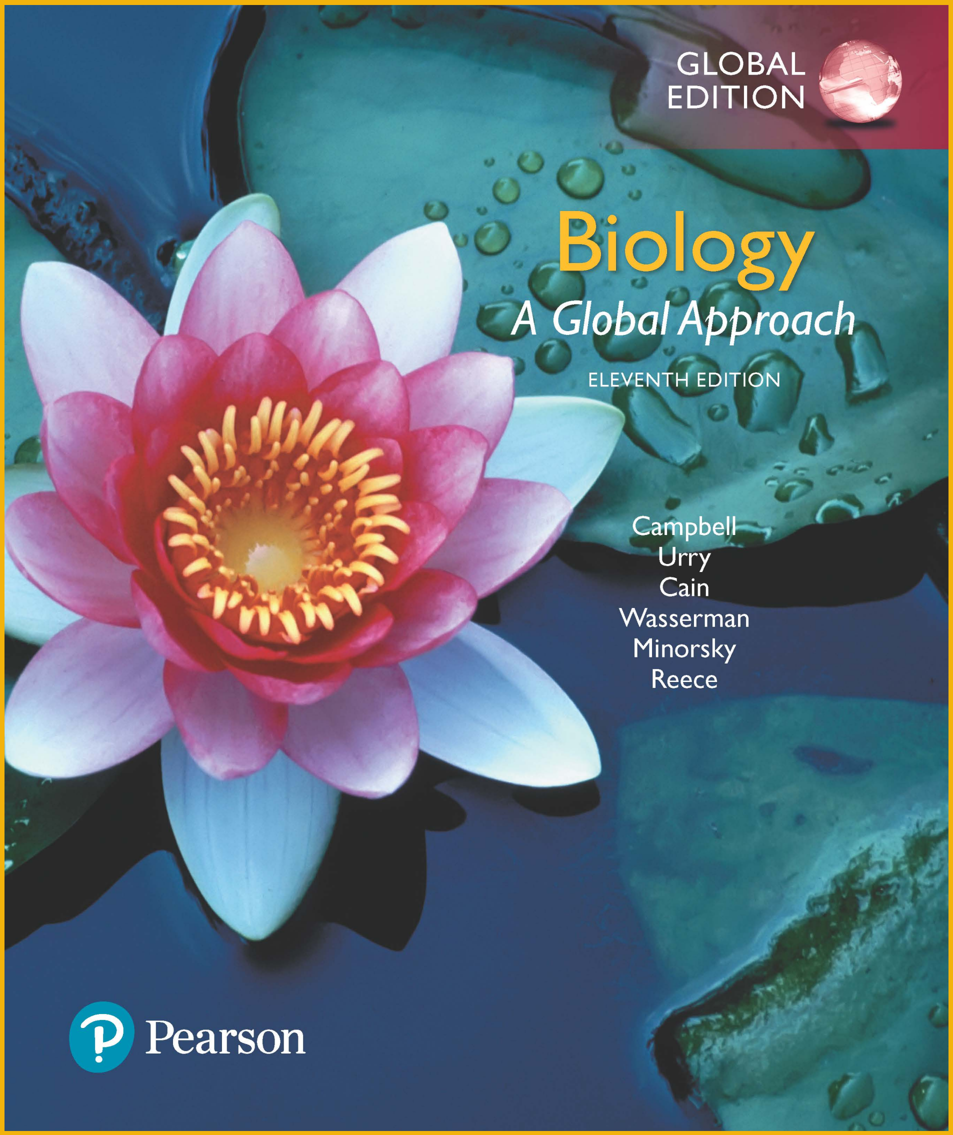



# Chapter 8

# Cell Membranes

Lecture Presentations by
Nicole Tunbridge and
Kathleen Fitzpatrick

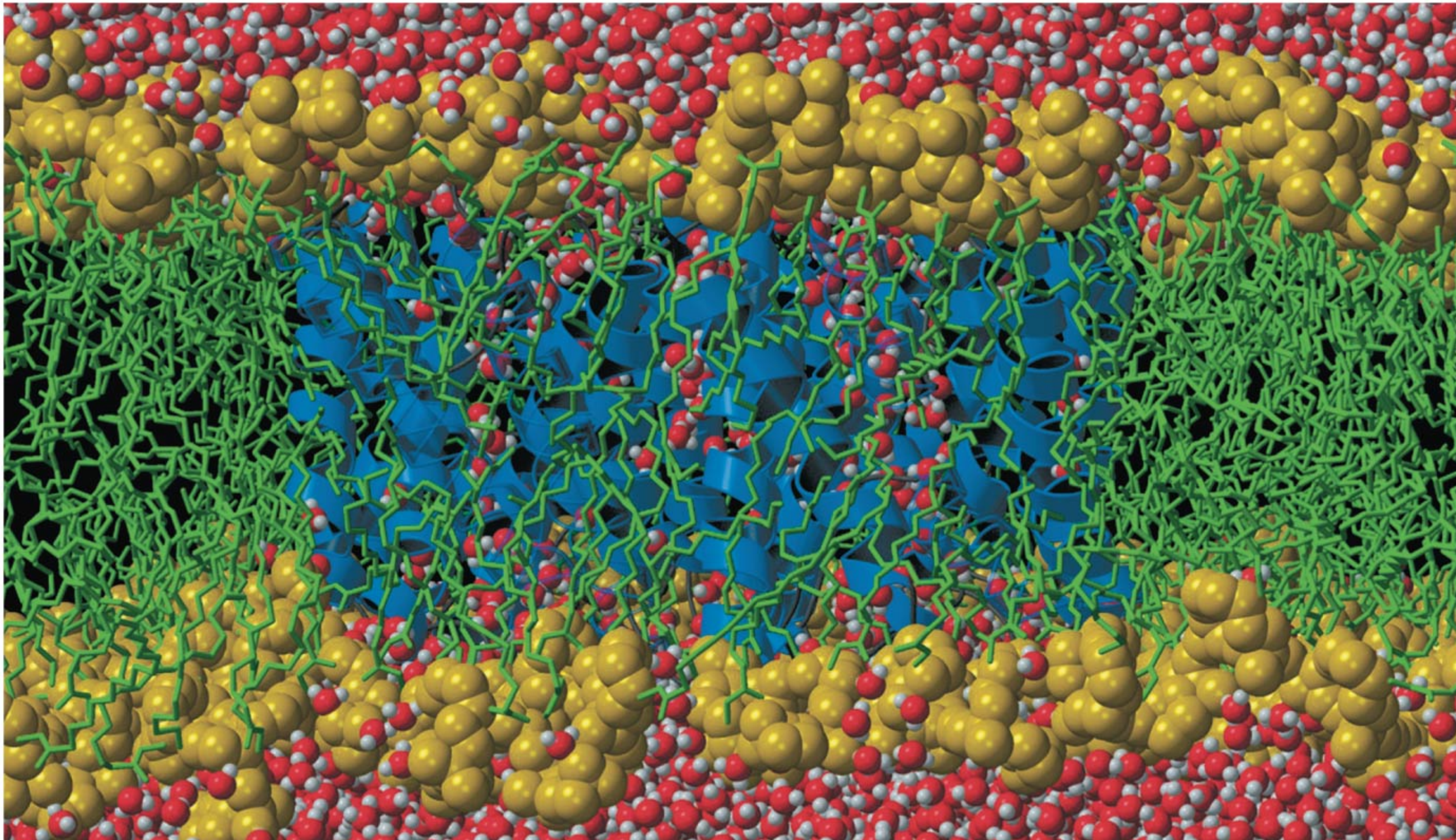
© 2018 Pearson Education Ltd.

# ife at the Edge

- The plasma membrane is the boundary that separates the living cell from its surroundings
- The plasma membrane exhibits **selective permeability**, allowing some substances to cross it more easily than others
- Transport proteins are often responsible for controlling passage across cellular membranes

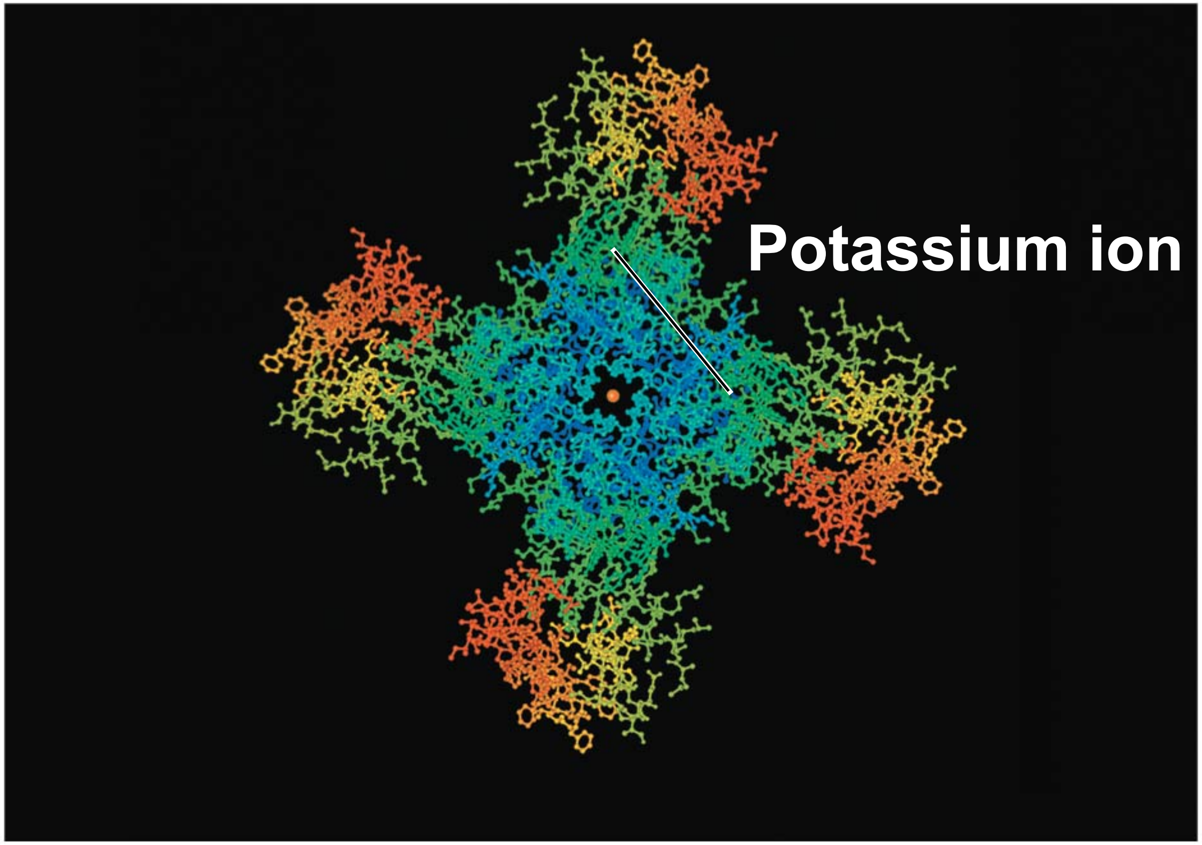
© 2018 Pearson Education Ltd.

Figure 8.1



© 2018 Pearson Education Ltd.

Figure 8.1a




Potassium ion channel protein

© 2018 Pearson Education Ltd.

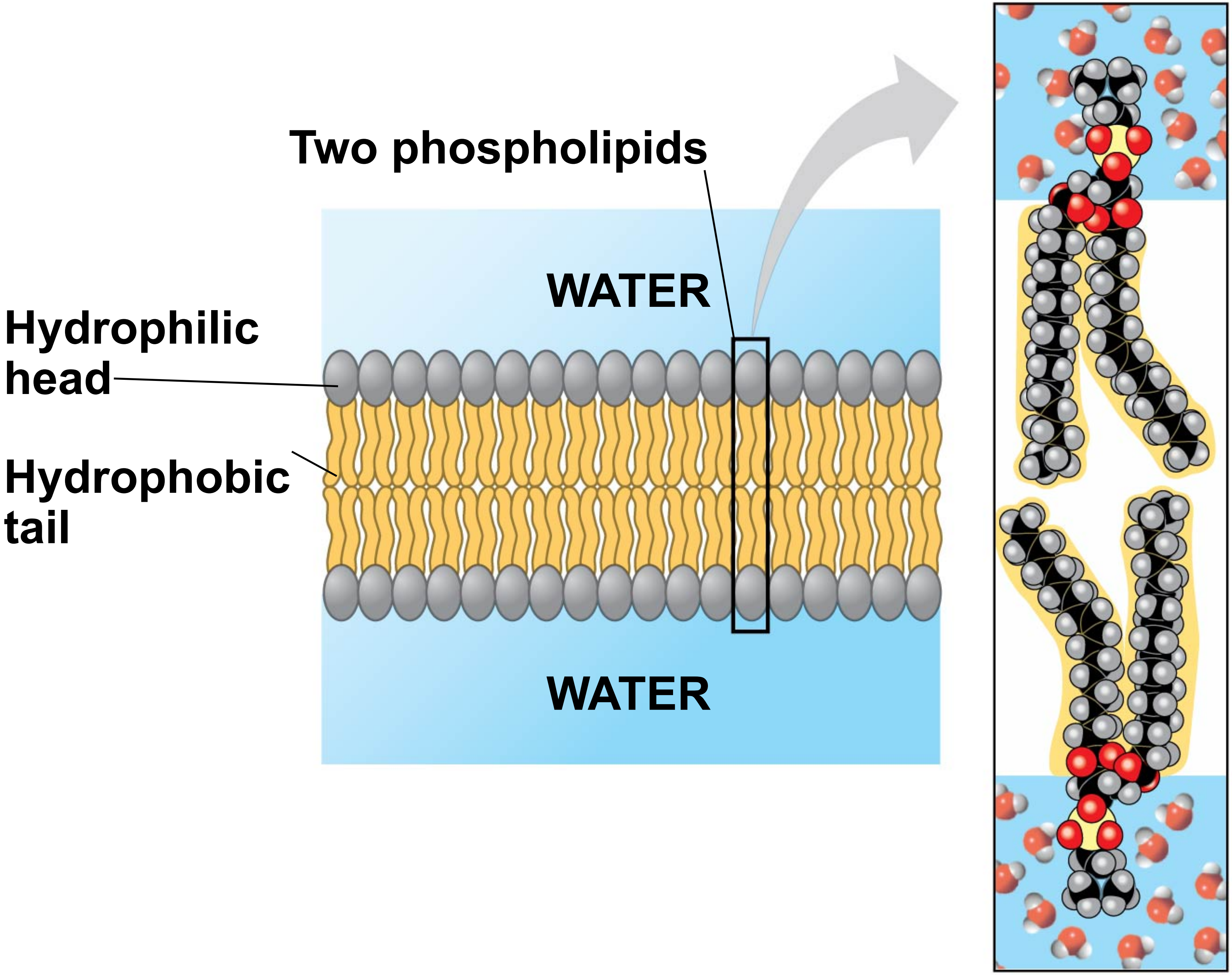
# oncept 8.1: Cellular membranes are fluid mosaics of lipids and proteins

- Phospholipids are the most abundant lipid in the plasma membrane
- Phospholipids are **amphipathic** (*) molecules, containing hydrophobic ("water-fearing") and hydrophilic ("water-loving") regions
- The hydrophobic tails of the phospholipids are sheltered inside the membrane, while the hydrophilic heads are exposed to water on either side

(*) Some proteins are amphipathic as well — having polar parts to the outer sides are hydrophobic parts to the interior.

© 2018 Pearson Education Ltd.

Figure 8.2




© 2018 Pearson Education Ltd.

- In the **fluid mosaic model**, the membrane is a mosaic of protein molecules bobbing in a fluid bilayer of phospholipids
- Proteins are not randomly distributed in the membrane

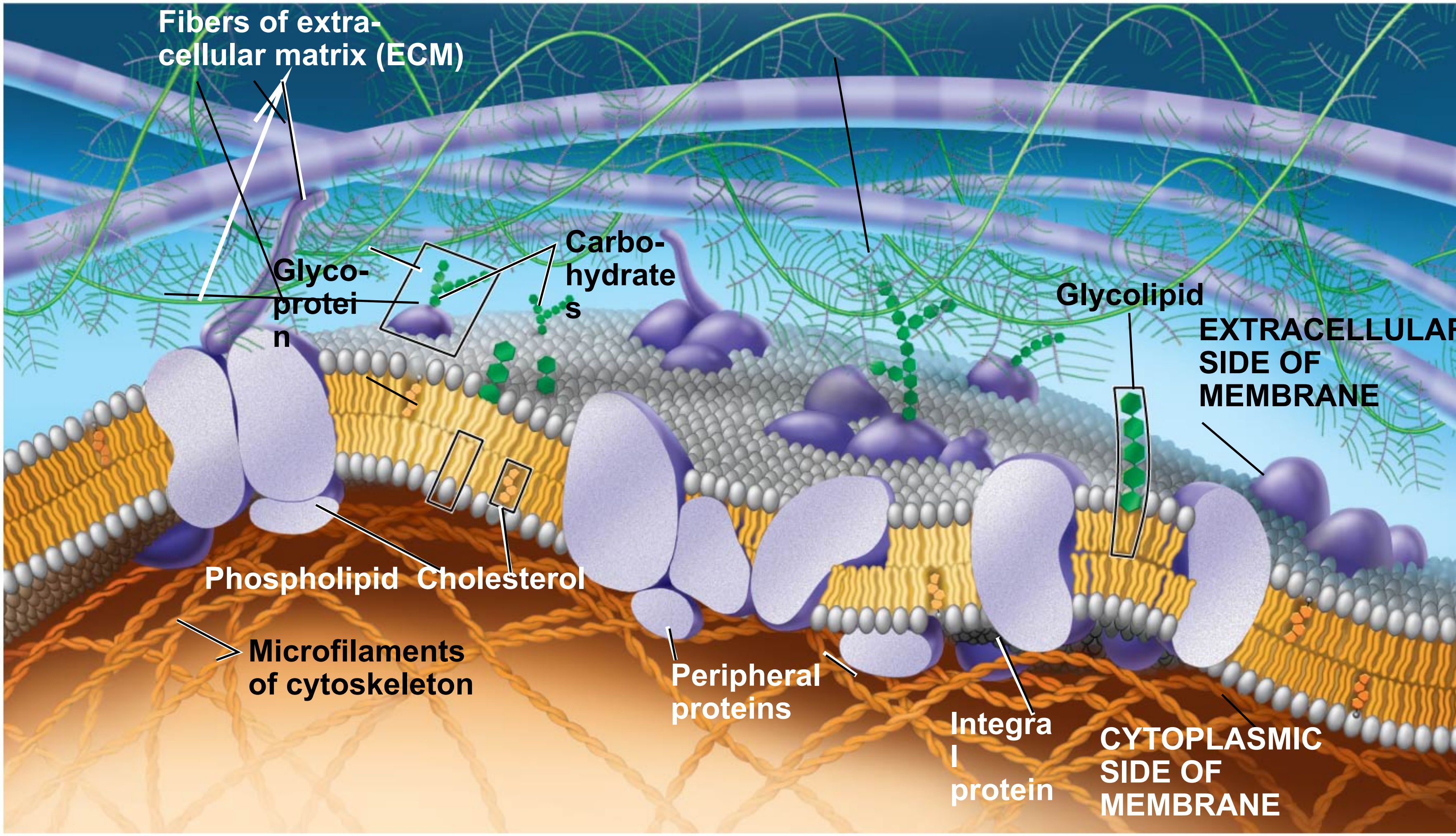
(*) They are associated in long-lasting specialized patches where they carry out common functions.

(+) lipid rafts are specific lipids found in patches [similar to the above (*)]

→ still not sure about whether they are really there or are artifacts due to Biochemical techniques.

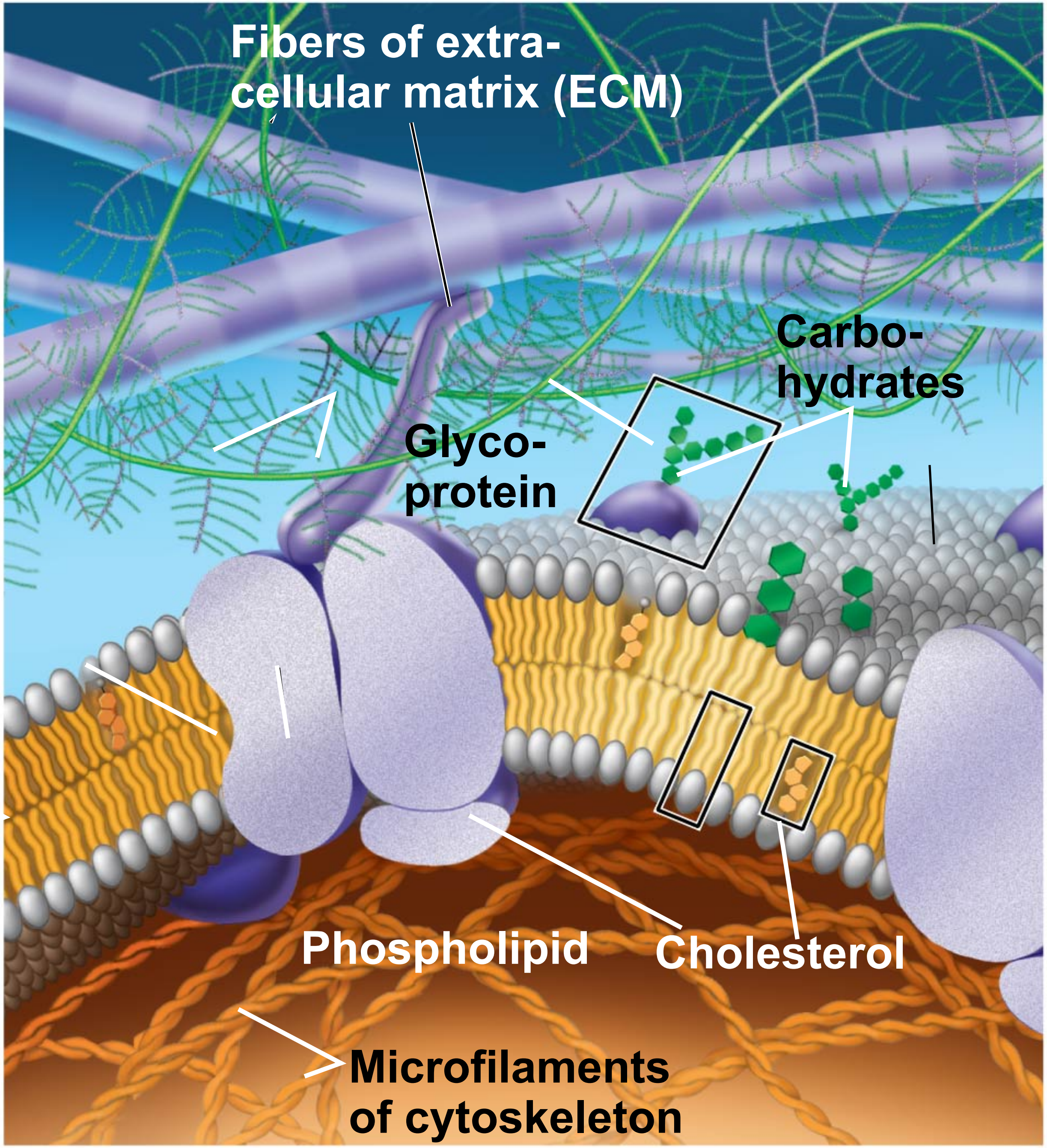
© 2018 Pearson Education Ltd.

Figure 8.3



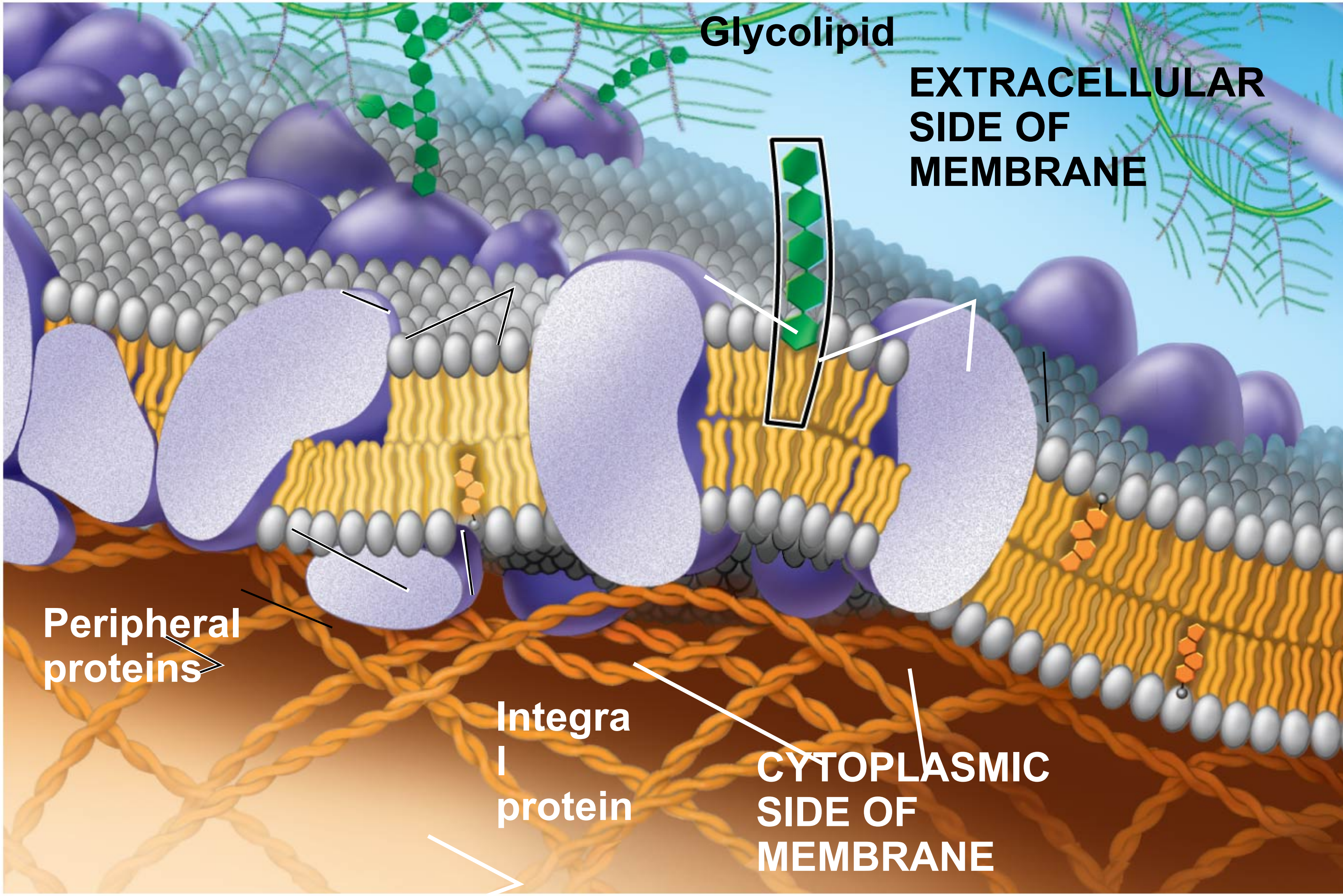

© 2018 Pearson Education Ltd.

Figure 8.3a




© 2018 Pearson Education Ltd.

Figure 8.3b




© 2018 Pearson Education Ltd.

# he Fluidity of Membranes

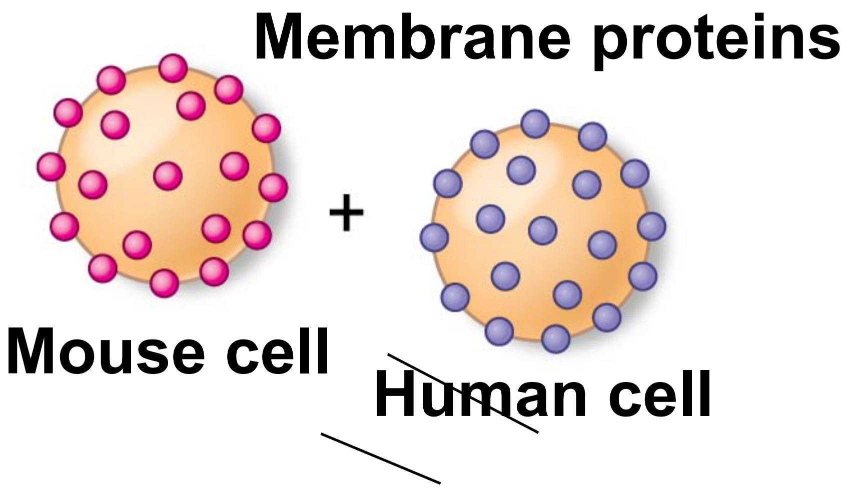
- Membranes are held together mainly by weak hydrophobic interactions
- Most of the lipids and some proteins can move sideways within the membrane
- Rarely, a lipid may flip-flop across the membrane, from one phospholipid layer to the other

⊛ Side-way movement of phospholipids is rapid.
They can switch positions about $10^7$ times / second.
about 2 μm ≈ a bacterial length.

⊛ Protein movement is slower and sometimes restricted by their attachment to the cytoskeleton or the extracellular matrix.

© 2018 Pearson Education Ltd.

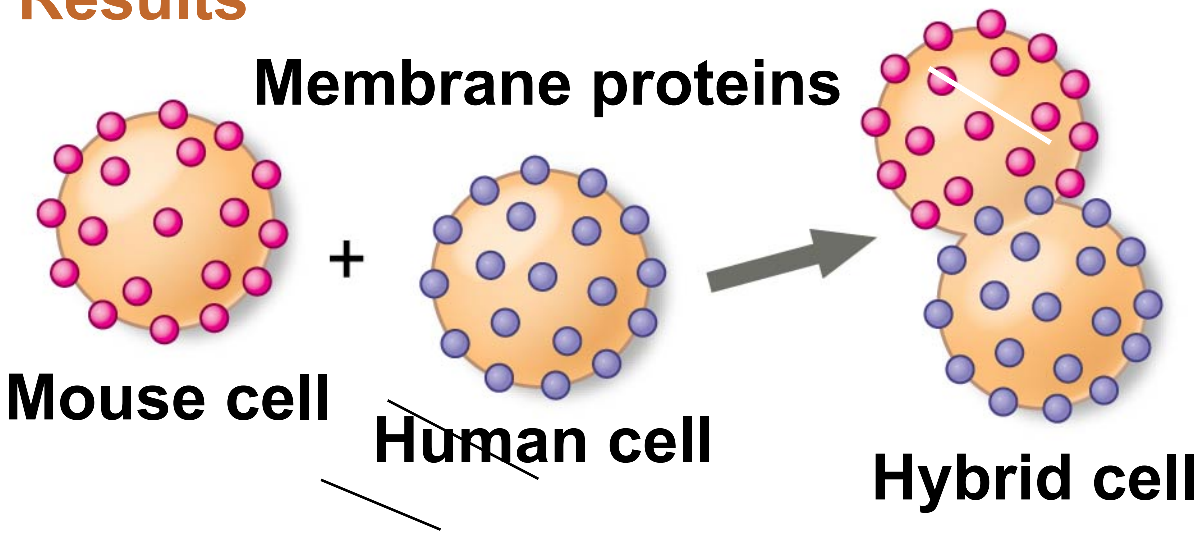
## Results




Data from L. D. Frye and M. Edidin, The rapid intermixing of cell surface antigens after formation of mouse-human heterokaryons, *Journal of Cell Science* 7:319 (1970).

© 2018 Pearson Education Ltd.

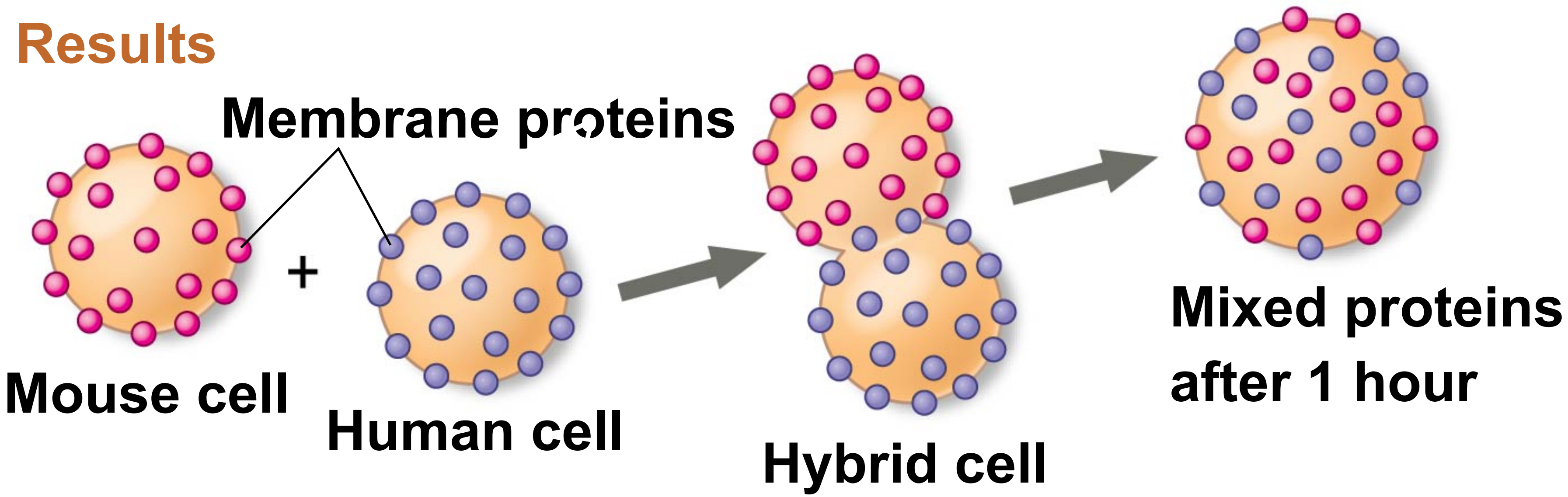
## Results




Data from L. D. Frye and M. Edidin, The rapid intermixing of cell surface antigens after formation of mouse-human heterokaryons, *Journal of Cell Science* 7:319 (1970).

© 2018 Pearson Education Ltd.

## Results




**Data from L. D. Frye and M. Edidin, The rapid intermixing of cell surface antigens after formation of mouse-human heterokaryons, *Journal of Cell Science* 7:319 (1970).**

© 2018 Pearson Education Ltd.

(*) Some proteins in the membrane are driven along cytoskeletal fibers in an ordered manner.
(*) others simply drift in the membrane.

- As temperatures cool, membranes switch from a fluid state to a solid state
- The temperature at which a membrane solidifies depends on the types of lipids
- Membranes rich in unsaturated fatty acids are more fluid than those rich in saturated fatty acids
- Membranes must be fluid to work properly; (*) membranes are usually about as fluid as salad oil

(*) (1) permeability
(2) mobility of protein → their functioning spots.

(*) Over-fluidity is no good either.

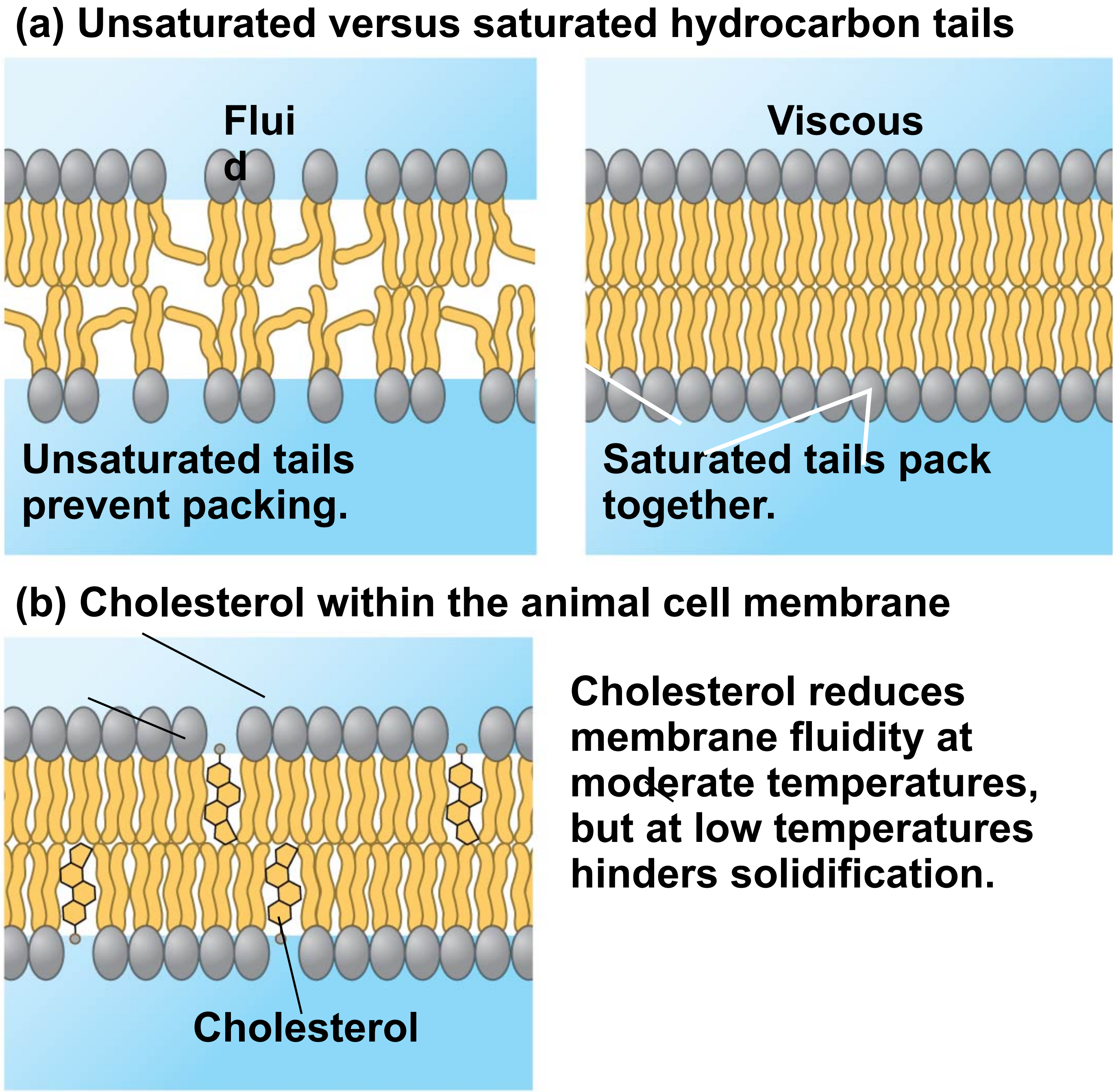
© 2018 Pearson Education Ltd.

- The steroid cholesterol has different effects on the membrane fluidity of animal cells at different temperatures
- At warm temperatures (such as 37ºC), cholesterol restrains movement of phospholipids
- At cool temperatures, it maintains fluidity by preventing tight packing
- Though cholesterol is present in plants, they use related steroid lipids to buffer membrane fluidity

Cholesterol is a "fluidity buffer".

© 2018 Pearson Education Ltd.

Figure 8.5




Cholesterol reduces membrane fluidity at moderate temperatures, but at low temperatures hinders solidification.

© 2018 Pearson Education Ltd.

# volution of Differences in Membrane Lipid Composition

- Variations in lipid composition of cell membranes of many species appear to be adaptations to specific environmental conditions
- Ability to change the lipid compositions in response to temperature changes has evolved in organisms that live where temperatures vary

Examples: (A) – extreme hot , (B) – extreme cold.

(A) some Bacteria & Archaea → unusual lipids preventing over-fluidity.

(B) V. cold water fish → high proportion of unsaturated hydrocarbon tails preventing tight packing.
Some plants

⇒ % of unsaturated fats increase in autumn.

© 2018 Pearson Education Ltd.

# lembrane Proteins and Their Functions

- Somewhat like a tile mosaic, a membrane is a collage of different proteins, often clustered in groups, embedded in the fluid matrix of the lipid bilayer
- Phospholipids form the main fabric of the membrane
- Proteins determine most of the membrane's functions

⊛ RBC's (red blood cells) e.g. have been found to have more than 50 different kinds of proteins.

© 2018 Pearson Education Ltd.

Figure 8.UN01

© 2018 Pearson Education Ltd.

often to the exposed parts of integral proteins.

- **Peripheral proteins** are bound to the surface of the membrane

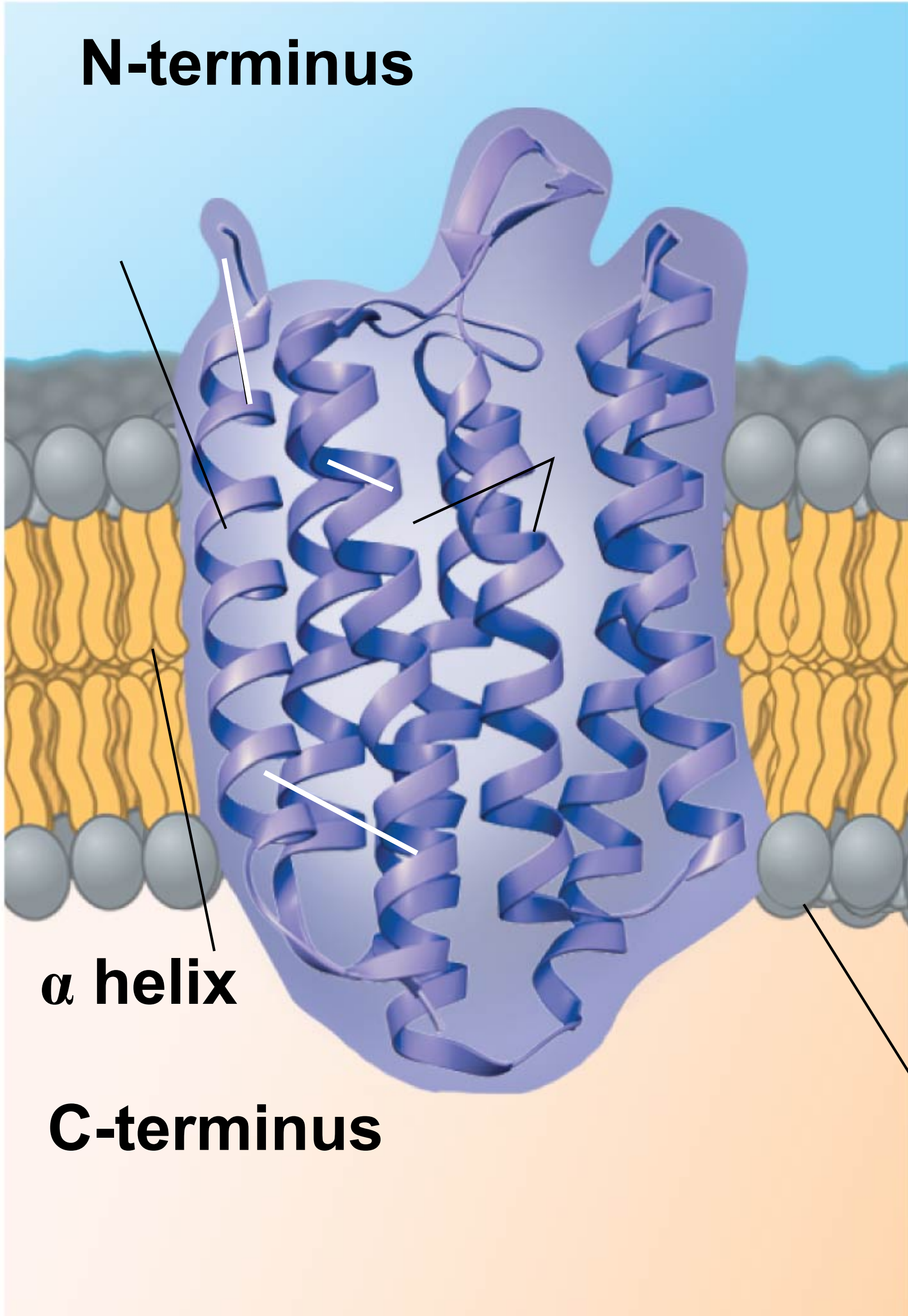
single-side penetration → no "special" name.
double-side penetration → transmembrane proteins

- **Integral proteins** penetrate the hydrophobic core
- Integral proteins that span the membrane are called transmembrane proteins
- The hydrophobic regions of an integral protein consist of one or more stretches of nonpolar amino acids, often coiled into α helices

typically 20→30 a. acids.

© 2018 Pearson Education Ltd.

Figure 8.6




**EXTRACELLULAR SIDE**

* To support the membrane framework:

Some membrane proteins are bound to:

(a) cytoskeletal fibers

(b) extracellular matrix

e.g. integrins [integral, transmembrane proteins]

bond to ECM e.g. fibronectins

materials in the

(see ch. 7.6)

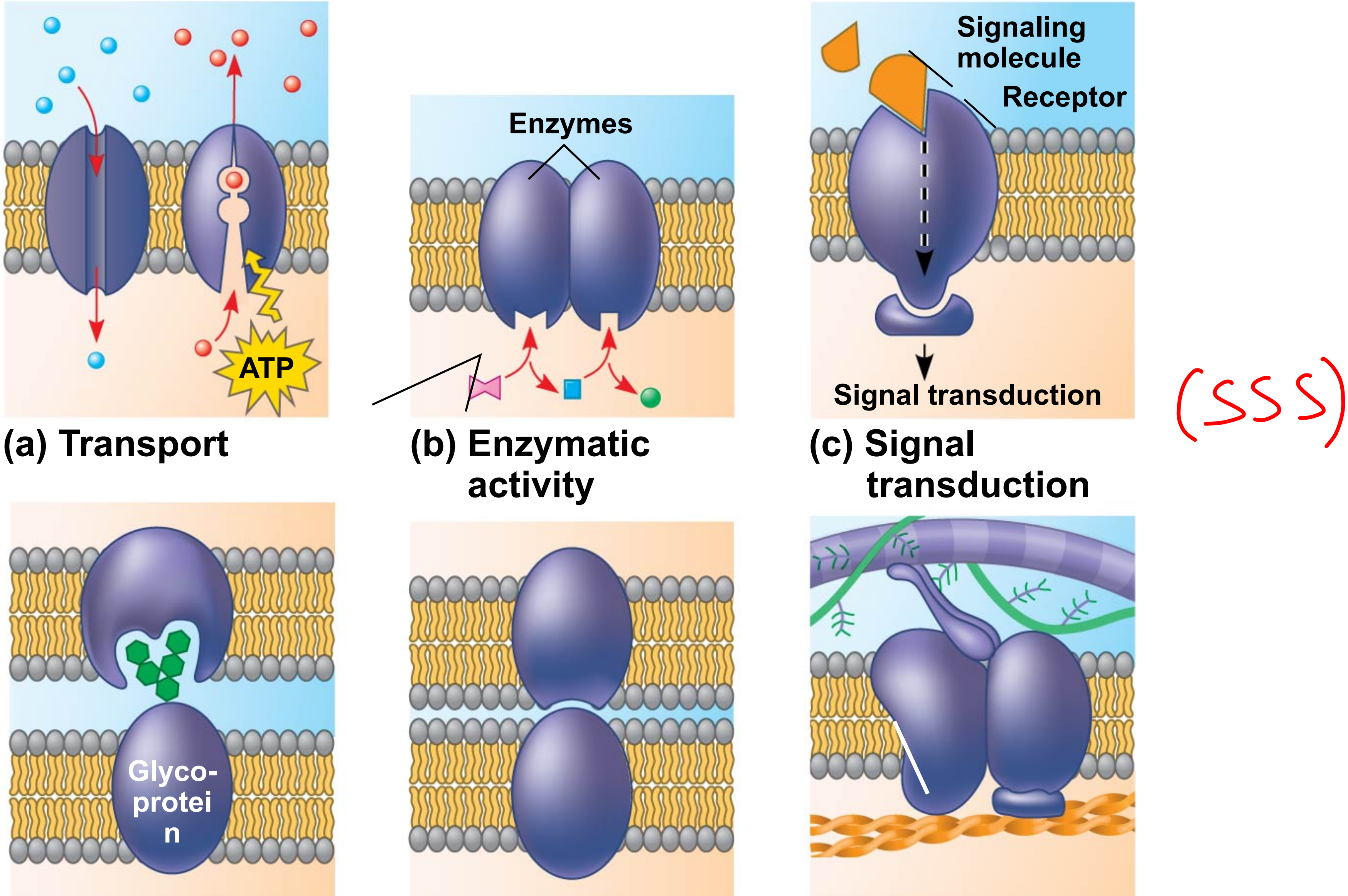
**CYTOPLASMIC SIDE**

© 2018 Pearson Education Ltd.

- Cell-surface membranes can carry out several functions:
  - Transport
  - Enzymatic activity
  - Signal transduction
  - Cell-cell recognition
  - Intercellular joining
  - Attachment to the cytoskeleton and extracellular matrix (ECM)

© 2018 Pearson Education Ltd.

Figure 8.7




(a) Transport

(b) Enzymatic activity

(c) Signal transduction

(d) Cell-cell recognition

(e) Intercellular joining

(f) Attachment to the cytoskeleton and extracellular matrix (ECM)

© 2018 Pearson Education Ltd.

Figure 8.7a

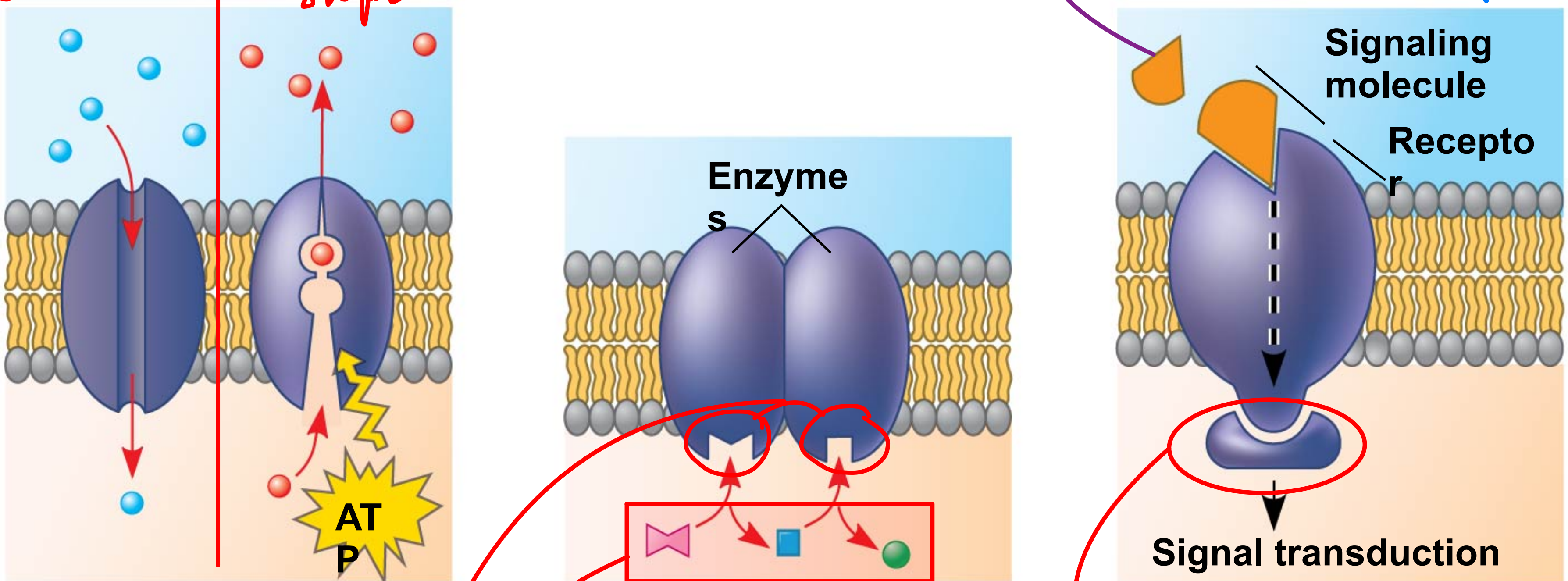
"Shuttling" transport proteins

Spanning proteins

Selective channels

transport by changing shape } → requires energy.

Chem. Messengers e.g. Hormones may cause the protein to change shape.




(a) Transport

(b) Enzymatic activity

(c) Signal transduction

active sites

→ sequential steps of a metabolic path

→ signals may be transmitted to the interior by binding to cytoplasmic proteins.

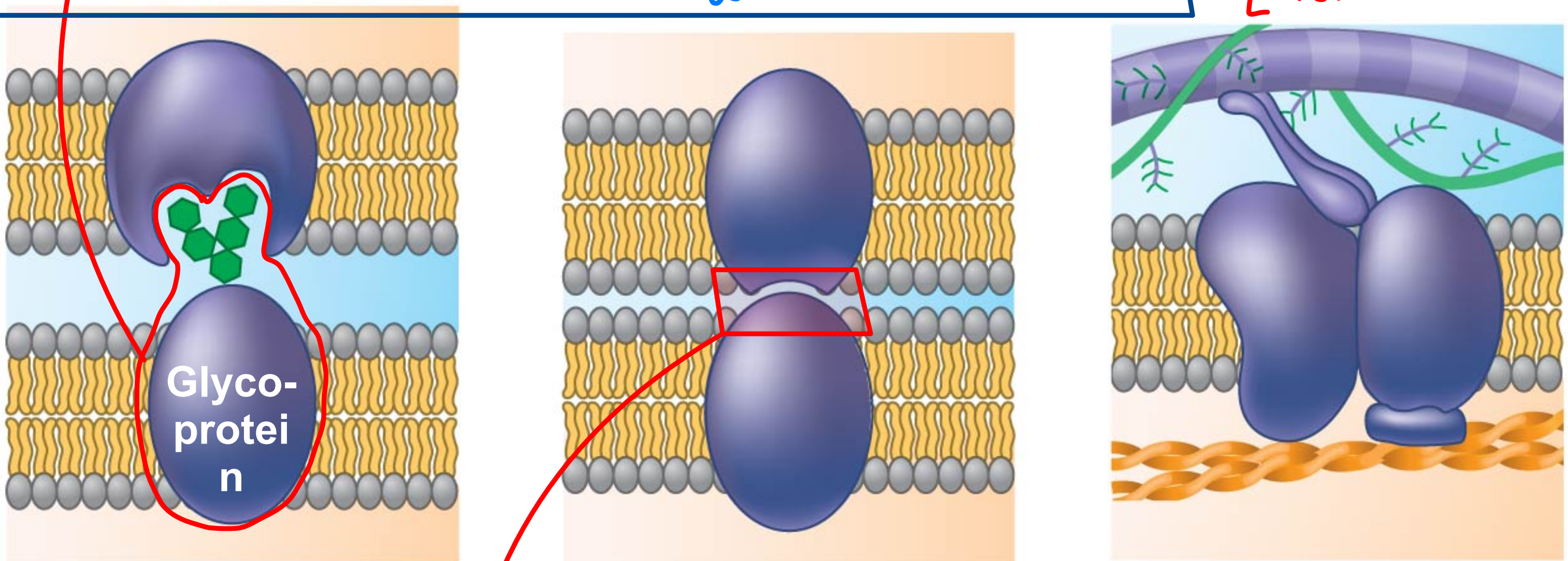
© 2018 Pearson Education Ltd.

Figure 8.7b

wrt : with respect to

Identification tags for a cell such as RBC's.
"short lasting binding".
wrt (e).

maintains cell's shape
stabilizes some m.proteins
[non-covalent bonding].




⊛ proteins that can bind to ECM molecules can coordinate extracellular or intracellular changes.

**(d) Cell-cell recognition**

**(e) Intercellular joining**

**(f) Attachment to the cytoskeleton and extracellular matrix (ECM)**

hooks between membrane protein as in tight and gap junctions (see ch. 7.7)
"long-lasting binding" wrt (d).

© 2018 Pearson Education Ltd.

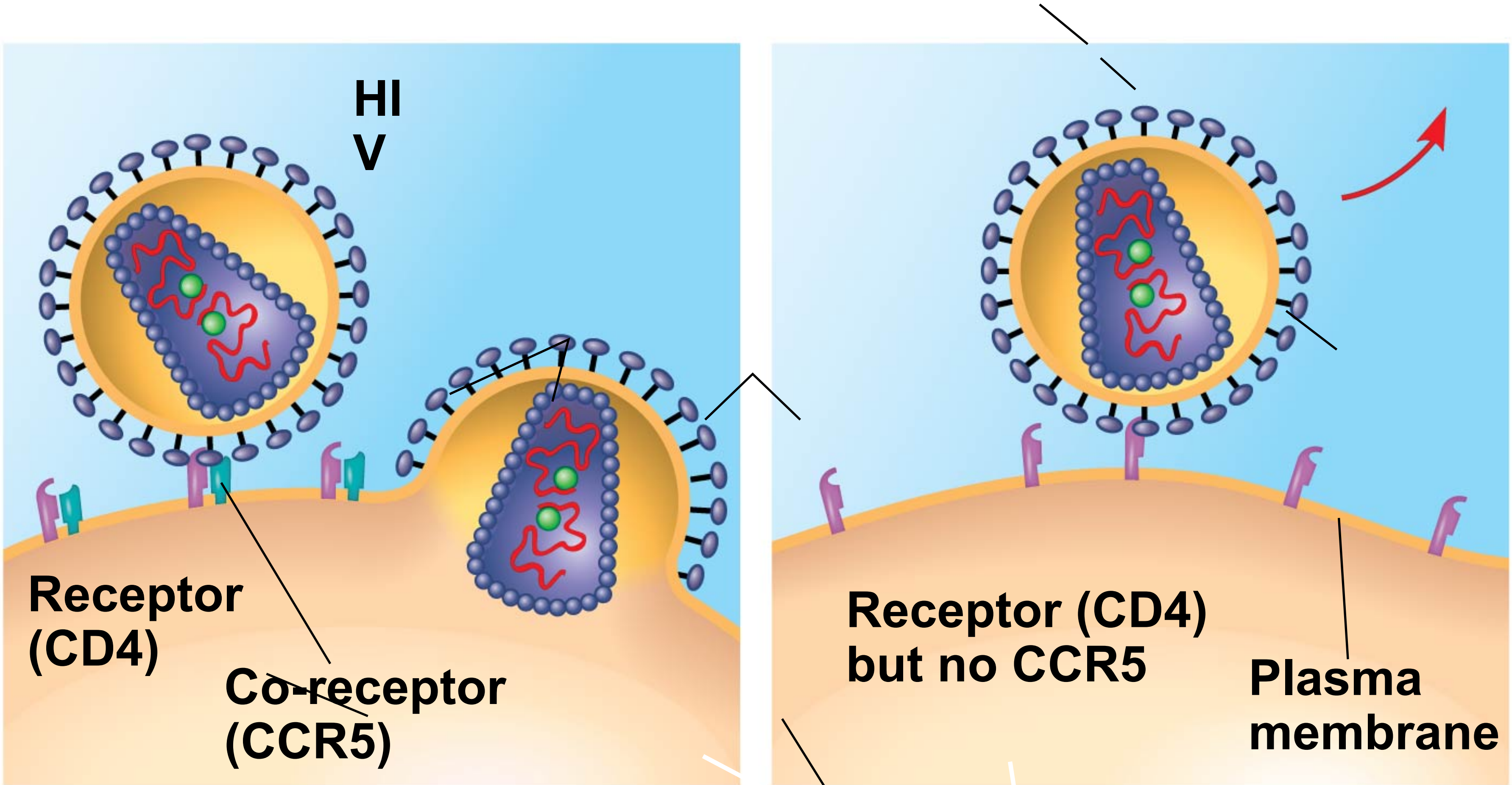
HIV : Human Immunodeficiency Virus
AIDS : Acquired Immune Deficiency Syndrome.

- Cell-surface proteins are important in the medical field
  - For example, HIV must bind to the immune cell-surface protein CD4 and a "co-receptor" CCR5 in order to infect a cell
  - HIV cannot enter the cells of resistant individuals who lack CCR5
  - Drugs are now being developed to mask the CCR5 protein

e.g. maravirox (by Selzentry) approved in 2007.

© 2018 Pearson Education Ltd.

Figure 8.8




(a) HIV can infect a cell with CCR5 on its surface, as in most people.

(b) HIV cannot infect a cell lacking CCR5 on its surface, as in resistant individuals.

due to gene alteration.

© 2018 Pearson Education Ltd.

# he Role of Membrane Carbohydrates in Cell-Cell Recognition

in an embryonic animal

an important eg is in the differentiation of cells into tissues

- Cells recognize each other by binding to molecules, often containing carbohydrates, on the extracellular surface of the plasma membrane

often short branched less than 15 sugar units.

- Membrane carbohydrates may be covalently bonded to lipids (forming **glycolipids**) or, more commonly, to proteins (forming **glycoproteins**)

- Carbohydrates on the extracellular side of the plasma membrane vary among species, individuals, and even cell types in an individual

RBC's O, A, B, AB

© 2018 Pearson Education Ltd.

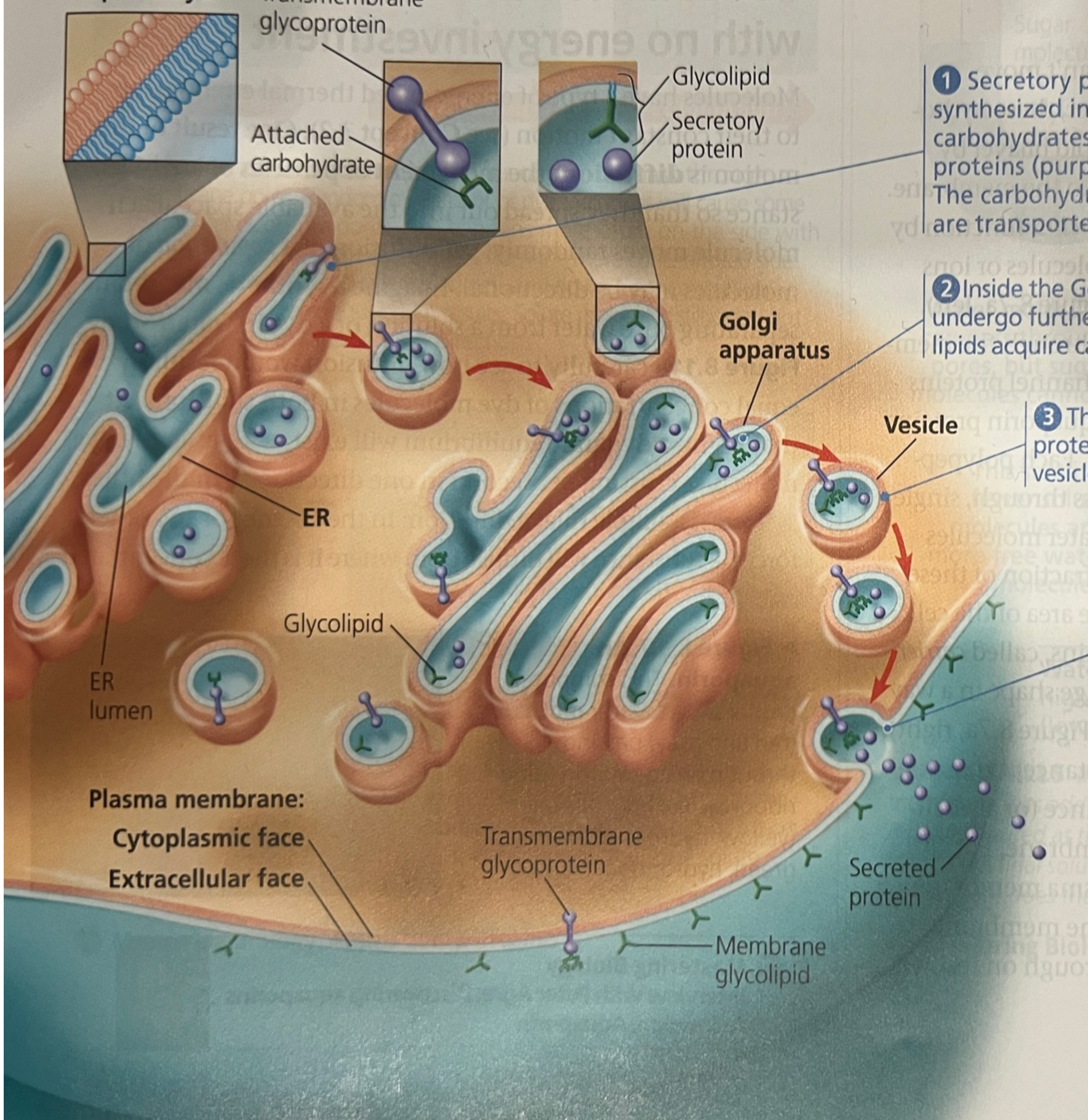
# ynthesis and Sidedness of Membranes

- Membranes have distinct inside and outside faces
- The asymmetrical distribution of proteins, lipids, and associated carbohydrates in the plasma membrane is determined when the membrane is built by the ER and Golgi apparatus [Important]

© 2018 Pearson Education Ltd.

Figure 8.9

**▼ Figure 8.9 Synthesis of membrane components and their orientation in the membrane.** The cytoplasmic (orange) face of the plasma membrane differs from the extracellular (aqua) face. The latter arises from the inside face of ER, Golgi, and vesicle membranes.




1 Secretory proteins, membrane proteins, and lipids are synthesized in the endoplasmic reticulum (ER). In the ER, carbohydrates (green) are added to the transmembrane proteins (purple dumbbells), making them glycoproteins. The carbohydrate portions may then be modified. Materials are transported in vesicles to the Golgi apparatus.

2 Inside the Golgi apparatus, the glycoproteins undergo further carbohydrate modification, and lipids acquire carbohydrates, becoming glycolipids.

3 The glycoproteins, glycolipids, and secretory proteins (purple spheres) are transported in vesicles to the plasma membrane.

4 As vesicles fuse with the plasma membrane, the outside face of the vesicle becomes continuous with the inside (cytoplasmic) face of the plasma membrane. This releases the secretory proteins from the cell, a process called *exocytosis*, and positions the carbohydrates of membrane glycoproteins and glycolipids on the outside (extracellular) face of the plasma membrane.

**DRAW IT** *Draw an integral membrane protein extending from partway through the ER membrane into the ER lumen. Next, draw the protein where it would be located in a series of numbered steps ending at the plasma membrane. Would the protein contact the cytoplasm or the extracellular fluid? Explain.*

# oncept 8.2: Membrane structure results in selective permeability

- A cell must exchange ⊛ materials with its surroundings, a process controlled by the plasma membrane
- Plasma membranes are selectively permeable, regulating the cell's molecular traffic

⊛ ⓐ take in materials such as $O_2$, sugars, A.acids ...

ⓑ expell waste products such as $CO_2$ ...

ⓒ regulate the concentrations of inorganic ions such as $Na^+$, $Cl^-$, $K^+$, $Ca^{2+}$ ...

© 2018 Pearson Education Ltd.

# he Permeability of the Lipid Bilayer

+ {$O_2$, $CO_2$}

- Hydrophobic (nonpolar) molecules, such as hydrocarbons, can dissolve in the lipid bilayer and pass through the membrane rapidly

selective permeability (1).

- Hydrophilic molecules including ions and polar molecules do not cross the membrane easily
- Proteins built into the membrane play key roles in regulating transport

© 2018 Pearson Education Ltd.

# Transport Proteins

- **Transport proteins** allow passage of hydrophilic substances across the membrane
- Some transport proteins, called channel proteins, have a hydrophilic channel that certain molecules or ions can use as a tunnel

only little amounts of water pass elsewhere.

- Channel proteins called **aquaporins** greatly facilitate the passage of water molecules

Aquaporins ⇒ Quaternary (4 identical subunits)

each having a channel for water passage

Allowing ≈ 3 billion $H_2O$ molecules per second.

© 2018 Pearson Education Ltd.

- Other transport proteins, called carrier proteins, bind to molecules and change shape to shuttle them across the membrane → selective permeability (2).
- A transport protein is specific for the substance it moves

e.g. Glucose carrier proteins speed up movement of glucose molecules' passage across the membrane of RBC's by a factor of 50,000.

these carrier proteins are so specific that they reject Fructose.

a structural isomer of glucose

© 2018 Pearson Education Ltd.

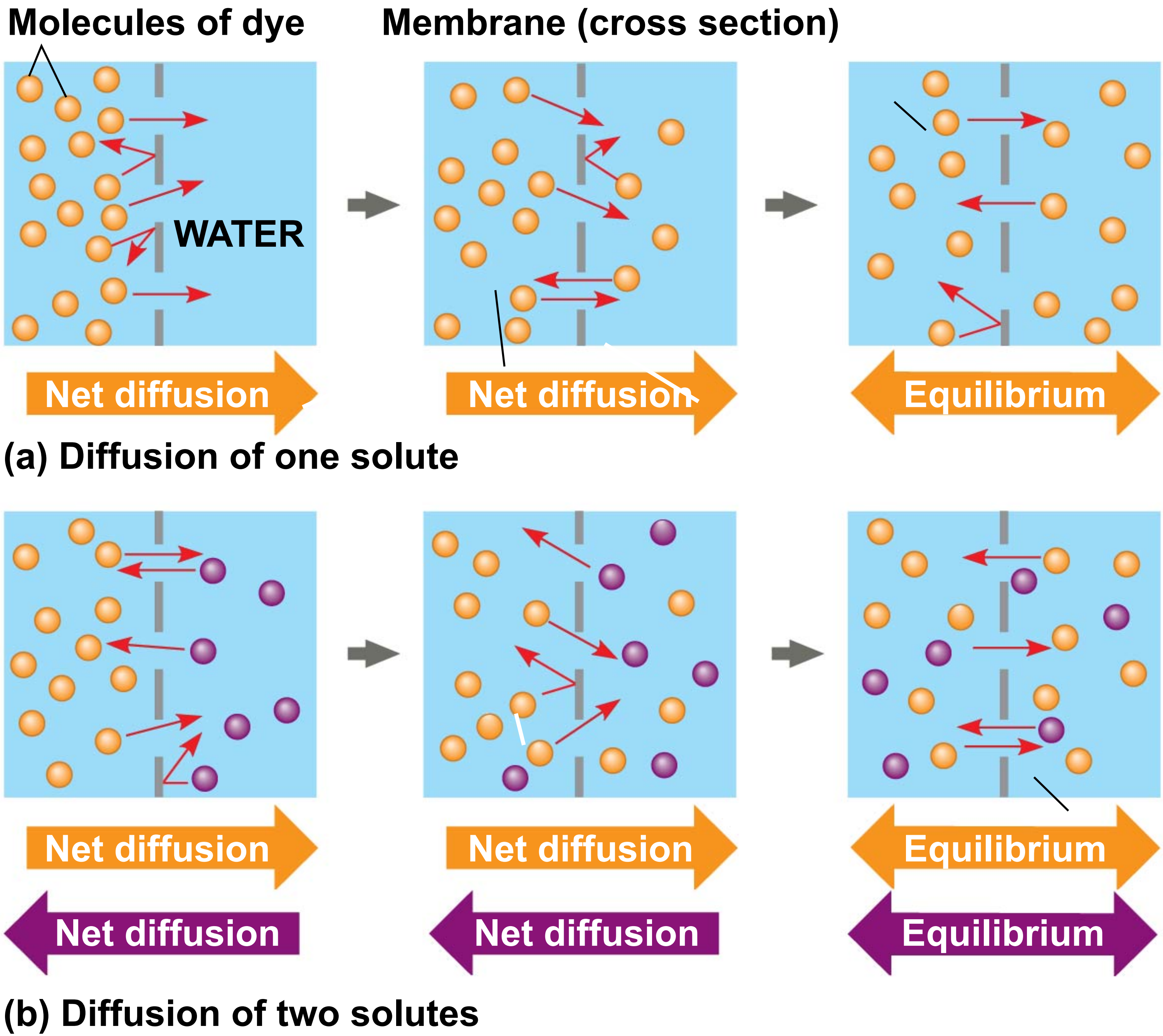
## oncept 8.3: Passive transport is diffusion of a substance across a membrane with no energy investment

- **Diffusion** is the tendency for molecules to spread out evenly into the available space
- Although each molecule moves randomly, diffusion of a population of molecules may be directional
- At dynamic equilibrium, as many molecules cross the membrane in one direction as in the other

(*) e.g. $O_2$ that is dissolved in water keeps moving into cells performing cellular respiration as it ($O_2$) is continuously being consumed by the cell.

© 2018 Pearson Education Ltd.

Figure 8.10




© 2018 Pearson Education Ltd.

- Substances diffuse down their **concentration gradient**, the region along which the density of a chemical substance increases or decreases
- No work must be done to move substances down the concentration gradient
- The diffusion of a substance across a biological membrane is **passive transport** because no energy is expended by the cell to make it happen

© 2018 Pearson Education Ltd.

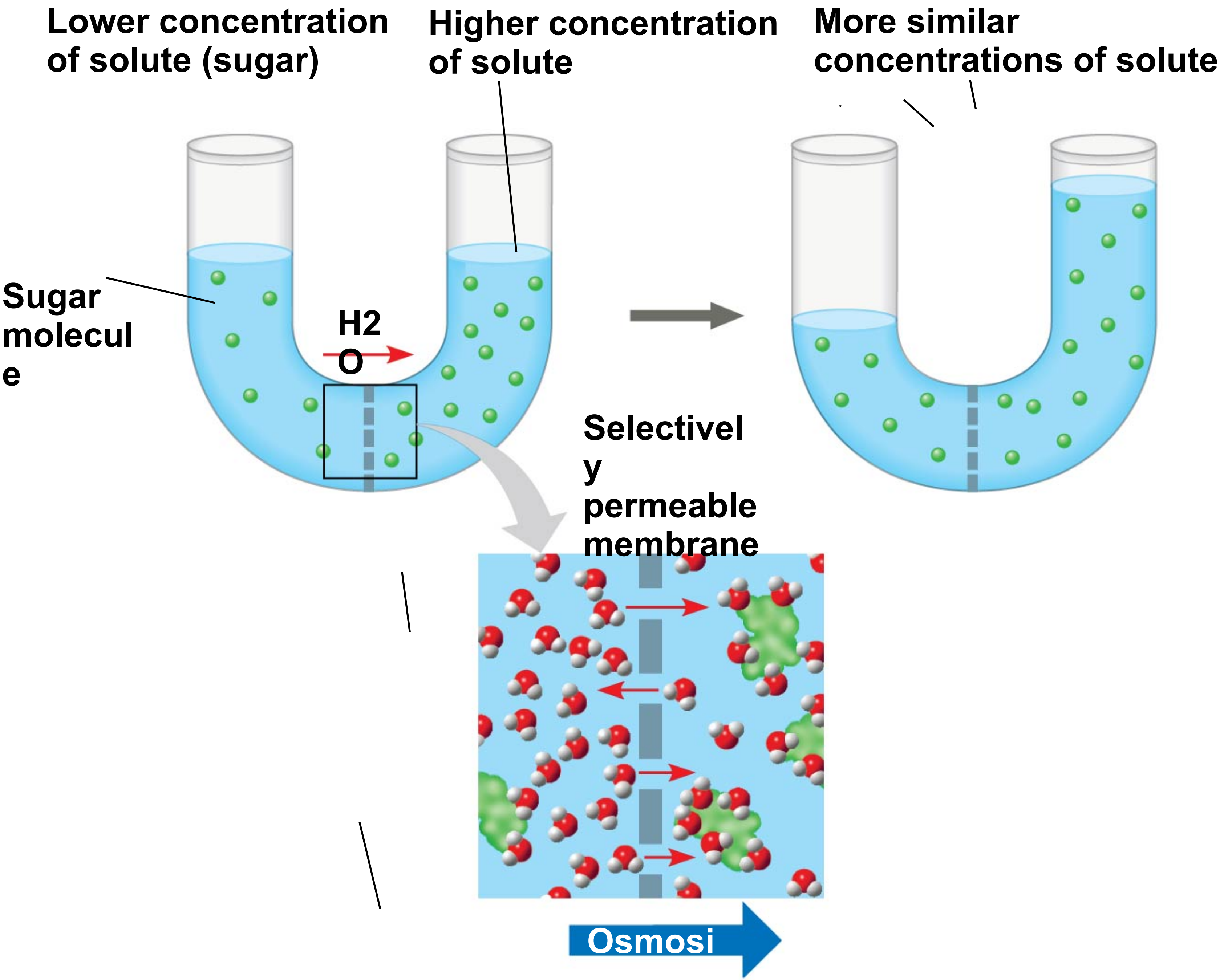
# ffects of Osmosis on Water Balance

free

- **Osmosis** is the diffusion of water across a selectively permeable membrane
- Water diffuses across a membrane from the region of lower solute concentration to the region of higher solute concentration until the solute concentration is equal on both sides

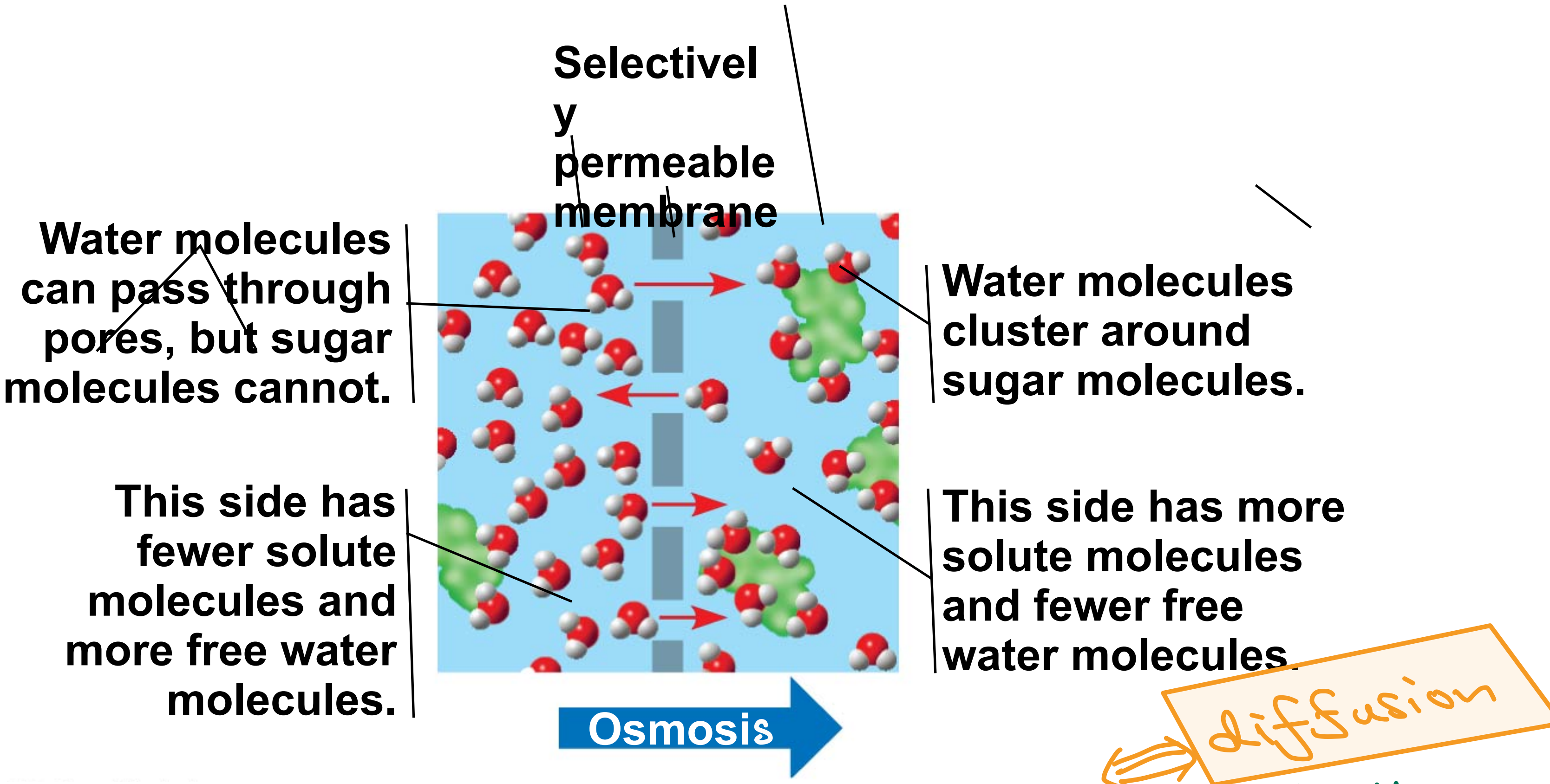
© 2018 Pearson Education Ltd.

Figure 8.11




© 2018 Pearson Education Ltd.

Figure 8.11a




→ Higher to lower free water concentration

⟷ lower to Higher solute concentration.

© 2018 Pearson Education Ltd.

# Water Balance of Cells Without Cell Walls

- **Tonicity** is the ability of a surrounding solution to cause a cell to gain or lose water
- The tonicity of a solution depends on its concentration of solutes that cannot cross the membrane relative to that inside the cell (*)

(*) aka. non-penetrating solutes.

(*) Osmosis is not affected by concentrations of "penetrating" solutes — they can diffuse evenly.

© 2018 Pearson Education Ltd.

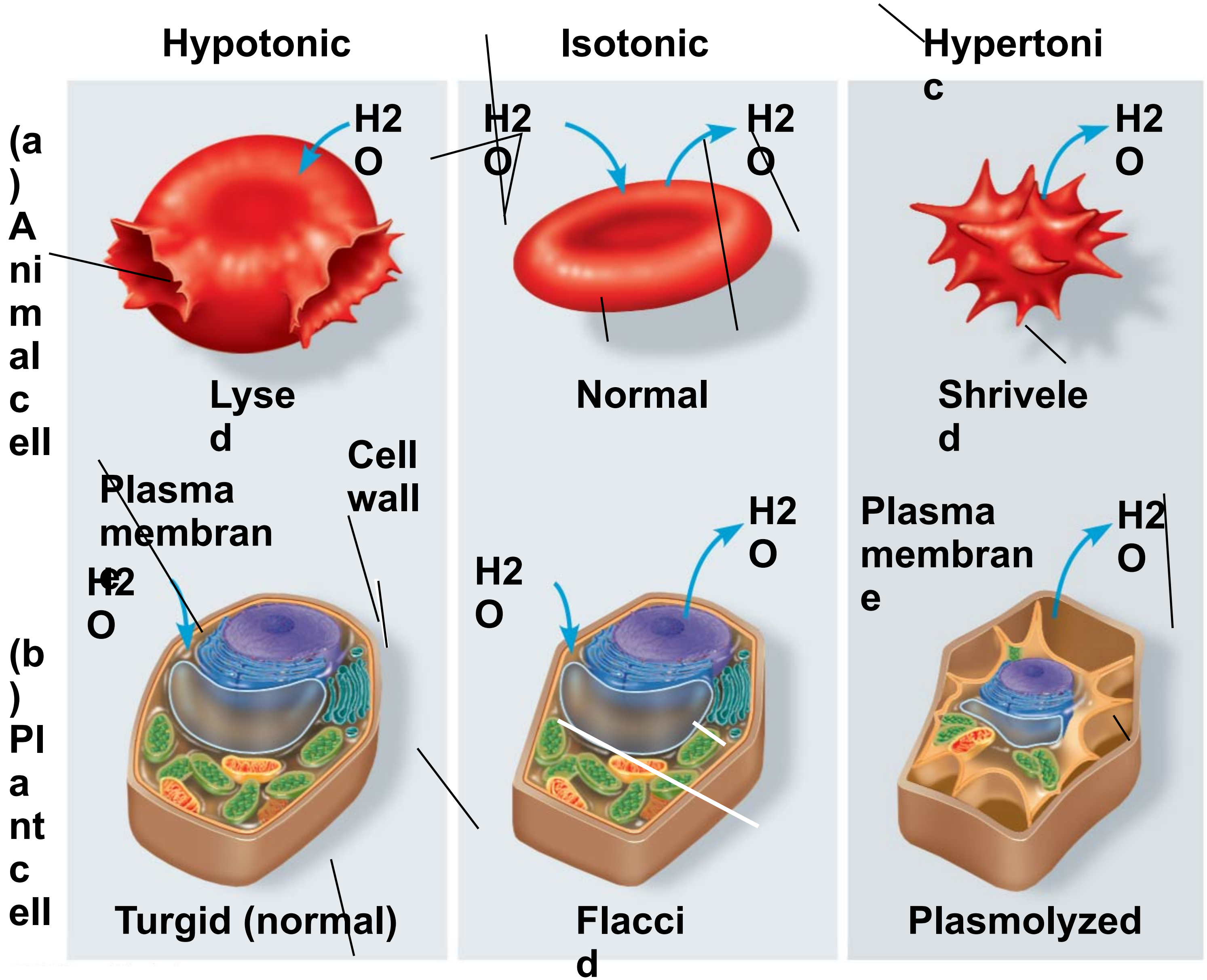
for this topic, Solutes ≡ non-penetrating Solutes as other solutes do not matter (are even).

- **Isotonic** solution: Solute concentration is the same as that inside the cell; no *net* water movement across the plasma membrane
- **Hypertonic** solution: Solute concentration is greater than that inside the cell; cell loses water
- **Hypotonic** solution: Solute concentration is less than that inside the cell; cell gains water
- Cells without cell walls will shrivel in hypertonic solution and lyse (burst) in a hypotonic solution

⊕ seawater is ISOTONIC to most marine vertebrates.

© 2018 Pearson Education Ltd.

Figure 8.12




© 2018 Pearson Education Ltd.

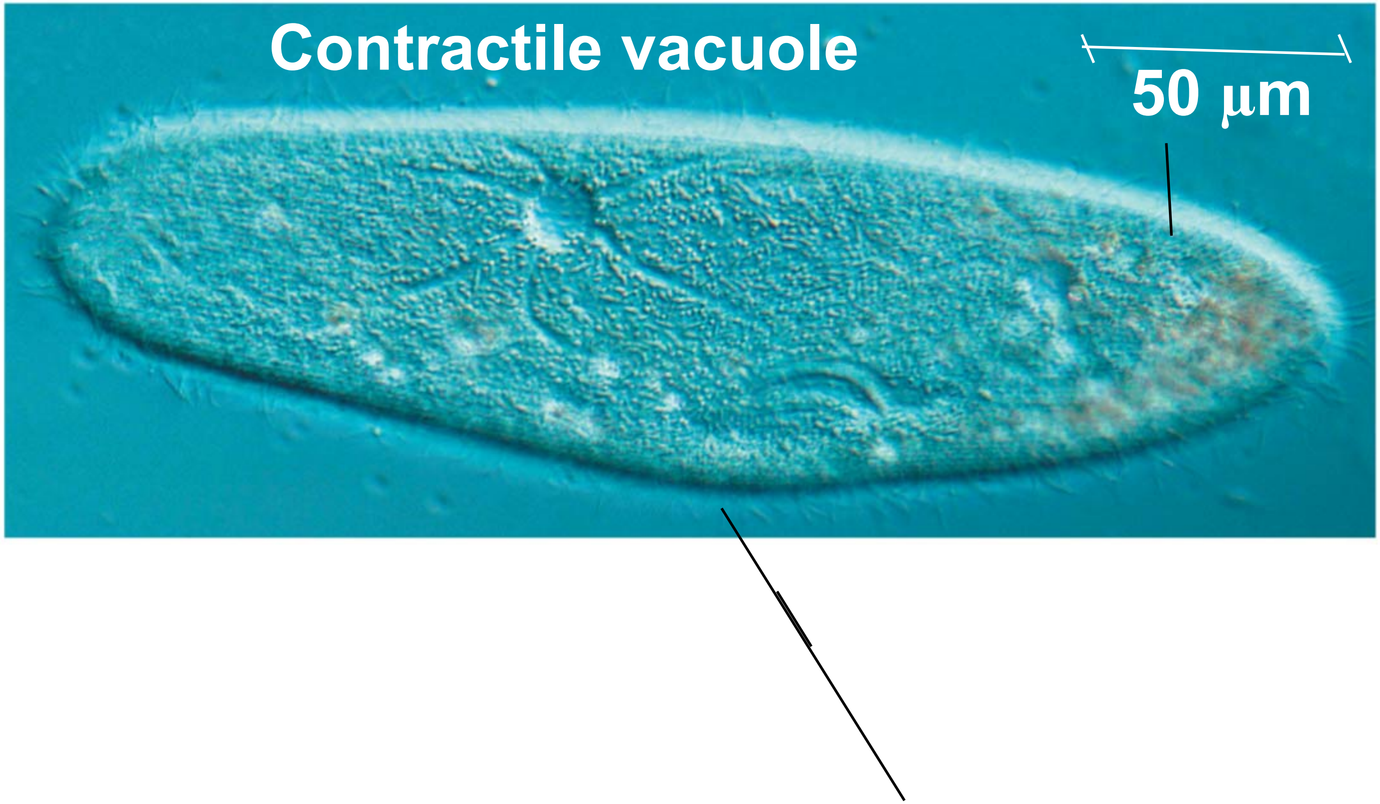
⊕ Cells of most terrestrial animals are bathed in an extracellular fluid the is ISOTONIC to the cells.

- Hypertonic or hypotonic environments create osmotic problems for organisms that have cells without rigid walls
- **Osmoregulation**, the control of solute concentrations and water balance, is a necessary adaptation for life in such environments
  - For example, the unicellular eukaryote (protist (specifying).) *Paramecium*, which is hypertonic to its pond water environment, has a contractile vacuole that acts as a pump

⊕ Parameciums' membranes are less permeable to water (than many other cells') which slows osmosis but does not stop it.

© 2018 Pearson Education Ltd.

Figure 8.13




© 2018 Pearson Education Ltd.

- Bacteria and archaea that live in hypersaline (excessively salty) environments have cellular mechanisms to balance internal and external solute concentrations

© 2018 Pearson Education Ltd.

# Water Balance of Cells with Cell Walls

pressure by Cell walls on the interior is Turgor pressure.

- Cell walls help maintain water balance
- A plant cell in a hypotonic solution swells until the wall opposes uptake; the cell is now **turgid** (firm)
- If a plant cell and its surroundings are isotonic, there is no net movement of water into the cell; the cell becomes **flaccid** (limp)

wilts.

© 2018 Pearson Education Ltd.

- In a hypertonic environment, plant cells lose water
- The membrane pulls away from the cell wall, causing the plant to wilt, a potentially lethal effect called **plasmolysis**

Bacteria and Fungi also experience plasmolysis in HYPERTONIC Conditions.

© 2018 Pearson Education Ltd.

# acilitated Diffusion: Passive Transport Aided by Proteins

- In **facilitated diffusion**, transport proteins speed the passive movement of molecules across the plasma membrane
- Transport proteins include channel proteins and carrier proteins

© 2018 Pearson Education Ltd.

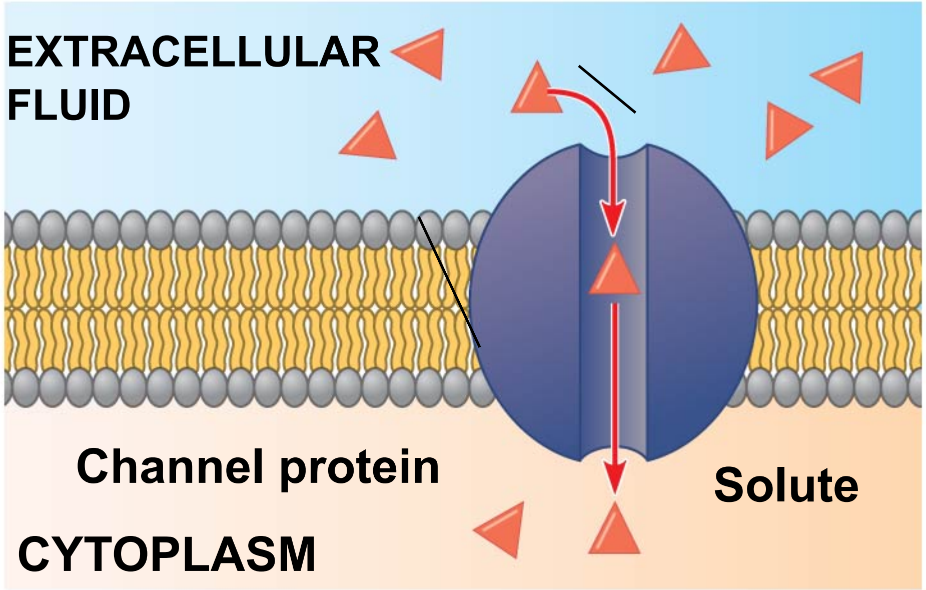
↑ (*) aquaporins are abundant in Kidney Cells.
↘ take in water from Urine into

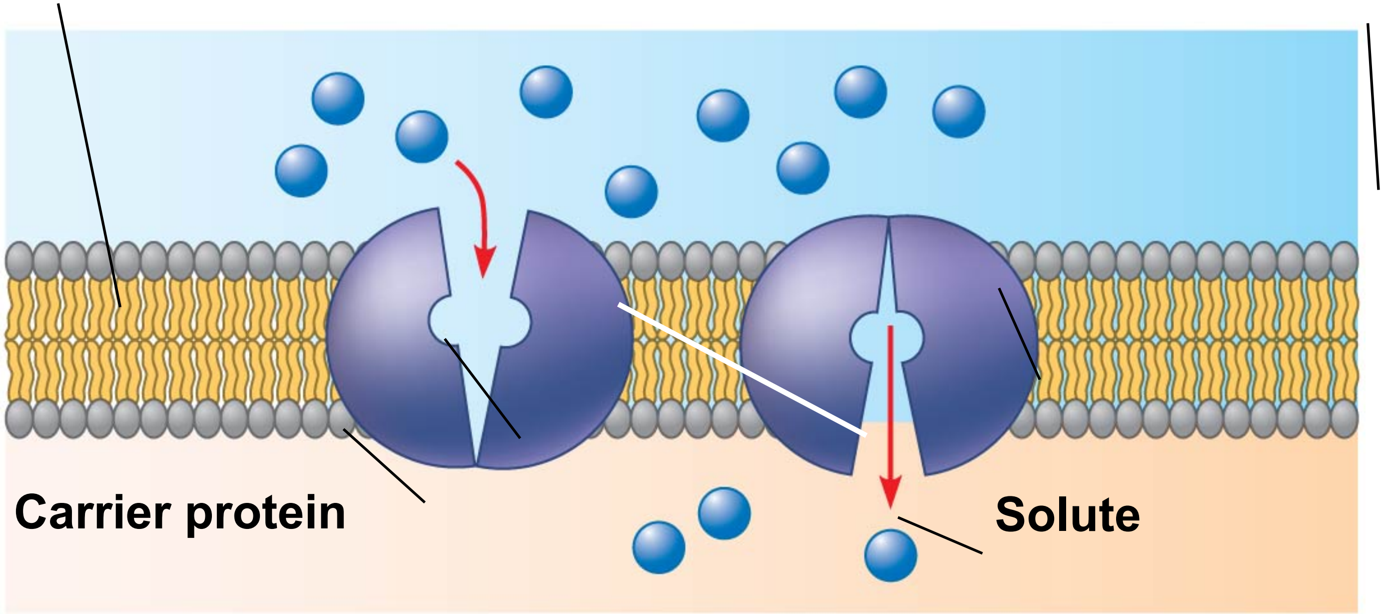
- Channel proteins provide corridors that allow a specific molecule or ion to cross the membrane
- Aquaporins (*) facilitate the diffusion of water
- **Ion channels** facilitate the transport of ions
- Some ion channels, called **gated channels**, open or close in response to a stimulus } → another e.g. Chemical stimulus by binding of non-transported substances.
  - For example, in nerve cells, ion channels open in response to electrical stimulus

e.g. e. Voltage difference sensitive $K^+$ channels. allow the exit of a stream of $K^+$, restoring the cells capability to Fire again.

© 2018 Pearson Education Ltd.

Figure 8.14




(b) A carrier protein

© 2018 Pearson Education Ltd.

- Carrier proteins undergo a subtle change in shape that translocates the solute-binding site across the membrane
- This change in shape can be triggered by the binding and release of the transported molecule

⊛ All methods of transport up to this point Do Not require energy; as they are [down the concentration gradient]

© 2018 Pearson Education Ltd.

## oncept 8.4: Active transport uses energy to move solutes against their gradients

- Facilitated diffusion is still passive because the solute moves down its concentration gradient, and the transport requires no energy
- Some transport proteins, however, can move solutes against their concentration gradients

© 2018 Pearson Education Ltd.

# he Need for Energy in Active Transport

- **Active transport** requires energy, usually in the form of ATP hydrolysis, to move substances against their concentration gradients
- All proteins involved in active transport are carrier proteins ] → Important.

© 2018 Pearson Education Ltd.

- Active transport allows cells to maintain concentration gradients that differ from their surroundings
  - For example, an animal cell has a much higher potassium (K+) and a much lower sodium (Na+) concentration compared to its surroundings
  - This is controlled by the **sodium-potassium pump**, a transport protein that is energized by transfer of a phosphate group from the hydrolysis of ATP

Status (0): non-phosphorylated → High affinity for $Na^+$ (3 ions) [open to the inside]
Status (1): Phosphorylated ⟶ High affinity for $K^+$ (2 ions) [open to the outside].

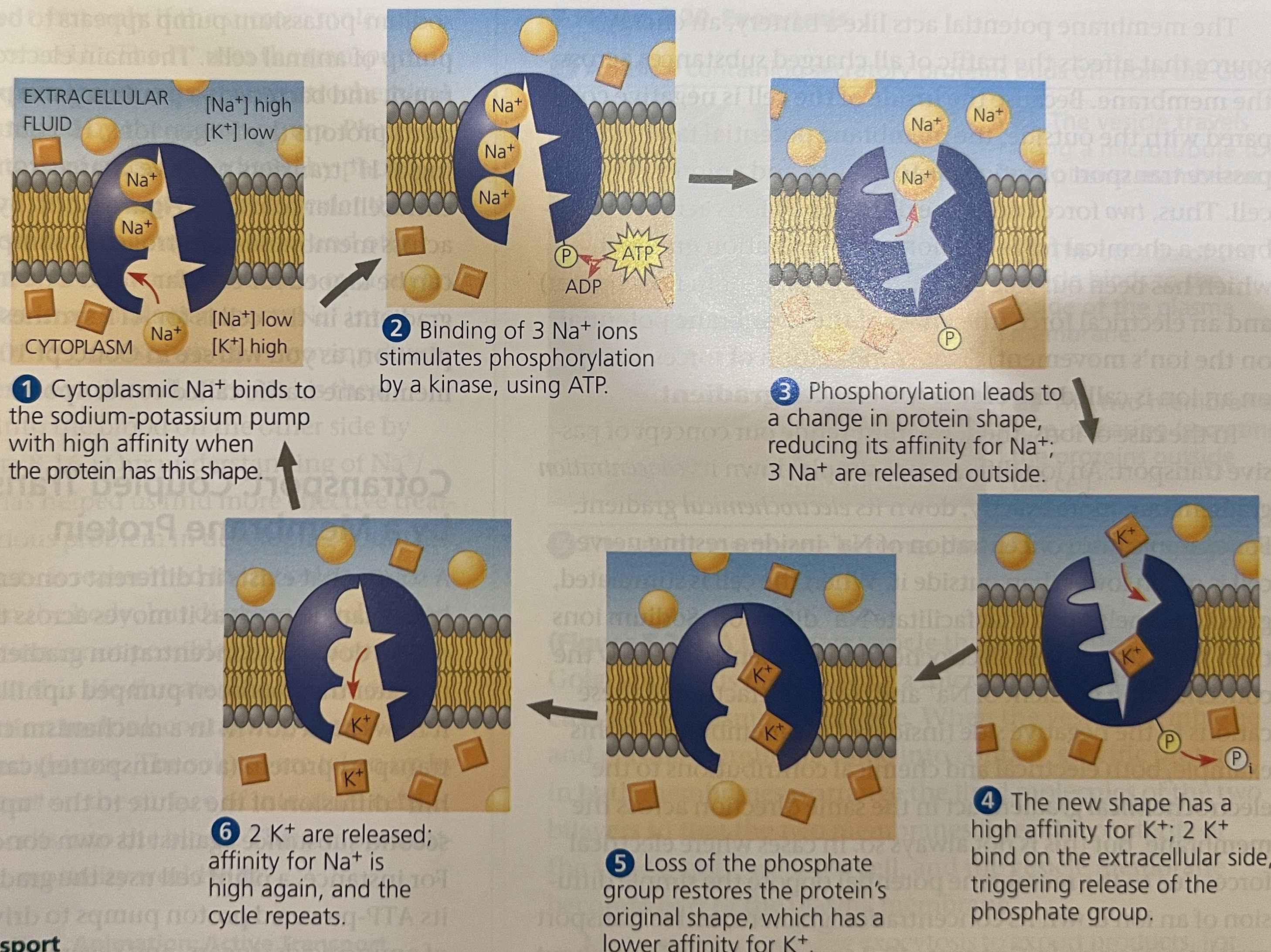
© 2018 Pearson Education Ltd.

Figure 8.15

▶ **Figure 8.16 The sodium-potassium pump: a specific case of active transport.** This transport system pumps ions against steep concentration gradients. The pump oscillates between two shapes in a cycle that moves $Na^+$ out of the cell (steps 1–3) and $K^+$ into the cell (steps 4–6). The two shapes have different binding affinities for $Na^+$ and $K^+$. ATP hydrolysis powers the shape change by transferring a phosphate group to the transport protein (phosphorylating the protein).

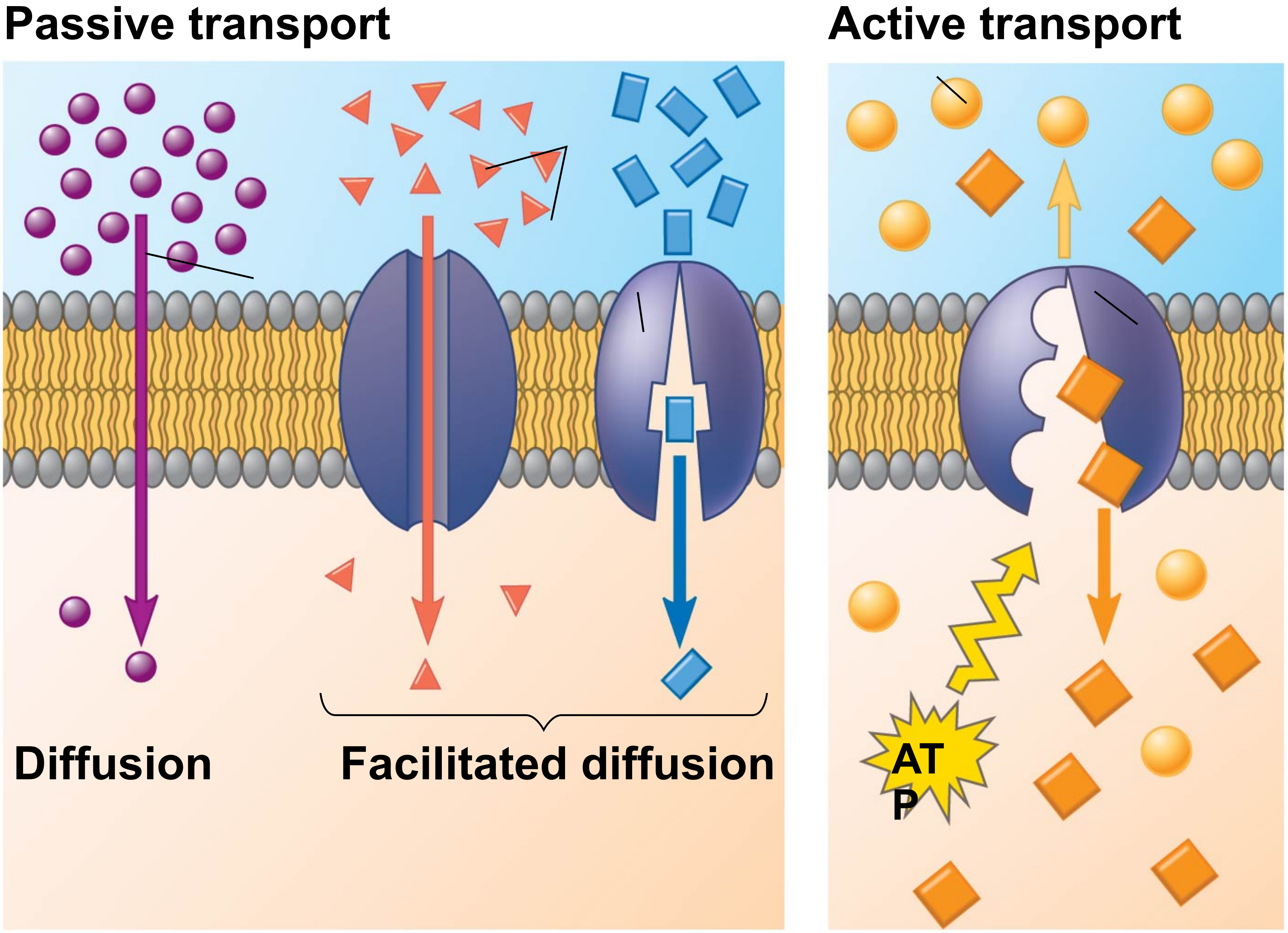
**VISUAL SKILLS** *For each ion ($Na^+$ and $K^+$), describe its concentration inside the cell relative to outside. How many $Na^+$ are moved out of the cell and how many $K^+$ moved in per cycle?*

**Mastering Biology Animation: Active Transport**




© 2018 Pearson Education Ltd.

Figure 8.16




© 2018 Pearson Education Ltd.

# ow Ion Pumps Maintain Membrane Potential

- **Membrane potential** is the voltage across a membrane
- Voltage is created by differences in the distribution of positive and negative ions across a membrane
- The cytoplasmic side of the membrane is negative in charge relative to the extracellular side

MEM. Potential $\in [-200, -50]$ mV.

MEM. Potential = $V_{cytoplasm} - V_{ECSide}$

The negative number indicates that $V_{cyt.} < V_{EC\ side}$

© 2018 Pearson Education Ltd.

- Two combined forces, collectively called the **electrochemical gradient**, drive the diffusion of ions across a membrane
  - A chemical force (the ion's concentration gradient)
  - An electrical force (the effect of the membrane potential on the ion's movement)

⊕ Because $V_{cyt.} < 0$ [negative]

Mem. Potential favors ① passive transport of cations inwards. (attraction)

② " " of anions outwards. (repulsion)

© 2018 Pearson Education Ltd.

Diffusion of ions (+/−) across the plasma membrane is Controlled by 2 gradients

1. Chemical: Concentration (simple diffusion).
2. Electrical: wrt the membrane potential ⊕ inwards ⊖ outwards

The combination of both gradients is called

The Electrochemical gradient.

$\vec{E}$ & $\vec{C}$ can act together as in the case of $Na^+$ ions when the cell is stimulated (⊕ goes inwards) & ($Na^+$ is much higher outside). [in nerve cells.]

gates facilitate diffusion as well.

or against each other [active transport may be needed].

Each "crank" of the ($Na^+/K^+$) pump introduces a net charge transport of (1).

- An **electrogenic pump** is a transport protein that generates voltage across a membrane
- The sodium-potassium pump is the major electrogenic pump of animal cells
- The main electrogenic pump of plants, fungi, and bacteria is a **proton pump**, which actively transports hydrogen ions (H+) out of the cell
- Electrogenic pumps help store energy that can be used for cellular work

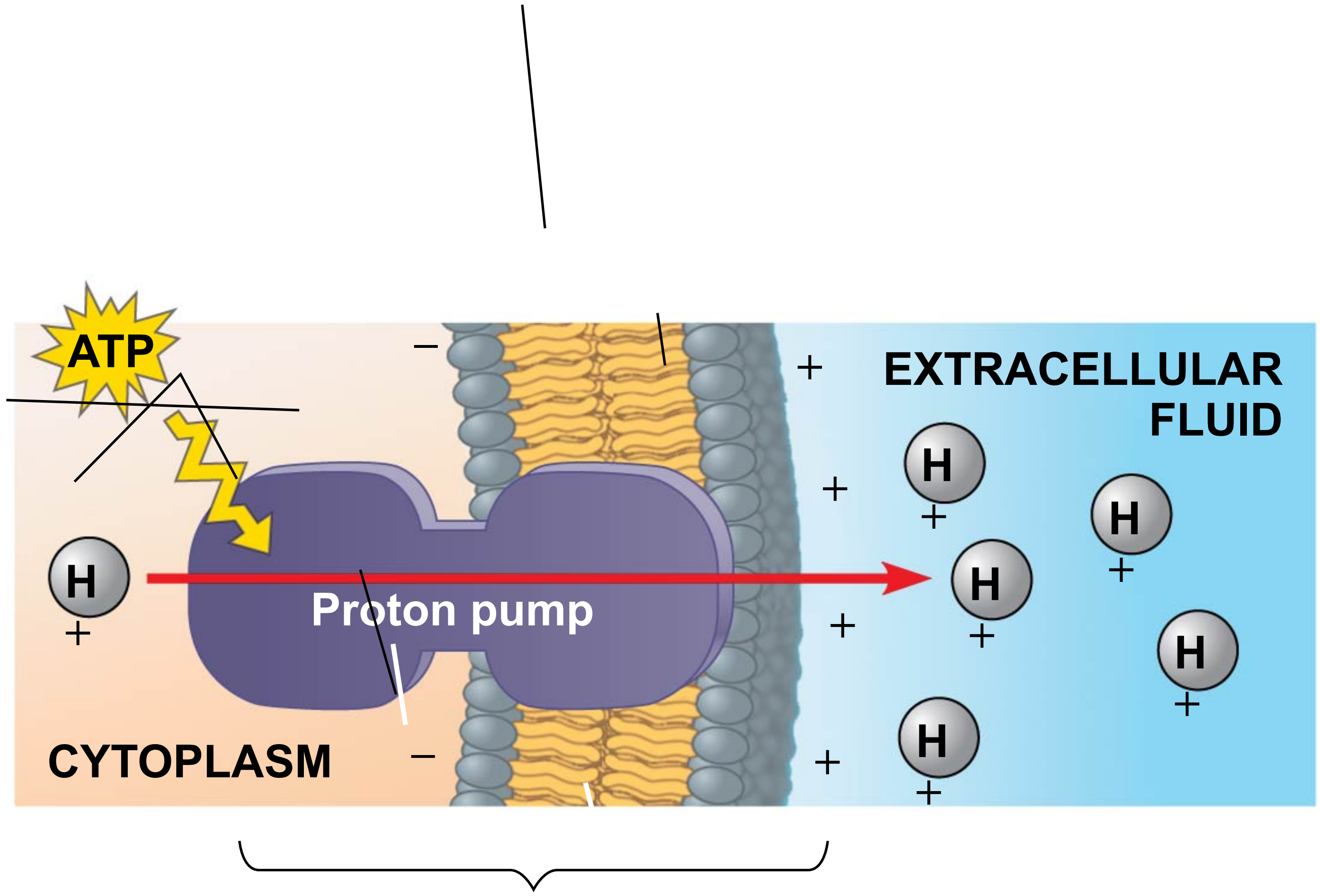
in the form of voltage difference.

e.g. ① ATP synthesis

② cotransport.

© 2018 Pearson Education Ltd.

Figure 8.17




© 2018 Pearson Education Ltd.

# otransport: Coupled Transport by a Membrane Protein

- **Cotransport** occurs when active transport of a solute indirectly drives transport of other substances
- The diffusion of an actively transported solute down its concentration gradient is coupled with the transport of a second substance (*) against its own concentration gradient } → Important.

(*) such as A. acids or sugars.

usually small molecules

(proteins & polysaccharides) are transported in bulk.

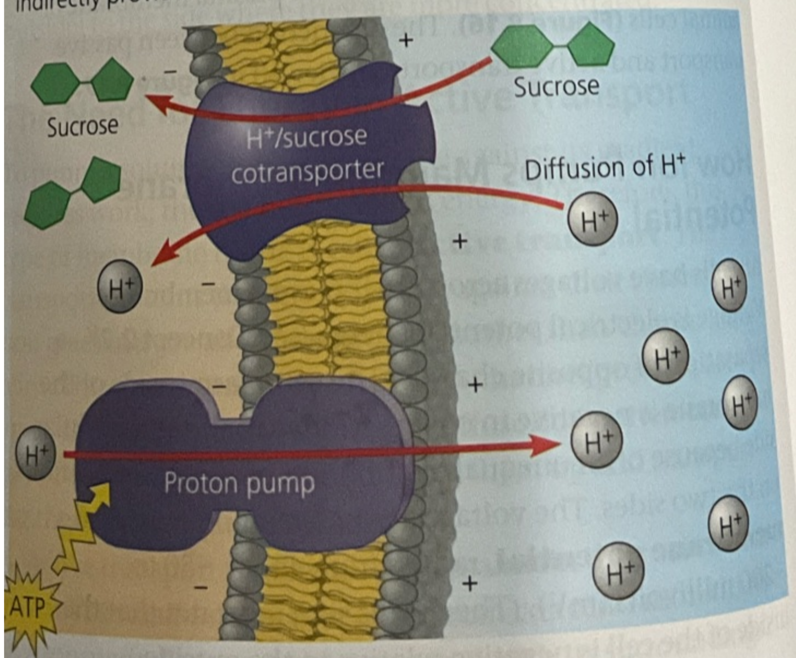
(See 8.5).

© 2018 Pearson Education Ltd.

Figure 8.18

plants load sucrose into cells in the veins of leaves to be transported "vascularily" into non-photosynthetic organs.

▼ **Figure 8.19 Cotransport: active transport driven by a concentration gradient.** A carrier protein, such as this $H^+$/sucrose cotransporter in a plant cell (top), is able to use the diffusion of $H^+$ down its electrochemical gradient into the cell to drive the uptake of sucrose. (The cell wall is not shown.) Although not technically part of the cotransport process, an ATP-driven proton pump is shown here (bottom), which concentrates $H^+$ outside the cell. The resulting $H^+$ gradient represents potential energy that can be used for active transport—of sucrose, in this case. Thus, ATP hydrolysis indirectly provides the energy necessary for cotransport.




A similar cotransporter in animals transports $Na^+$ into intestinal cells together with glucose, which is moving down its concentration gradient into the cell. (The $Na^+$ is then pumped out of the cell into the blood on the other side by $Na^+/K^+$ pumps; see Figure 8.16.) Our understanding of $Na^+$/glucose cotransporters has helped us find more effective treatments for diarrhea, a serious problem in developing countries. Normally, sodium in waste is reabsorbed in the colon, maintaining constant levels in the body, but diarrhea expels waste so rapidly that reabsorption is not possible, and sodium levels fall precipitously. To treat this life-threatening condition, patients are given a solution to drink containing high concentrations of salt (NaCl) and glucose. The solutes are taken up by $Na^+$/glucose cotransporters on the surface of intestinal cells and passed through the cells into the blood. This simple treatment has lowered infant mortality worldwide.

© 2018 Pearson Education Ltd.

# oncept 8.5: Bulk transport across the plasma membrane occurs by exocytosis and endocytosis

- Small molecules and water enter or leave the cell through the lipid bilayer or via transport proteins
- Large molecules, such as polysaccharides and proteins, cross the membrane in bulk via vesicles
- Bulk transport requires energy *

* but is not named "active transport". (1/2)

© 2018 Pearson Education Ltd.

# xocytosis

- In **exocytosis**, transport vesicles migrate to the membrane, fuse with it, and release their contents outside the cell

  (4) proteins in both membranes
  specific → help with the change in phospholipid arrangement.

- Many secretory cells use exocytosis to export their products → Such as (1) pancreatic cells (secrete insulin).

  (2) release of neurotransmitters for signals.

  (3) release of necessary carbohydrates and other materials when building cell walls.

© 2018 Pearson Education Ltd.

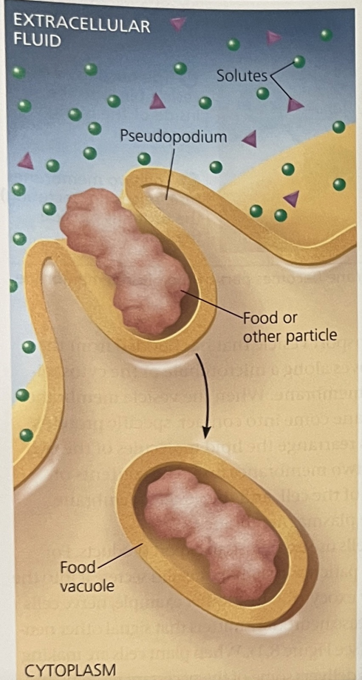
# ndocytosis

- In **endocytosis**, the cell takes in macromolecules by forming vesicles from the plasma membrane
- Endocytosis is a reversal of exocytosis, involving different proteins
- There are three types of endocytosis
  - Phagocytosis ("cellular eating")
  - Pinocytosis ("cellular drinking")
  - Receptor-mediated endocytosis

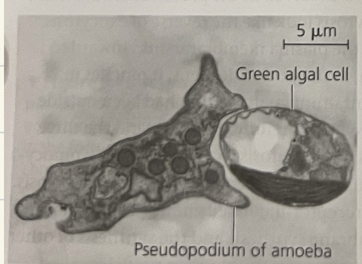
© 2018 Pearson Education Ltd.

## Figure 8.21 Exploring Endocytosis in Animal Cells

### Phagocytosis

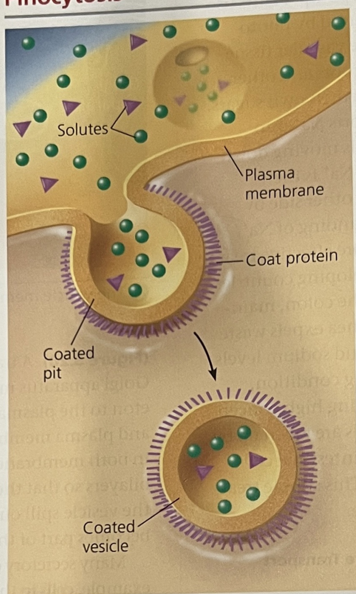



In **phagocytosis**, a cell engulfs a particle by extending pseudopodia (singular, *pseudopodium*) around it and packaging it within a membranous sac called a food vacuole. The particle will be digested after the food vacuole fuses with a lysosome containing hydrolytic enzymes (see Figure 7.13a).

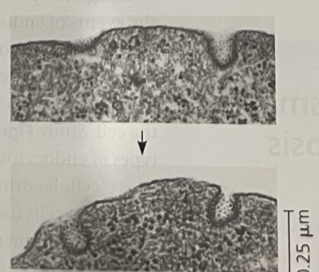



An amoeba engulfing a green algal cell via phagocytosis (TEM).

### Pinocytosis

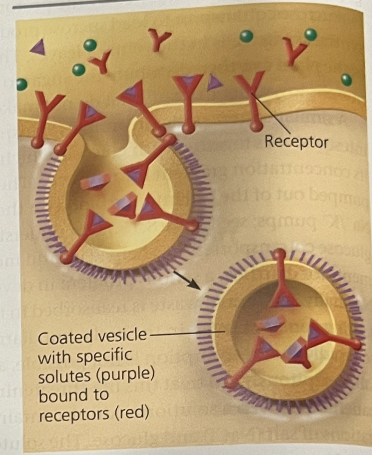



In **pinocytosis**, a cell continually "gulps" droplets of extracellular fluid into tiny vesicles, formed by infoldings of the plasma membrane. In this way, the cell obtains molecules dissolved in the droplets. Because any and all solutes are taken into the cell, pinocytosis as shown here is nonspecific for the substances it transports. In many cases, the parts of the plasma membrane that form vesicles are lined on their cytoplasmic side by a fuzzy layer of coat protein; the "pits" and resulting vesicles are called *coated pits*.

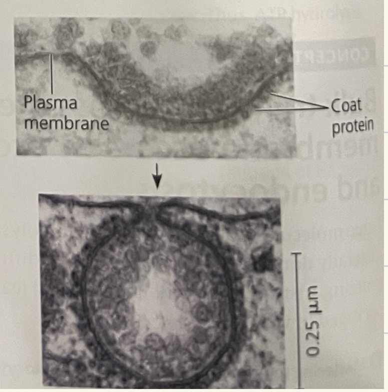



Pinocytotic vesicles forming (TEMs).

### Receptor-Mediated Endocytosis




**Receptor-mediated endocytosis** is a specialized type of pinocytosis that enables the cell to acquire bulk quantities of specific substances, even though those substances may not be very concentrated in the extracellular fluid. Embedded in the plasma membrane are proteins with receptor sites exposed to the extracellular fluid. Specific solutes bind to the receptors. The receptor proteins then cluster in coated pits, and each coated pit forms a vesicle containing the bound molecules. The diagram shows only bound molecules (purple triangles) inside the vesicle, but other molecules from the extracellular fluid are also present. After the ingested material is liberated from the vesicle, the emptied receptors are recycled to the plasma membrane by the same vesicle (not shown).




**VISUAL SKILLS** *Use the scale bars to estimate the diameters of (a) the food vacuole that will form around the algal cell (left ...*

Plasma membrane SA loss by endocytosis is Balanced by exocytosis.

Phagocytosis and Pinocytosis are not specific unlike R.M. Endocytosis.

- Human cells use receptor-mediated endocytosis to take in cholesterol, which is carried in particles called low-density lipoproteins (LDLs) ⊛ a complex of lipids and a protein.
- Individuals with the disease familial hypercholesterolemia have missing or defective LDL receptor proteins

↳ contributing to high [LDL's] in blood

thus causing early atherosclerosis ≡ the build-up of Lipids within blood vessels' walls.

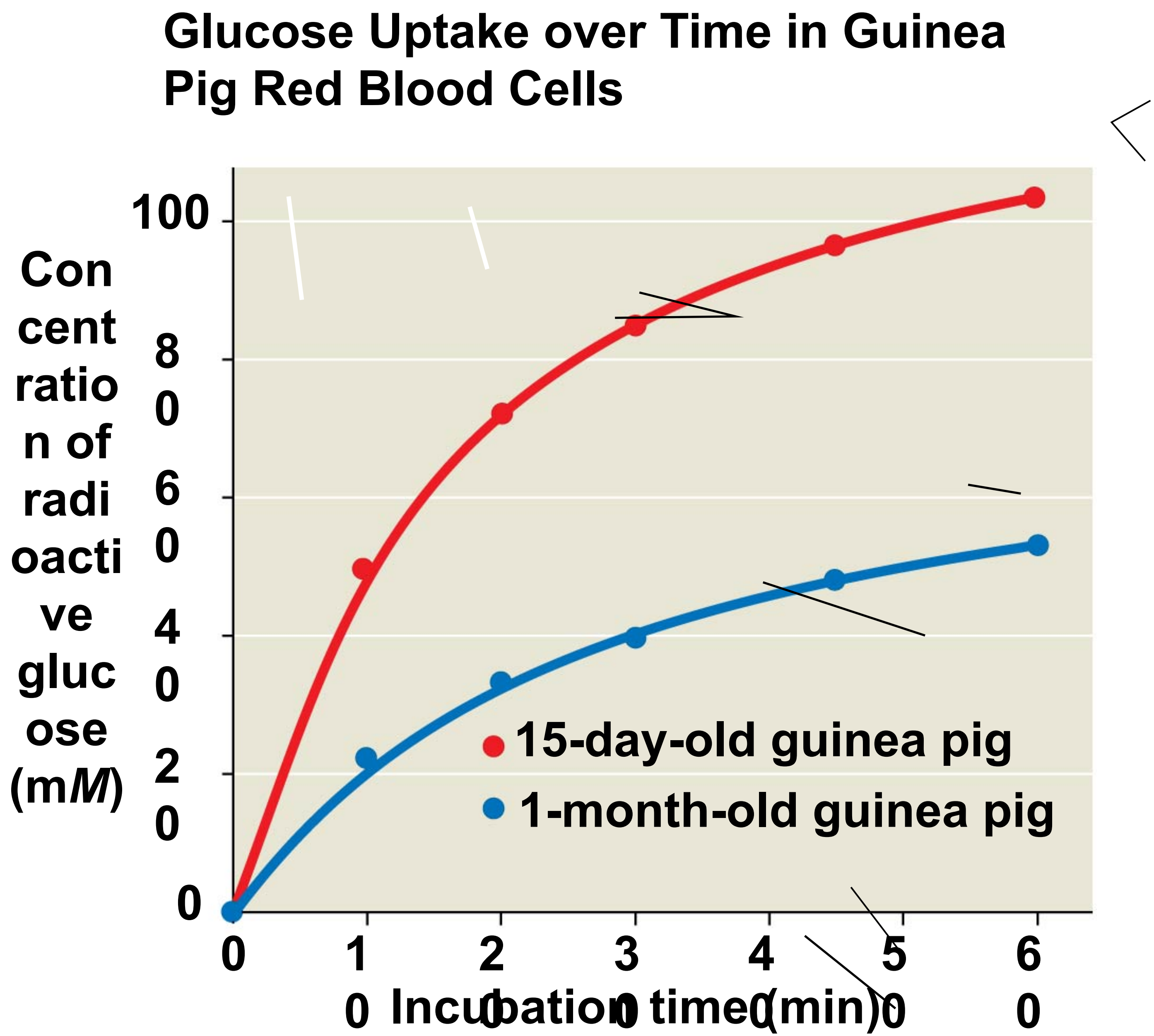
mentioned earlier in saturated and trans-fats.

⇓

heart damage and strokes.

© 2018 Pearson Education Ltd.

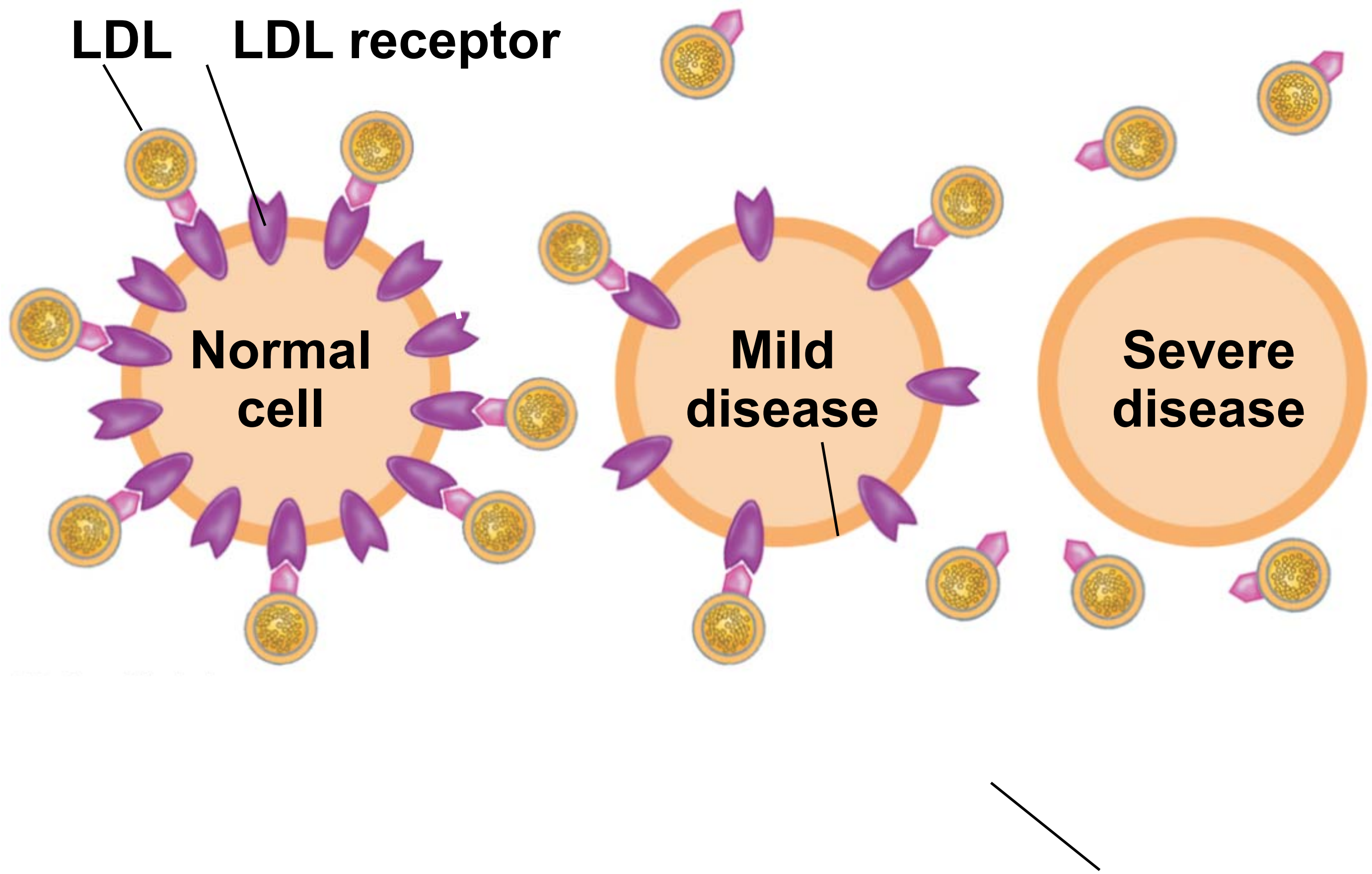
Figure 8.UN02a




Data from T. Kondo and E. Beutler, Developmental changes in glucose transport of guinea pig erythrocytes, *Journal of Clinical Investigation* 65:1–4 (1980).

© 2018 Pearson Education Ltd.

Figure 8.UN03




© 2018 Pearson Education Ltd.