MEMBRANE STRUCTURE

Cell Fractionation

Fluid Mosaic Model

Plasma Membrane

- Also known as the cell membrane
- All cells and organelles are surrounded by a flexible membrane

Organelle

- Organs:
  - specialized structures in the body that perform specific life processes
- Organelles:
  - specialized structures inside the cell that perform specific cellular processes
  - often surrounded by a membrane

Cell Fractionation

- A method of separating cell parts to study their function
- **Homogenization**: disruption of cell membrane without damaging organelle
- **Centrifuge**: instrument that spins at high speeds to separate contents by density

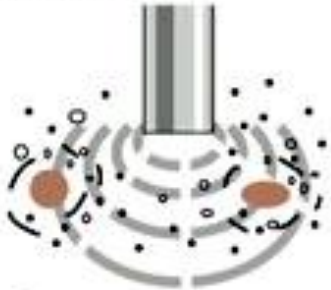
BREAKING CELLS AND TISSUES

The first step in the purification of most proteins is to disrupt tissues and cells in a controlled fashion.

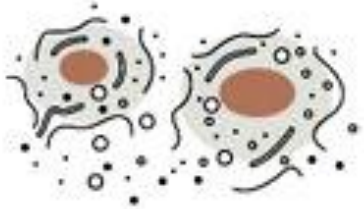
Using gentle mechanical procedures, called homogenization, the plasma membranes of cells can be ruptured so that the cell contents are released. Four commonly used procedures are shown here.

The resulting thick soup (called a homogenate or an extract) contains large and small molecules from the cytosol, such as enzymes, ribosomes, and metabolites, as well as all the membrane-bounded organelles.

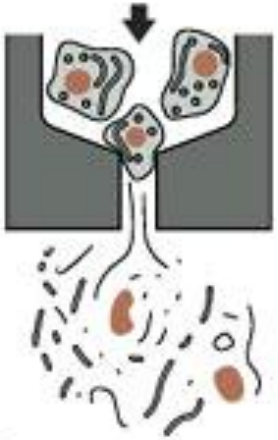
cell suspension or tissue



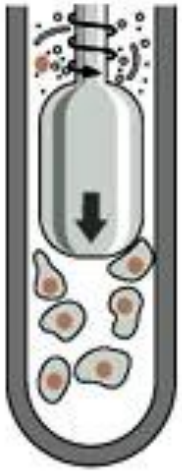
(1) break cells with high frequency sound



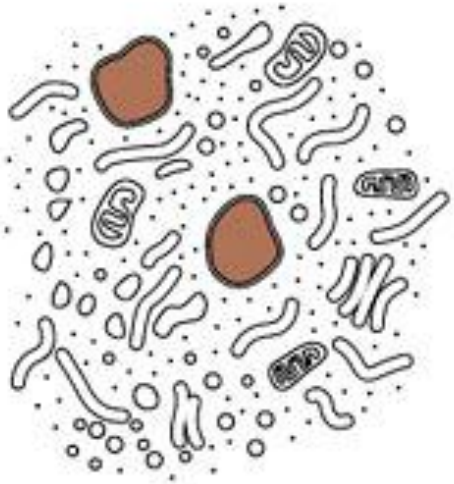
(2) use a mild detergent to make holes in the plasma membrane



(3) force cells through a small hole using high pressure

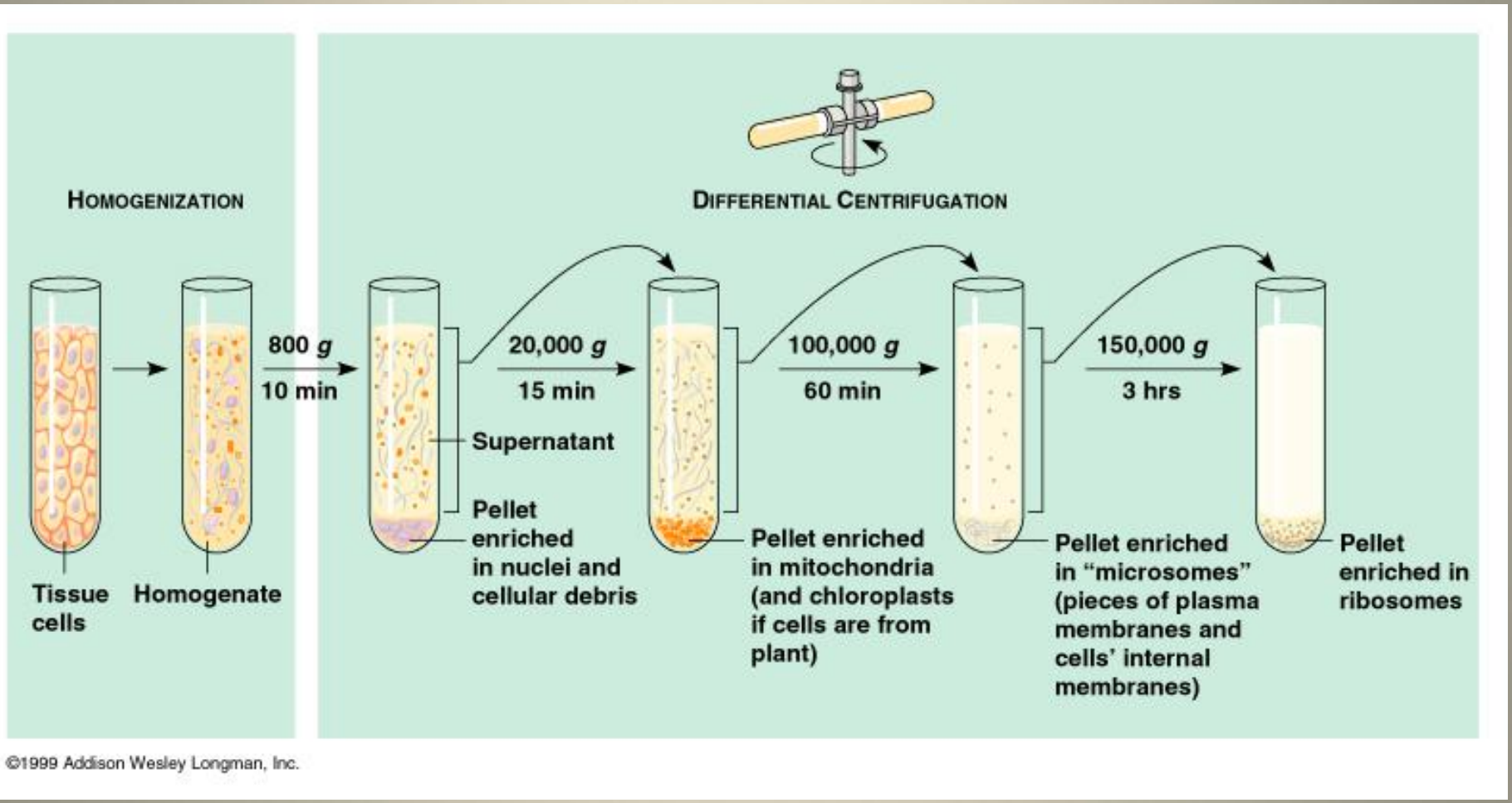


(4) shear cells between a close-fitting rotating plunger and the thick walls of a glass vessel



When carefully applied, homogenization leaves most of the membrane-bounded organelles intact.

Cell Fractionation



http://www.freewebs.com/ltaing/chpt7.3Cellfractionation.gif

Steps to Cell Fractionation

1. Homogenize
2. Centrifuge
   - Pellet: larger, more dense components
   - Supernatant: lighter, suspended in liquid above the pellet
3. Decant supernatant
4. Repeat centrifugation at higher speeds to separate into smaller components

Thought Questions

- Which centrifuged layer (supernatant or pellet) is transferred to the next fractionation step? Why?
- Which fractionation step produces the least dense organelles?
- What is the difference between each of the fractionation step?
- Why is this difference needed?
- List the 4 methods of homogenization

Fluid Mosaic Model

- Model developed by Singer and Nicolson (1972) to understand membrane structure
- Fluid implies movement on membrane
- Mosaic implies that the membrane consists of many different molecules

Topic List

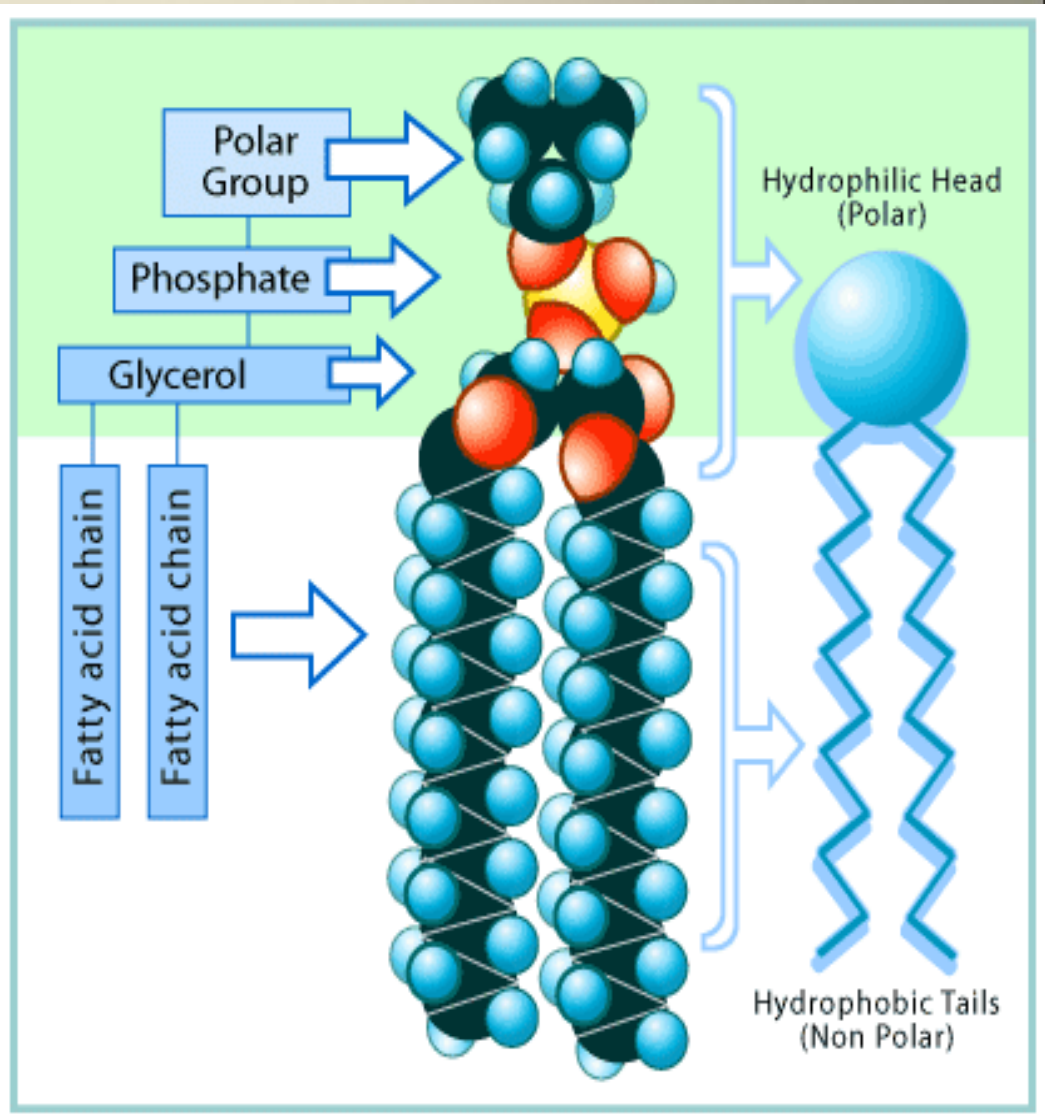
- Membrane Composition
  - Phospholipids
  - Membrane Proteins
    - Integral
    - Peripheral
  - Carbohydrates
  - Cholesterol
- Membrane Characteristic
  - Fluidity
  - Asymmetry

Membrane Composition: Mosaic

- Plasma membrane is composed of many different molecules:
  - Phospholipids
  - Membrane Proteins
    - Integral
    - Peripheral
  - Carbohydrates
  - Cholesterol

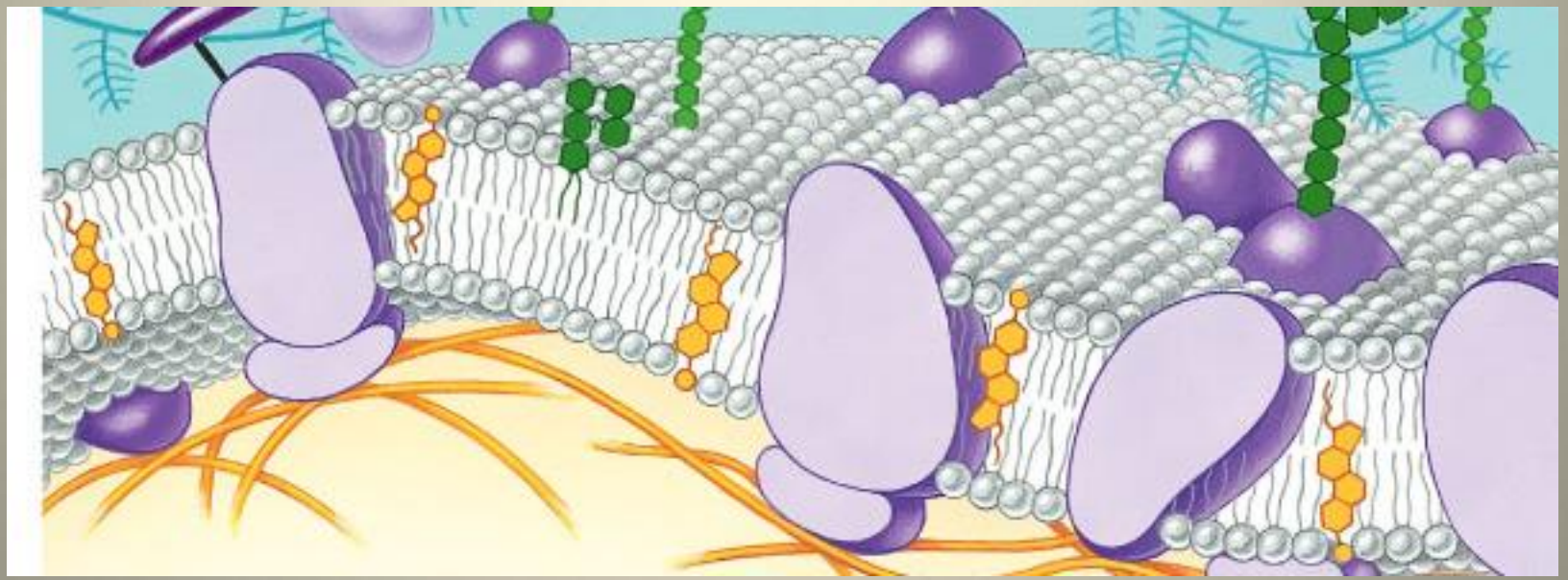
Plasma Membrane Structure

- Cell membrane made of **phospholipid**
- Phospholipids also form the membrane around organelles



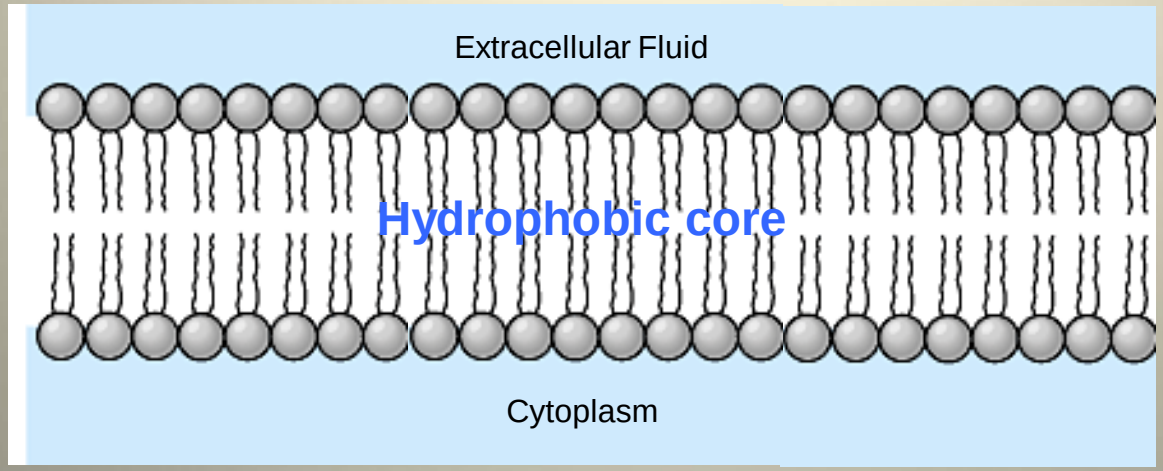
Phospholipid Bilayer

- Bilayer = 2 layers
- Each layer is called a leaflet and composed of phospholipids



Phospholipid Bilayer

- Water is on the intracellular and extracellular side
  - Cell is in a water (polar) environment
  - Cytoplasm (cell interior) is also a water environment
- Phospholipid arranged so that hydrophobic tails do not face water
  - Hydrophobic tails can not face outside or inside the cell
  - Hydrophobic tails face inwards forming a hydrophobic core
  - Hydrophilic heads face outwards



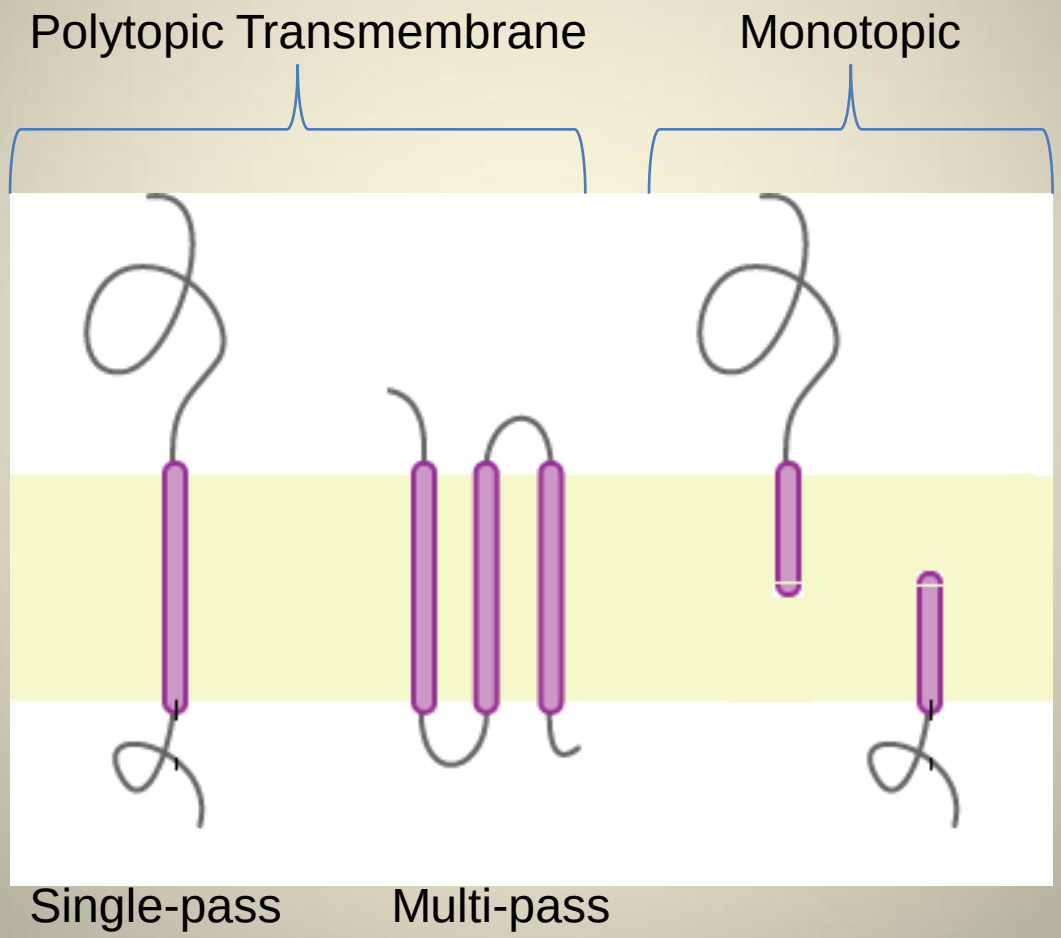
Types of Membrane Proteins

	Classification	Function

Integral	• Polytopic Transmembrane
	  • Single-pass
	  • Multi-pass
	• Monotopic
		• Receptor
		• Recognition
		• Transport
		  • Channel
		  • Carrier / Pump
		• Cell adhesion
		  • Anchoring
		  • Occluding
		  • Channel forming

Peripheral	• Extracellular • Intracellular	• Communication • Structural support

Structural Classes of Integral Membrane Proteins



Structural Classes of Integral Membrane Proteins

- Polytopic: faces both sides of membrane
  - Transmembrane: spans entire phospholipid bilayer
  - Single-pass: crosses membrane once
  - Multi-pass: crosses membrane several times
- Monotopic: associated with membrane on one side (e.g. one leaflet), does not span entire bilayer

Types of Membrane Proteins

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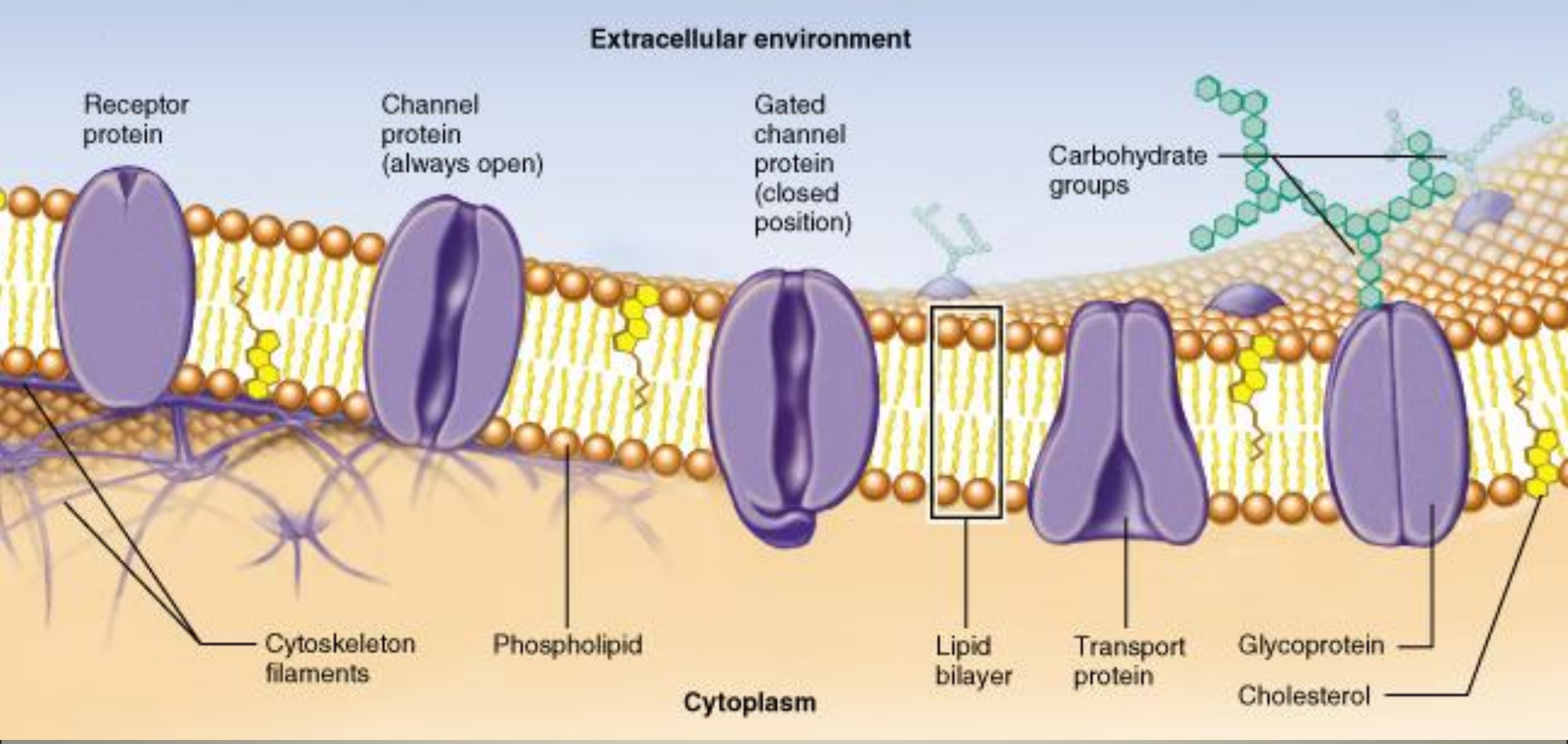
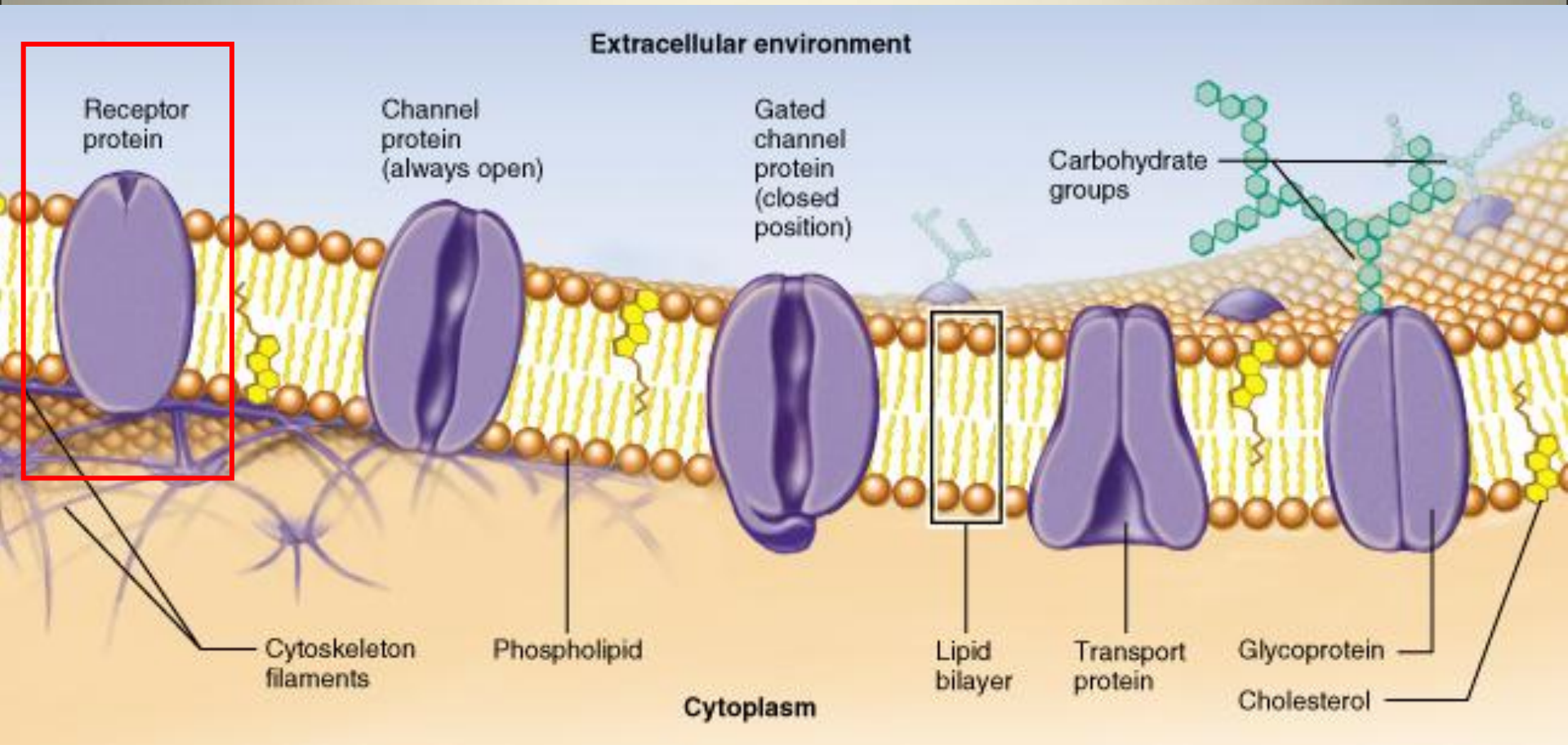
Types of Transmembrane Proteins



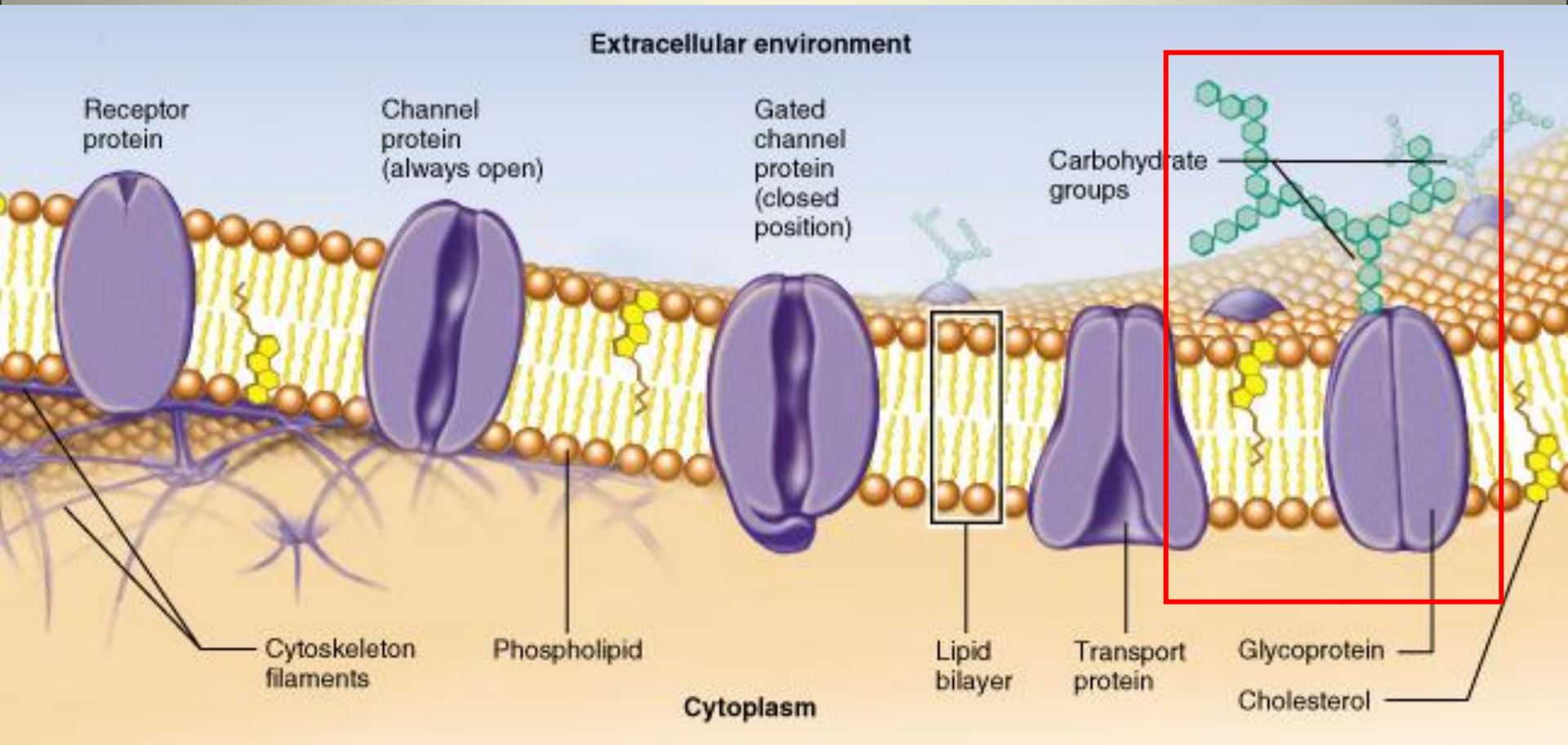
Receptor Protein

- Has a binding site for the ligand



Recognition Protein

- Glycoprotein: surface carbohydrate groups help identify cell (e.g. antigens)

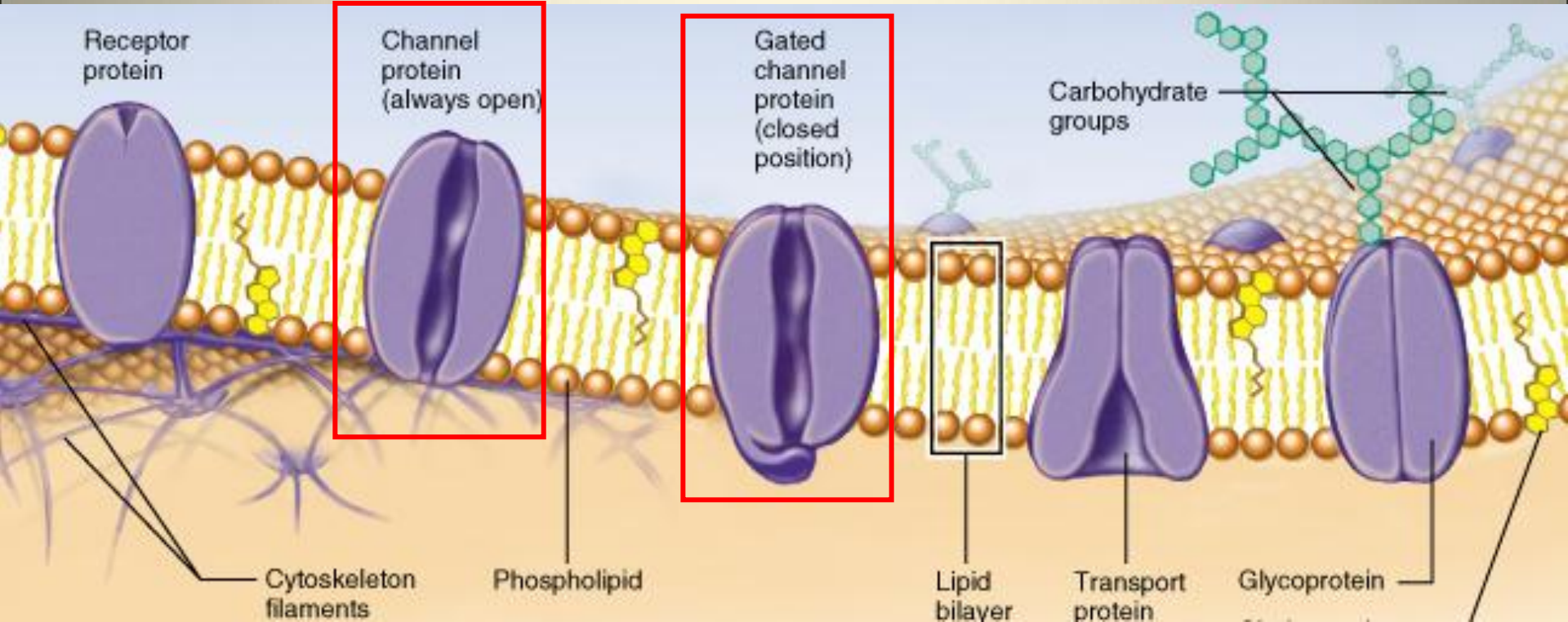


Transport Proteins

- Channel
  - Un-gated (leak channels)
  - Gated (open or closed position)
- Carrier / Pump

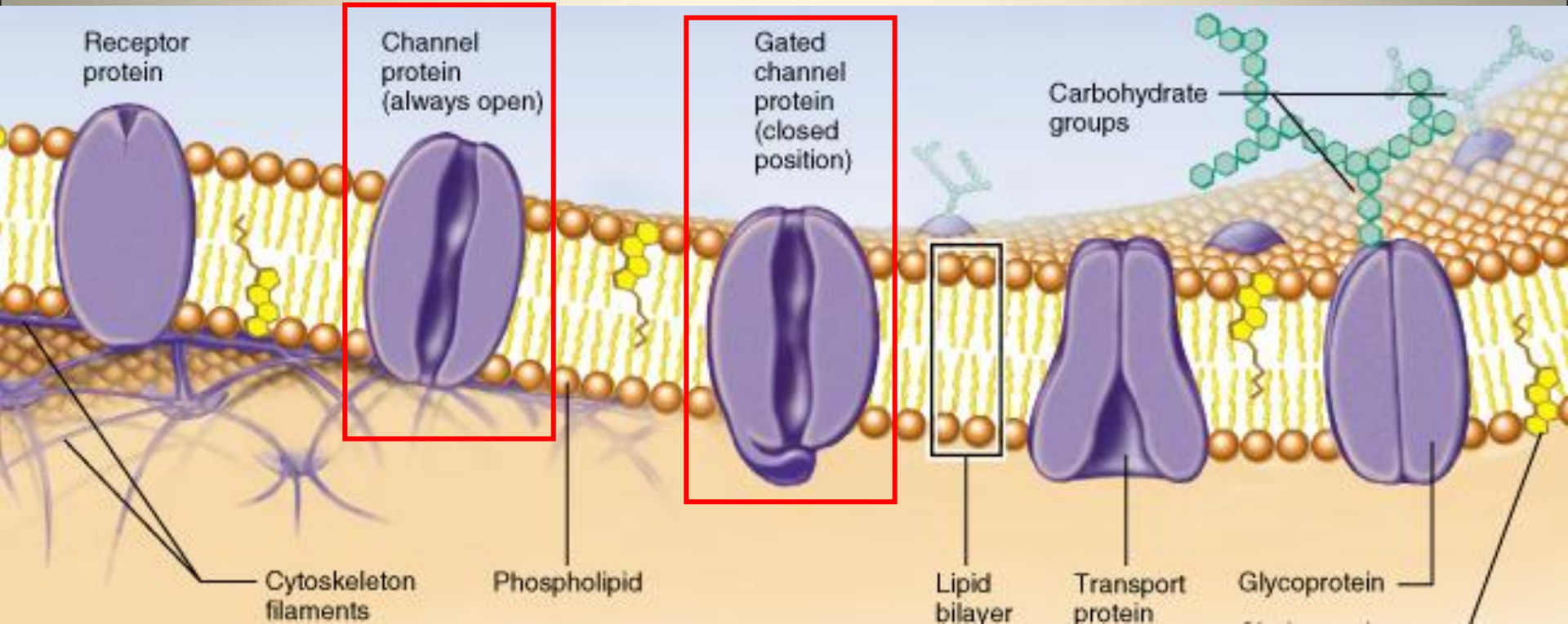
Channel Proteins

- Act like tunnels
- Molecules move through protein passively (no energy involved)
- Moves small molecules or charged ions



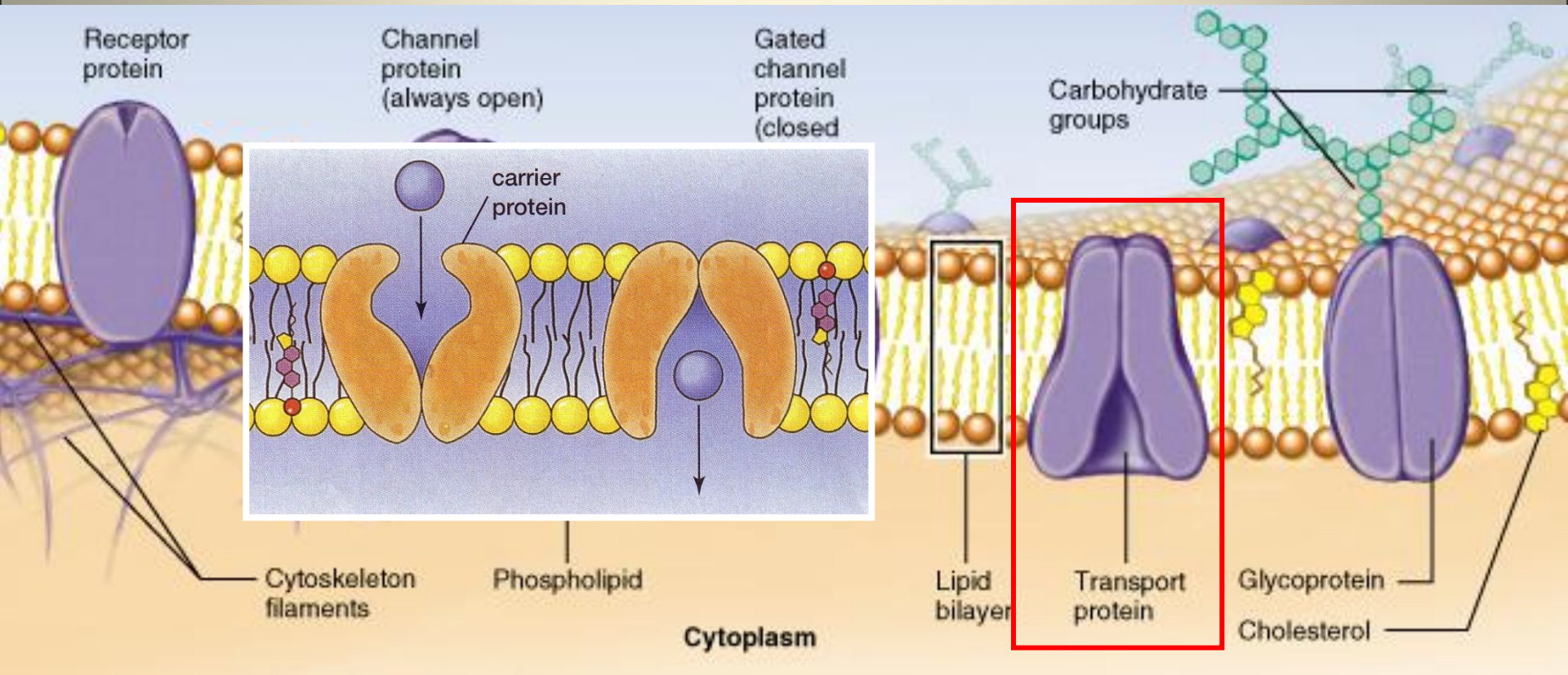
Types of Channel Proteins

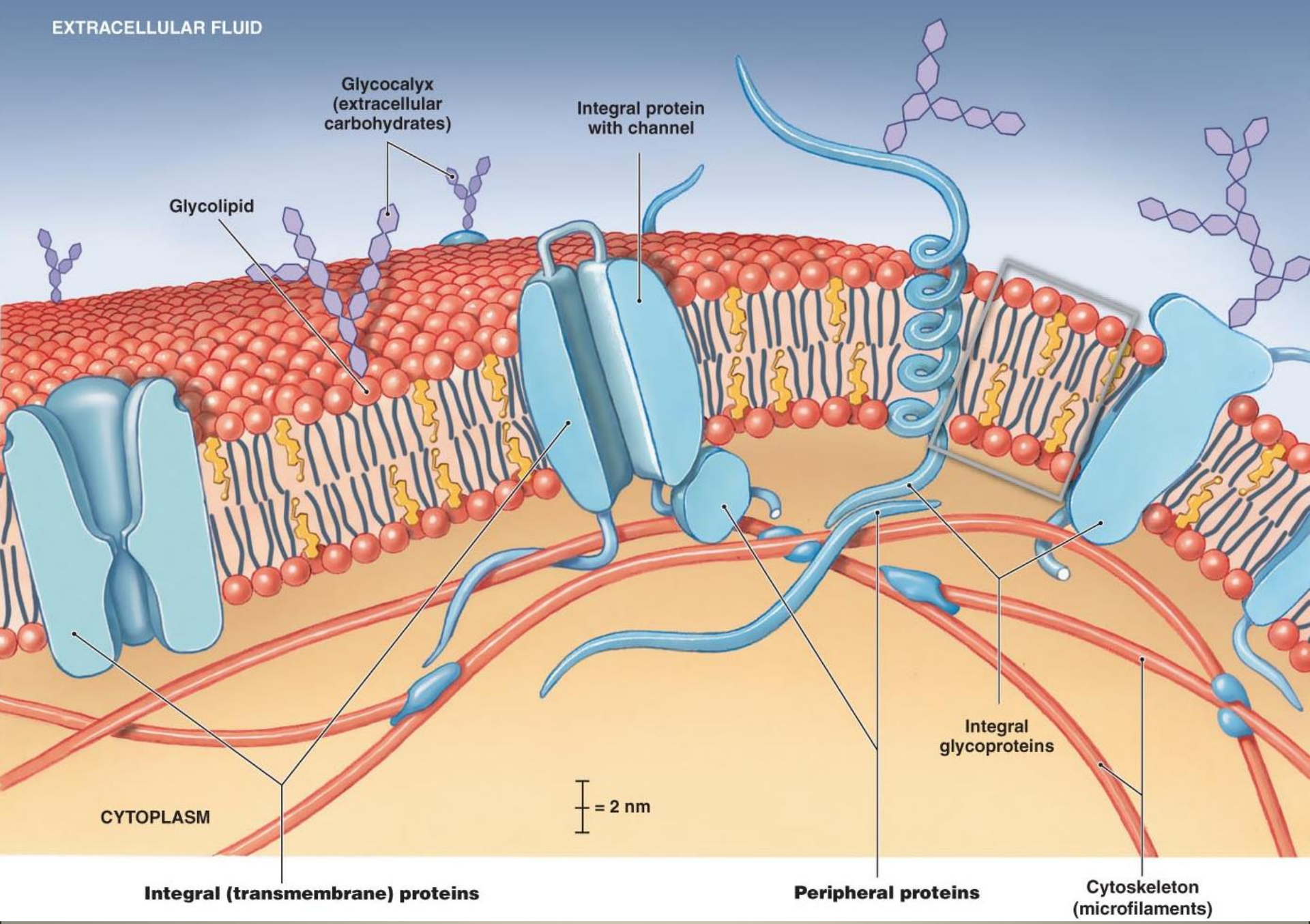
- Ungated (leak channels): always opened
- Gated: have open and closed conformations
  - Changes stimulated by changes in external environment



Carrier Proteins / Pumps

- Acts like a turnstile or revolving door
- Undergo conformational change to allow molecules through





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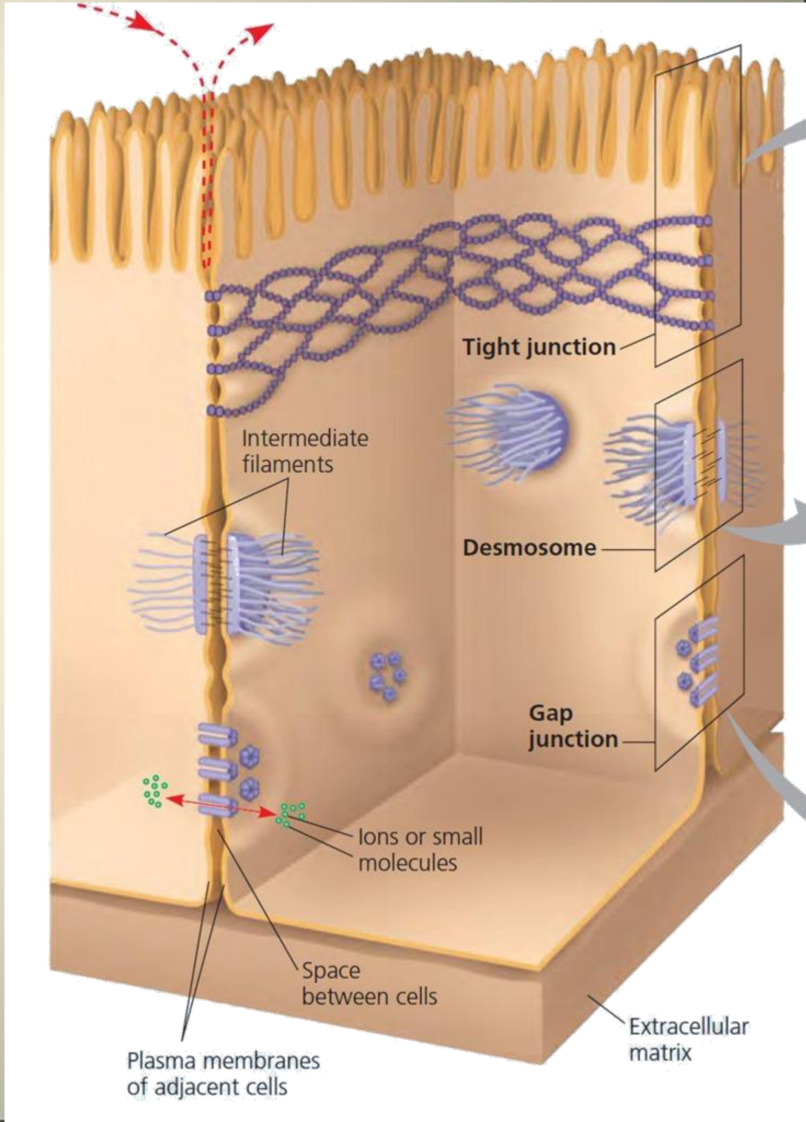
		  • Anchoring
		  • Occluding
		  • Channel forming

Peripheral	• Extracellular • Intracellular	• Communication • Structural support

Cell Adhesion: Cell Junctions

- Structures that connect cell to cell
- Allow cells to adhere to each other
- Types:
  - Channel-forming junction
  - Occluding junction
  - Anchoring junction



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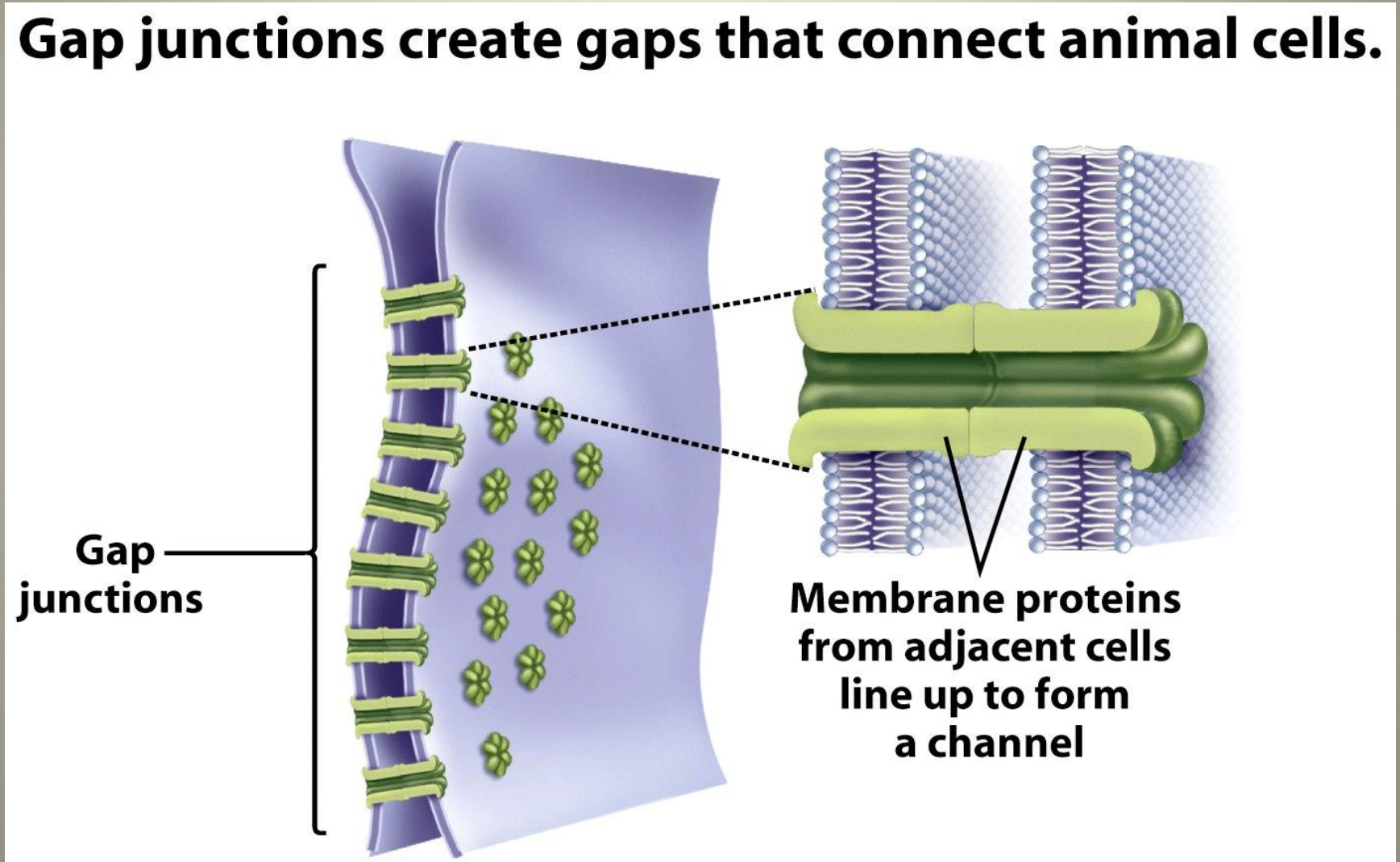
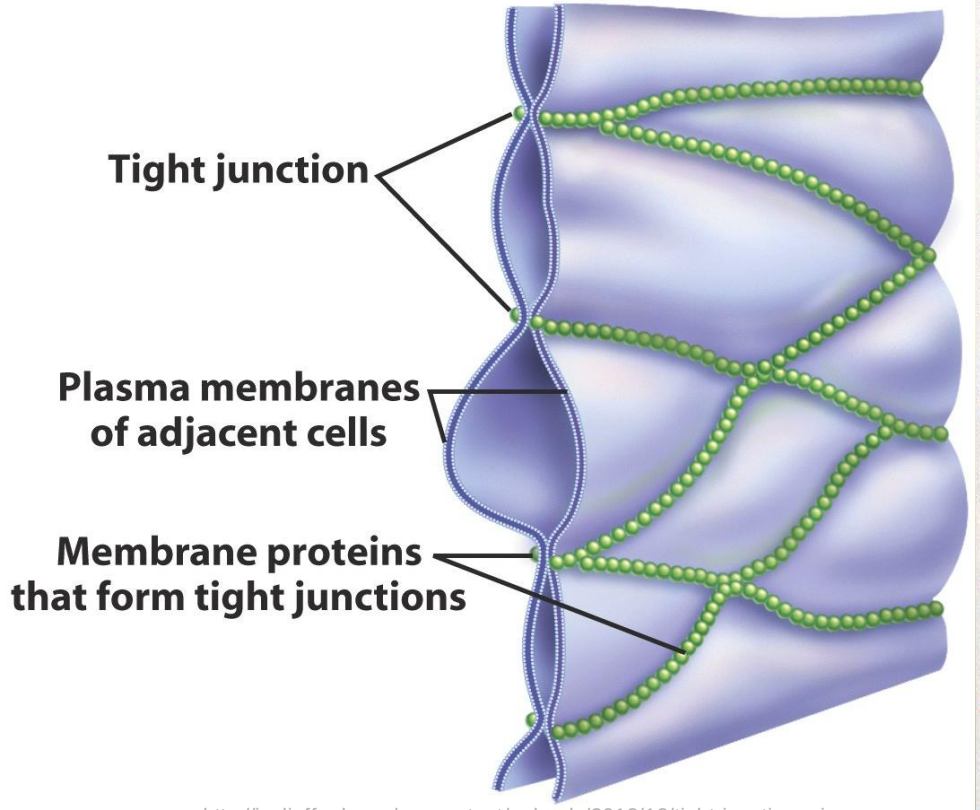
Channel Forming: Gap Junctions



Occluding: Tight Junctions

- Forms impermeable barrier between cells



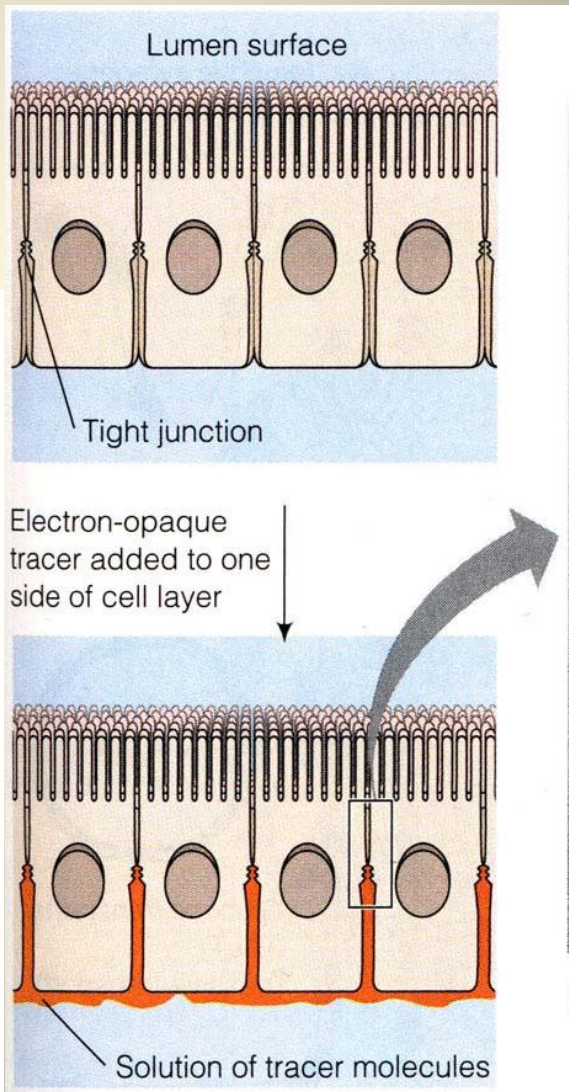


Figure 8-9b Biological Science, 2/e

http://ionlieffmd.com/wp-content/uploads/2013/12/tight-junctions-.jpg

http://cc.scu.edu.cn/G2S/eWebEditor/uploadfile/20120810143050626.jpg

Occluding: Tight Junctions

- Think: Where in your body, would this be crucial?

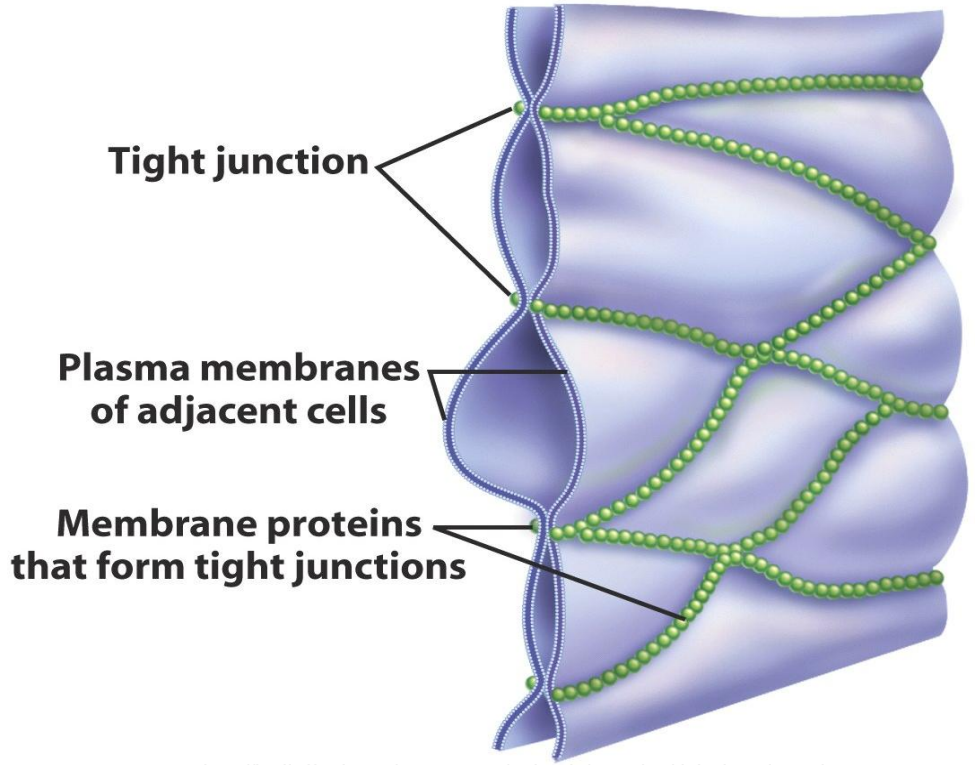


Figure 8-9b Biological Science, 2/e

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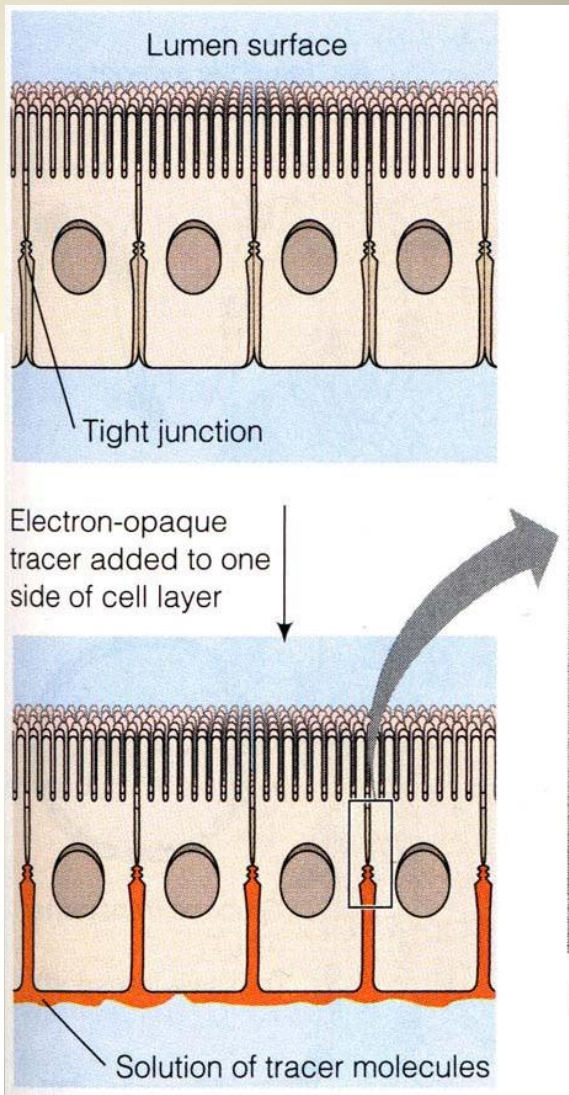
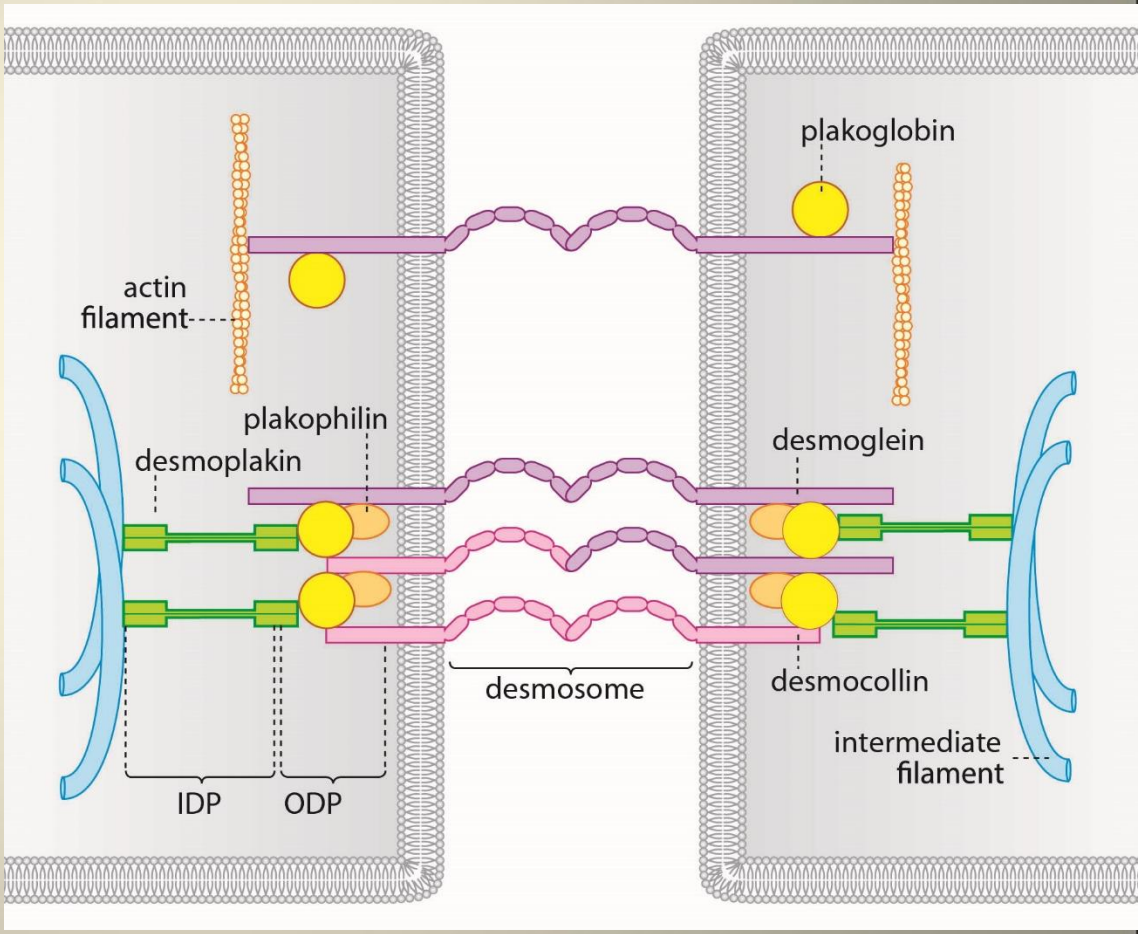


http://cc.scu.edu.cn/G2S/eWebEditor/uploadfile/20120810143050626.jpg

Anchoring: Desmosome

- Desmosomes bind to desmosomes on adjacent cells
- Attached to cytoskeleton
- Helps resist shearing force



http://www.ls1.anatomie.med.uni-muenchen.de/bilder/ag_spindler/pemphigus_fig1.jpg

Anchoring: Desmosome

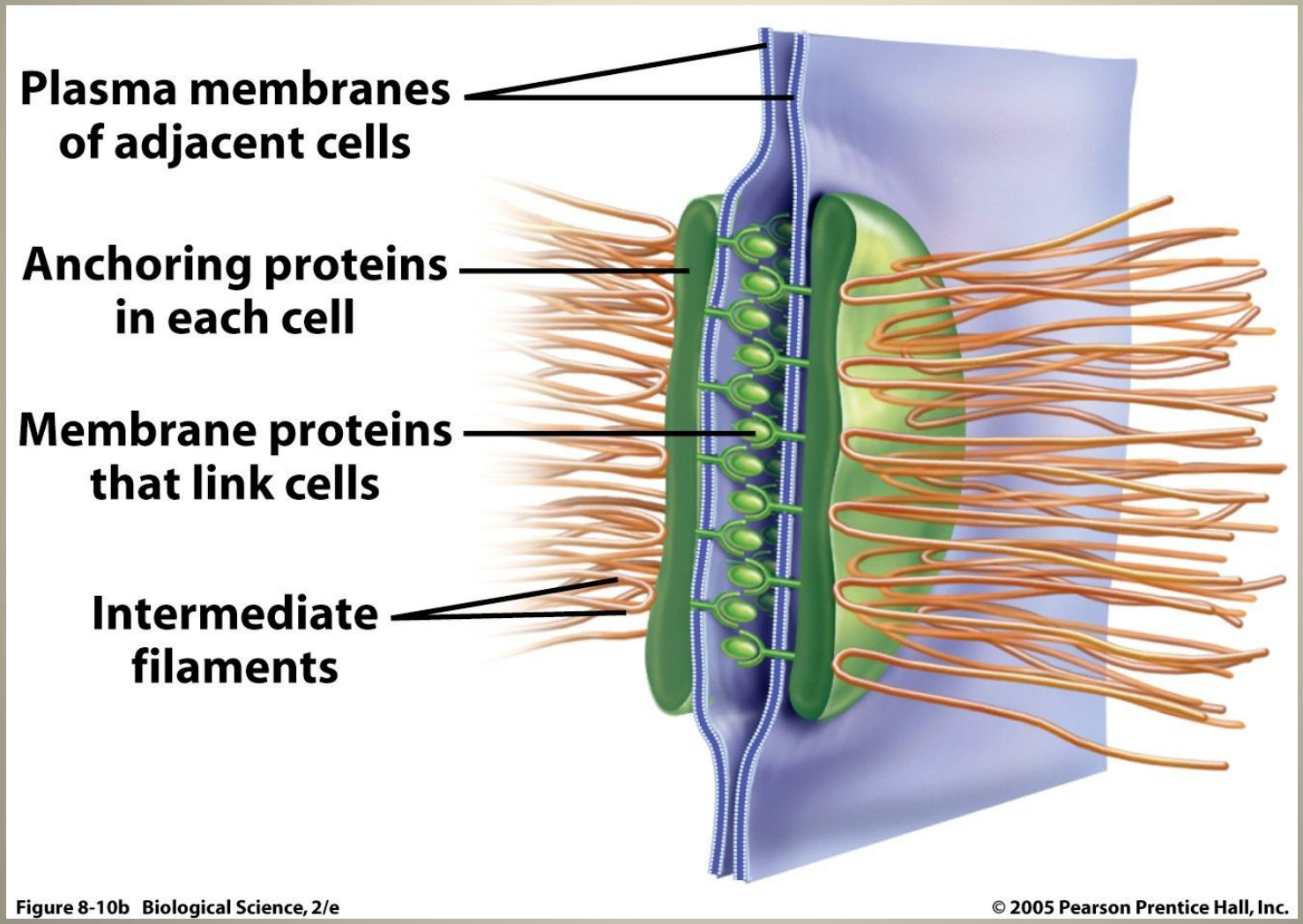


Figure 8-10b Biological Science, 2/e

http://www.uic.edu/classes/bios/bios100/l06pm/desmosomes.jpg

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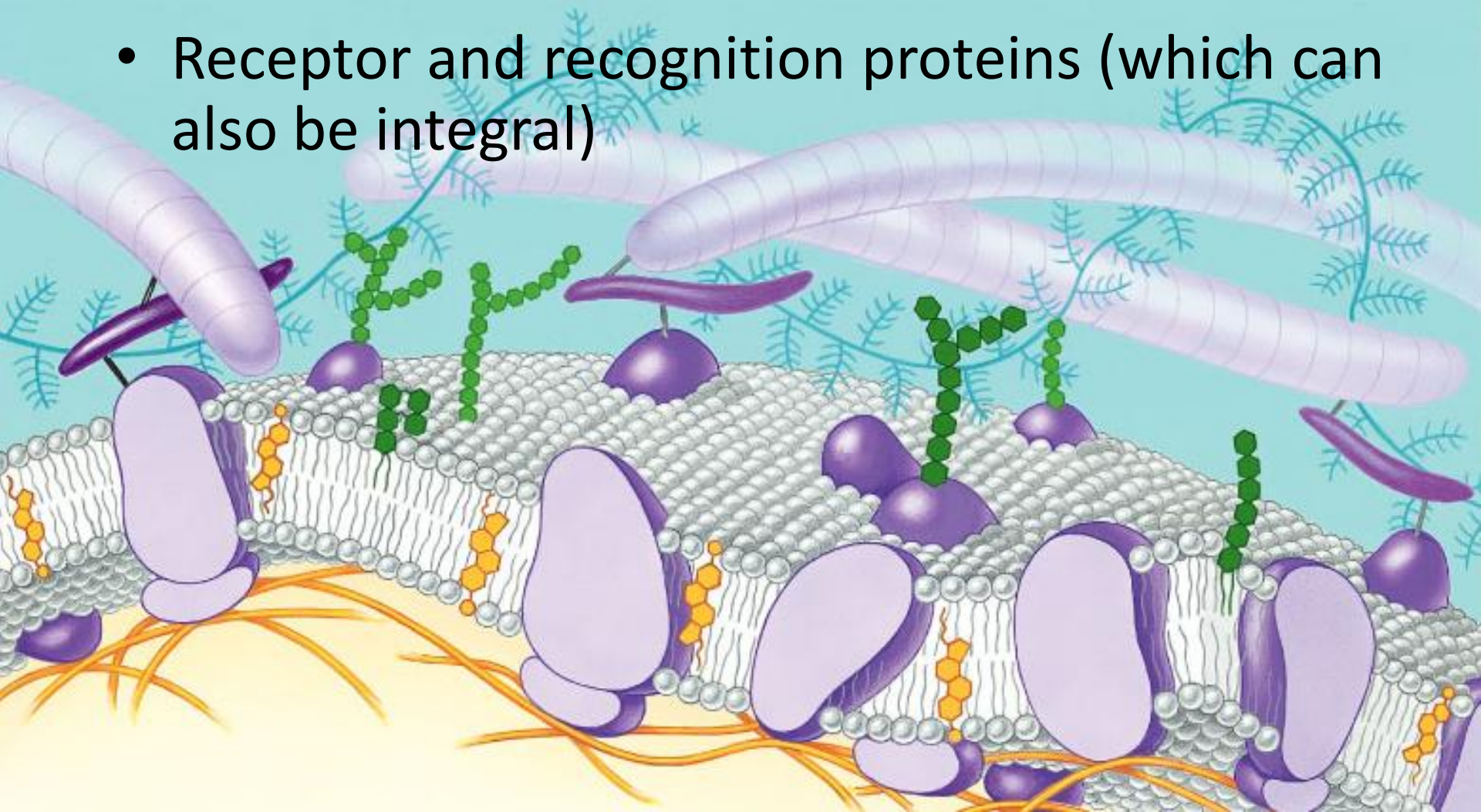
Peripheral	• Extracellular • Intracellular	• Communication • Structural support

Peripheral Membrane Proteins

- Bound non-covalently to either surface of the membrane
- Function
  - Extracellular side: communication
  - Intracellular side: structural support

Extracellular Peripheral Protein: Communication

- Located on outer leaflet and surface
- Receptor and recognition proteins (which can also be integral)



Extracellular Matrix (ECM): Components

- A matrix of glycoproteins
- Secreted by cells
- Varies with type of tissue

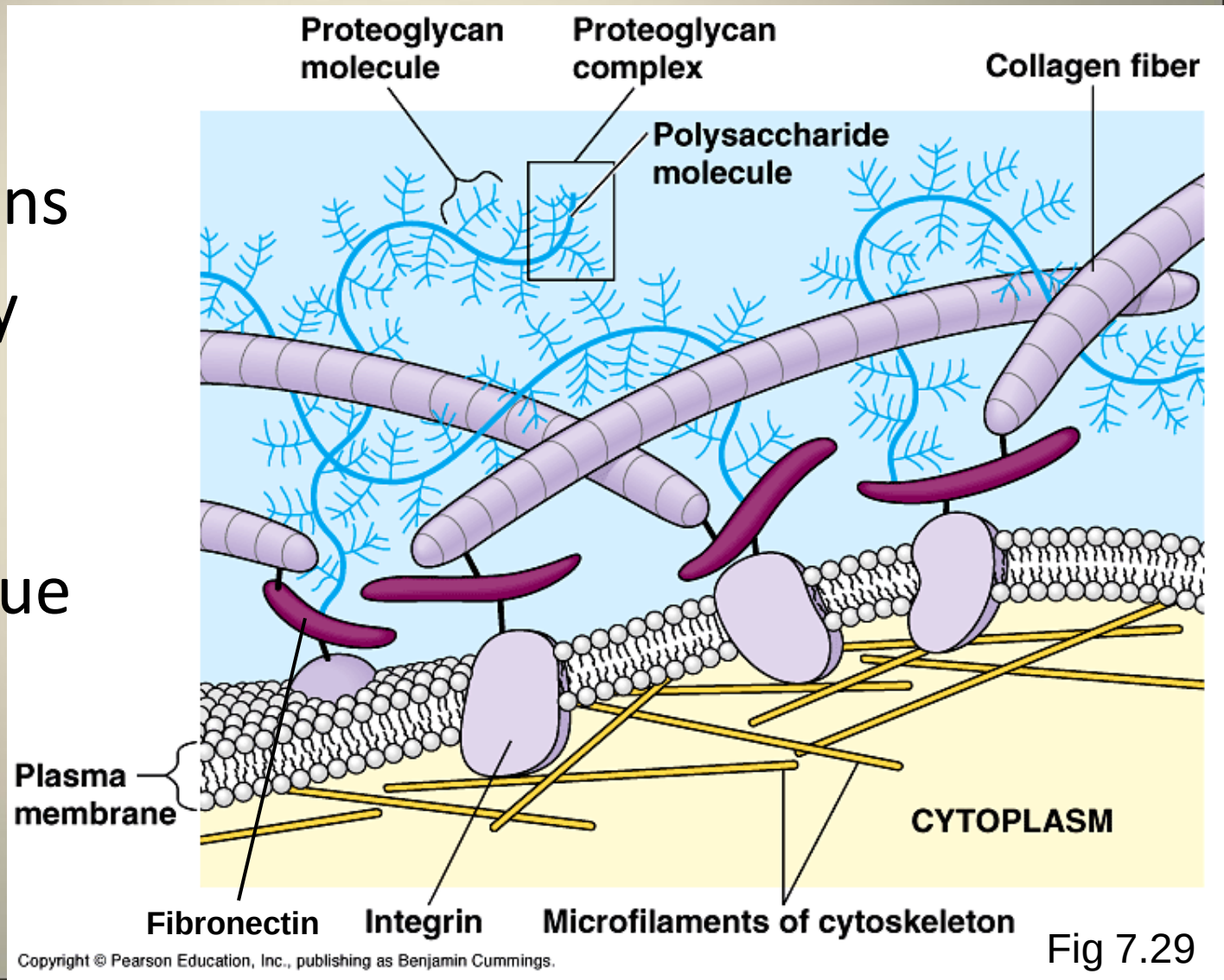


Fig 7.29

Extracellular Matrix (ECM): Function

- Supports cell structure
- Anchors cell
- Separates tissues
- Functions in cell signalling

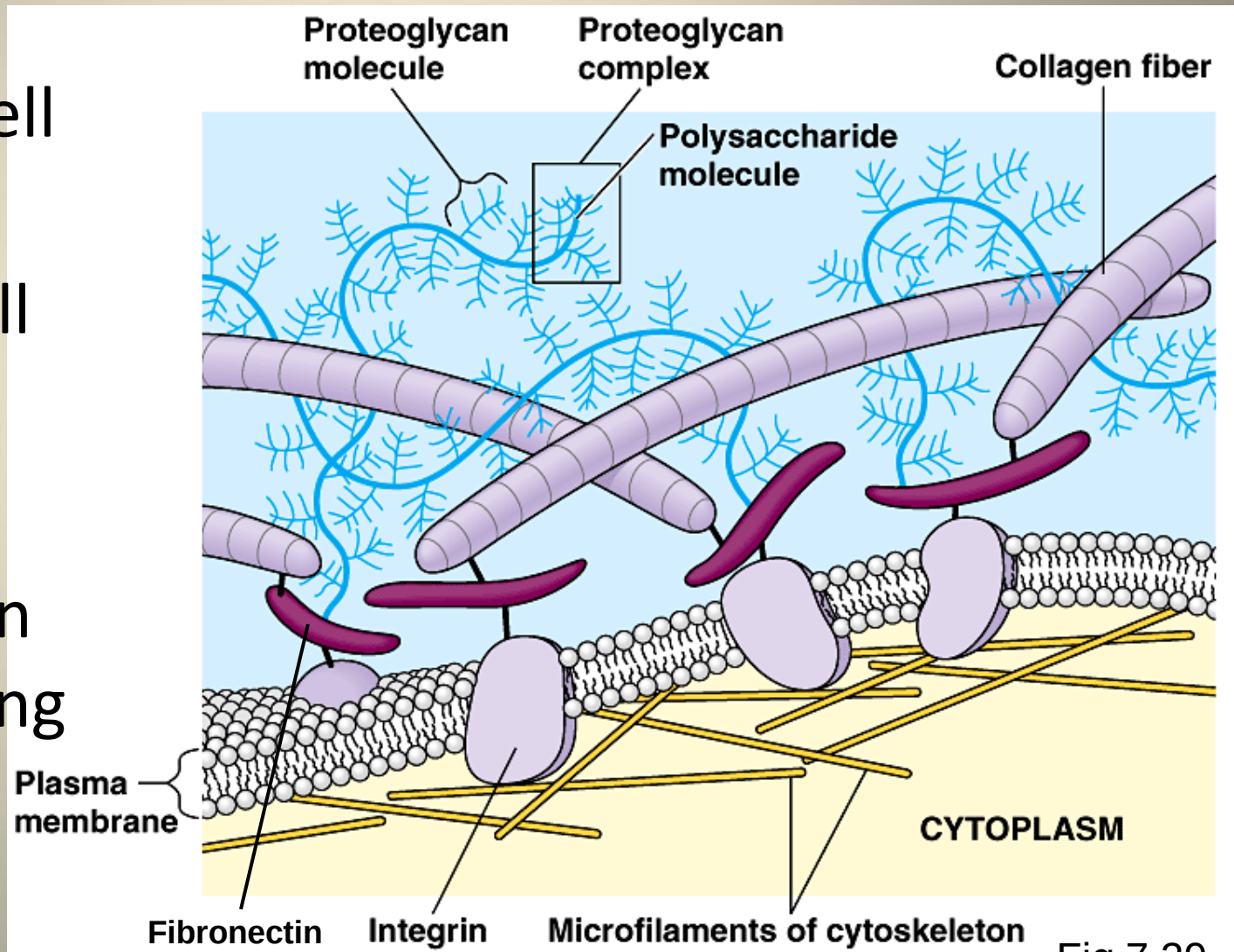
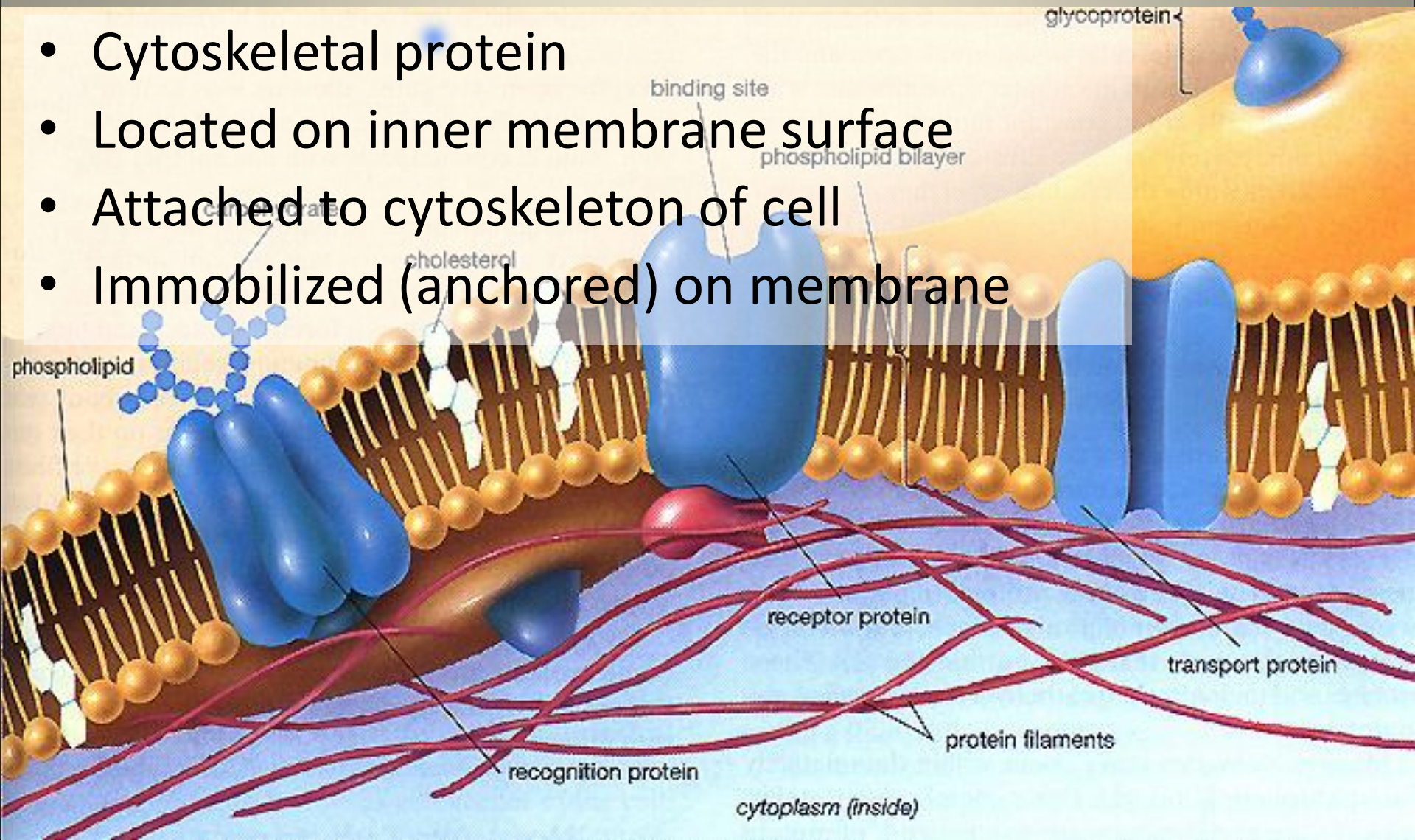


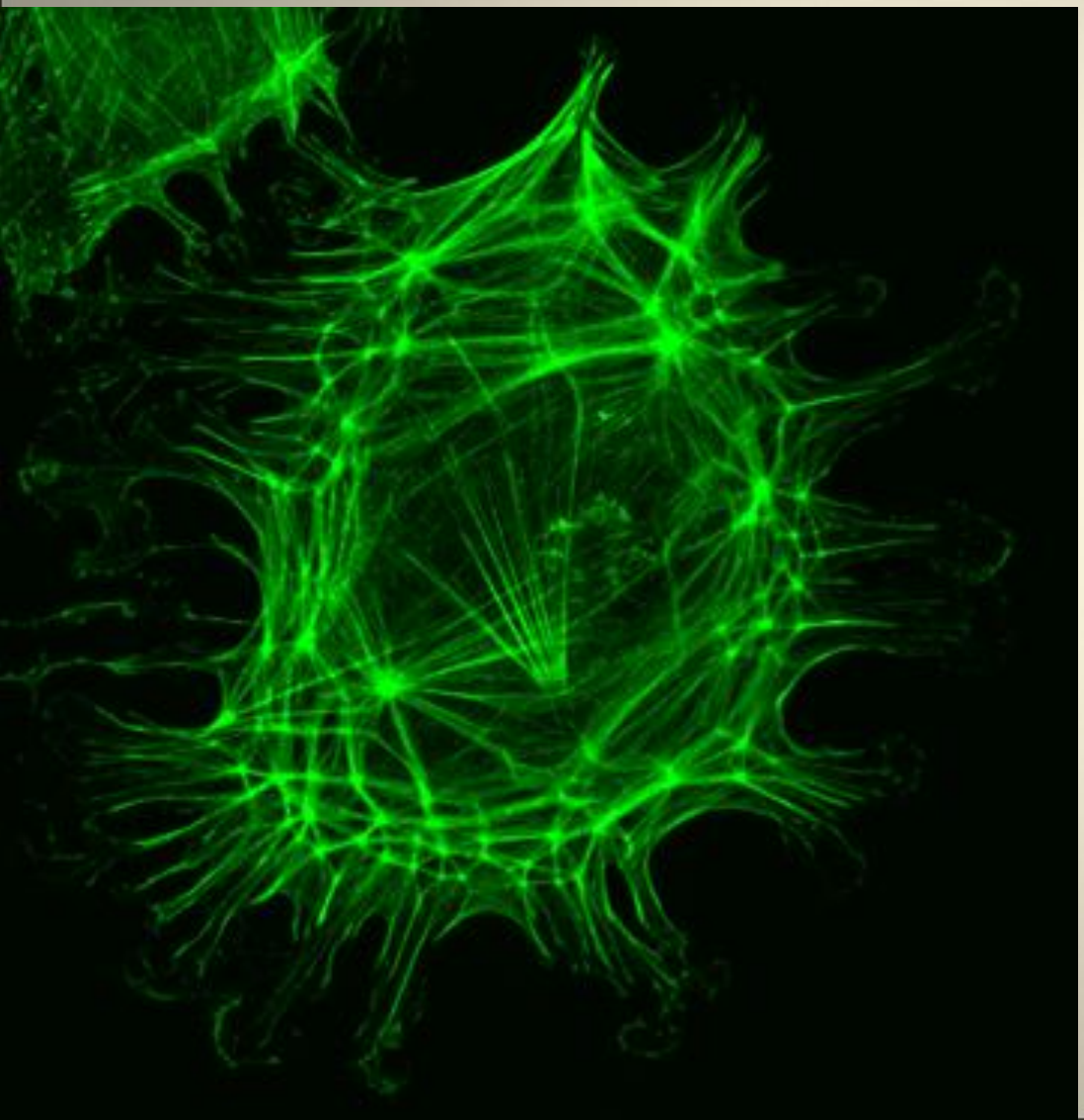
Fig 7.29

Intracellular Peripheral Protein: Structural

- Cytoskeletal protein
- Located on inner membrane surface
- Attached to cytoskeleton of cell
- Immobilized (anchored) on membrane



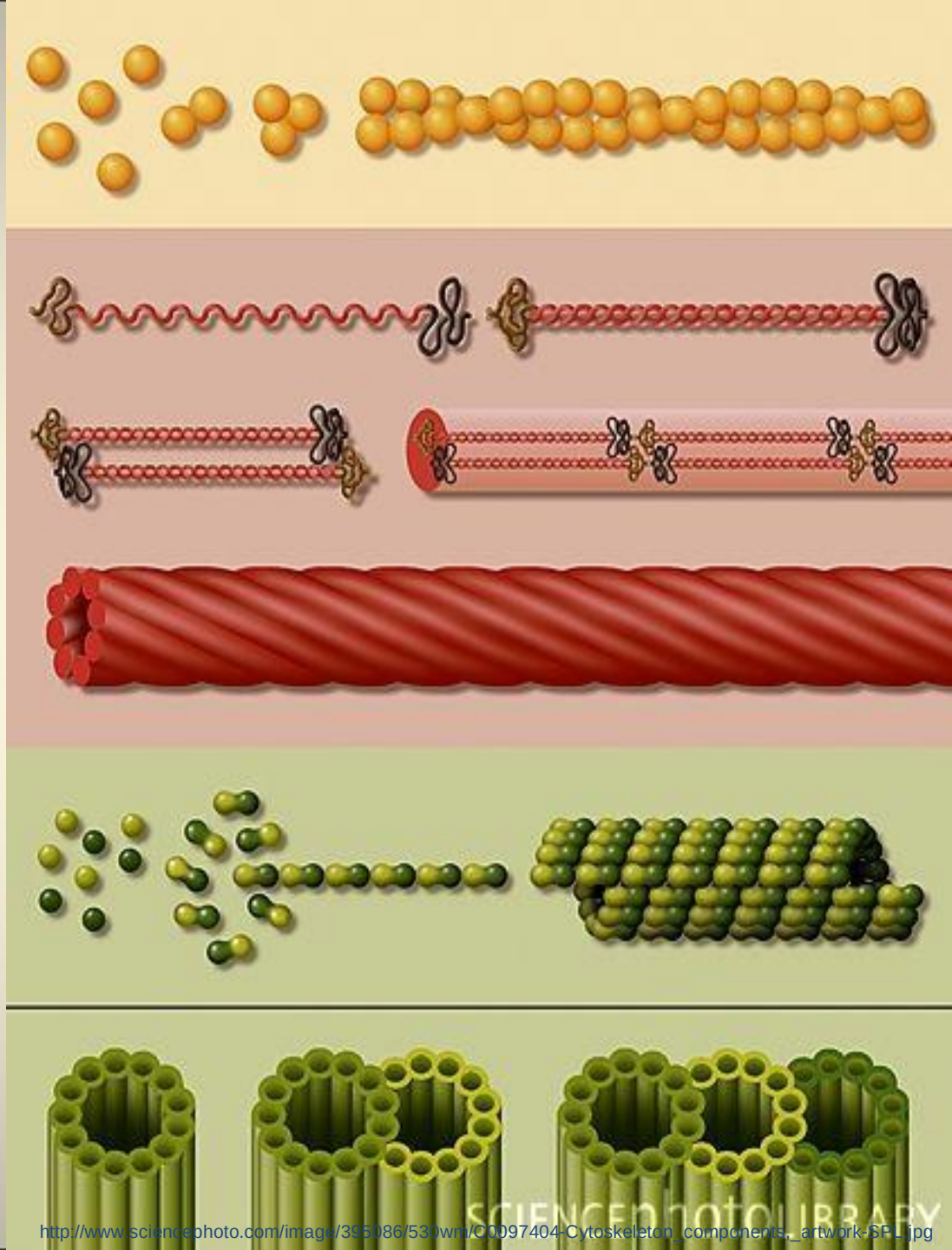
Cytoskeleton



- A network of fibers extending throughout the cytoplasm
- Dynamic: can be quickly dismantled and reassembled in a new location

Cytoskeleton Component

- Microfilament: actin
- Intermediate filament
- Microtubules: tubulin



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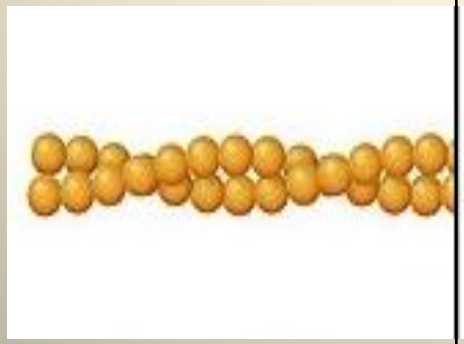
Cytoskeleton Component

Type	Microfilament	Intermediate Filament	Microtubule
Structure	2 intertwined strands of actin	Fibrous protein supercoiled	Hollow tube of 13 tubulin columns
Diameter	7 nm	8-12 nm	25 nm
Diagram			

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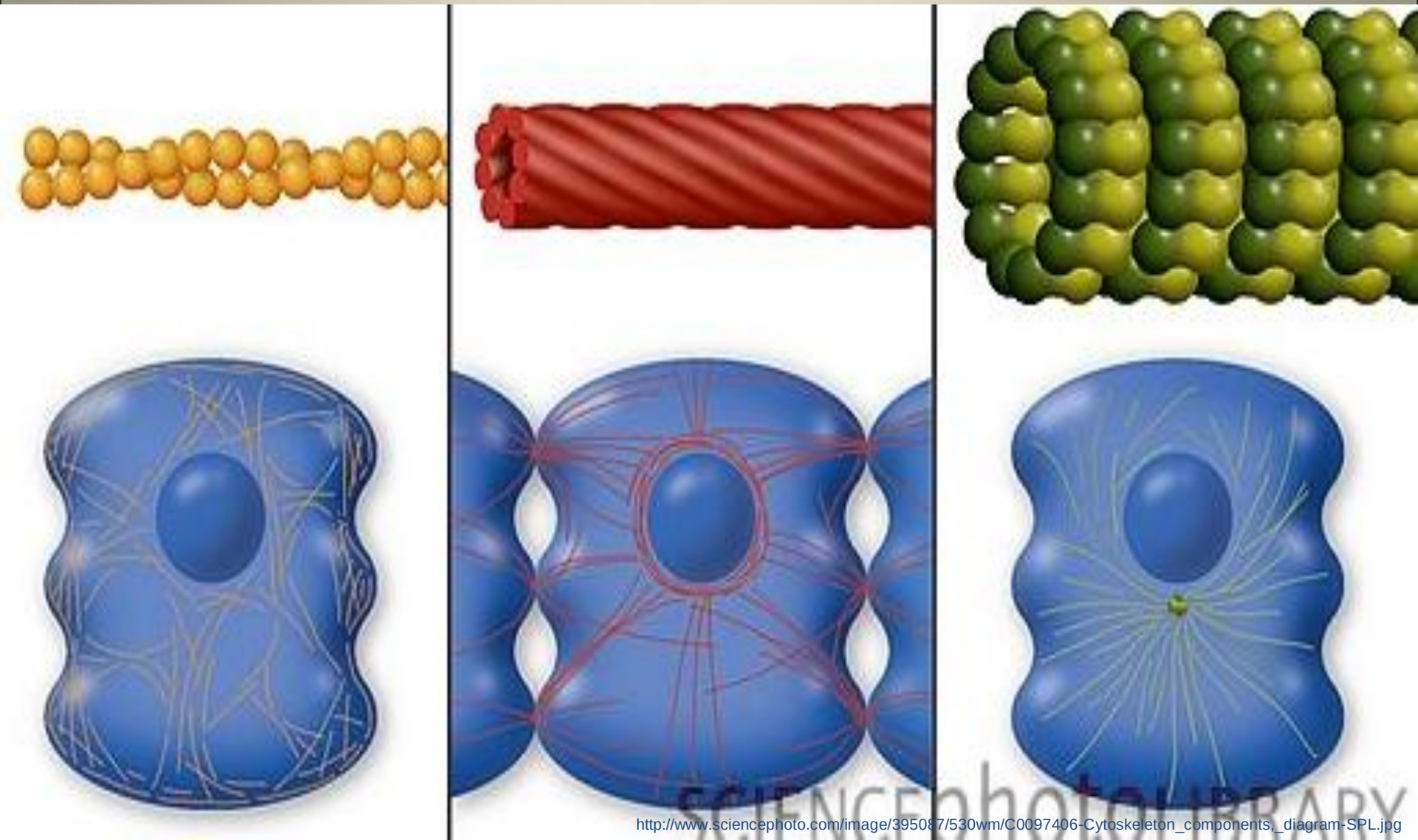
Cytoskeleton Component

Type	Microfilament	Intermediate Filament	Microtubule
Intracellular Function	Maintain cell shape (e.g. furrow)	Anchorage of organelles and cytosolic proteins	Path for organelle, vesicle & chromosome movement (e.g. spindle fibers)
Other Function	Muscle contraction		Cell motility (e.g. cilia)

http://www.sciencephoto.com/image/395087/530wm/C0097406-Cytoskeleton_components,_diagram-SPL.jpg

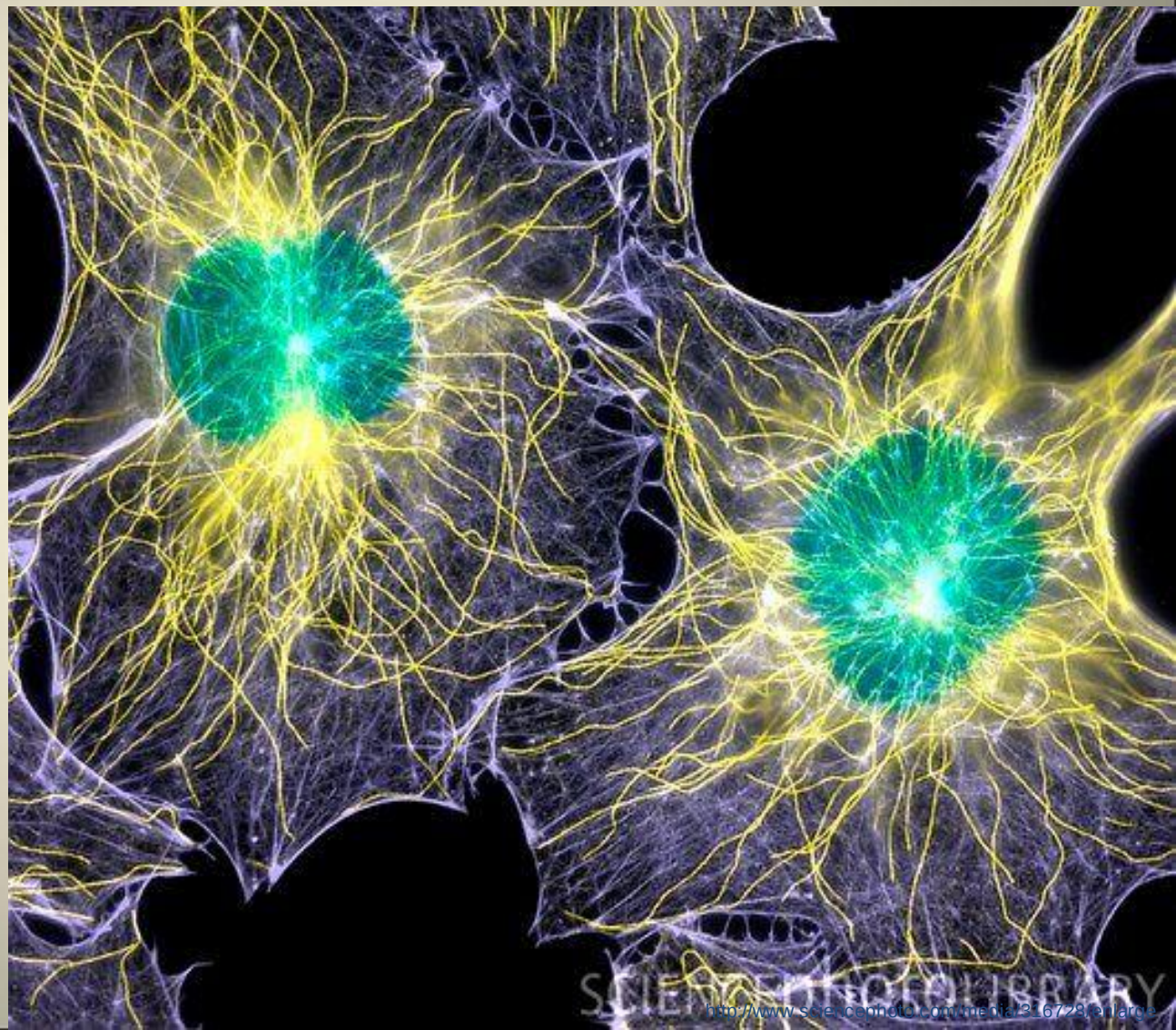
Cytoskeleton Component



http://www.sciencephoto.com/image/395087/530wm/C0097406-Cytoskeleton_components,_diagram-SPL.jpg

Cytoskeleton

- Fluorescent light micrograph of fibroblast cells
- Nuclei (green)
- Cytoskeleton:
  - microfilaments (actin) (purple)
  - microtubules (yellow)



Carbohydrates

- Glycoprotein = carbohydrate + protein
- Glycolipid = carbohydate + lipid (phospholipid)
- Extracellular side
- Function of cell surface carbohydrates:
  - identifies the cell (like a name) helping other cells recognize it
  - acts as a signal for communication

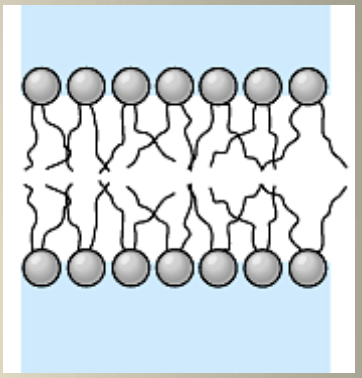
Thought Question

- Of the component of the plasma membrane that was just studied, which would have an affect on the fluidity of the membrane?
  - Phospholipids
  - Proteins
  - Carbohydrates
- Explain.

Membrane Characteristic: Fluid

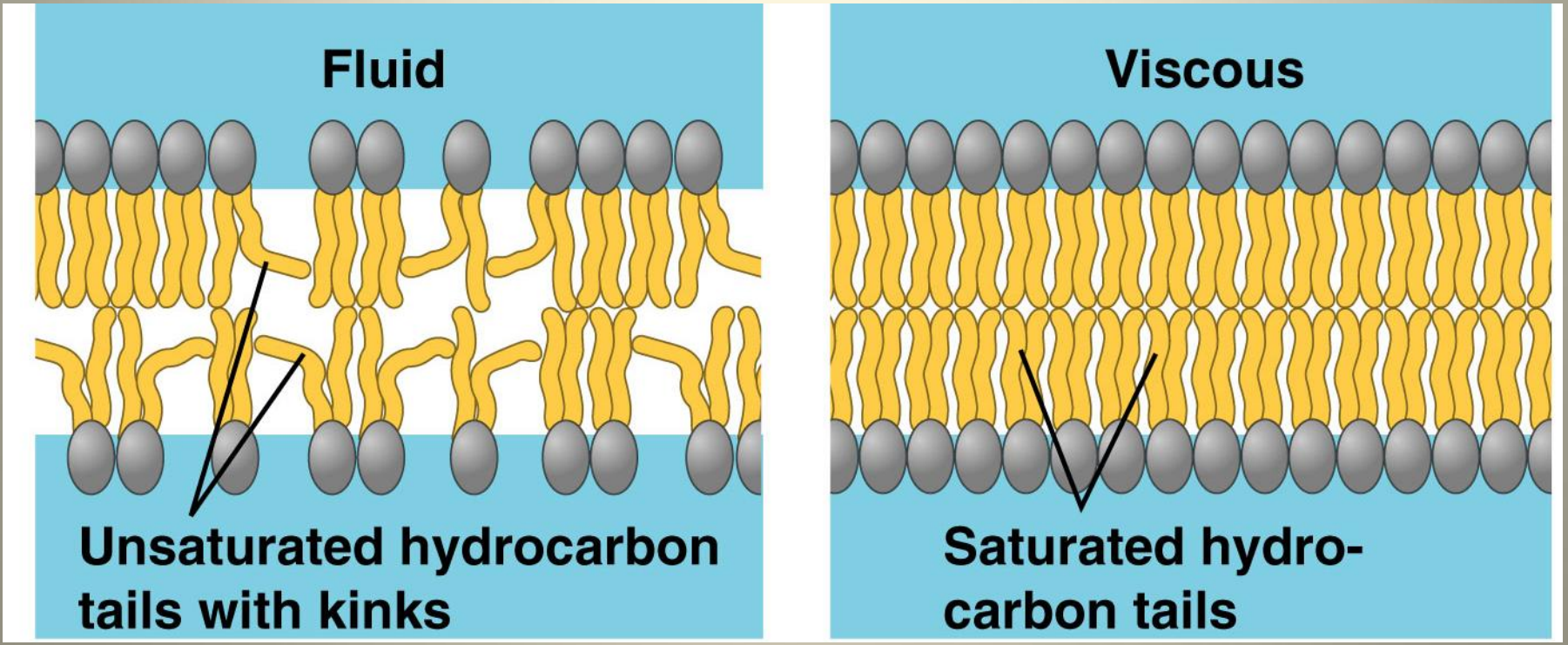
Membrane fluidity is affected by:

- Saturation of fatty acid
- Hydrophobic restrictions
- Cholesterol and temperature

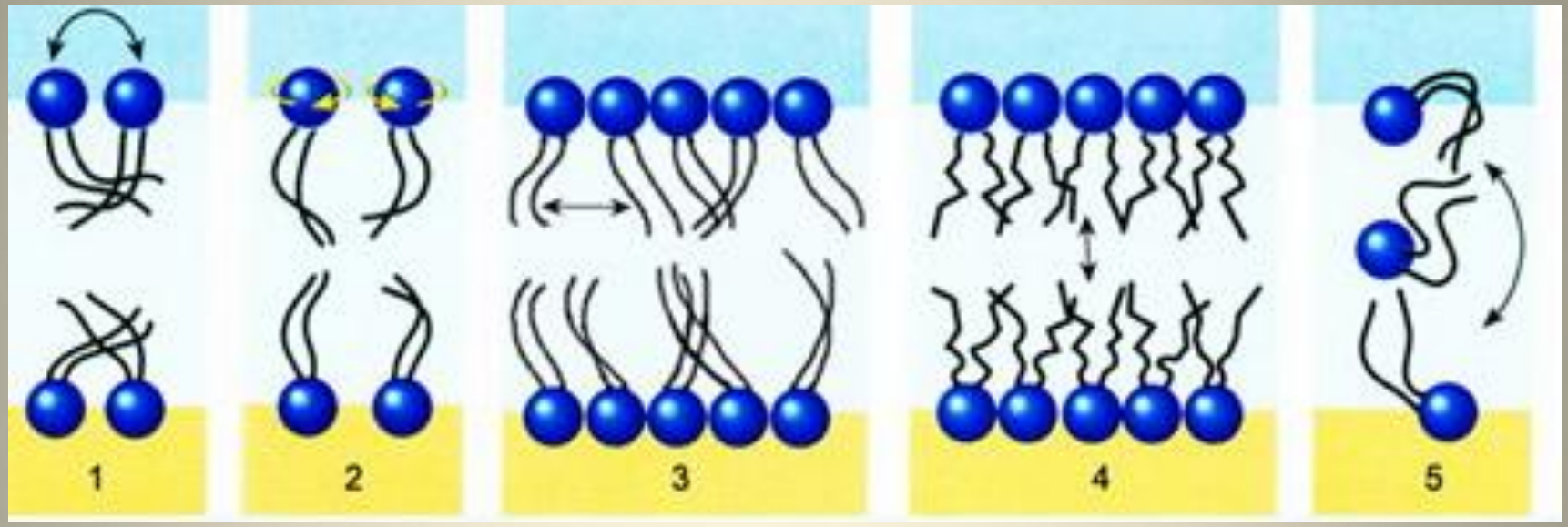


Saturation of Fatty Acid

- Double bonds bends fatty acid chains preventing phospholipids from tight packing



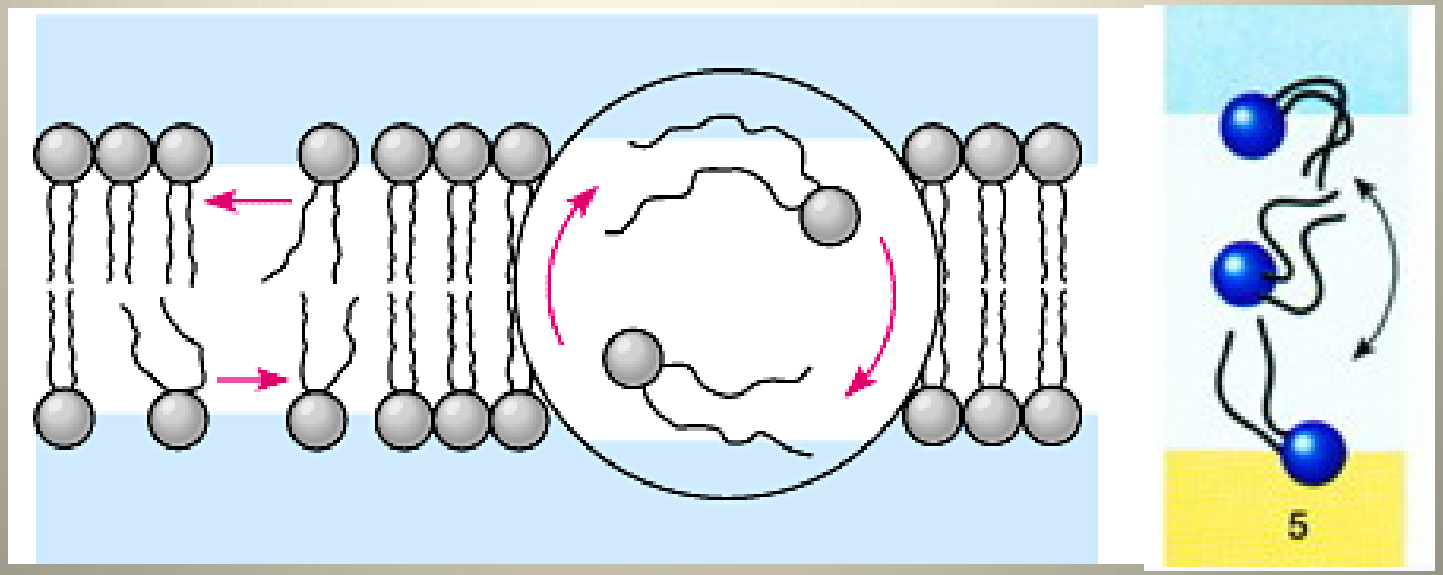
Movement within Membrane



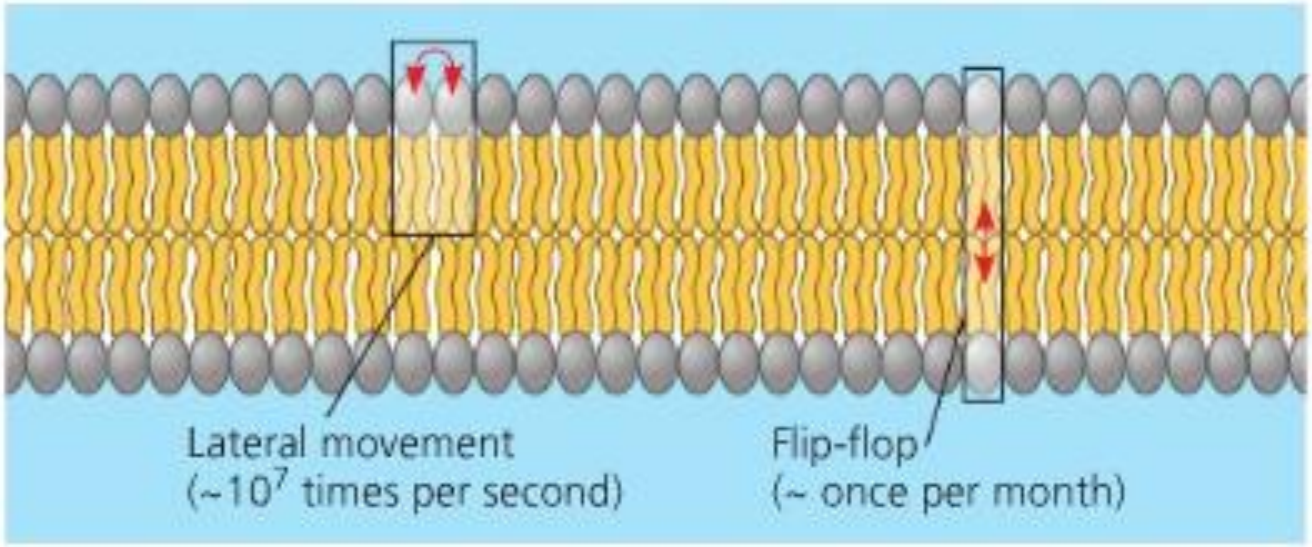
1. **Lateral Diffusion**: movement across same leaflet (phospholipids transpose with neighboring molecules)
2. **Rotation**: is when an individual molecule rotates quickly around its axis
3. **Swing**: from side-to-side
4. **Flexion**: contraction movement

Hydrophobic Restriction

- Transverse Diffusion (flip flop):
  - movement from one leaflet to the other
  - facilitated by enzyme **flippase**
  - rare because because the hydrophilic head of phospholipid must go cross the hydrophobic core to get to the leaflet



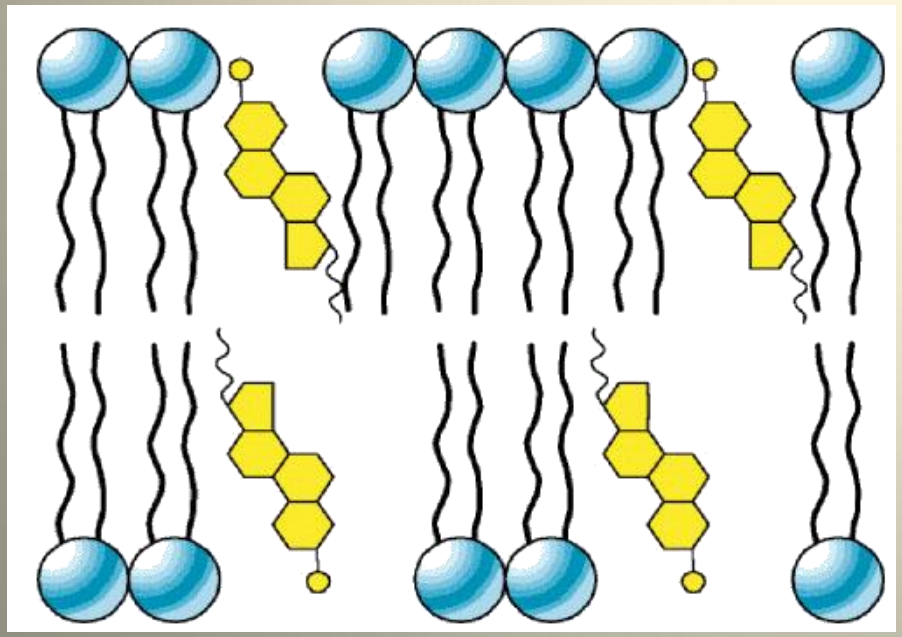
Hydrophobic Restrictions

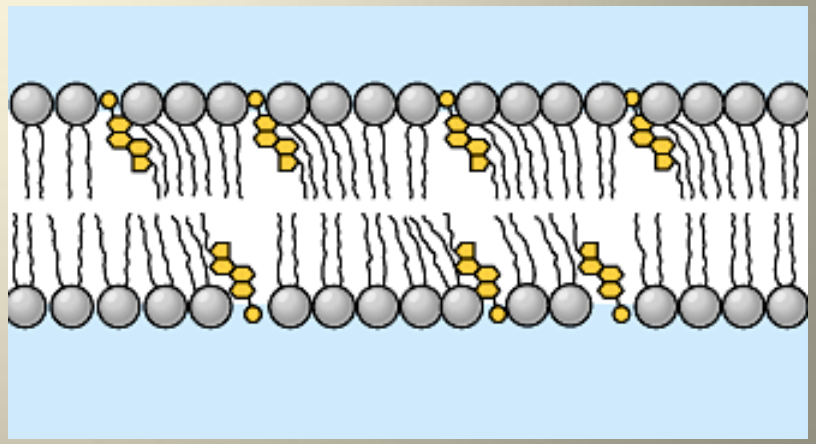


(a) Movement of phospholipids. Lipids move laterally in a membrane, but flip-flopping across the membrane is quite rare.

Properties of Cholesterol

- Large molecular size
  - Can interrupt intermolecular forces of attraction
- Nonpolar
  - Stabilizes hydrophobic interactions

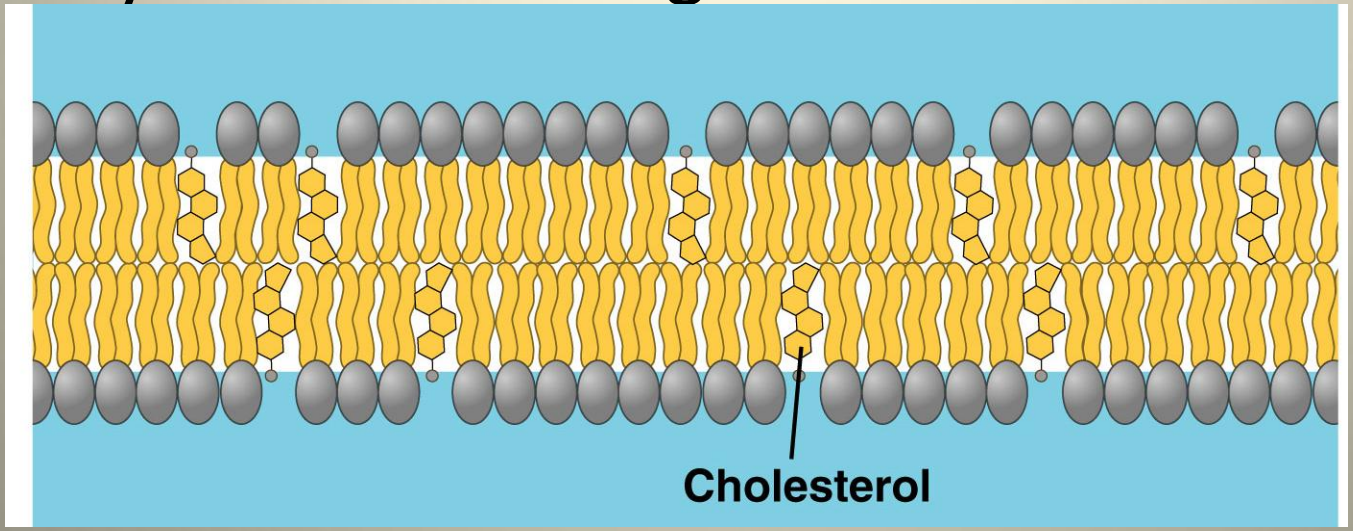




http://www.uic.edu/classes/bios/bios100/lectf03am/cholesterol.jpg

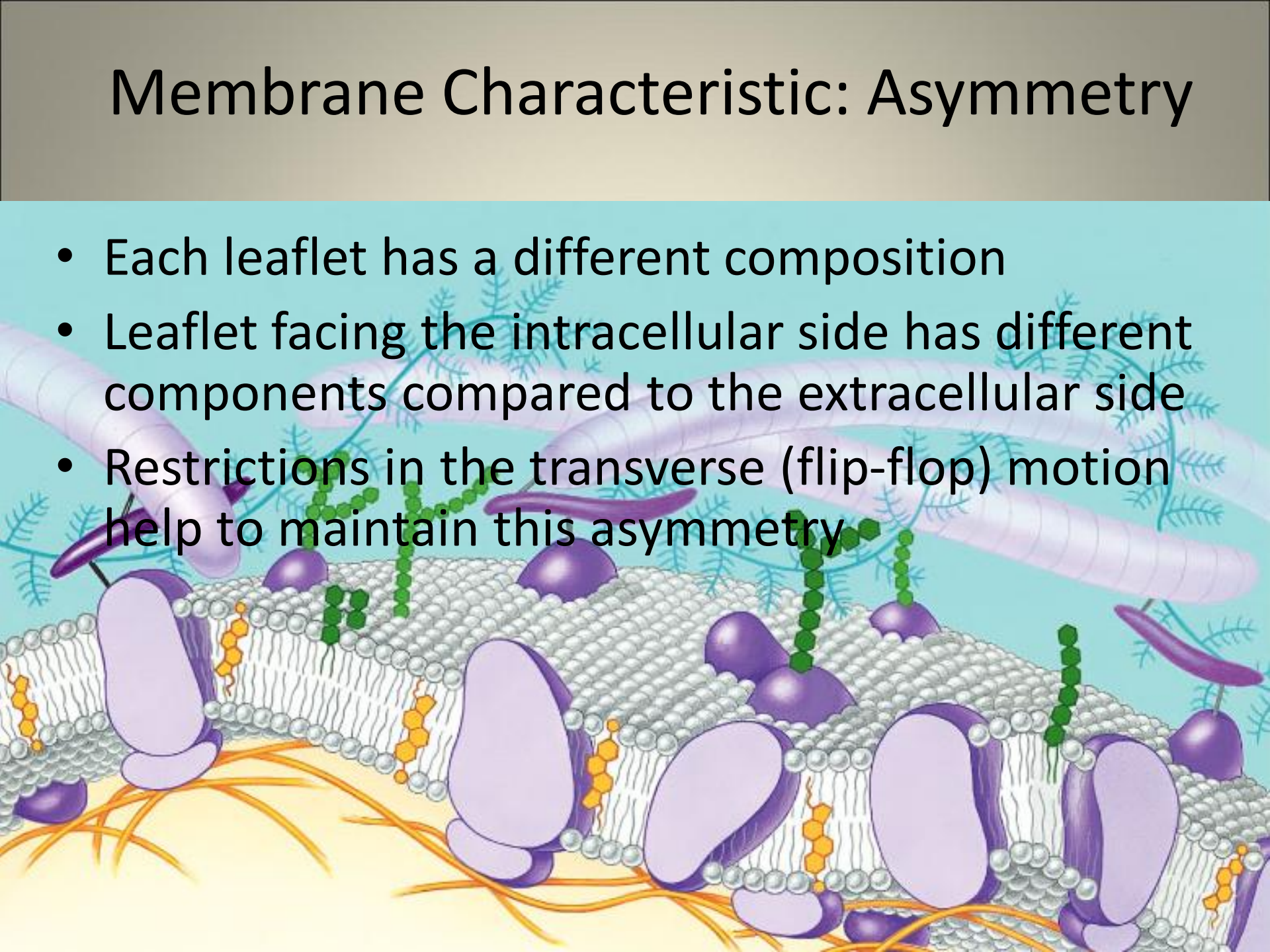
Properties of Cholesterol

- Explain which property of cholesterol plays a more significant role at:
  - Low temperature
  - High temperature
- Why is this advantageous for a cell?



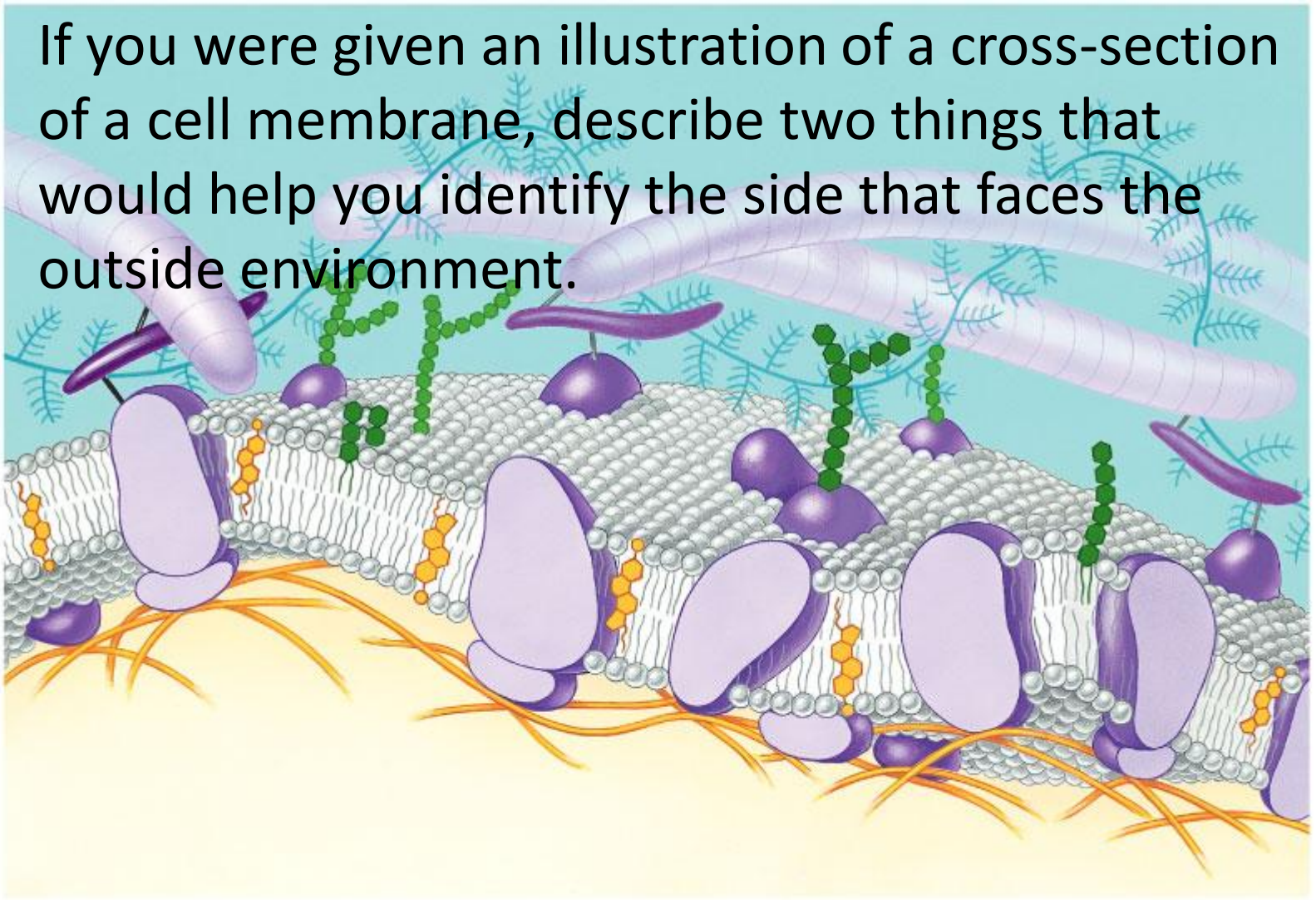
Membrane Characteristic: Asymmetry

- Each leaflet has a different composition
- Leaflet facing the intracellular side has different components compared to the extracellular side
- Restrictions in the transverse (flip-flop) motion help to maintain this asymmetry



Question

If you were given an illustration of a cross-section of a cell membrane, describe two things that would help you identify the side that faces the outside environment.



HW Question Help