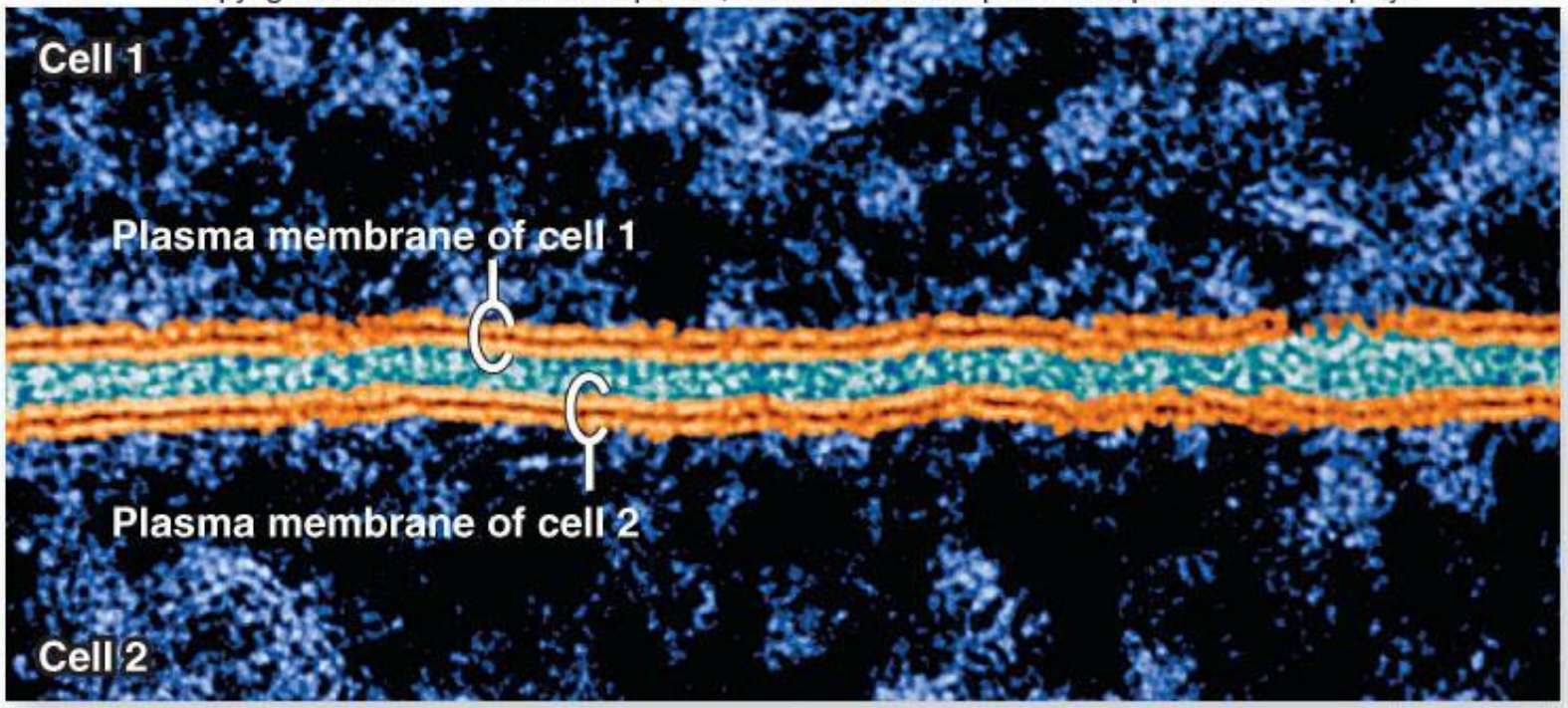
Membranes

Chapter 5

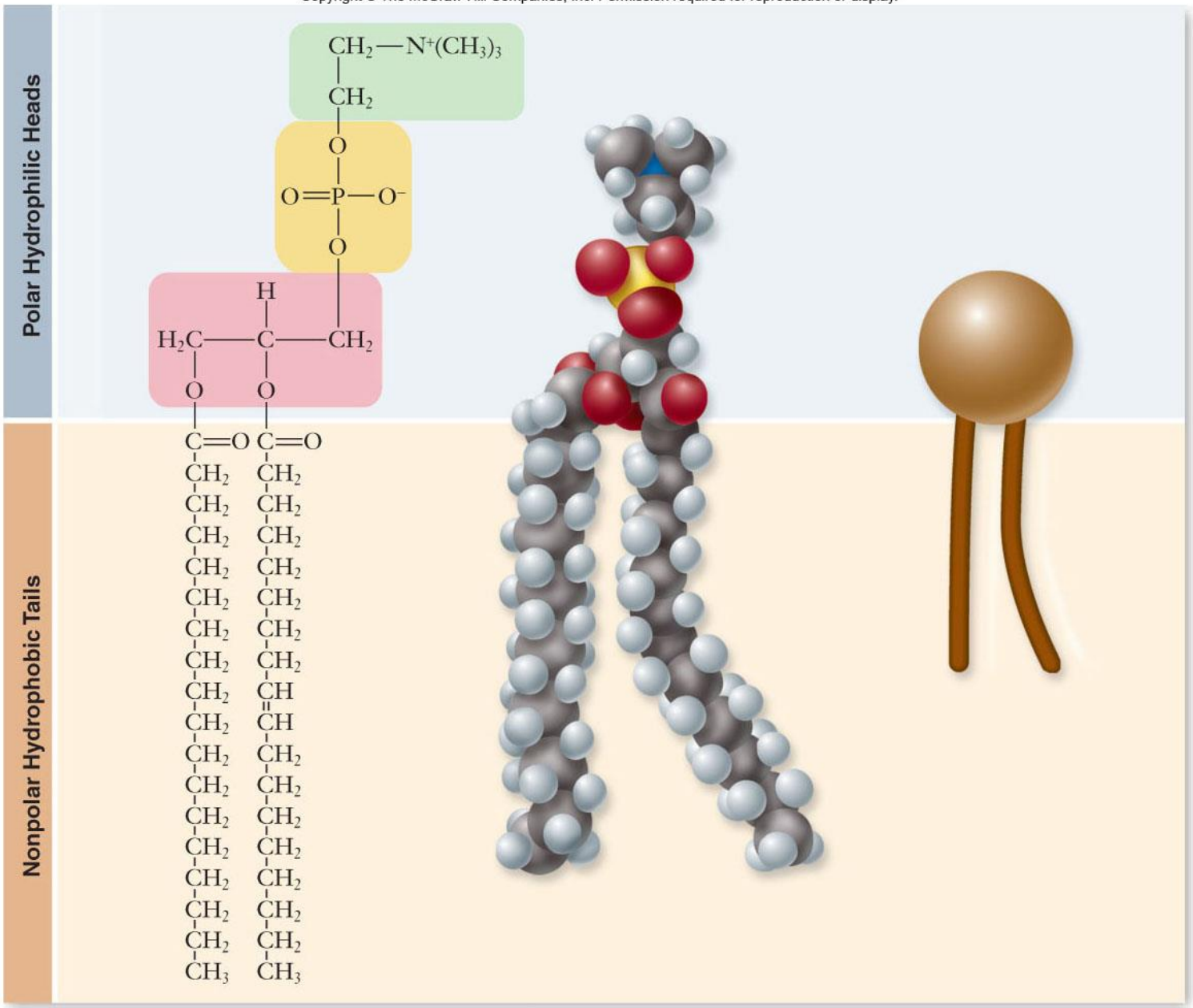


Membrane Structure

The **fluid mosaic model** of membrane structure contends that membranes consist of:

-**phospholipids** arranged in a bilayer

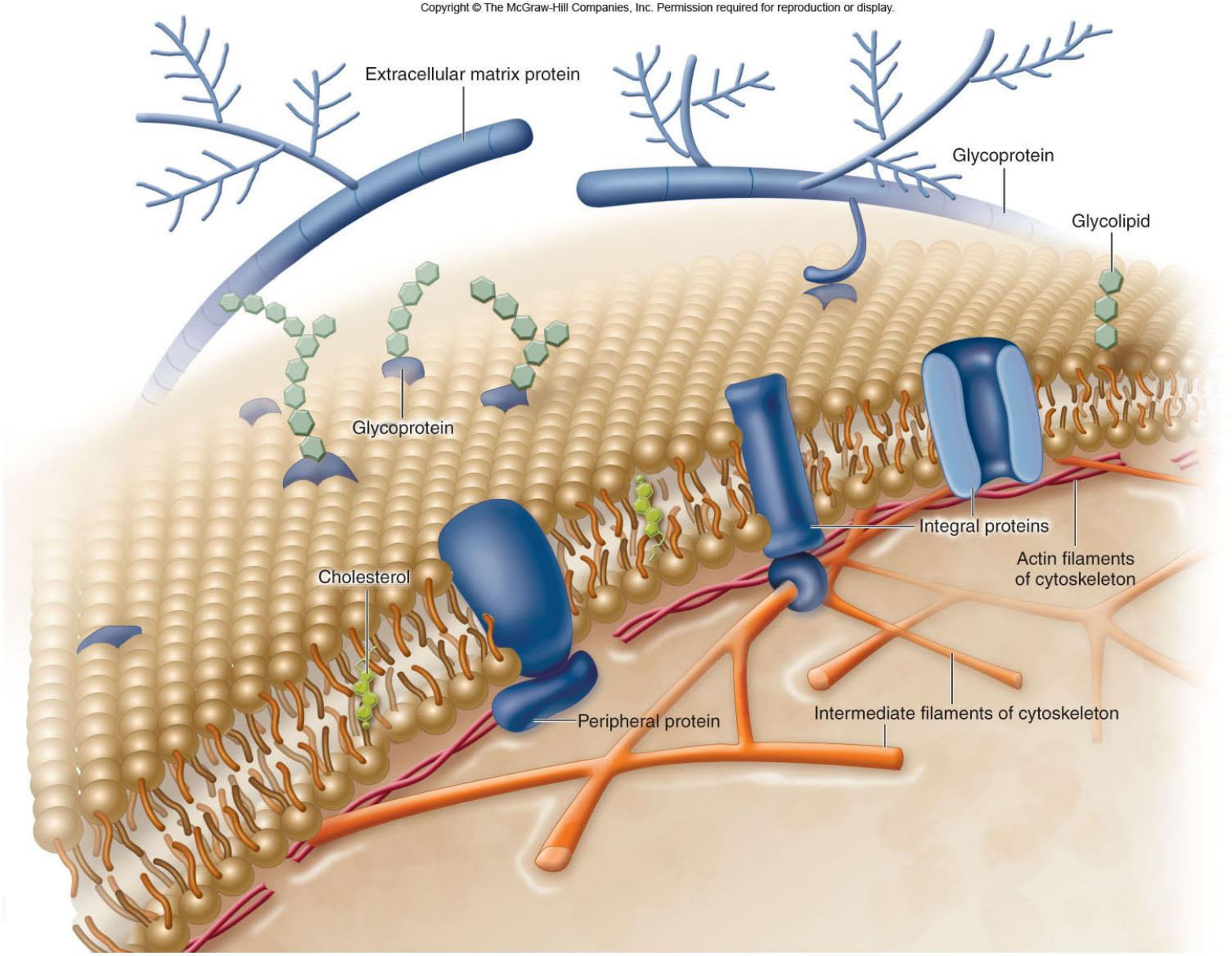
-**globular proteins** inserted in the lipid bilayer



Membrane Structure

Cellular membranes have 4 components:

1. phospholipid bilayer
2. transmembrane proteins
3. interior protein network
4. cell surface markers

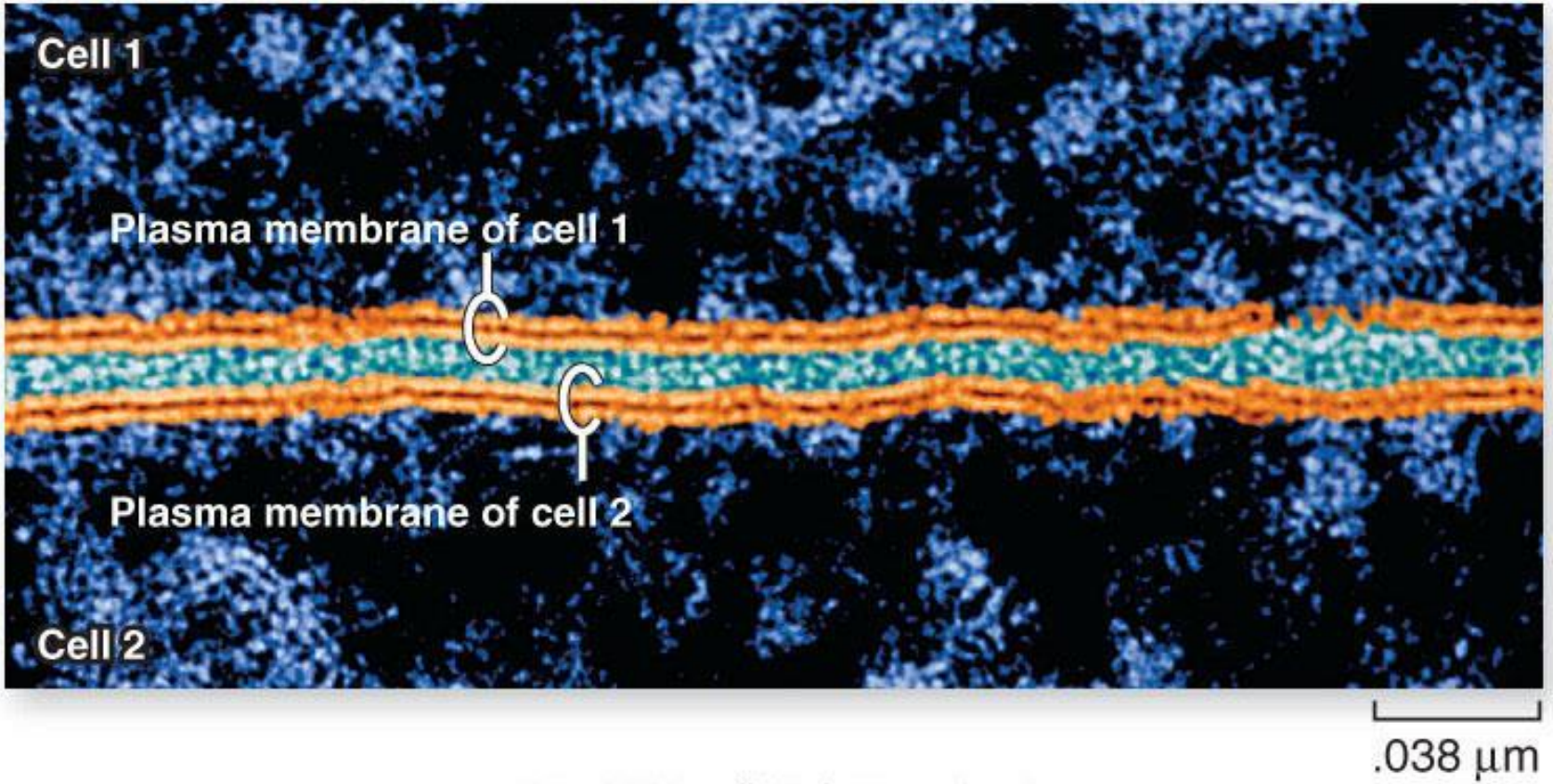


Membrane Structure

Membrane structure is visible using an electron microscope.

Transmission electron microscopes (TEM) can show the 2 layers of a membrane.

Freeze-fracturing techniques separate the layers and reveal membrane proteins.



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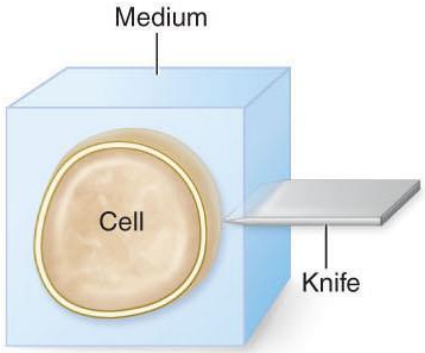
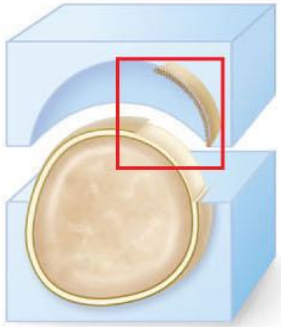
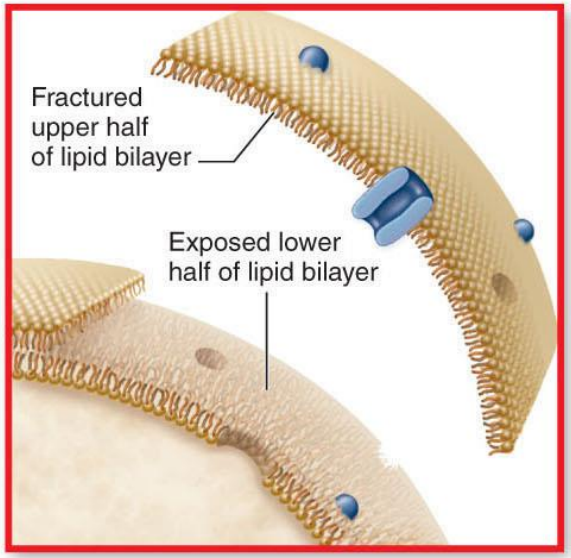
1. A cell frozen in medium is cracked with a knife blade.



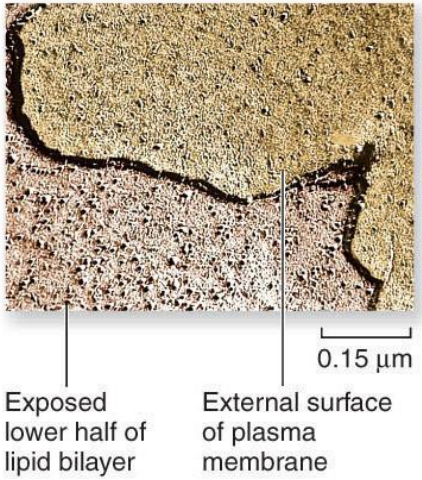
2. The cell often fractures through the interior, hydrophobic area of the lipid bilayer, splitting the plasma membrane into two layers.



3. The plasma membrane separates such that proteins and other embedded membrane structures remain within one or the other layers of the membrane.



4. The exposed membrane is coated with platinum, which forms a replica of the membrane. The underlying membrane is dissolved away, and the replica is then viewed with electron microscopy.



Phospholipids

Phospholipid structure consists of

-**glycerol** – a 3-carbon polyalcohol acting as a backbone for the phospholipid

-2 **fatty acids** attached to the glycerol

-**phosphate group** attached to the glycerol

Phospholipids

The fatty acids are nonpolar chains of carbon and hydrogen.

-Their nonpolar nature makes them **hydrophobic** (“water-fearing”).

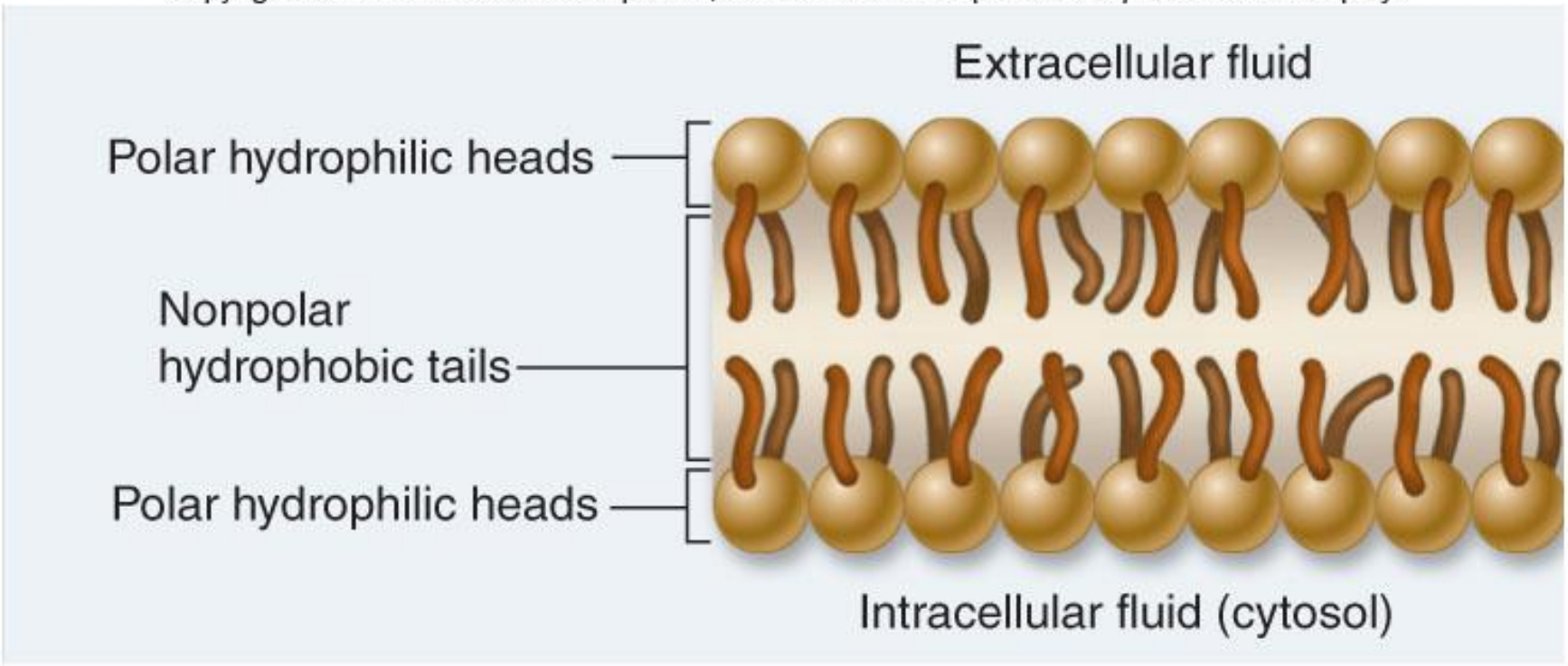
The phosphate group is polar and **hydrophilic** (“water-loving”).

Phospholipids

The partially hydrophilic, partially hydrophobic phospholipid spontaneously forms a bilayer:

-fatty acids are on the inside

-phosphate groups are on both surfaces of the bilayer



Phospholipids

Phospholipid bilayers are fluid.

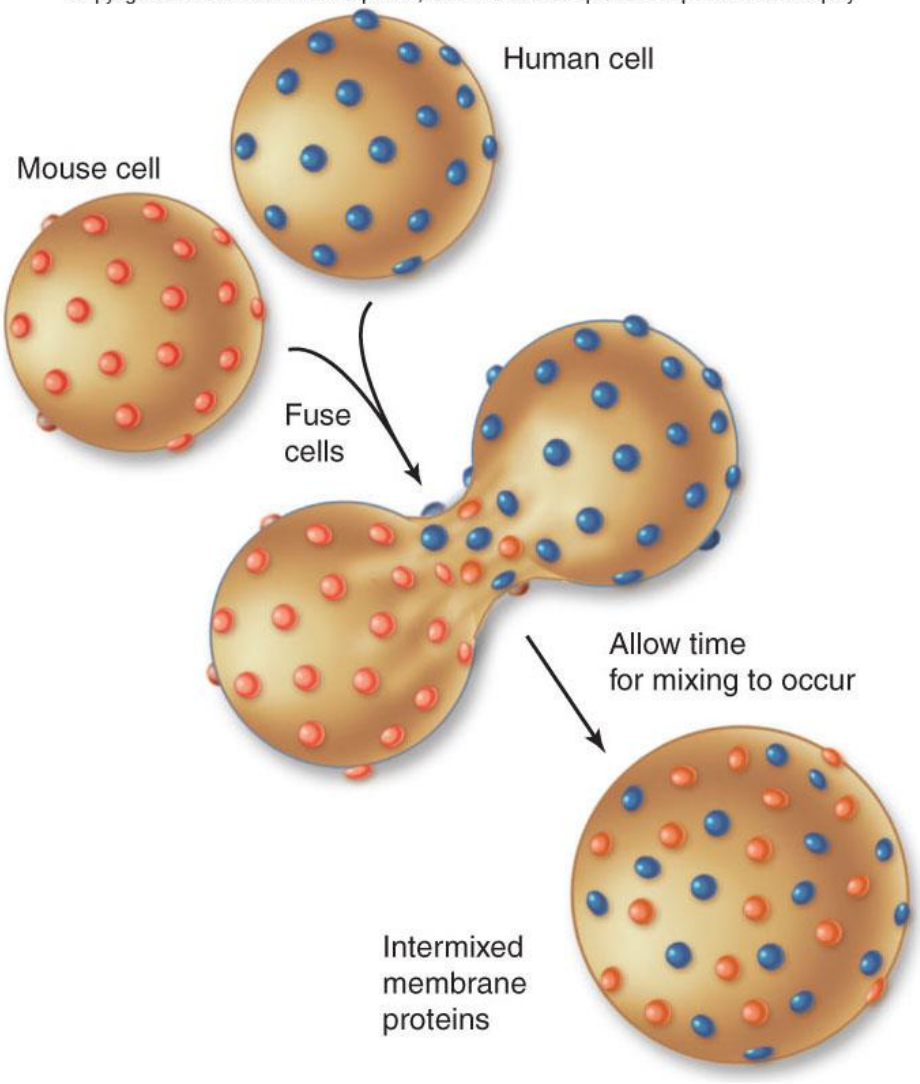
-hydrogen bonding of water holds the 2 layers together

-individual phospholipids and unanchored proteins can move through the membrane

-saturated fatty acids make the membrane less fluid than unsaturated fatty acids

-warm temperatures make the membrane more fluid than cold temperatures

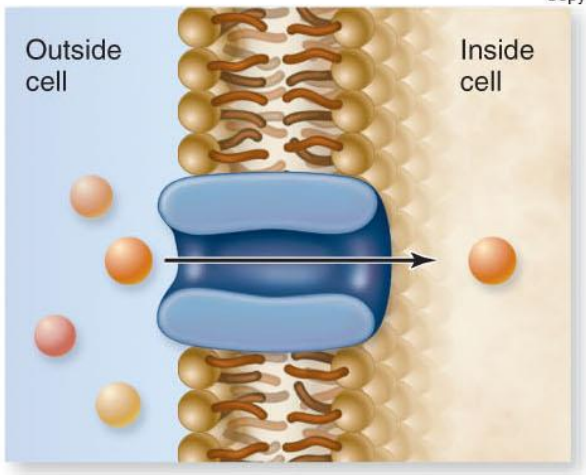
Phospholipids



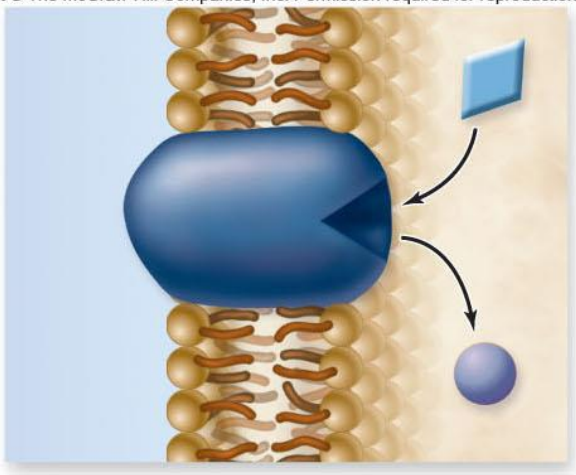
Membrane Proteins

Membrane proteins have various functions:

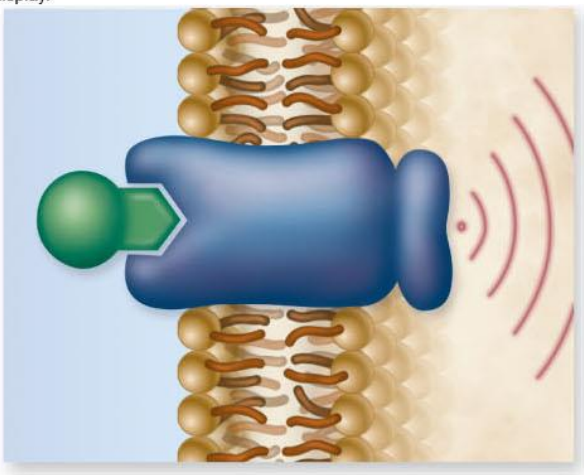
1. transporters
2. enzymes
3. cell surface receptors
4. cell surface identity markers
5. cell-to-cell adhesion proteins
6. attachments to the cytoskeleton



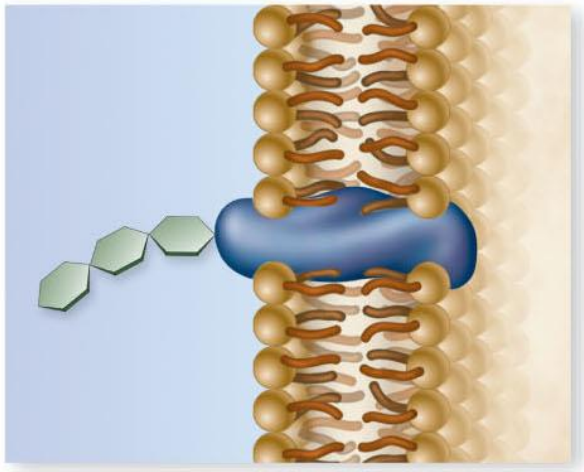
Transporter



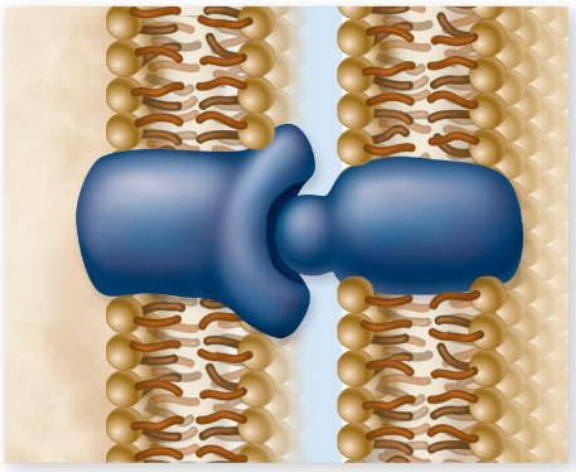
Enzyme



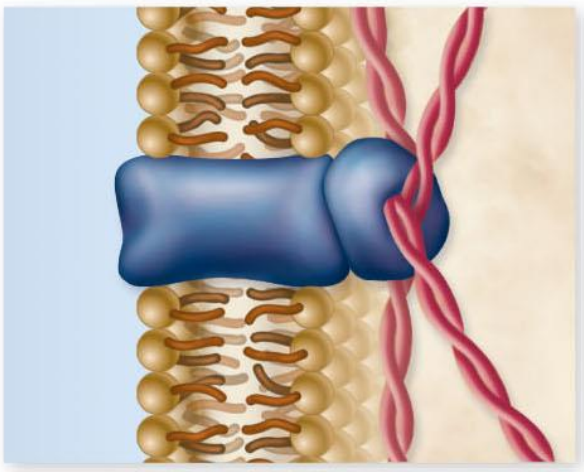
Cell surface receptor



Cell surface identity marker



Cell-to-cell adhesion



Attachment to the cytoskeleton

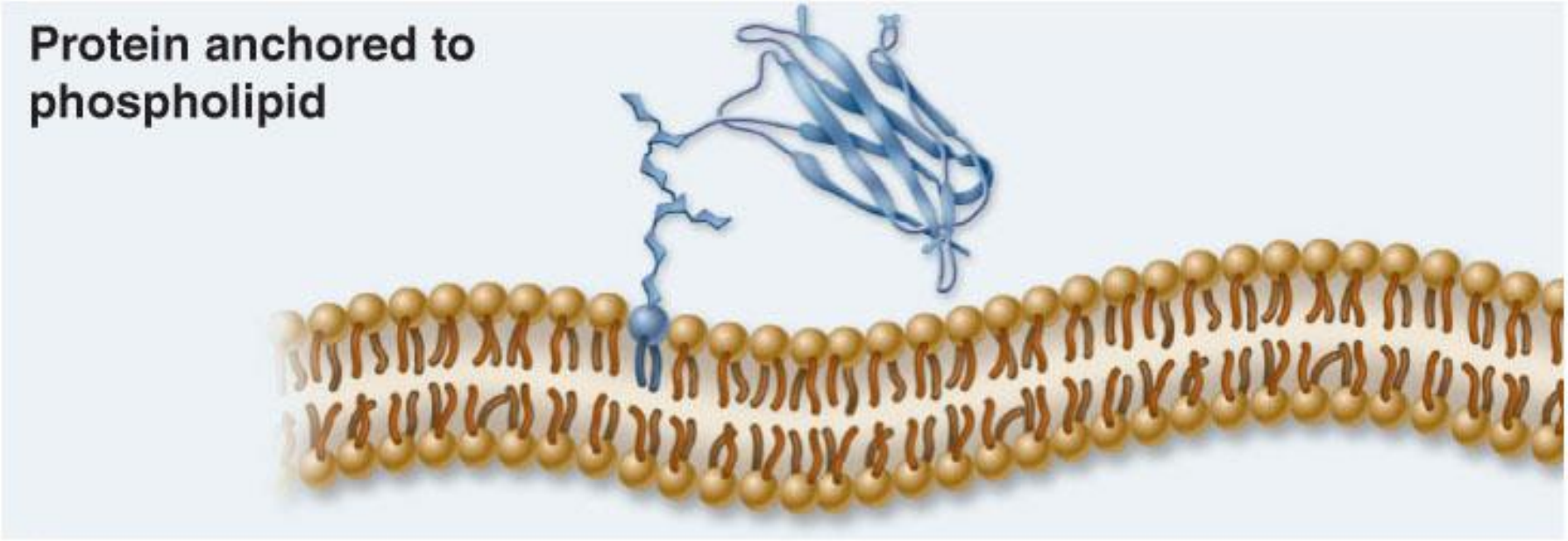
Membrane Proteins

Peripheral membrane proteins

-anchored to a phospholipid in one layer of the membrane

-possess nonpolar regions that are inserted in the lipid bilayer

-are free to move throughout one layer of the bilayer



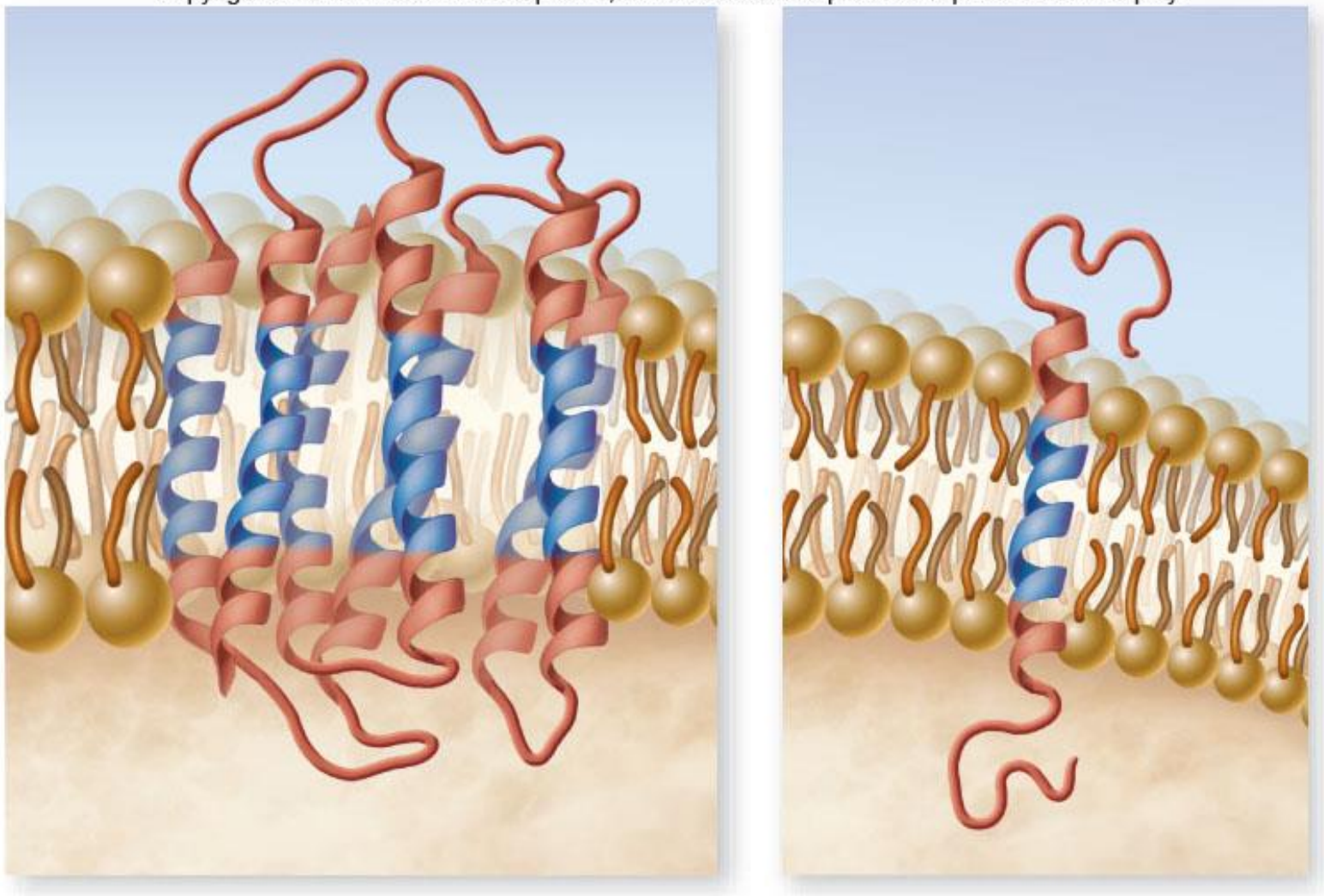
Membrane Proteins

Integral membrane proteins

-span the lipid bilayer (transmembrane proteins)

-nonpolar regions of the protein are embedded in the interior of the bilayer

-polar regions of the protein protrude from both sides of the bilayer



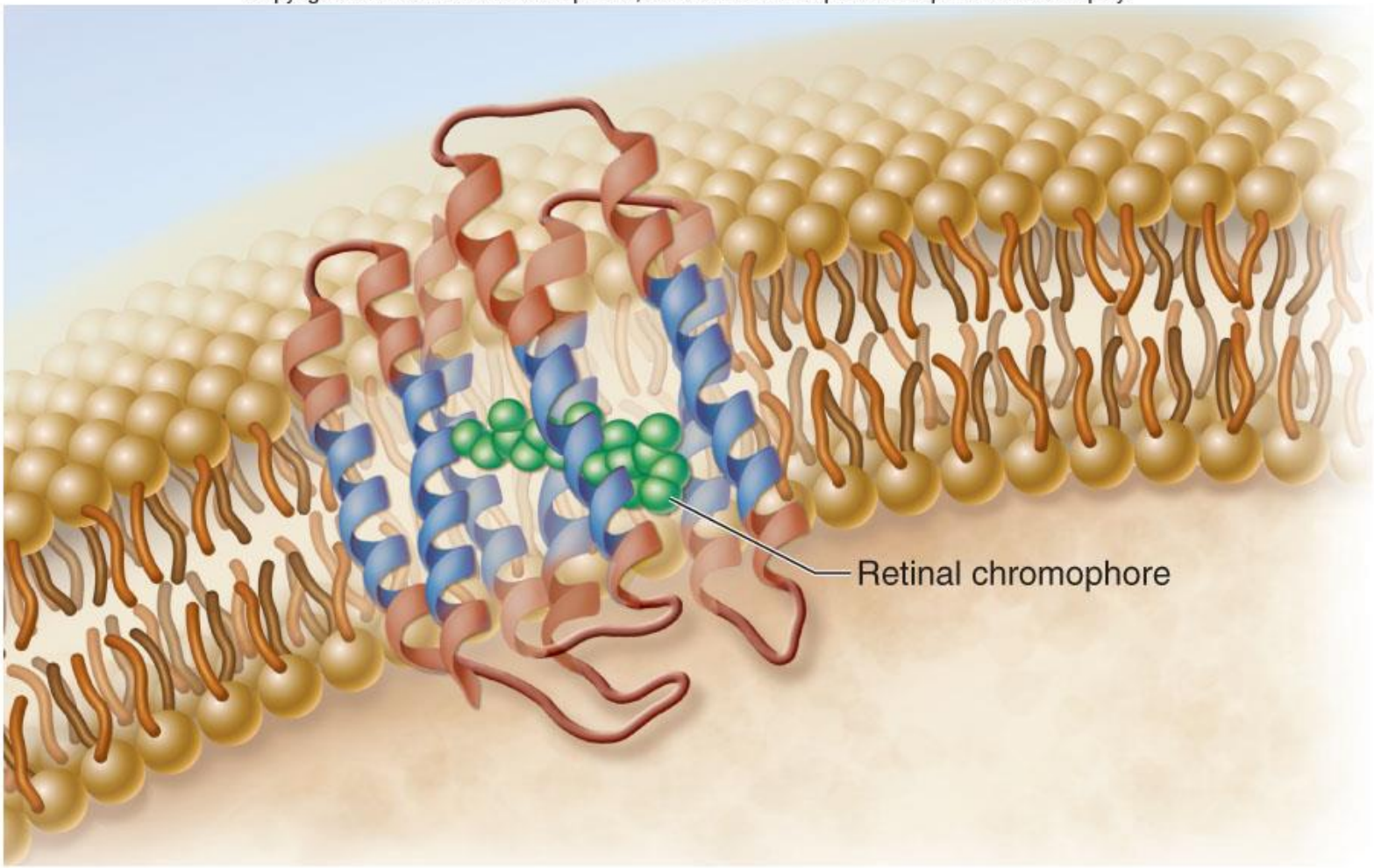
a. *b.*

Membrane Proteins

Integral proteins possess at least one **transmembrane domain**

-region of the protein containing hydrophobic amino acids

-spans the lipid bilayer

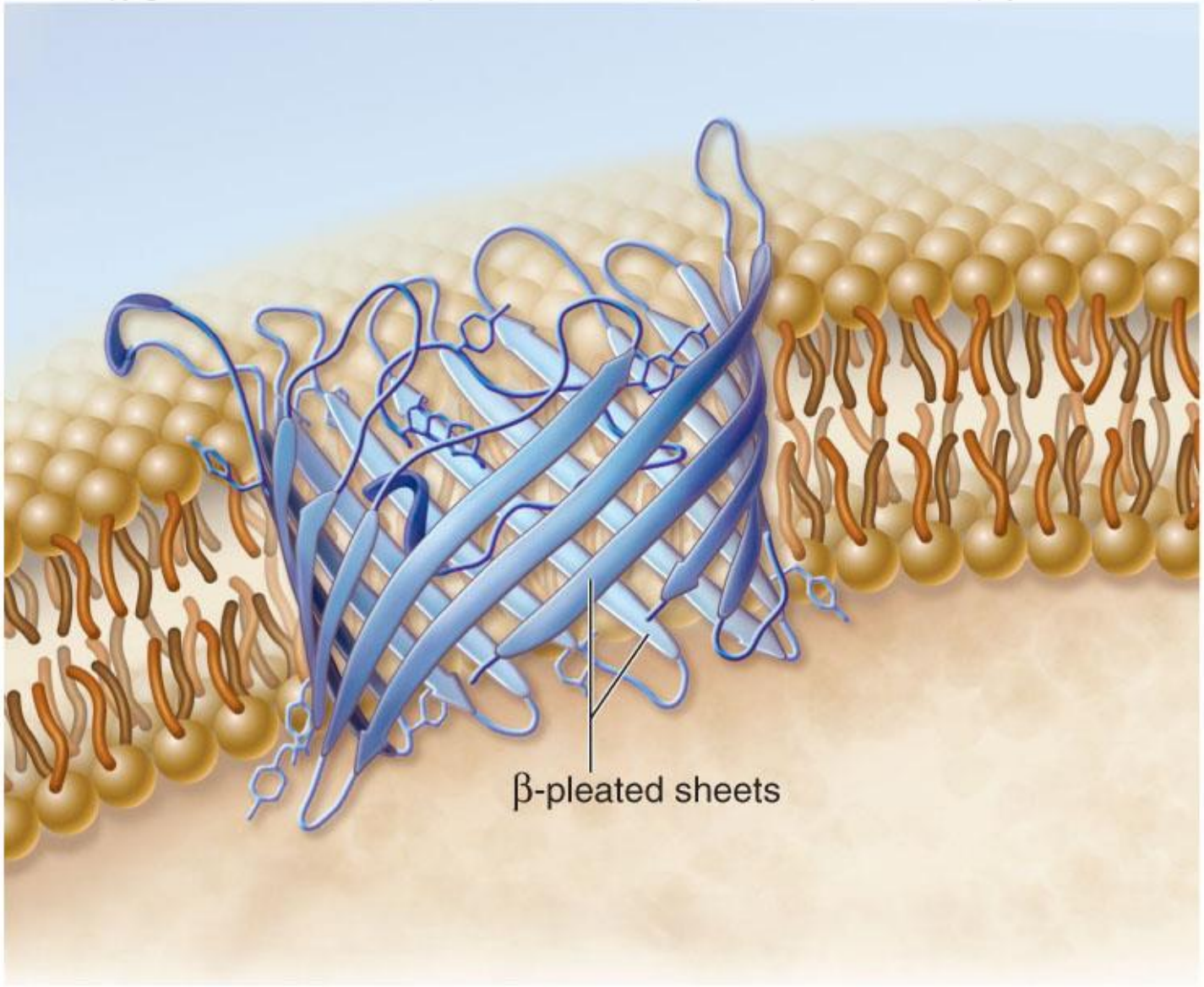


Membrane Proteins

Extensive nonpolar regions within a transmembrane protein can create a pore through the membrane.

-β sheets in the protein secondary structure form a cylinder called a **β-barrel**

-β-barrel interior is polar and allows water and small polar molecules to pass through the membrane



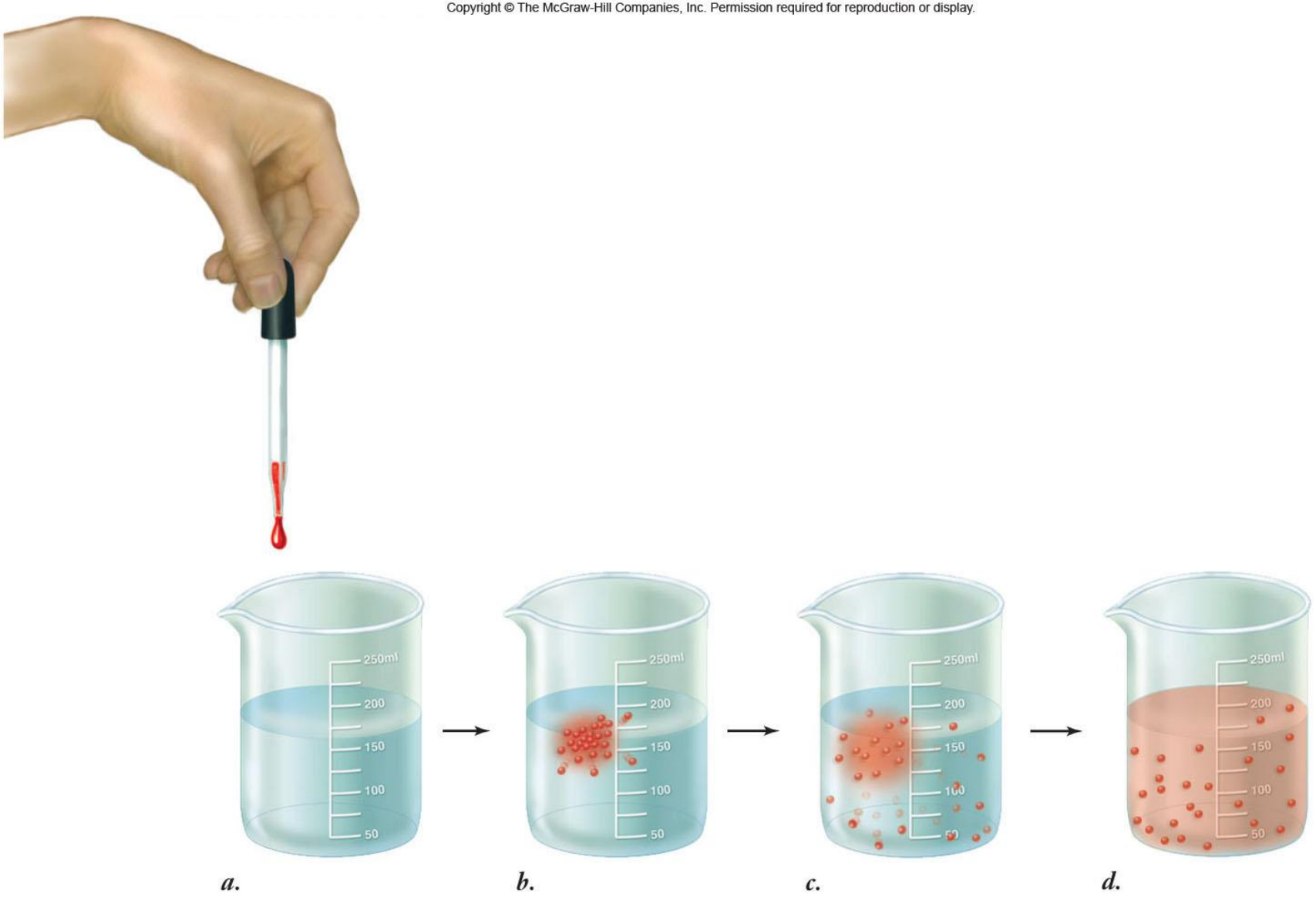
Passive Transport

Passive transport is movement of molecules through the membrane in which

-no energy is required

-molecules move in response to a **concentration gradient**

Diffusion is movement of molecules from high concentration to low concentration



Passive Transport

Selective permeability: integral membrane proteins allow the cell to be selective about what passes through the membrane.

Channel proteins have a polar interior allowing polar molecules to pass through.

Carrier proteins bind to a specific molecule to facilitate its passage.

Passive Transport

Channel proteins include:

-**ion channels** allow the passage of ions (charged atoms or molecules) which are associated with water

-**gated channels** are opened or closed in response to a stimulus

-the stimulus may be chemical or electrical

Passive Transport

Carrier proteins bind to the molecule that they transport across the membrane.

Facilitated diffusion is movement of a molecule from high to low concentration with the help of a carrier protein.

-is specific

-is passive

-saturates when all carriers are occupied

Passive Transport

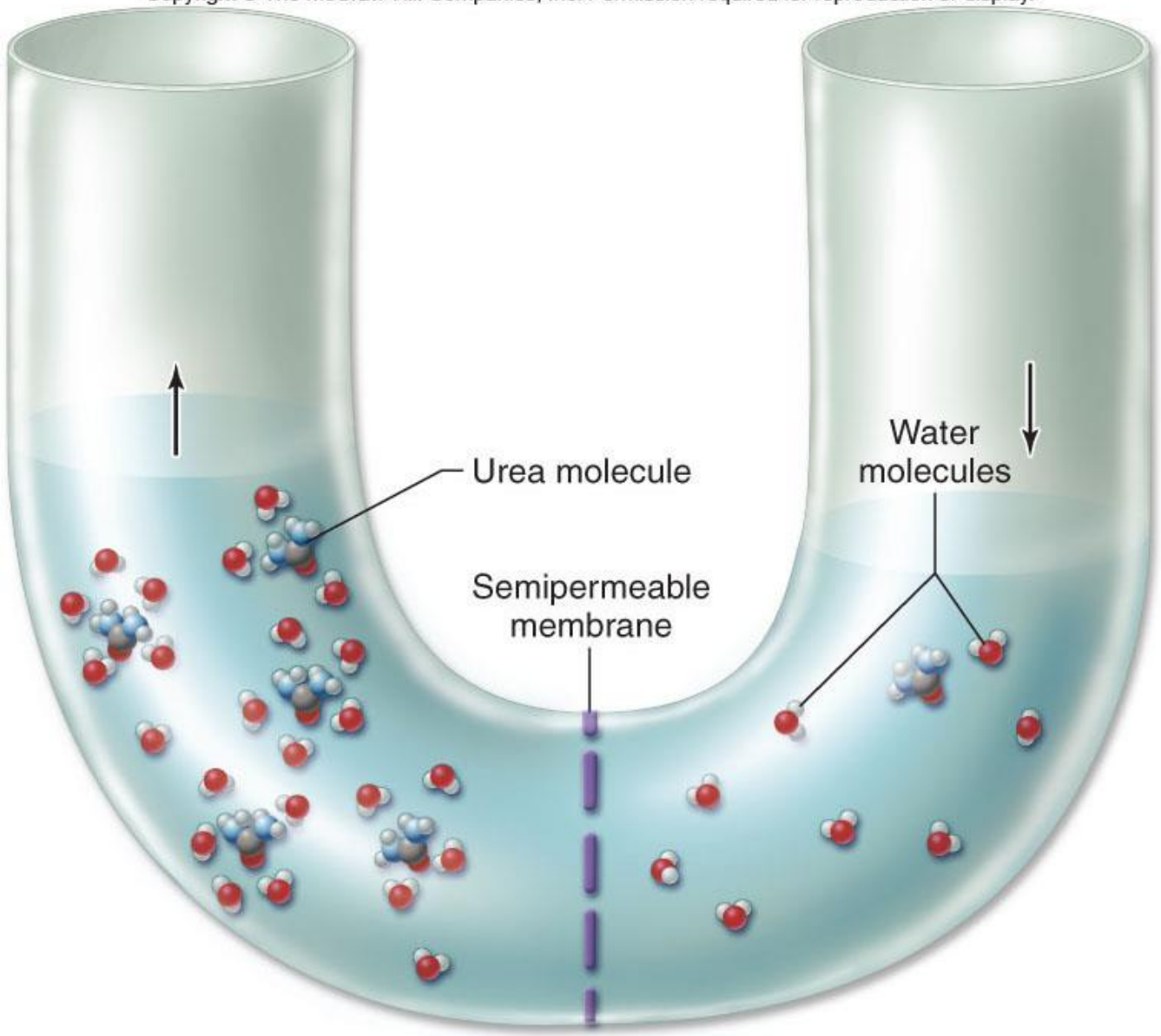
In an aqueous solution

-water is the **solvent**

-dissolved substances are the **solutes**

Osmosis is the movement of *water* from an area of high to low concentration of *water*

-movement of water toward an area of high *solute* concentration



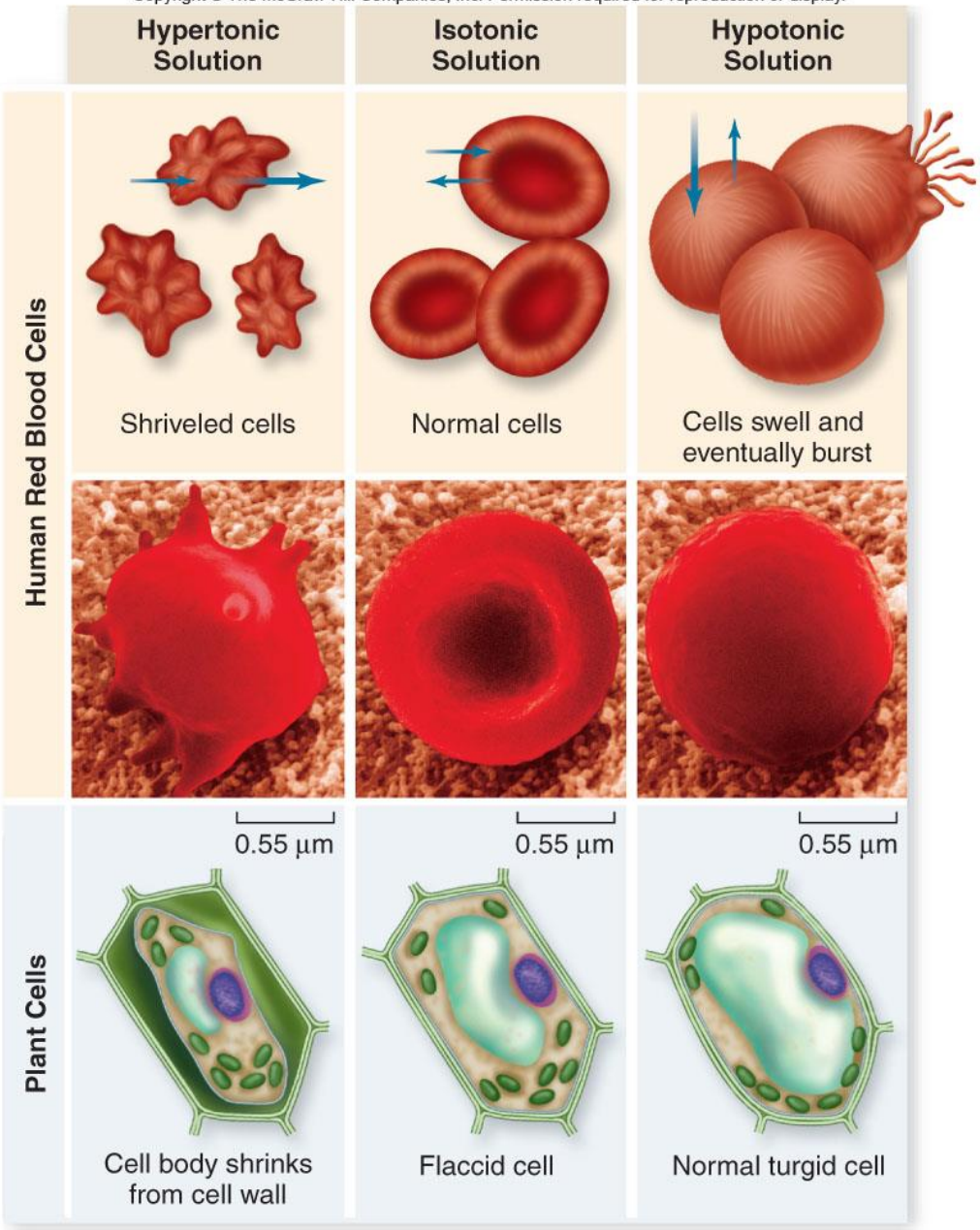
Passive Transport

When 2 solutions have different osmotic concentrations

-the **hypertonic solution** has a higher solute concentration

-the **hypotonic solution** has a lower solute concentration

Osmosis moves water through **aquaporins** toward the hypertonic solution.



Passive Transport

Organisms can maintain osmotic balance in different ways.

1. Some cells use **extrusion** in which water is ejected through contractile vacuoles.

2. **Isosmotic regulation** involves keeping cells isotonic with their environment.

3. Plant cells use **turgor pressure** to push the cell membrane against the cell wall and keep the cell rigid.

Active Transport

Active transport

-requires energy – ATP is used directly or indirectly to fuel active transport

-moves substances from low to high concentration

-requires the use of carrier proteins

Active Transport

Carrier proteins used in active transport include:

-**uniporters** – move one molecule at a time

-**symporters** – move two molecules in the same direction

-**antiporters** – move two molecules in opposite directions

Active Transport

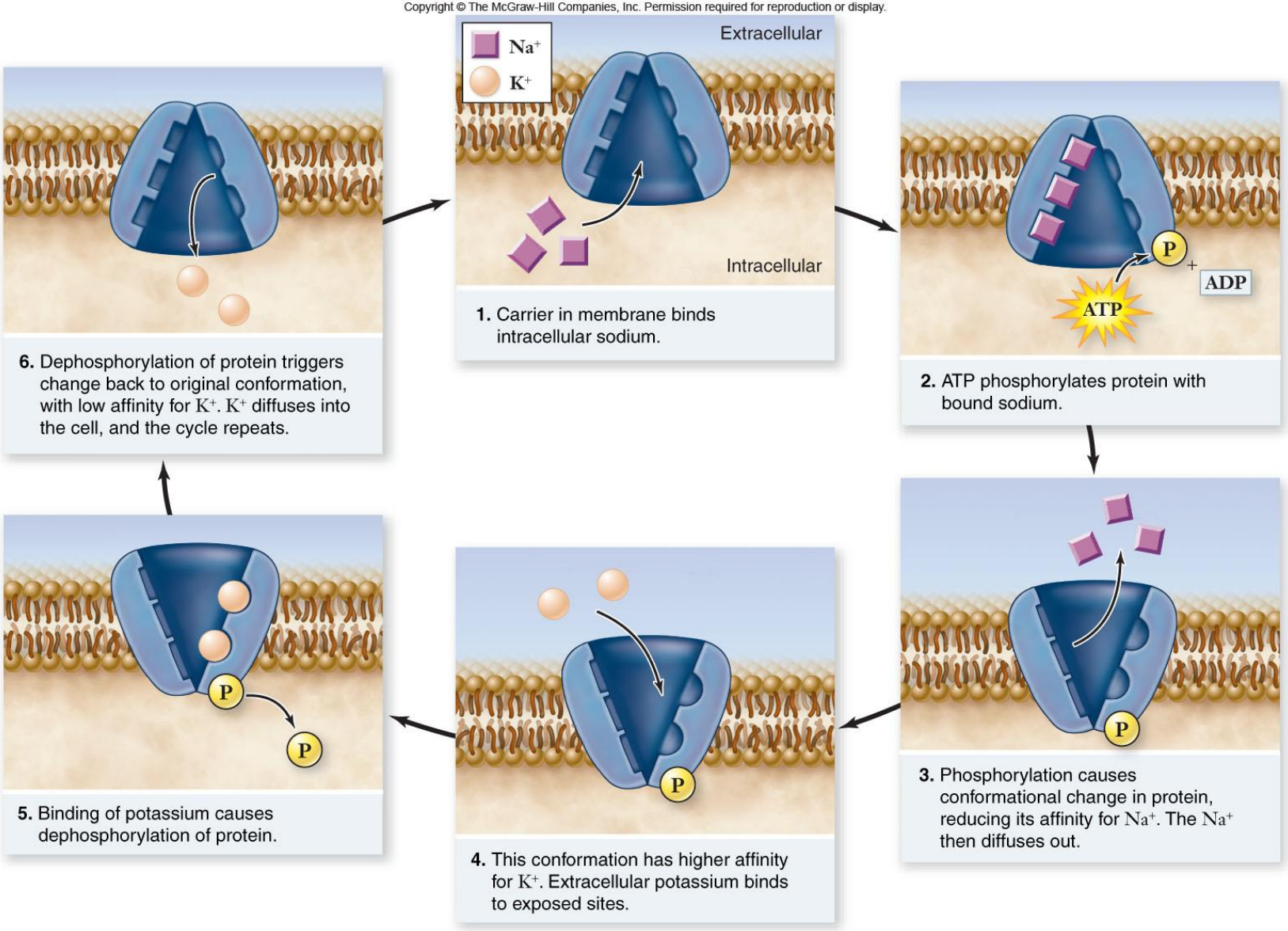
Sodium-potassium (Na^+-K^+) pump

-an active transport mechanism

-uses an antiporter to move 3 Na^+ out of the cell and 2 K^+ into the cell

-ATP energy is used to change the conformation of the carrier protein

-the affinity of the carrier protein for either Na^+ or K^+ changes so the ions can be carried across the membrane



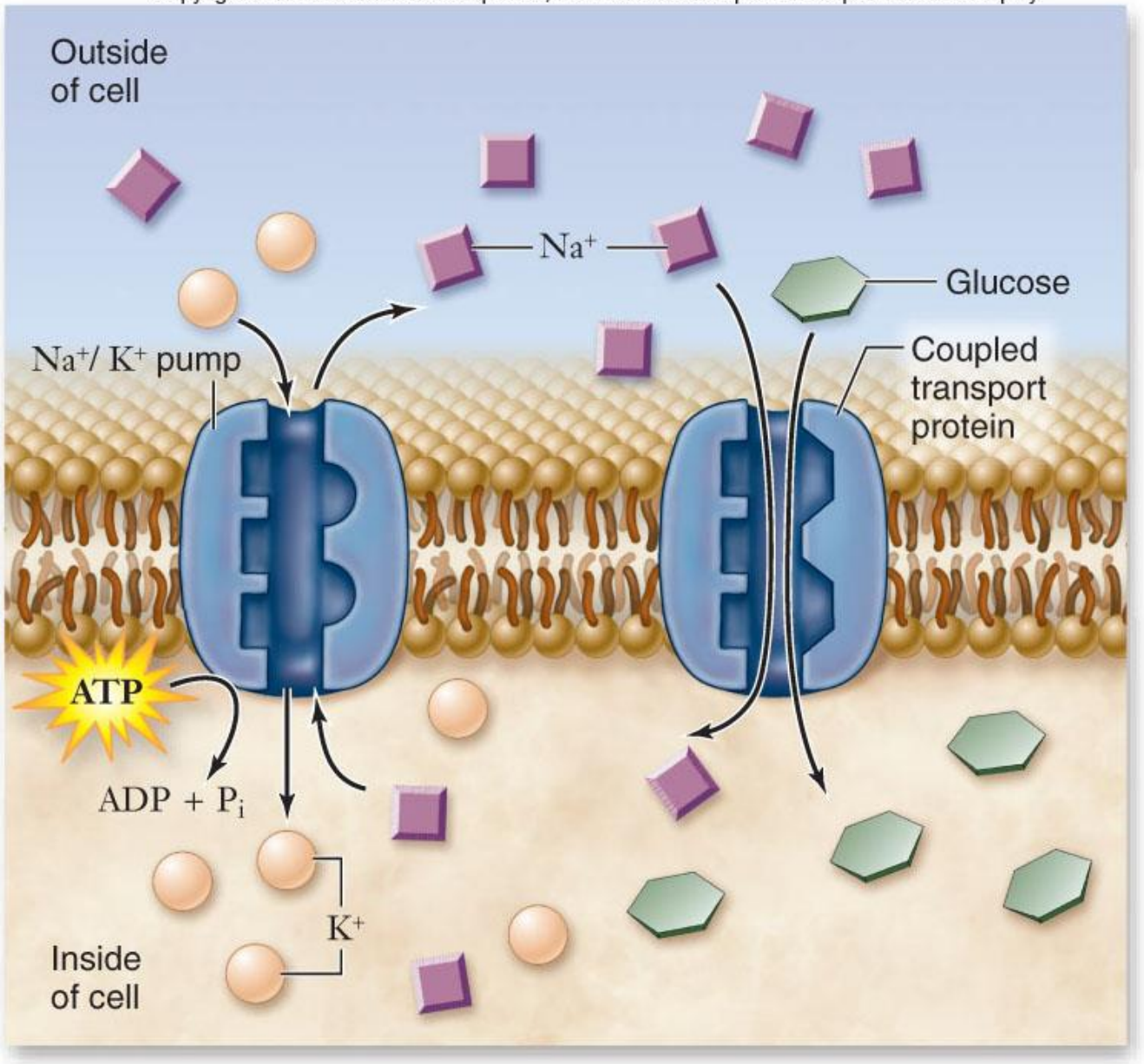
Active Transport

Coupled transport

-uses the energy released when a molecule moves by diffusion to supply energy to active transport of a different molecule

-a symporter is used

-glucose-Na^+ symporter captures the energy from Na^+ diffusion to move glucose against a concentration gradient



Bulk Transport

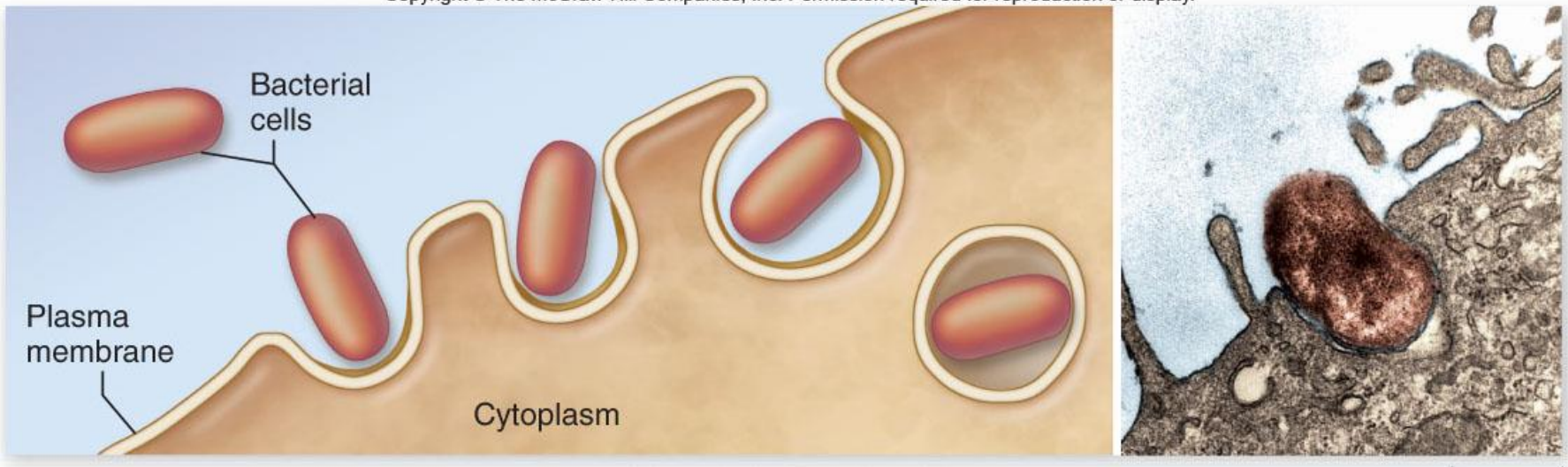
Bulk transport of substances is accomplished by

1. **endocytosis** – movement of substances into the cell
2. **exocytosis** – movement of materials out of the cell

Bulk Transport

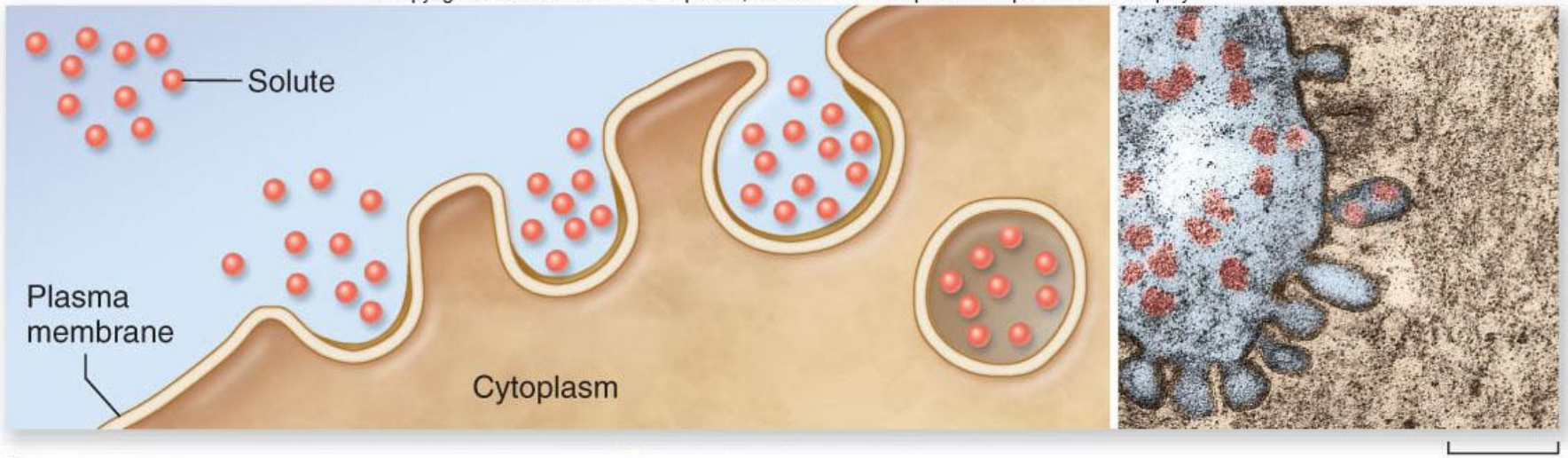
Endocytosis occurs when the plasma membrane envelops food particles and liquids.

1. **phagocytosis** – the cell takes in particulate matter
2. **pinocytosis** – the cell takes in only fluid
3. **receptor-mediated endocytosis** – specific molecules are taken in after they bind to a receptor

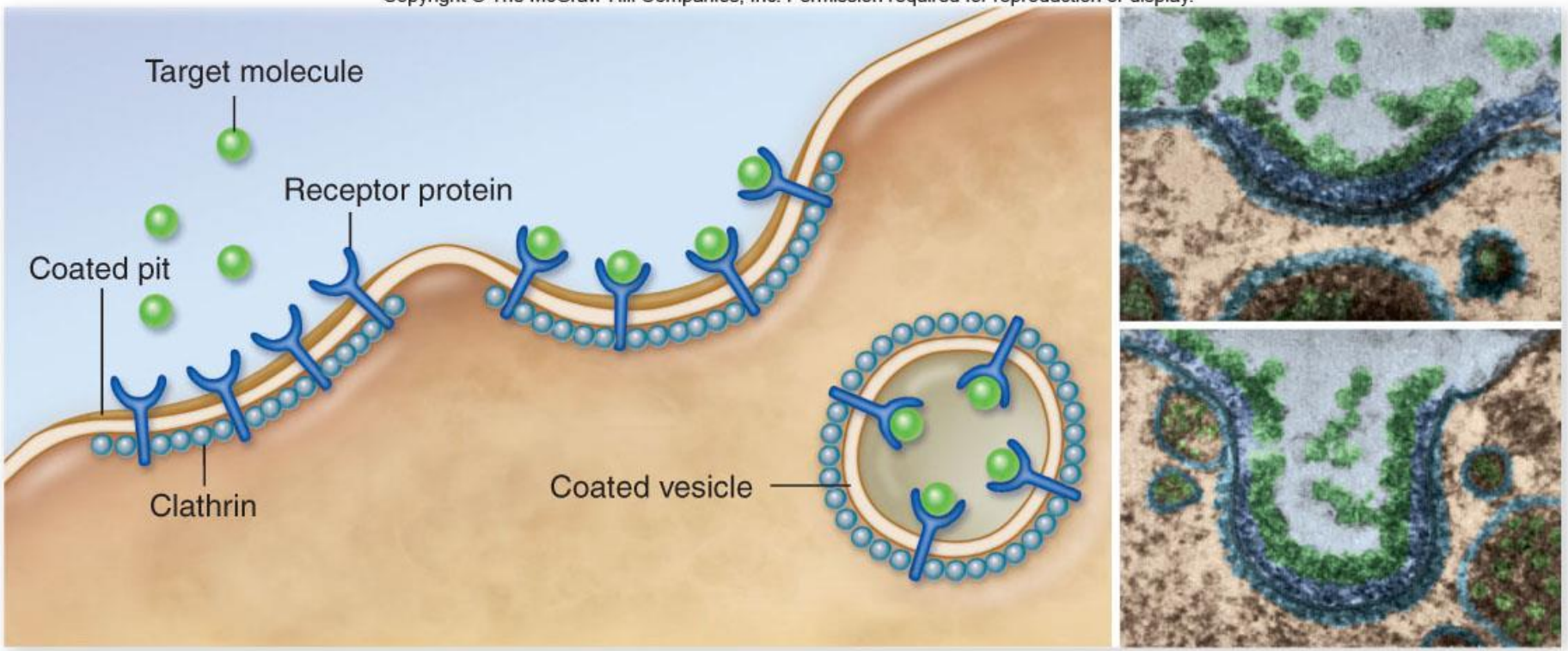


a. Phagocytosis

Micrograph Courtesy of the CDC/Dr. Edwin P. Ewing, Jr



b. Pinocytosis



c. Receptor-mediated endocytosis

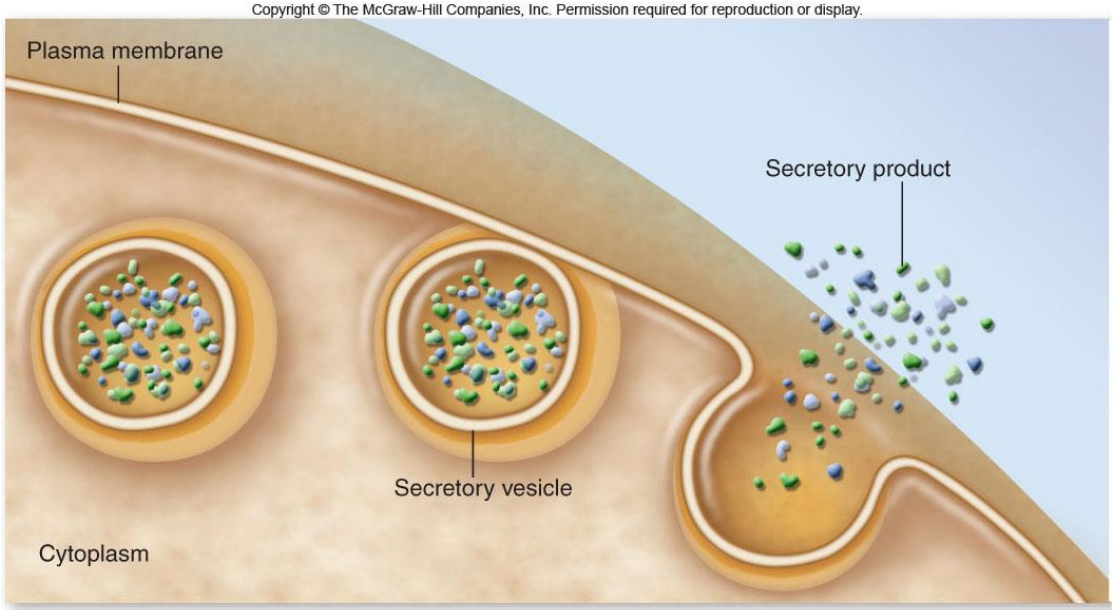
Bulk Transport

Exocytosis occurs when material is discharged from the cell.

-vesicles in the cytoplasm fuse with the cell membrane and release their contents to the exterior of the cell

-used in plants to export cell wall material

-used in animals to secrete hormones, neurotransmitters, digestive enzymes



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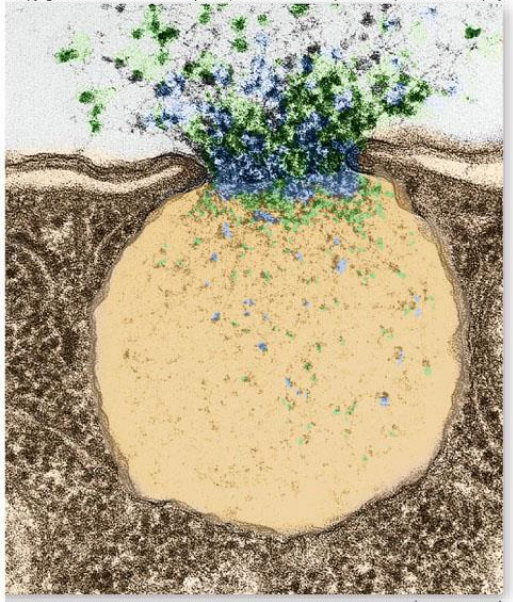

b.

Dr. Brigit Satir