipid through a membrane can be slow

It may be catalyzed by enzymes called flippases, floppases and scramblases

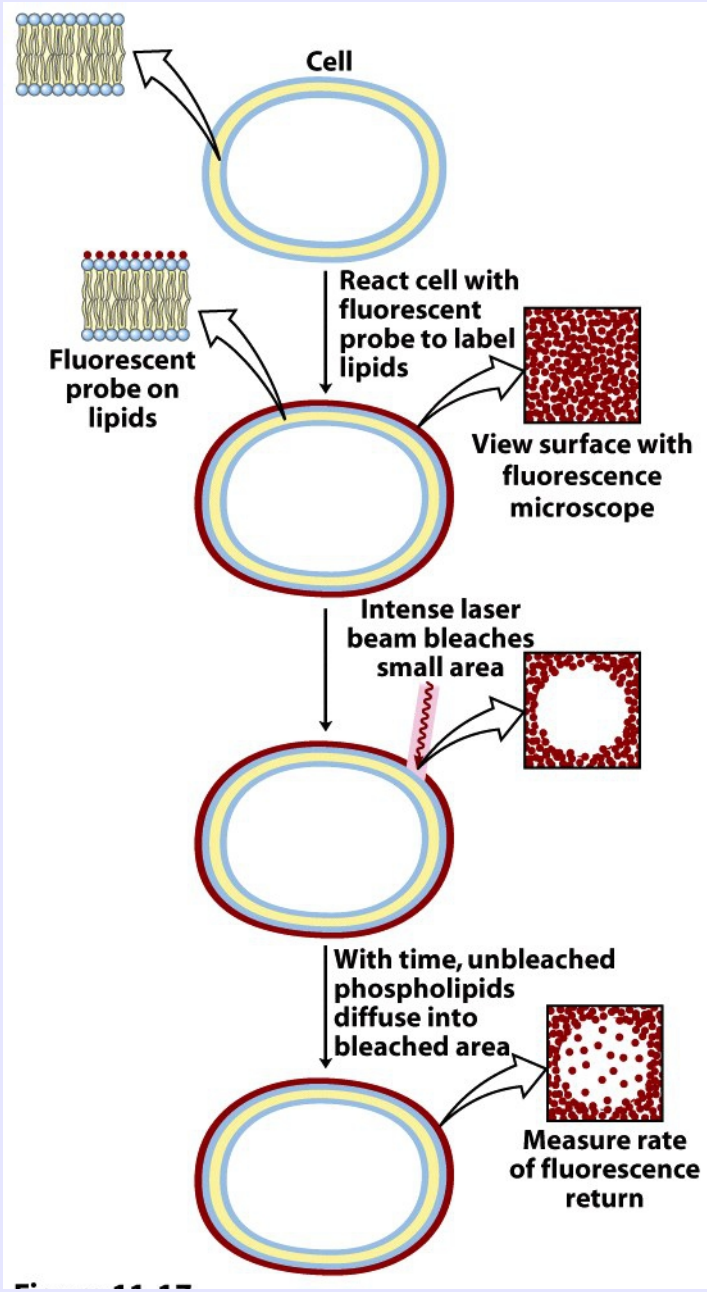
Flippases: out → in
Floppases: in → out
Scramblases: both directions



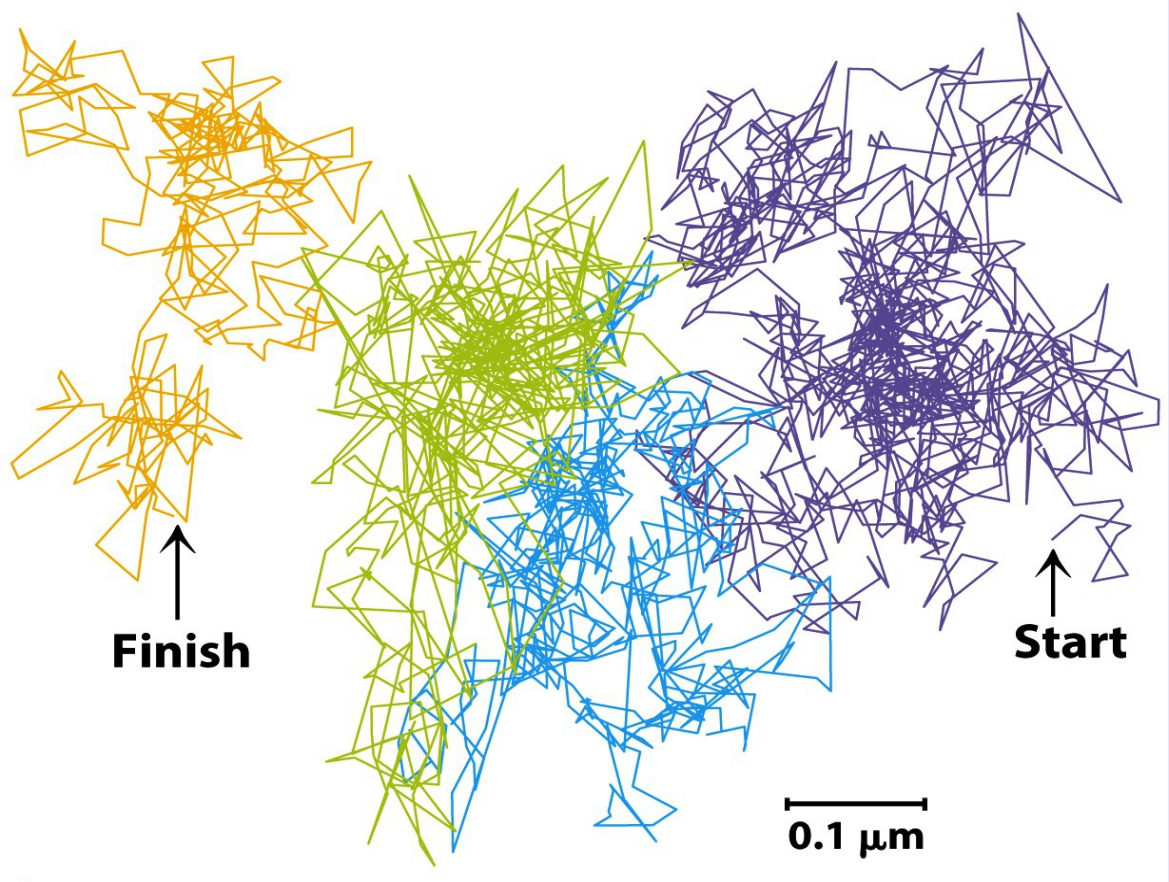
# Fluorescence Recovery After Photobleaching

## (FRAP)

is a method that is used to measure the lateral diffusion of lipids



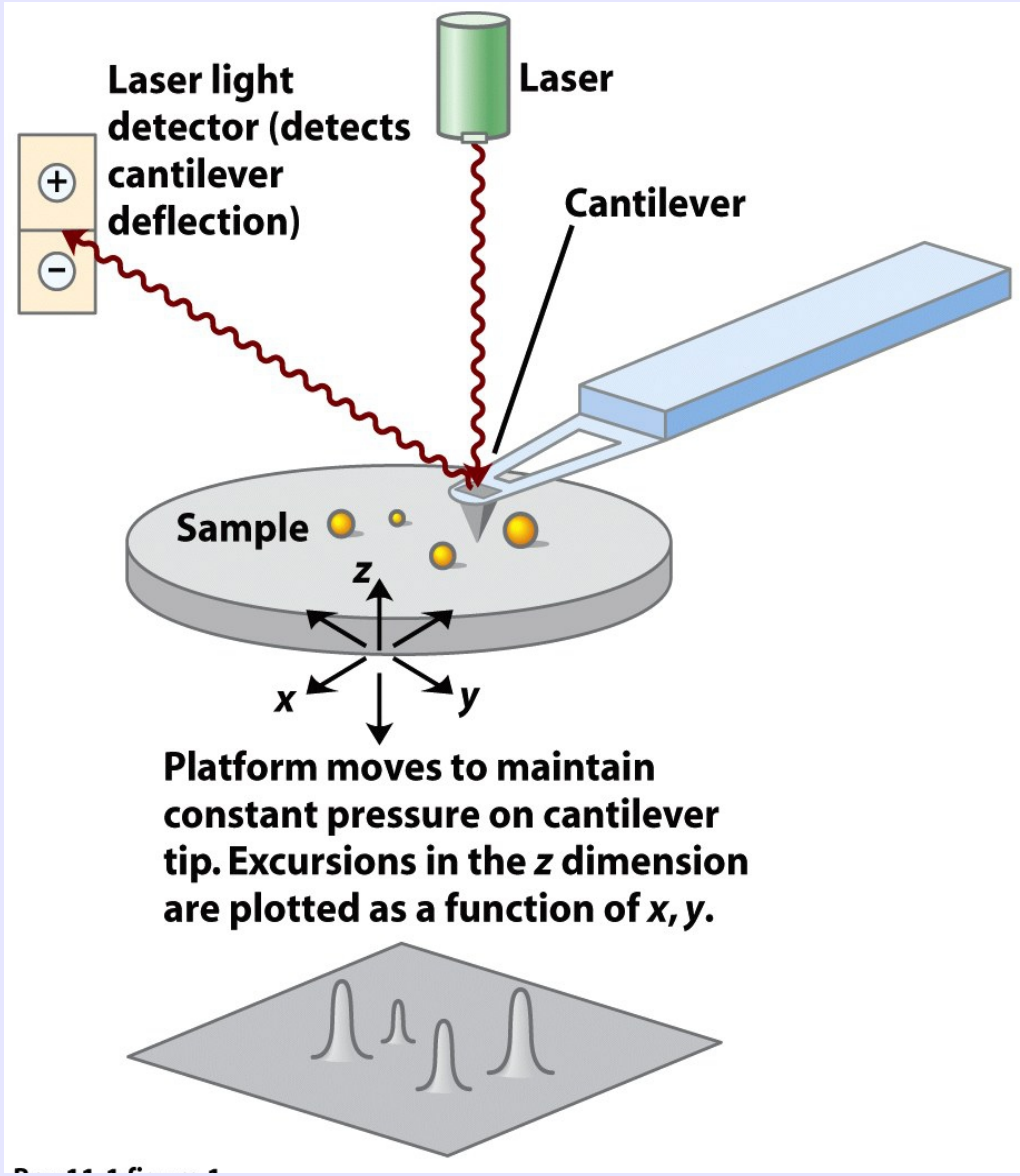
The membrane is made up of distinct domains, and lipids are restricted in each domain, and then jump by a process called 'hop diffusion'

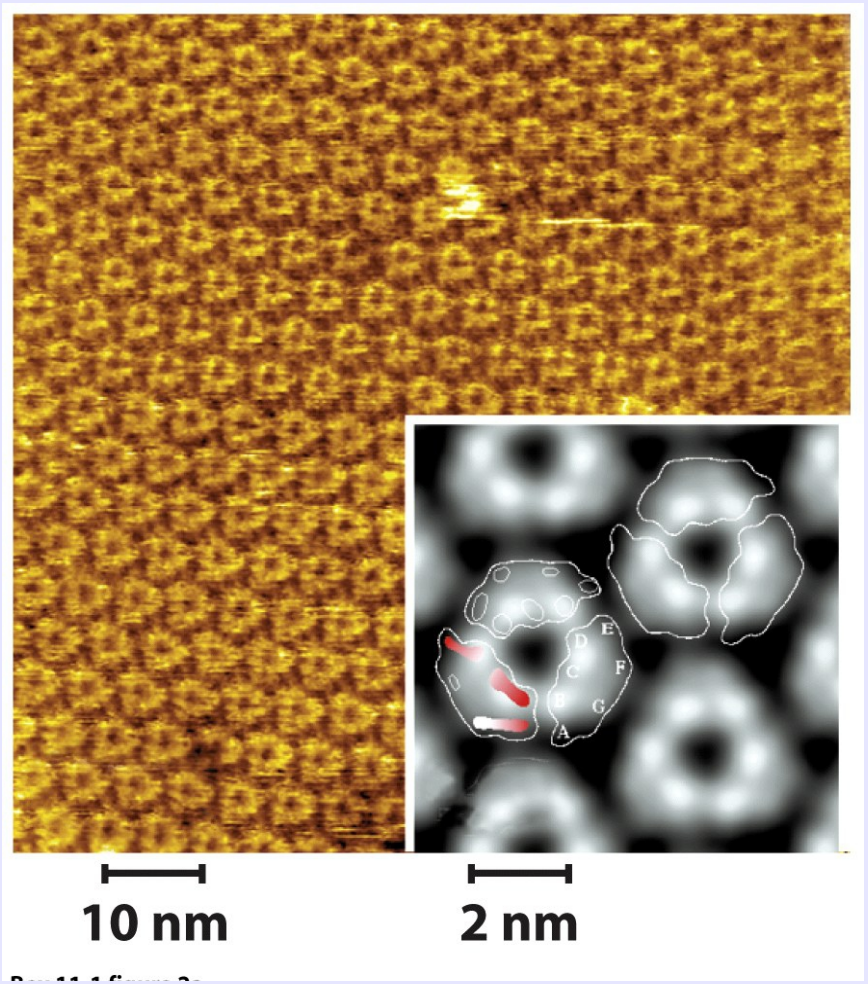



Hop diffusion

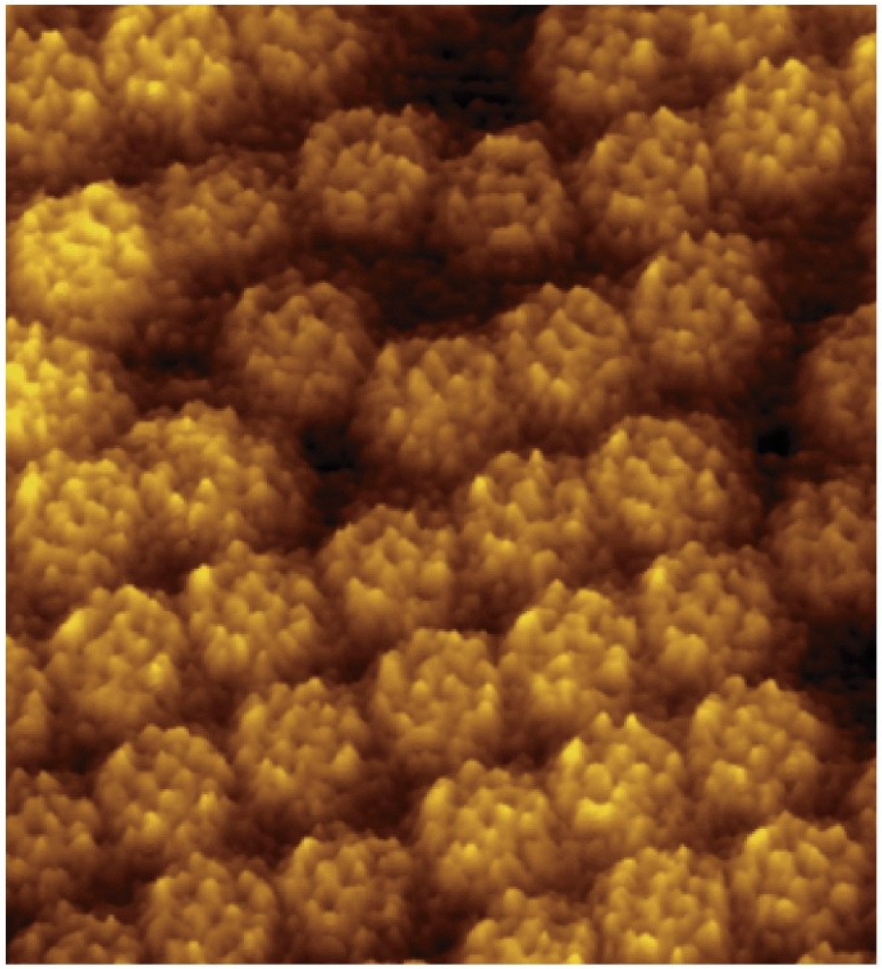
Atomic force microscopy (AFM) can be used to visualize membranes

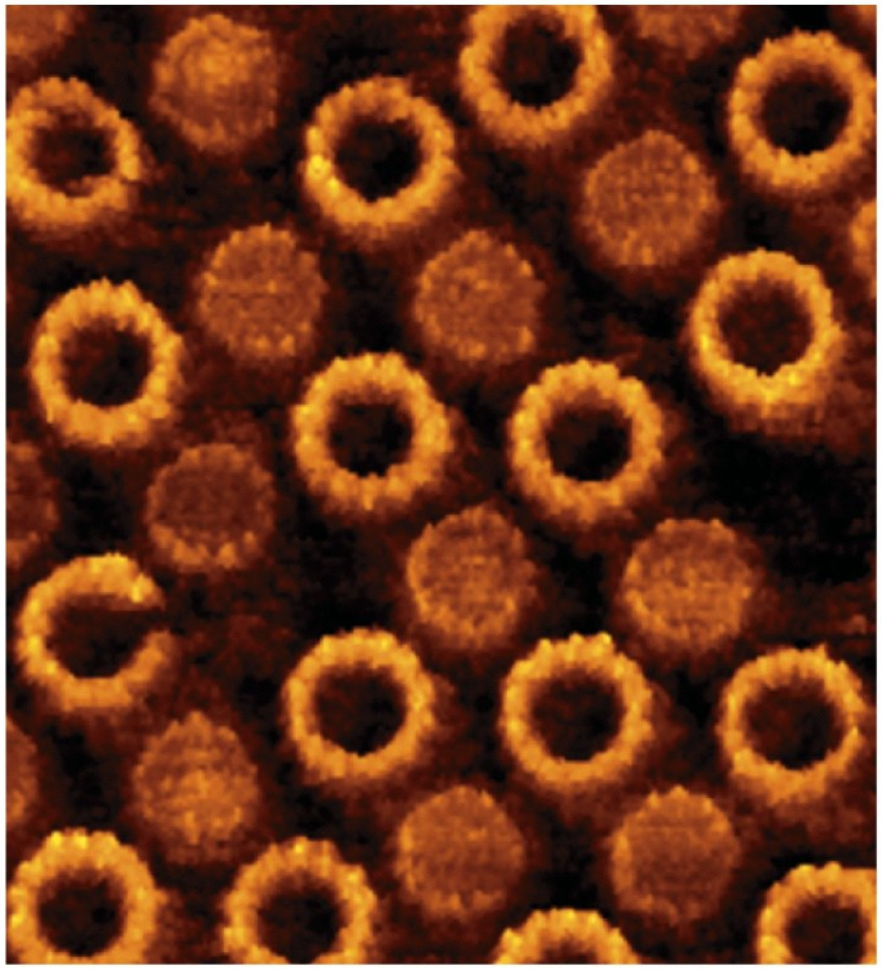
A microscopic probe will detect peaks and valleys on the membrane surface





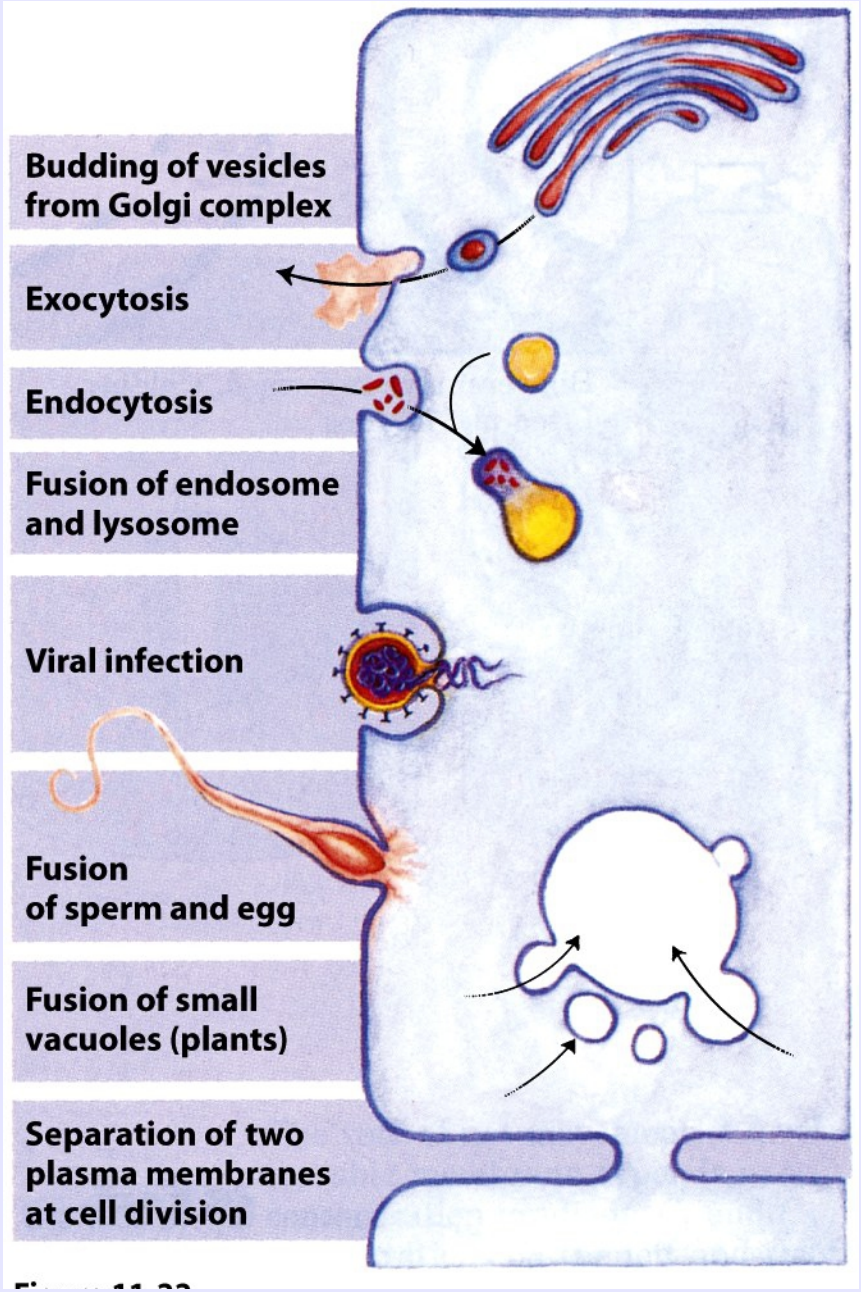

bacteriorhodopsin





*E.coli* aquaporin

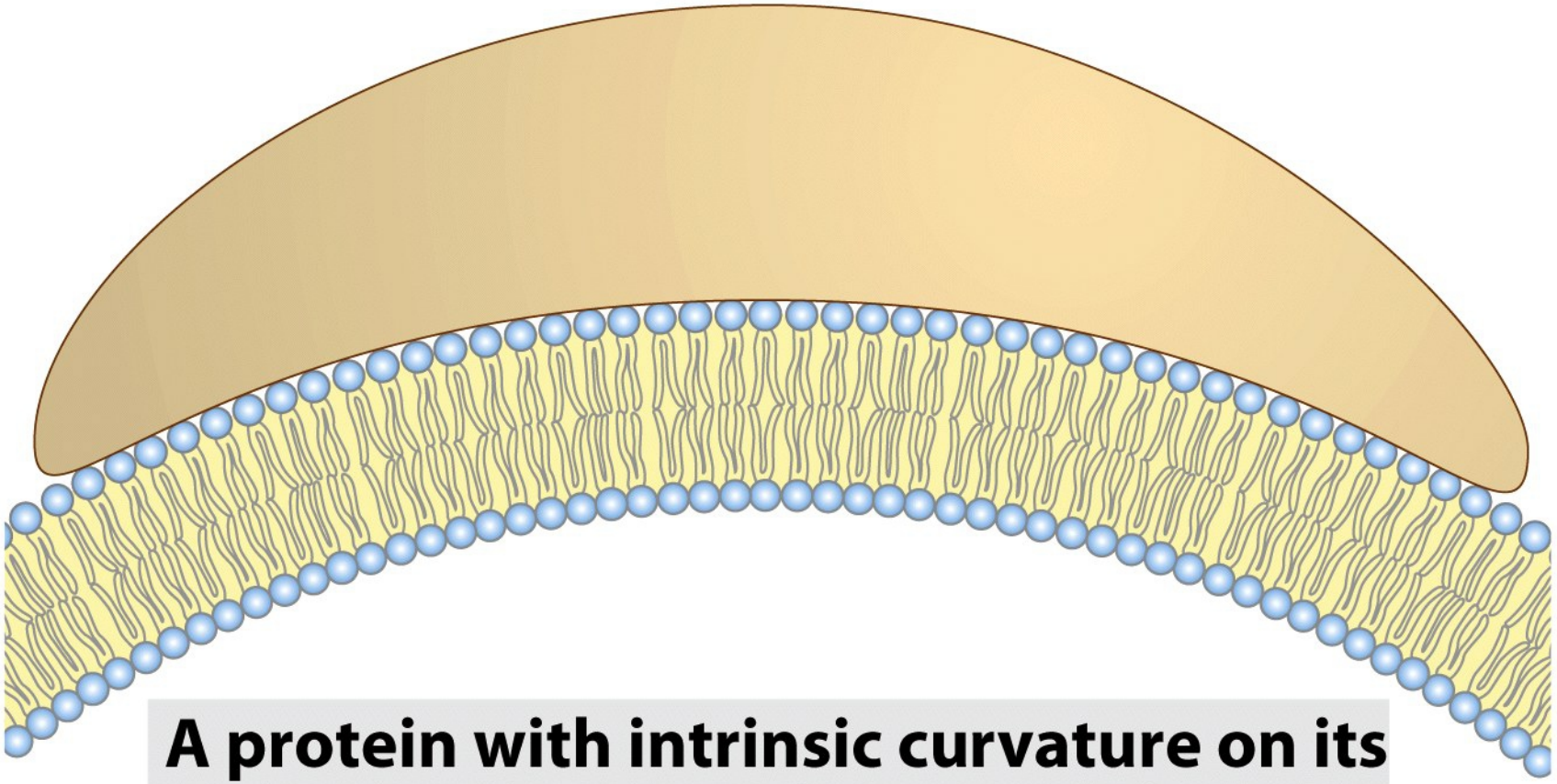
Chloroplast ATP synthase



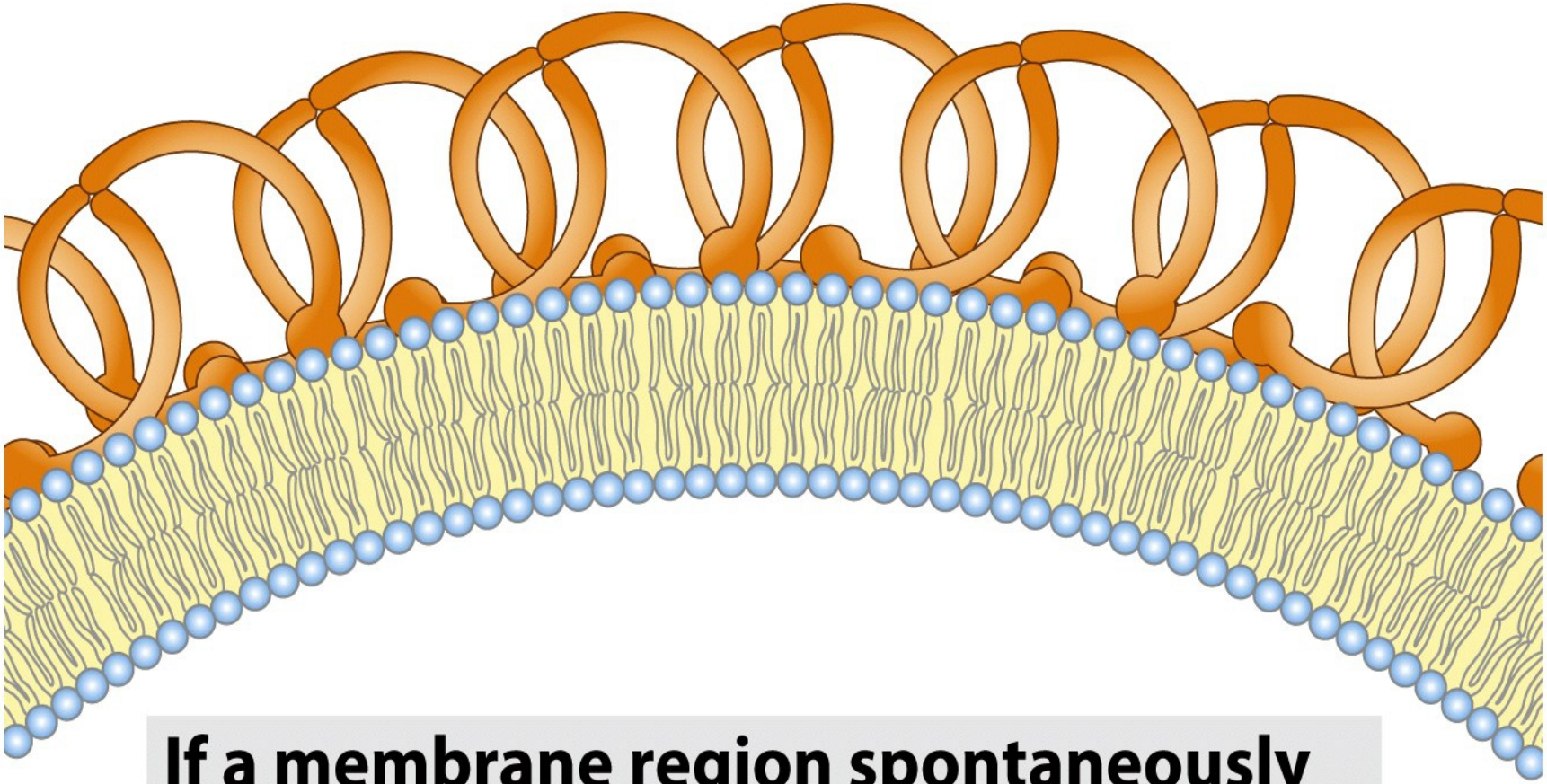

Membrane curvature and fusion are important in many biological processes

There are three mechanisms for inducing curvature in membranes

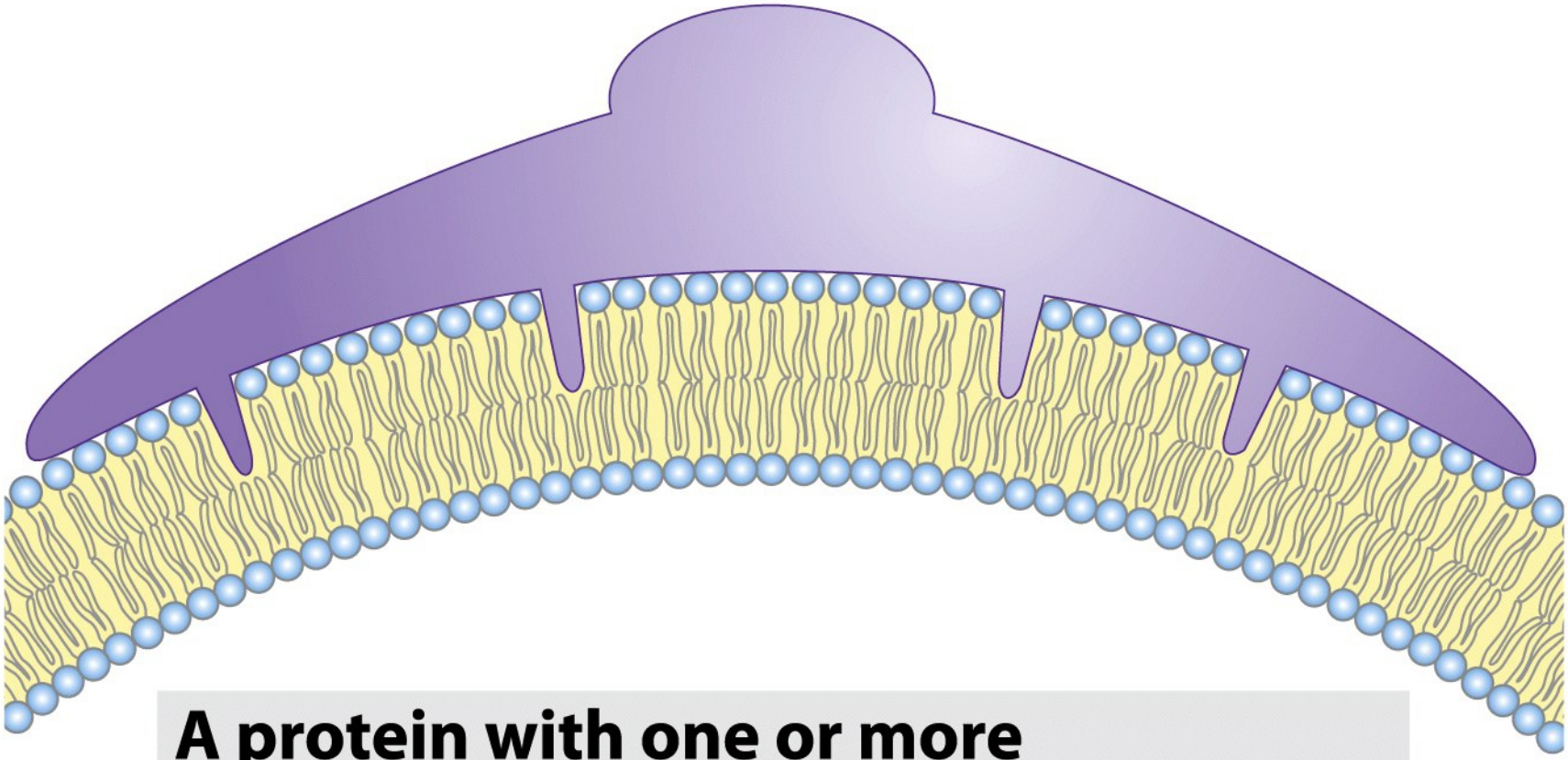
(as follows.....)



**A protein with intrinsic curvature on its surface interacts strongly with a curved membrane surface, allowing both membrane and protein to achieve their lowest energy.**



If a membrane region spontaneously curves, monomeric subunits of certain proteins can polymerize into a superstructure that favors and maintains the curvature.



**A protein with one or more amphipathic helices inserted into one leaflet of the bilayer crowds the lipids in that leaflet, forcing the membrane to bend.**

Fusion proteins mediate the fusion of membranes

Membrane fusion occurs at synapses when neurotransmitters are released from vesicles

This is mediated by v-SNAREs and t-SNAREs