SREE NARAYANA NURSING COLLEGE

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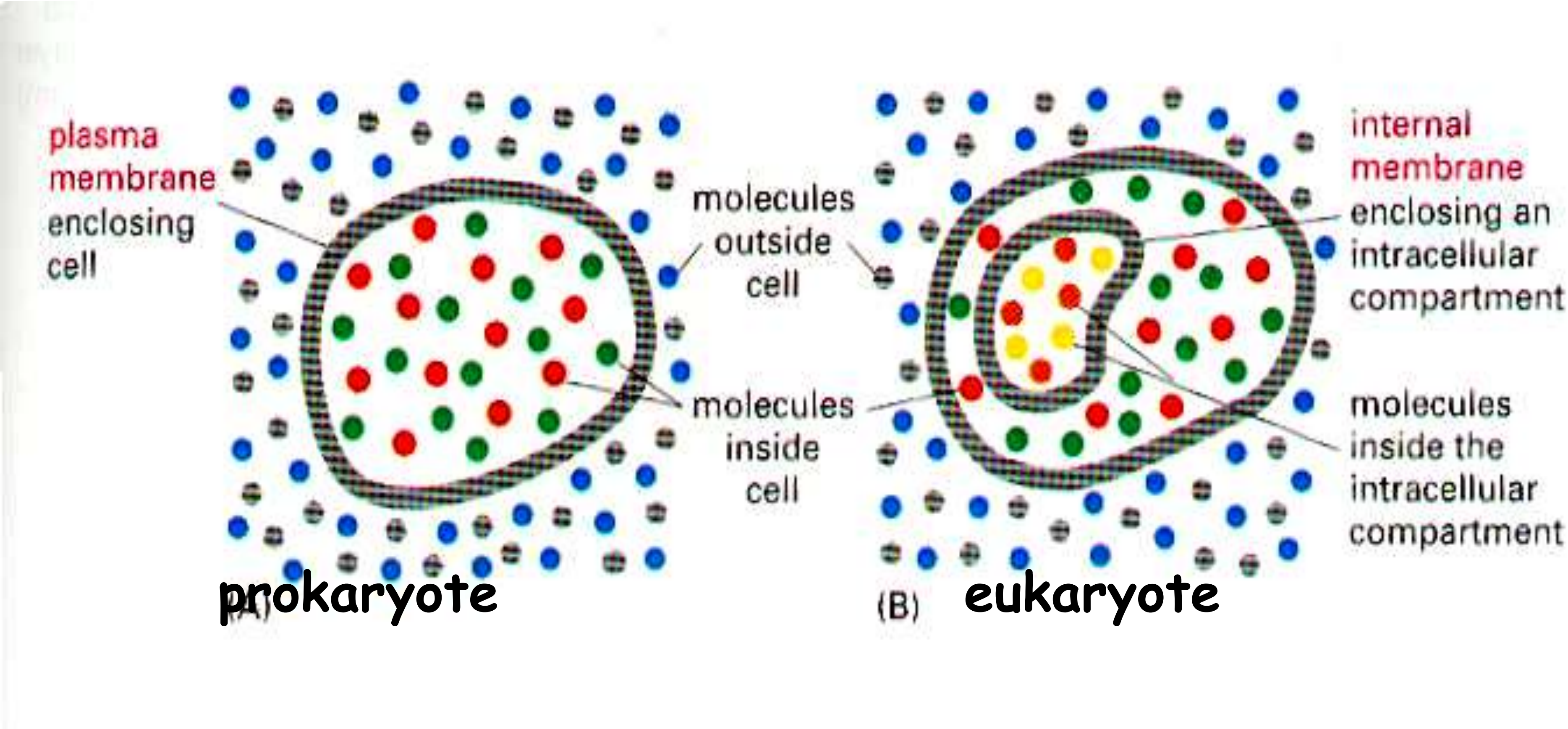
Cell membranes

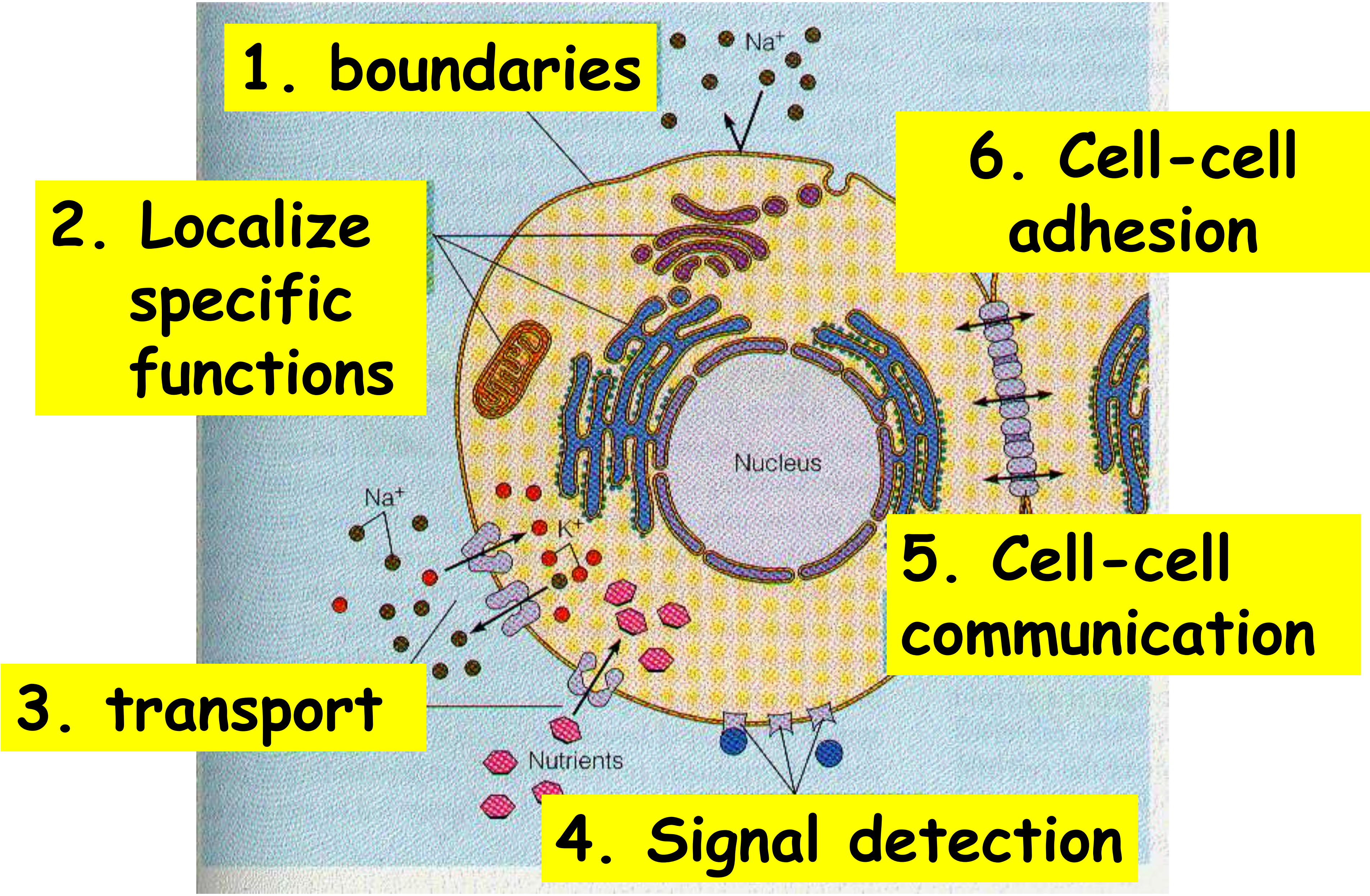
1. What are the functions of cell membranes?
2. What is the current model of membrane structure?
3. Evidence supporting the fluid mosaic model
4. How appropriate fluidity is maintained

Membrane: organized arrangement of lipids and proteins that encloses and separates the cell from its surroundings



Membranes define spaces with distinctive character and function

Membrane Functions



major functions of membrane proteins

(a)

Transport. (left) A protein that spans the membrane
may provide a hydrophilic channel across the
men ute.
(rig tance
from Some
of these proteins hydrolyze ATP as an energy ssource
to actively pump substances across the membrane.

3. transport

(b)

E he membrane
m xposed to
s some cases,
s ganized as
a of a
m

2. Localize specific functions

(c)

Signal transduction. A membrane protein may have
hape
he

4. Signal detection

conformational change in the protein (receptor) that
relays the message to the inside of the cell.

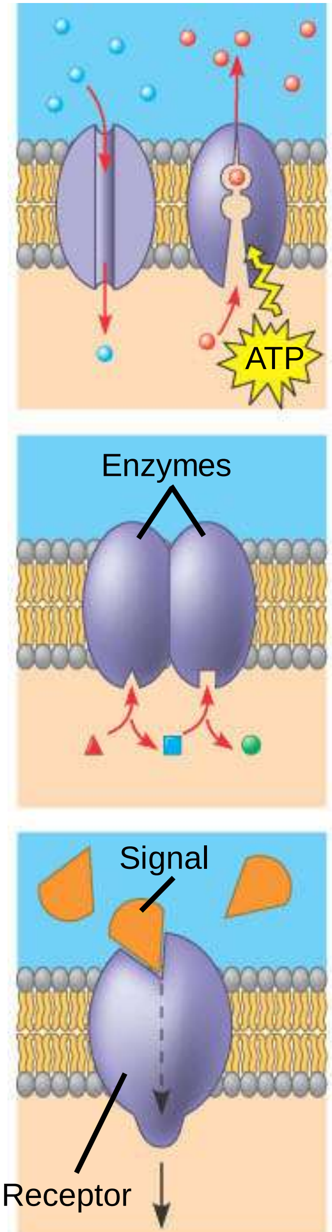
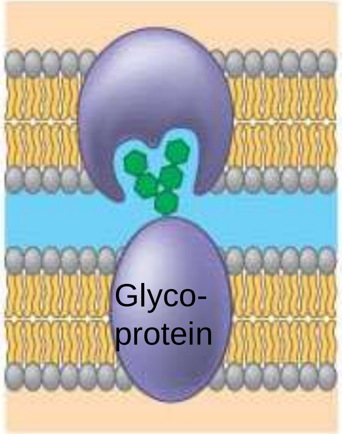


Figure 7.9

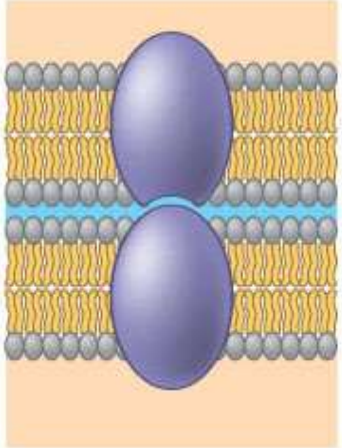
(d) **Cell-cell recognition.** Some glyco-proteins serve as identification tags that are specifically recognized

5. Cell-cell communication



(e) **Intercellular joining.** Membrane proteins of adjacent cells may hook together in various kinds of junctions, such as gap junctions or tight junctions (see Figure 6.31).

6. Cell-cell adhesion



(f) **Attachment to the cytoskeleton and extracellular matrix (ECM).** Microfilaments or other elements of the cytoskeleton may be bonded to membrane proteins, a d stabilizes th roteins that ac ular and intracellular changes (see Figure 6.29).

1. boundaries

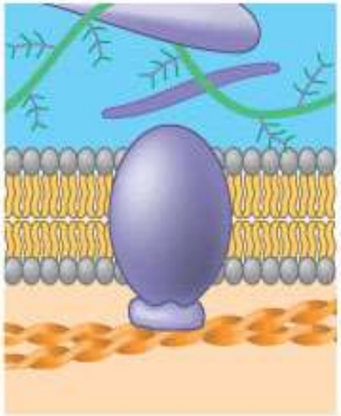


Figure 7.9

Transport – Lect 10

materials across membranes

Cell Signaling – Lect 11

external signals trigger internal events

Biochemical functions – Lects 16-19

Oxidative Phosphor, Photosynthesis

Importance of Membranes in biochemical Rxns

Current Understanding of Membrane Structue: Fluid Mosaic Model

1972 Singer & Nicholson

Proteins embedded and floating in a sea of phospholipids

Familiar features?

Problems ?

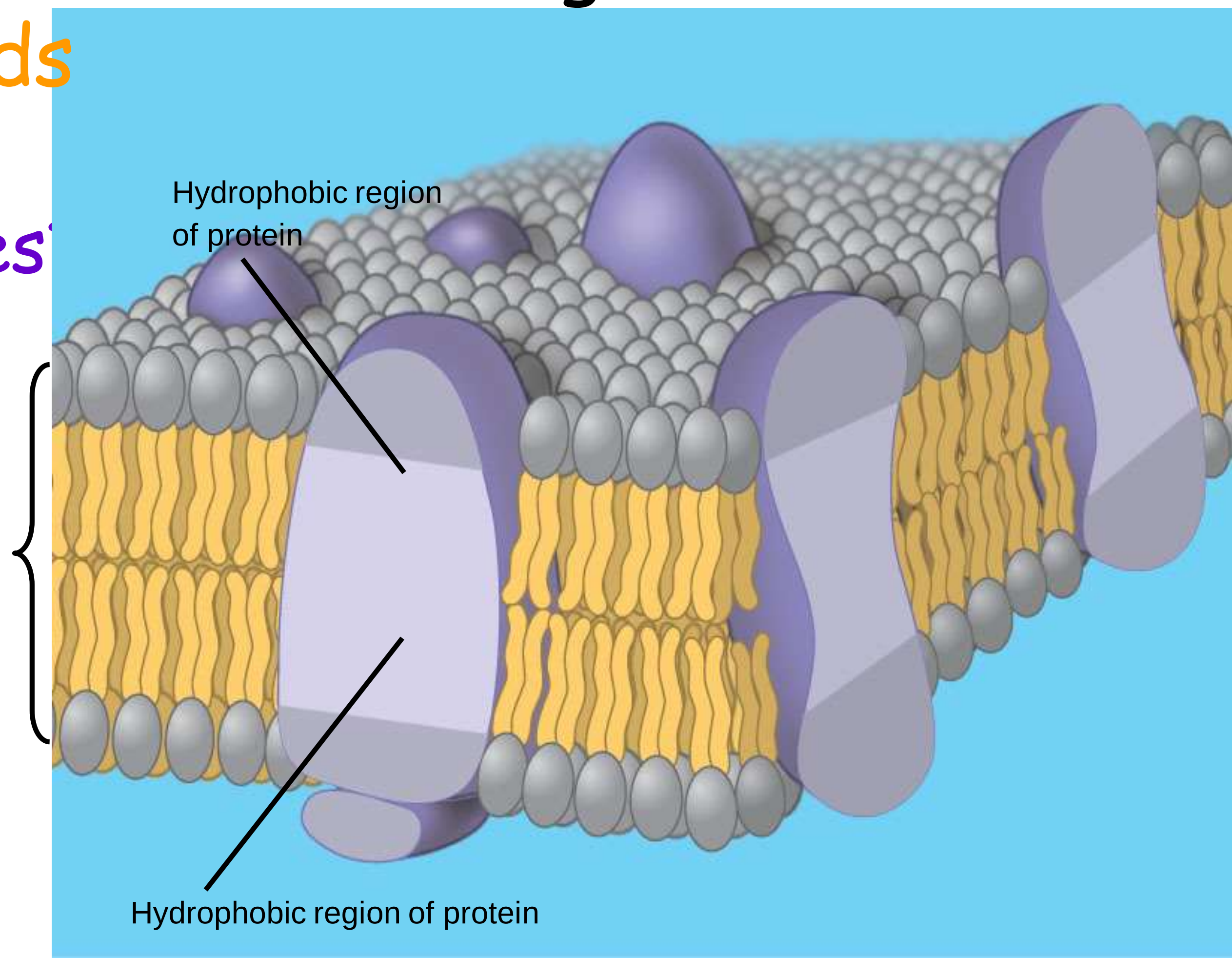


Figure 7.3

- Integral Membrane proteins

  Span the phospholipid bilayer – usually α-helices

Why do proteins cross membranes as α-helices?

Must present hydrophobic surface

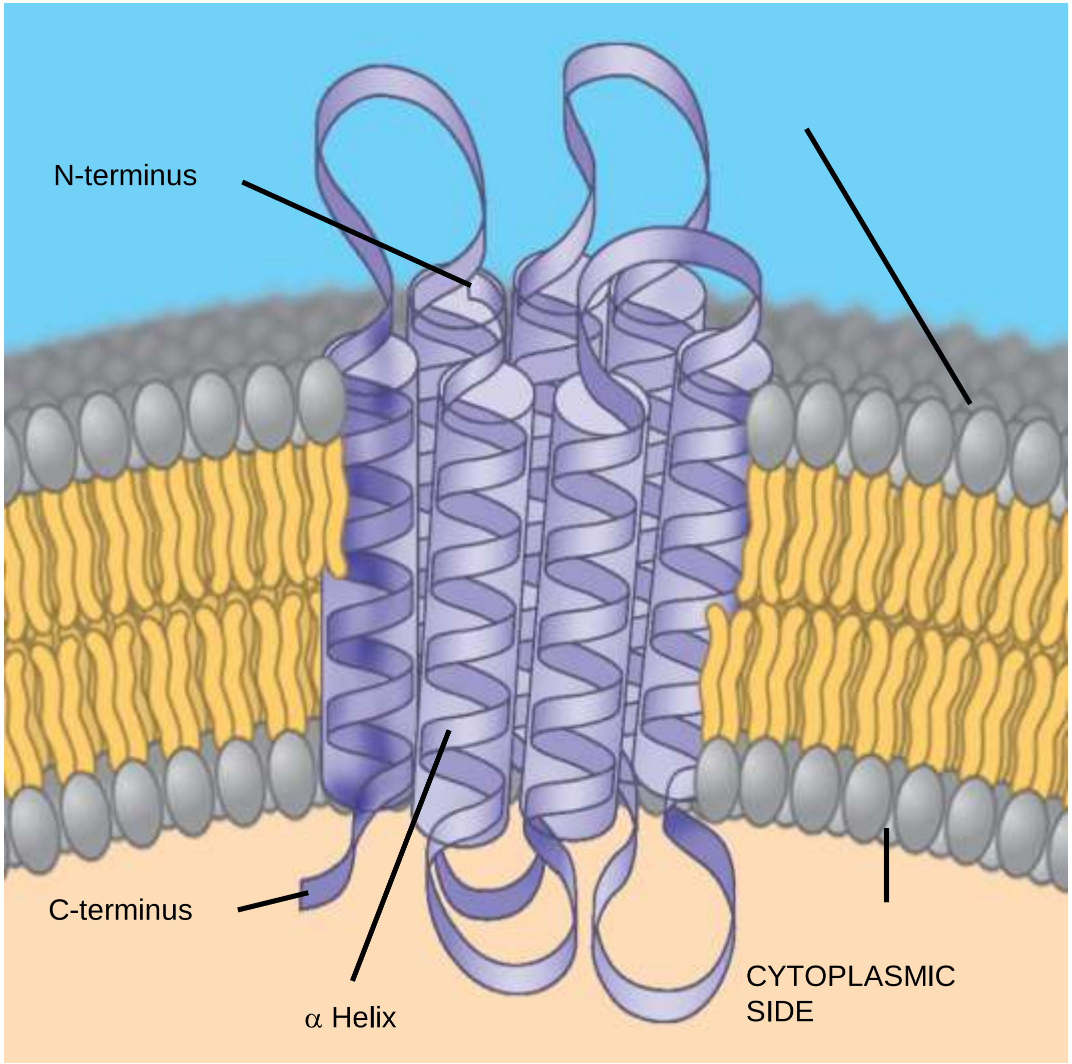
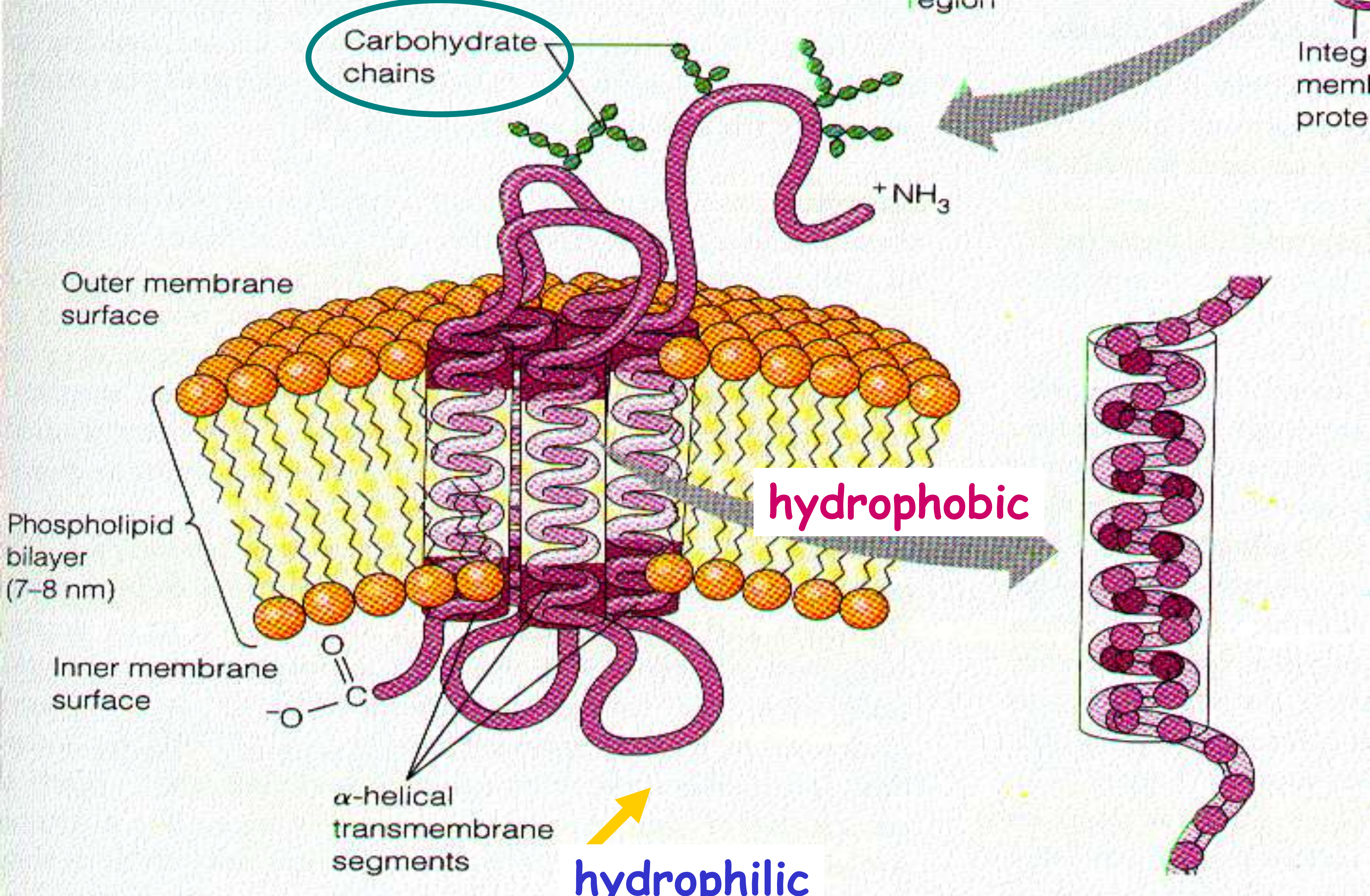


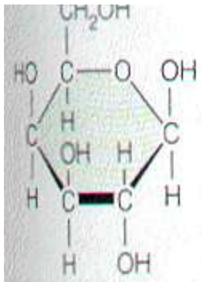
Figure 7.8



(b) An integral membrane protein

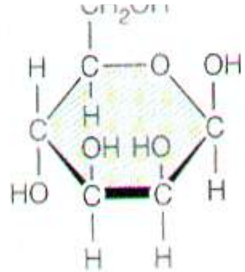
(c) An enlarged α-helical transmembrane segment (20–30 amino acids)

Sugars commonly found on glycoproteins

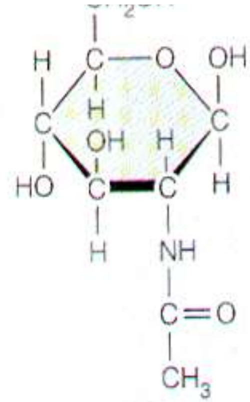


β-D-galactose (Gal)

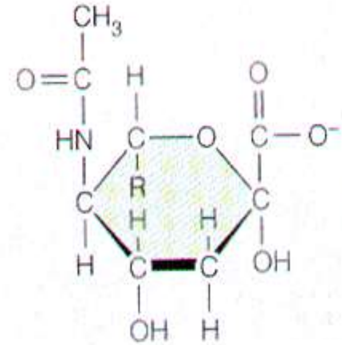
β-D-galactose



β-D-mannose

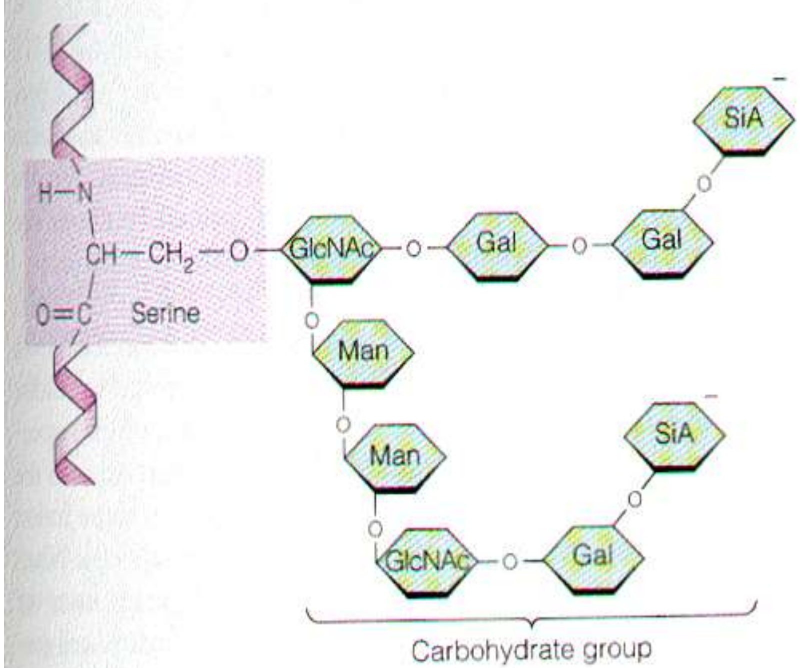


N-acetyl-β-D-glucosamine



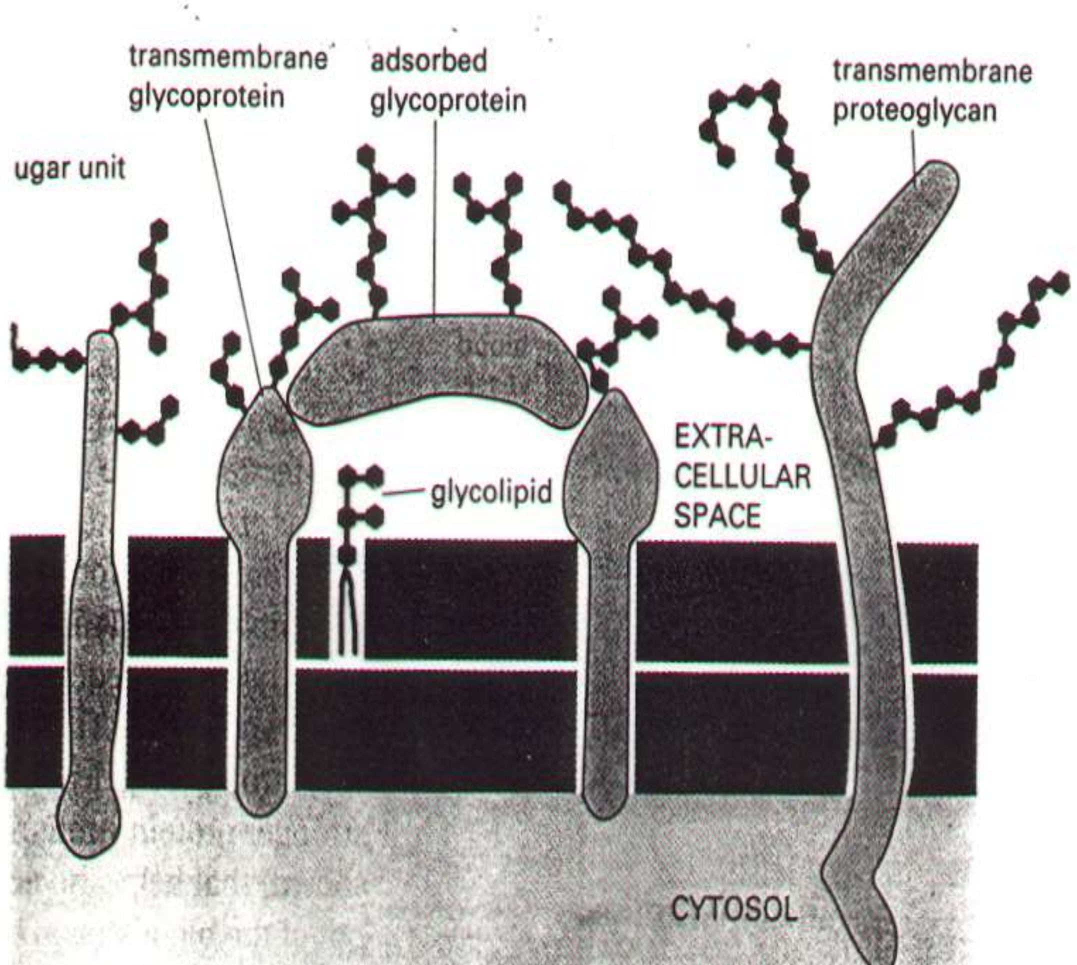
Sialic acid (SIA)
- charge

(a) Common sugars found in glycoproteins

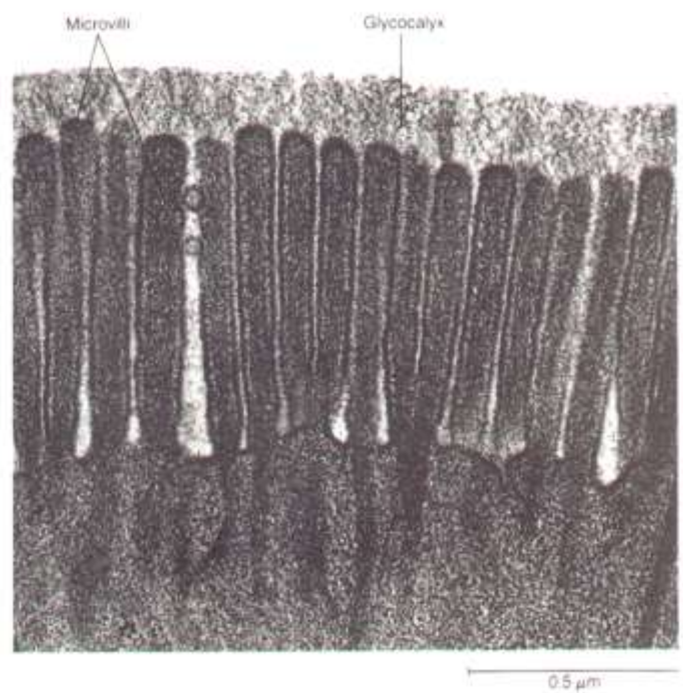


c. Carbohydrates – small amts often linked to proteins or lipids

Glycocalyx: *"sugar coat"*



Outside cell



Inside cell

- Membrane proteins and lipids
  - Are synthesized in the ER and Golgi apparatus

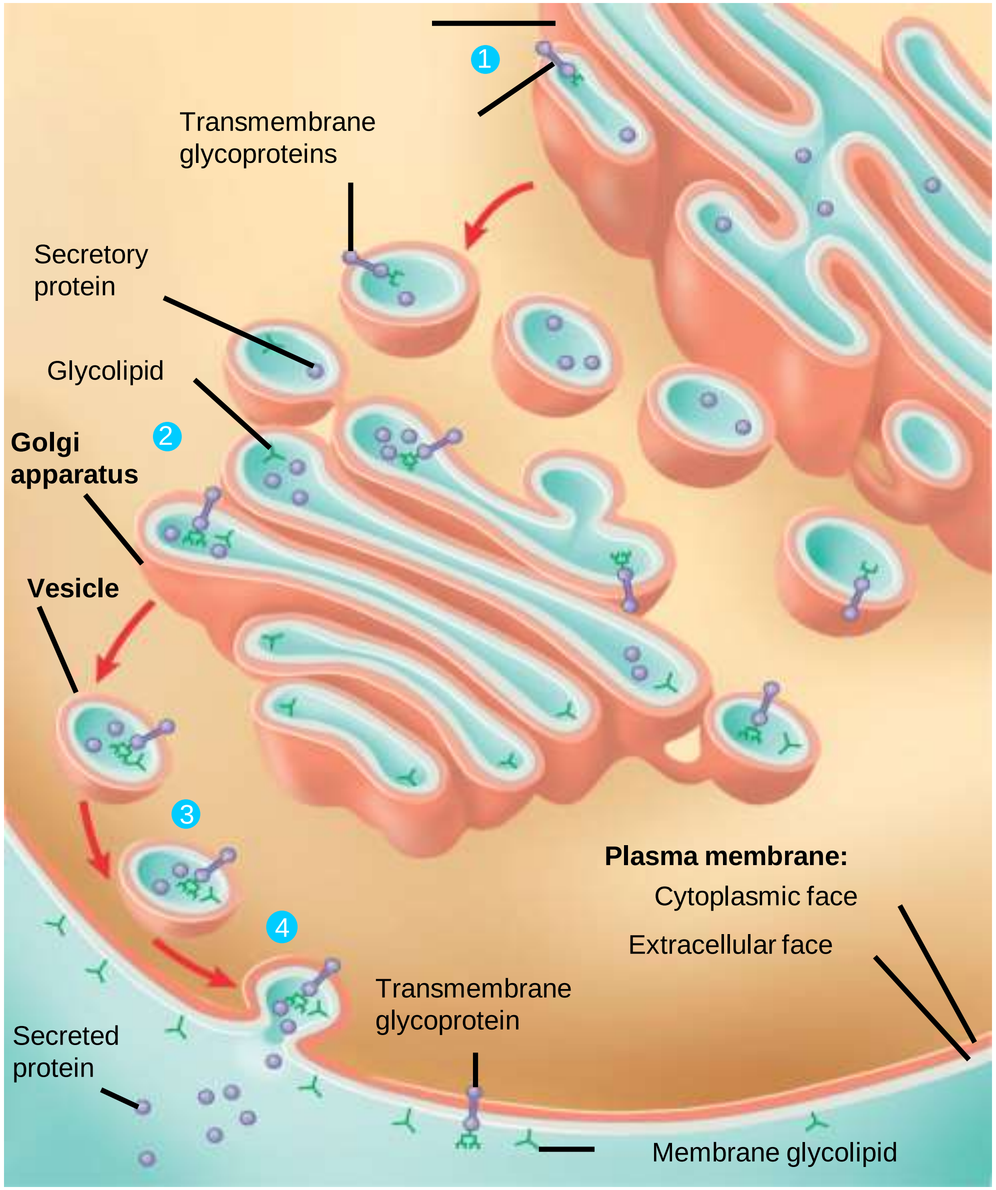
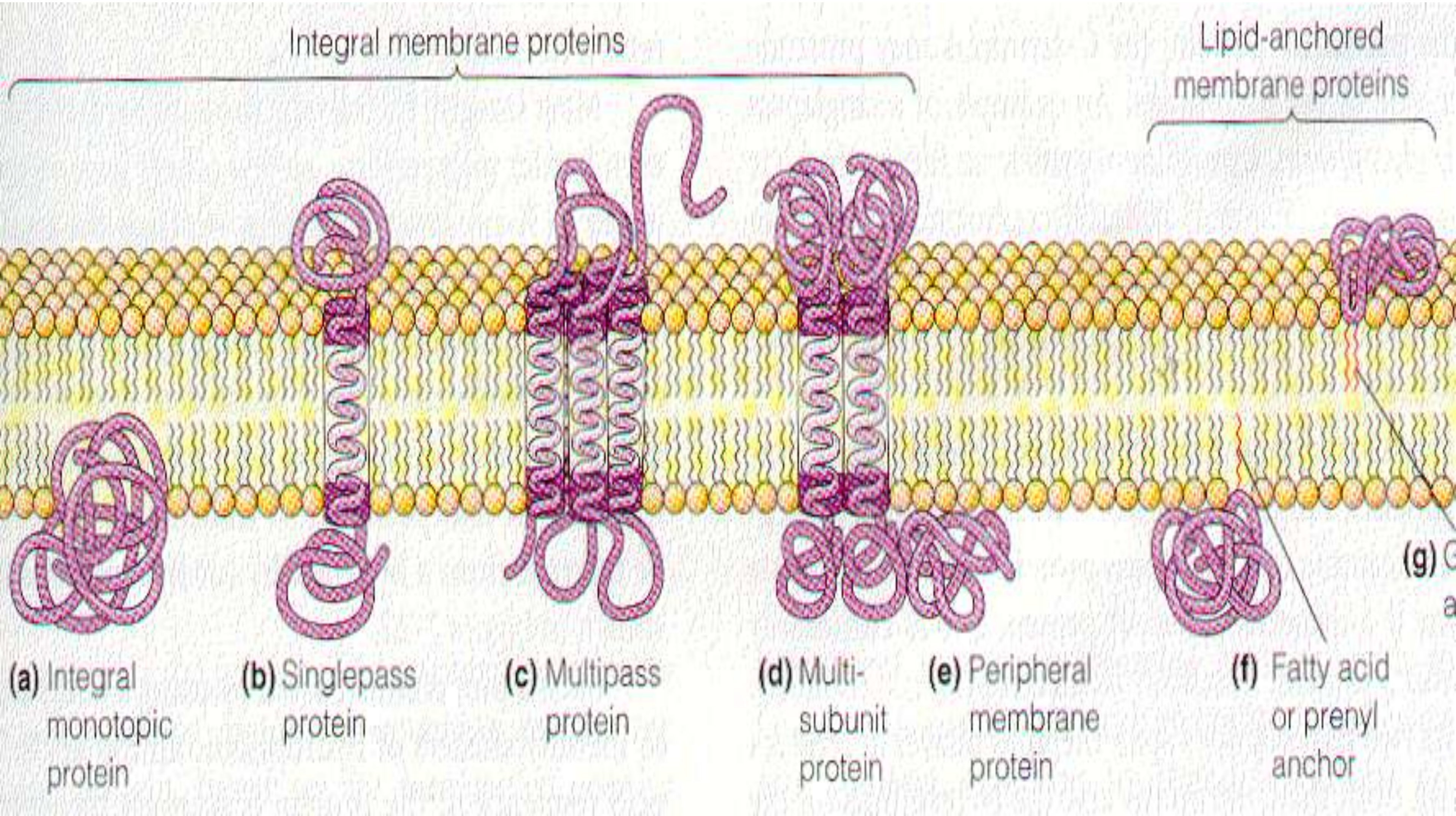


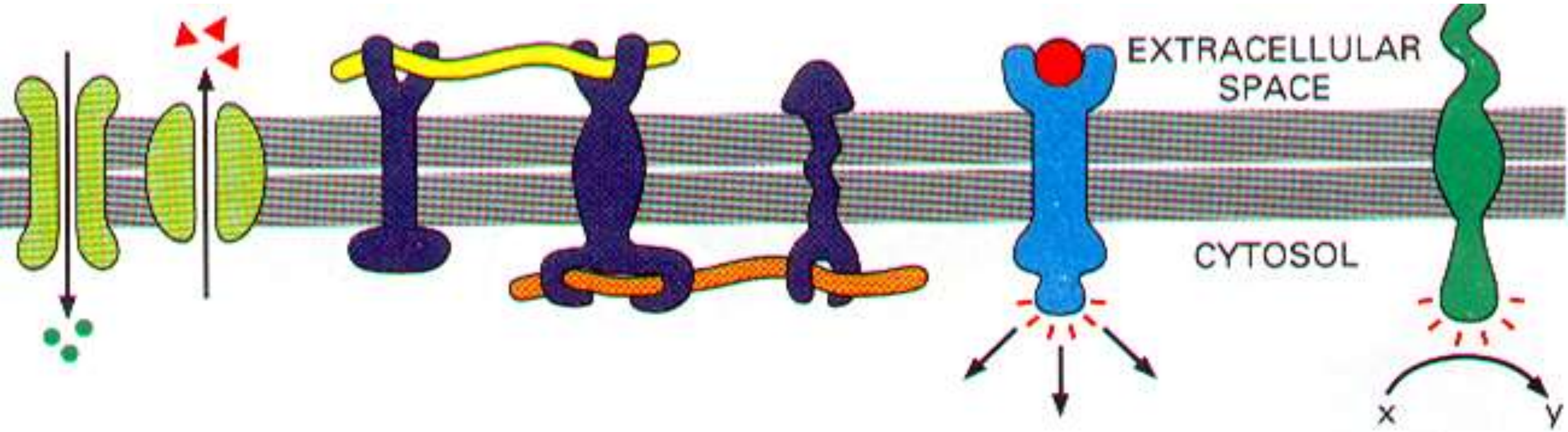
Figure 7.10

Membrane proteins

- Integral
  - Peripheral
    - Lipid-anchored



Roles of membrane proteins?

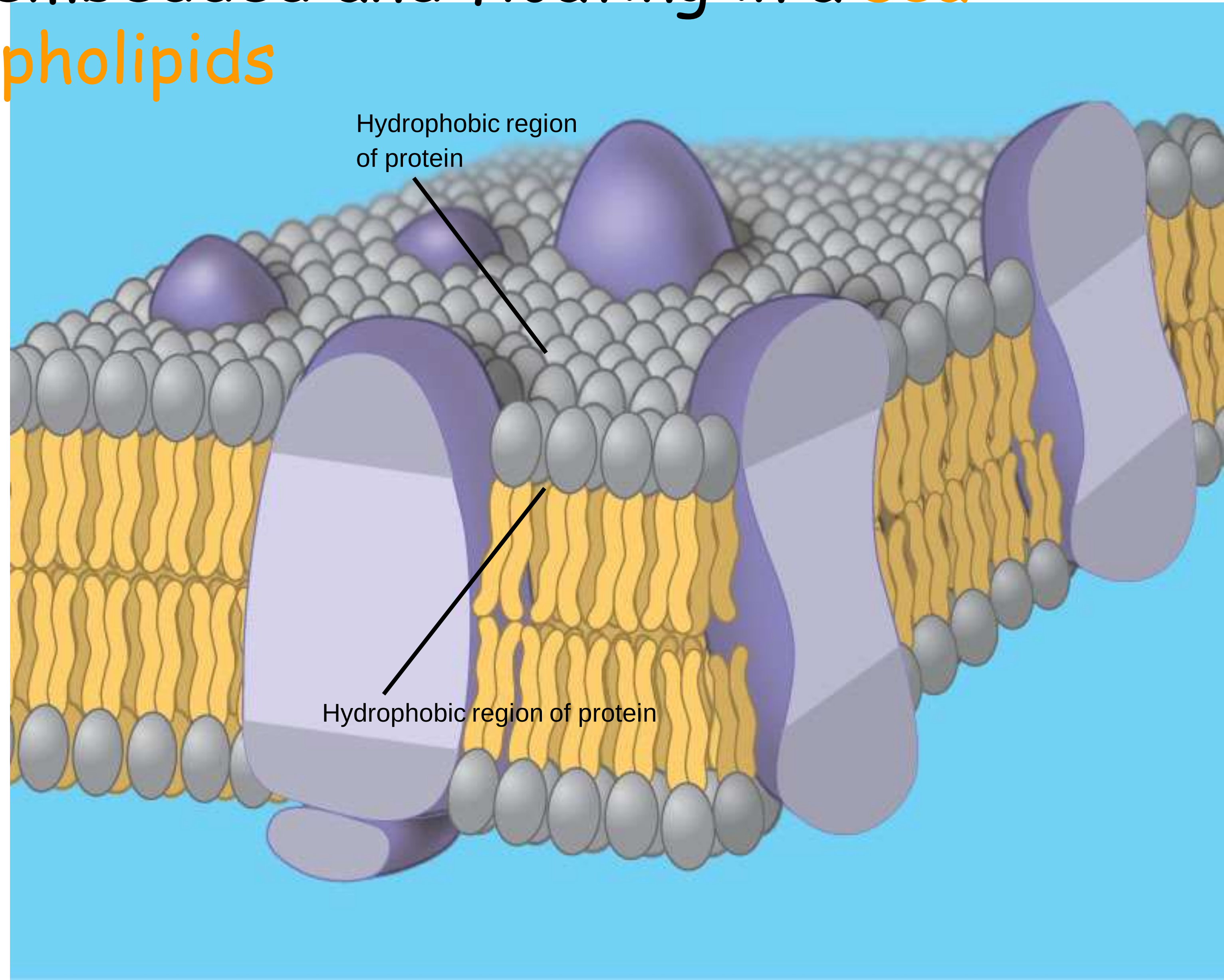


A. Transport - channels and pumps
B. Links to structural proteins
C. Receptors - doorbells
D. Enzymes - localized biochemical rxns
E. Energy Generation - utilize gradient

Fluid Mosaic Model

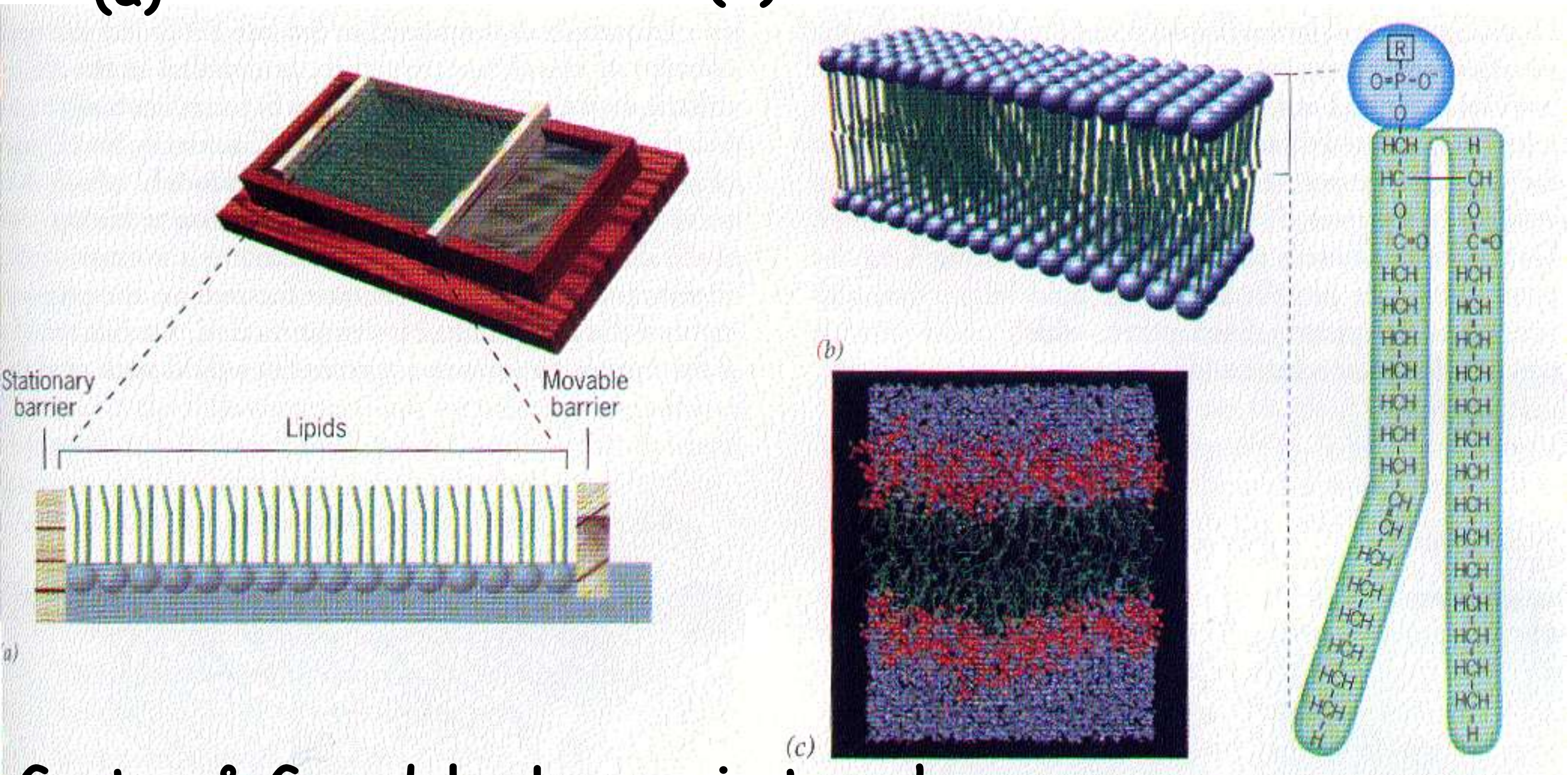
Proteins embedded and floating in a sea of phospholipids

Evidence?



Evidence for Phospholipid

(a) (b)

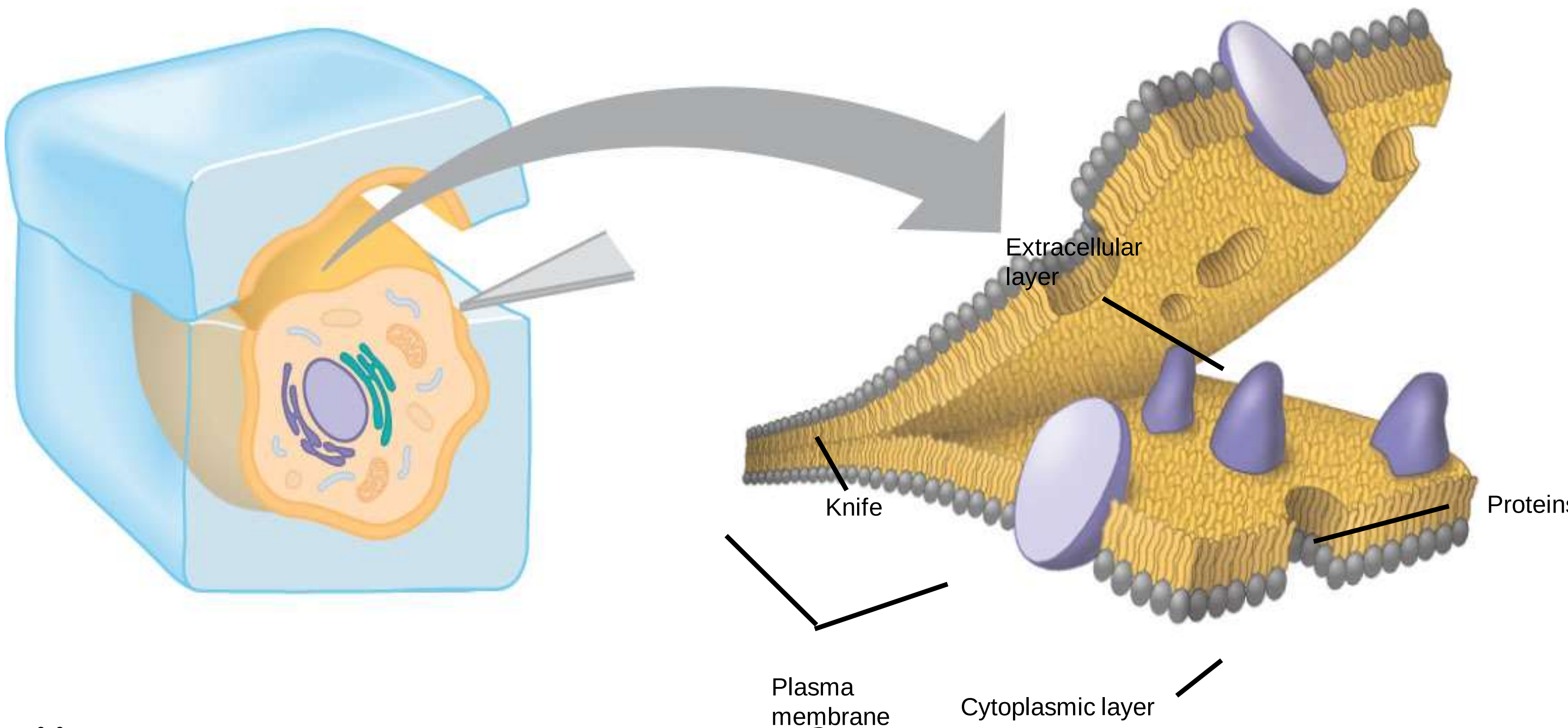


Gorter & Grendel – Langmuir trough

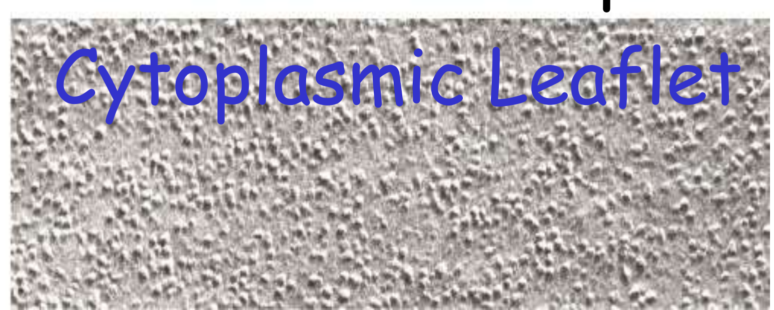
Red blood cells had enough lipid to twice cover their surface

Conclude lipid is a bilayer – hydrophilic heads faced aqueous environment

Evidence for integral membrane proteins: Freeze-Fracture Electron Microscopy



Illustrates: asymmetry of membrane componets

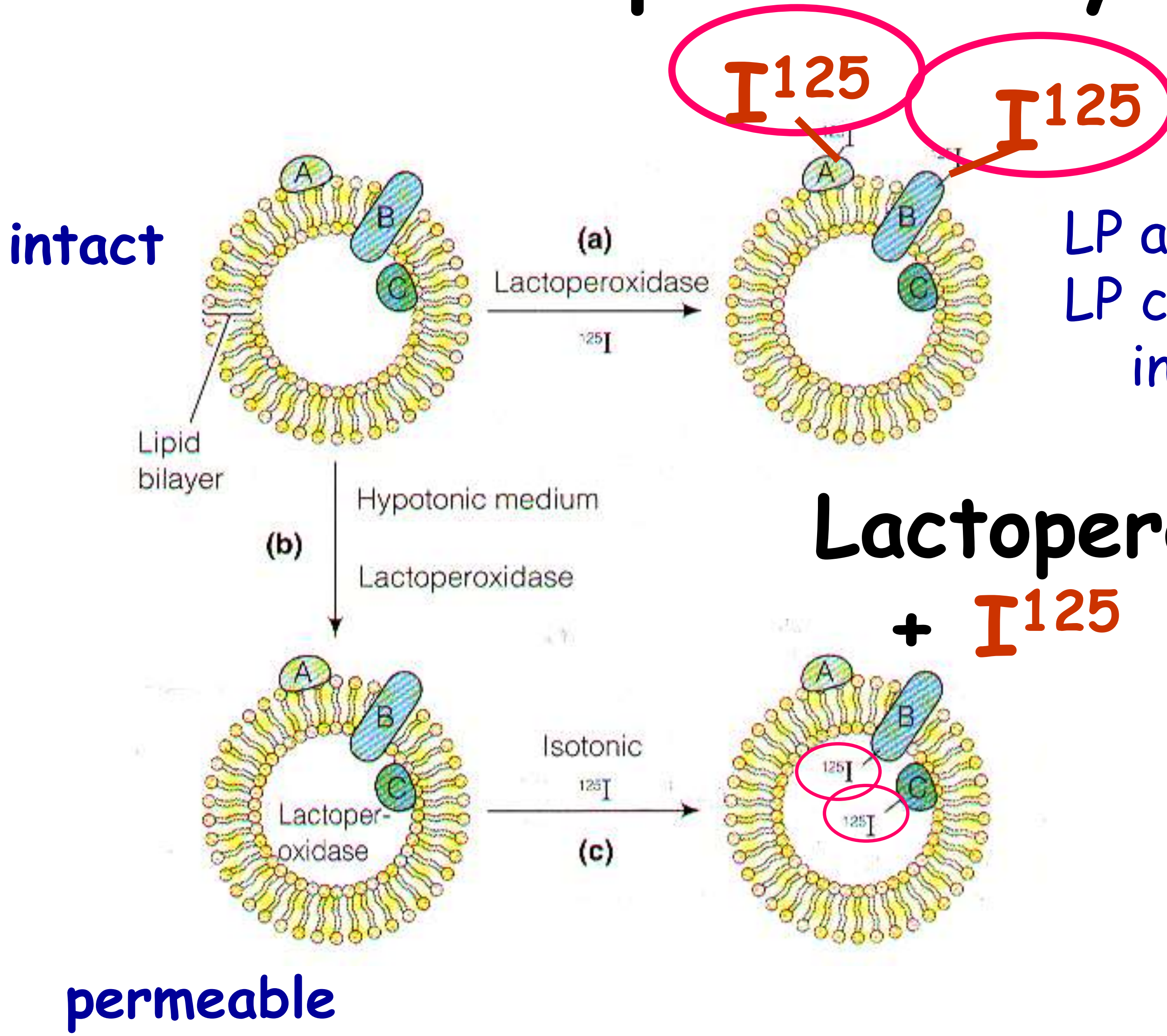


Fluid Mosaic Model predicts:

A. Membranes are fluid: lipids & proteins move in the plane of the bilayer

B. Proteins and lipids are asymmetrically distributed in the bilayers

Evidence for protein asymmetry



LP adds I to protein
LP can't pass thru intact membrane

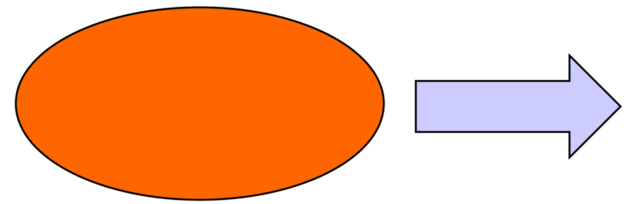
Lactoperoxidase (LP) + I^{125}

Evidence for lipid asymmetry?

Cut off head groups off of exposed lipids

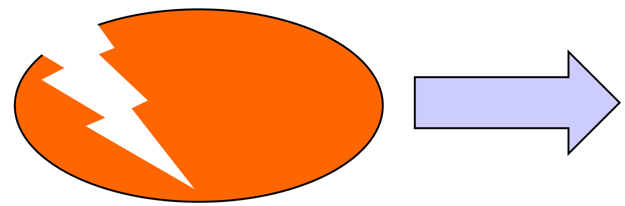
Digested them with phospholipase

Intact red blood cells



SM, PC

Broken red blood cells



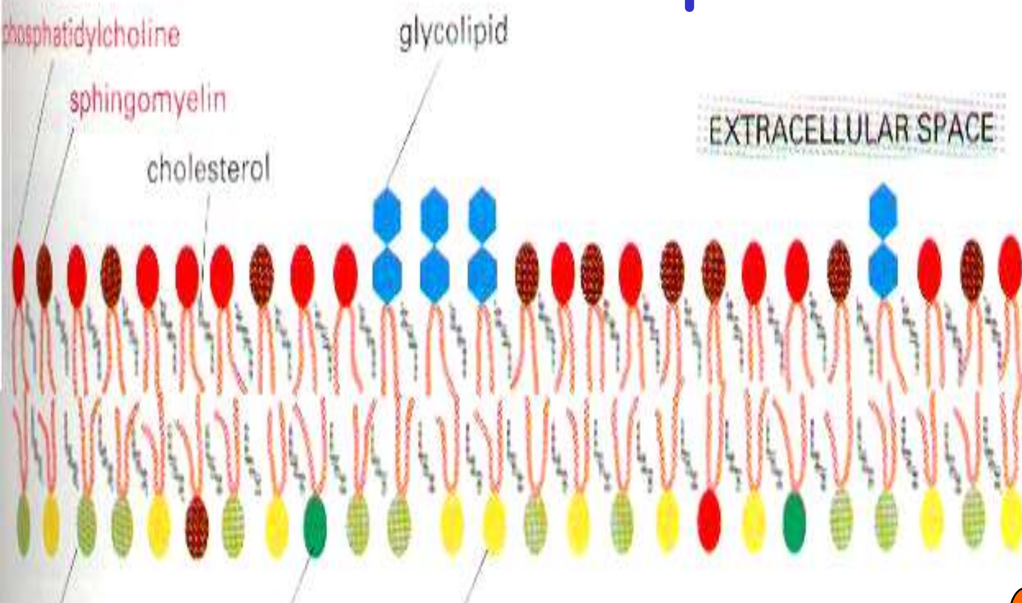
PE, PS
SM & PC

Results: ***isolated different types of phospholipids suggesting lipids were distributed <u>differently</u> in the inner and out parts of the bilayer***

SM, sphingomyelin; PC, phosphatidylcholine;
PE, phosphatidylcholine; PS phosphatidylserine

Mosaic: Lipids are asymmetrically distributed

Extracellular space



Cytosol

- phosphatidylcholine
- sphingomyelin
- glycolipid
- cholesterol

- phosphatidylinositol
- phosphatidylserine
- phosphatidylethanolamine

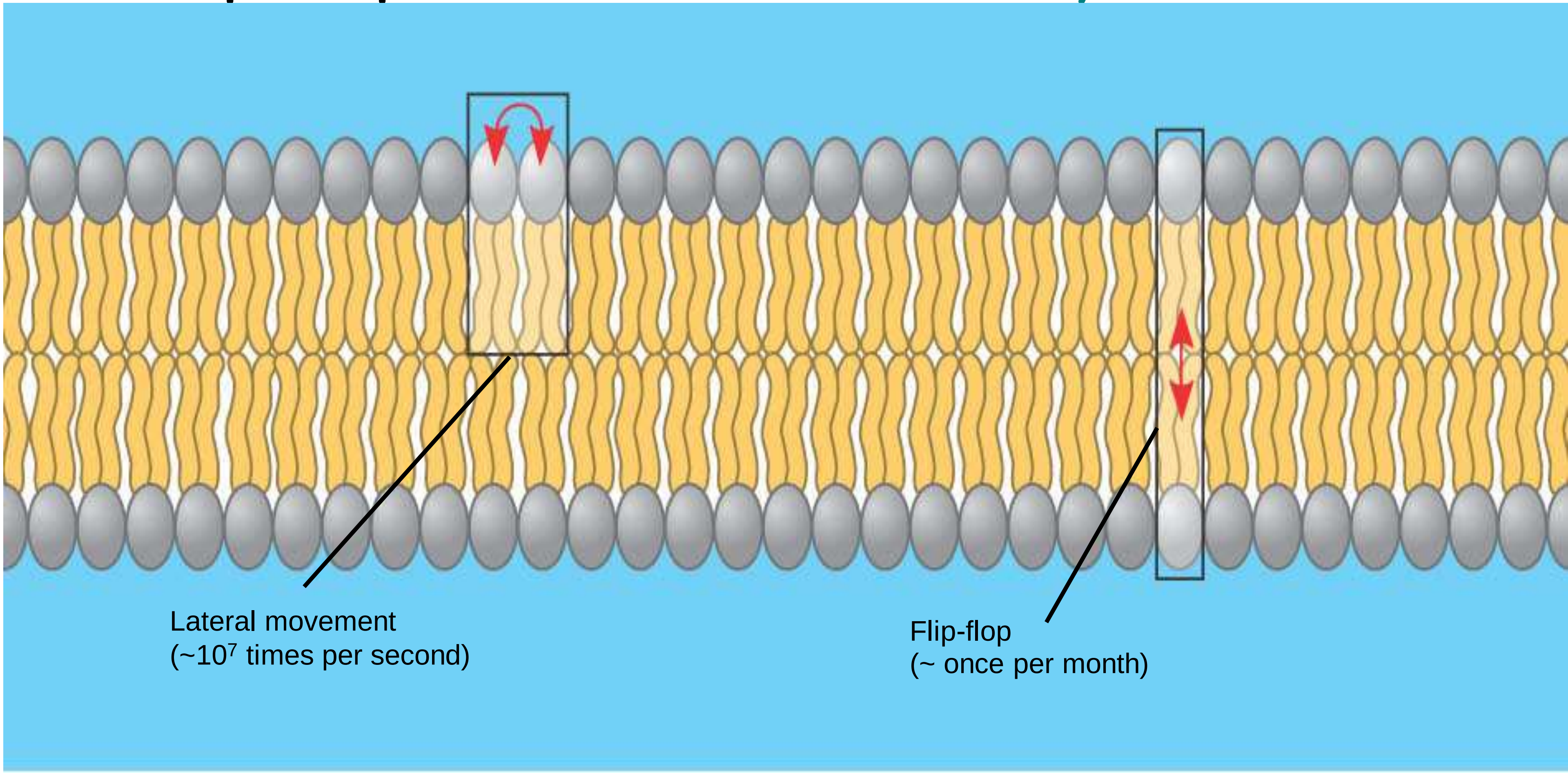
Fluid Mosaic Model predicts:

A. Membranes are fluid: lipids & proteins move in the plane of the bilayer

B. Proteins and lipids are asymmetrically distributed in the bilayers

The Fluidity of Membranes

- Phospholipids can move *laterally* within the

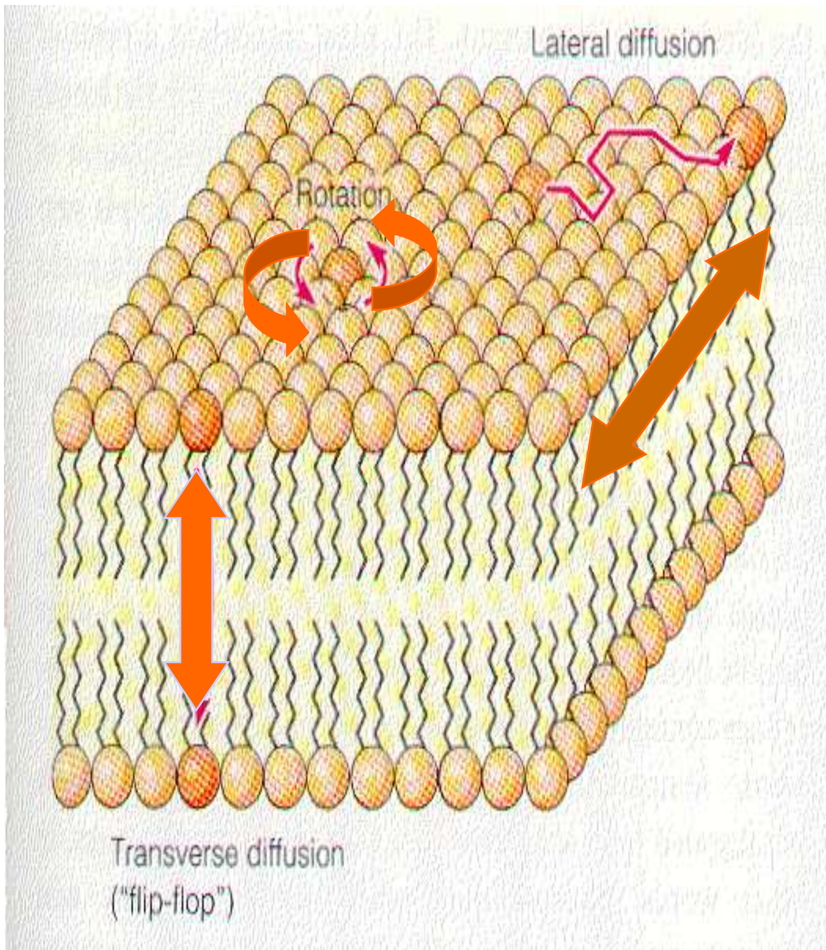


(a) Movement of phospholipids

Figure 7.5 A

Movement of membrane phospholipids

1. Rotation about long axis



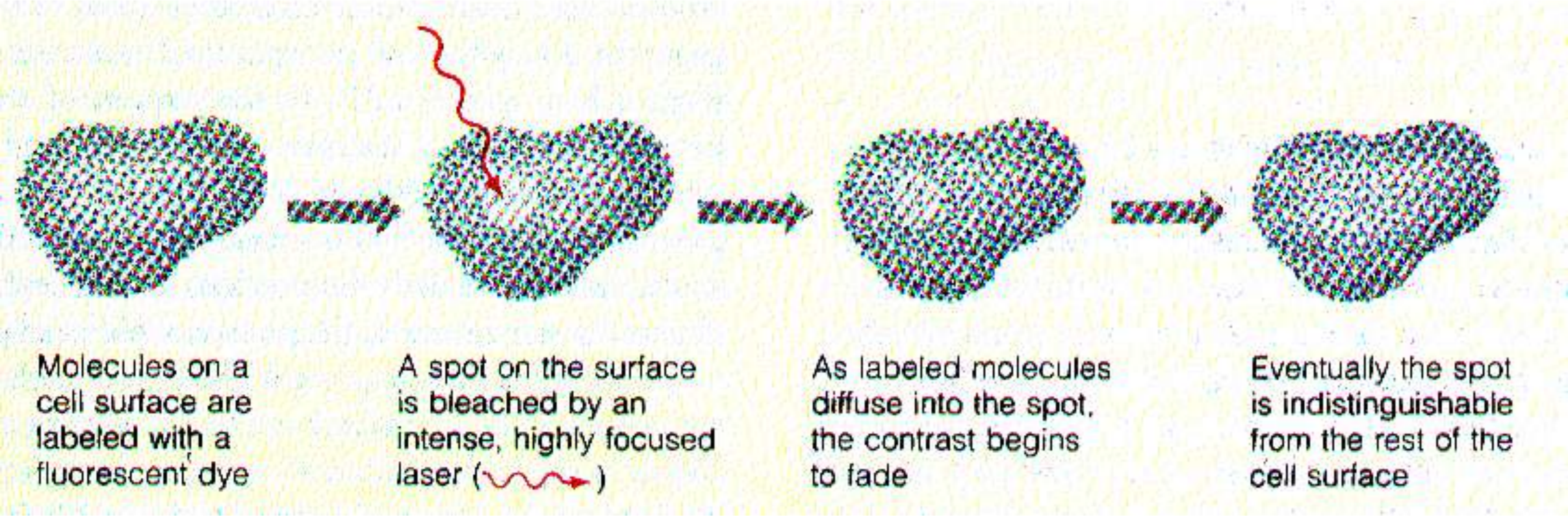
2. Lateral exchanges 1×10^7 times/sec.
moves several μm/sec

3. Flip-flop – *rare*

<1 time/wk to 1 time/few hrs

"*flippases*"

Evidence for lipid fluidity: Photobleaching



Evidence for membrane protein fluidity?

Cell fusion: 1970 D. Frye & M. Edidin

mouse

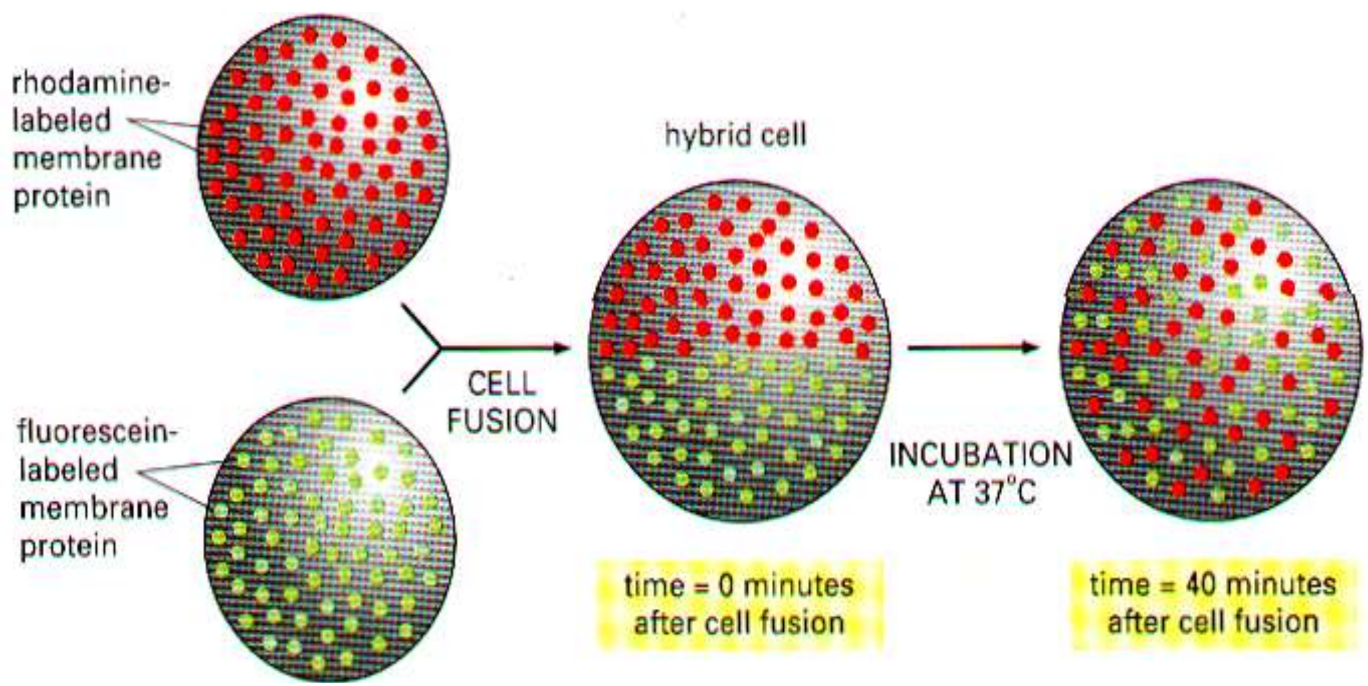


Figure 7.6

human

Lipids: critical role in maintaining membrane fluidity

- Saturated fatty acids stack nicely

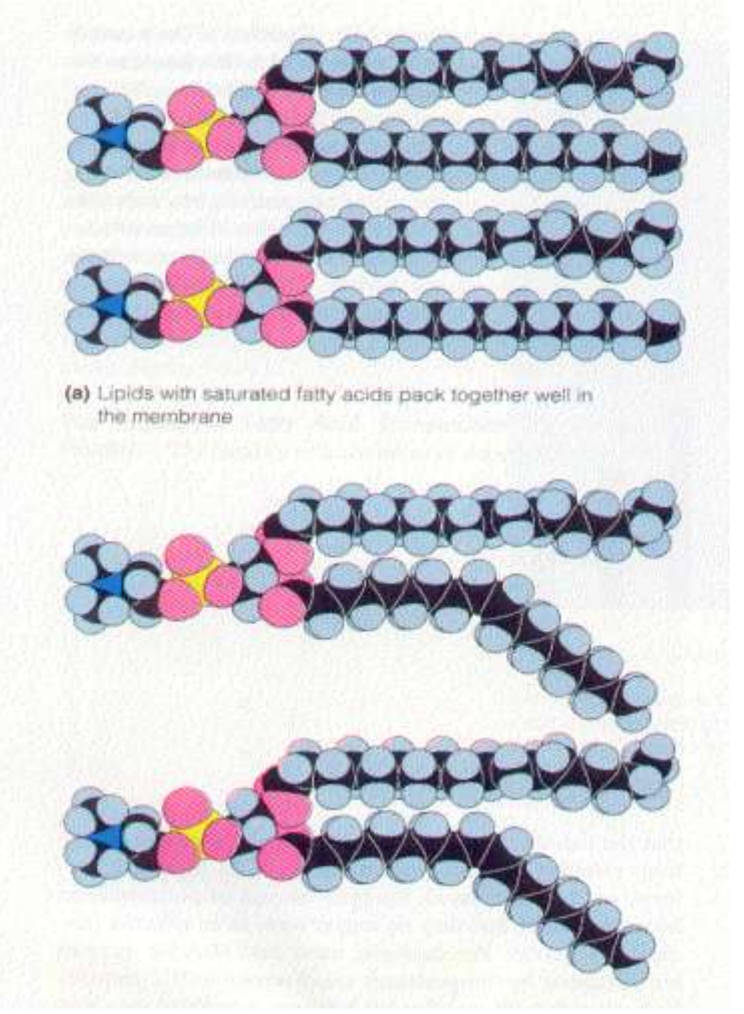
stiffer

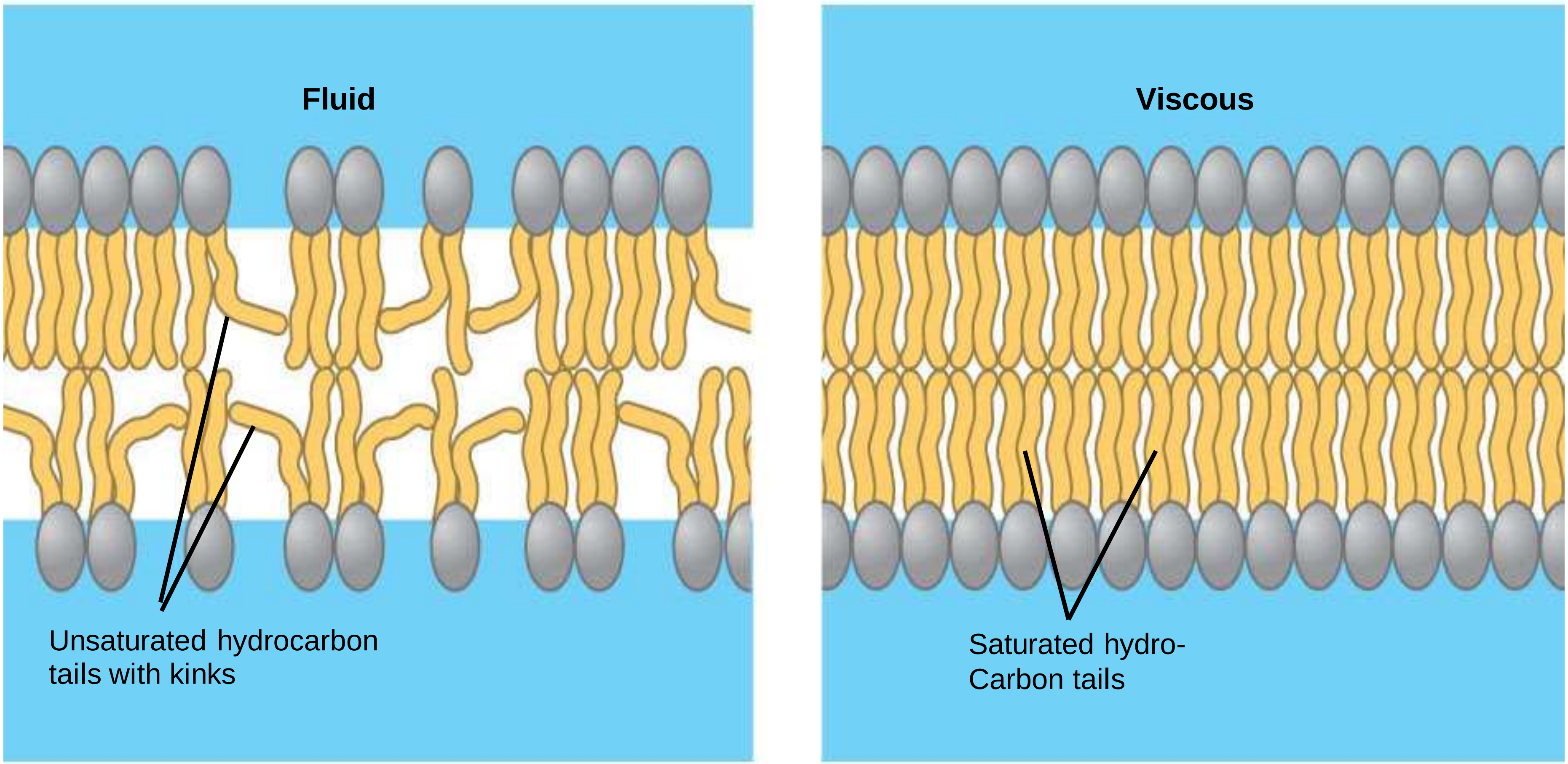
- Unsaturated fatty acids – more fluid; double bond causes kinks
Stacks poorly

More fluid

Shorter chains – stack poorly; More movement

Length & saturation of hydrocarbon tails affect packing & membrane fluidity

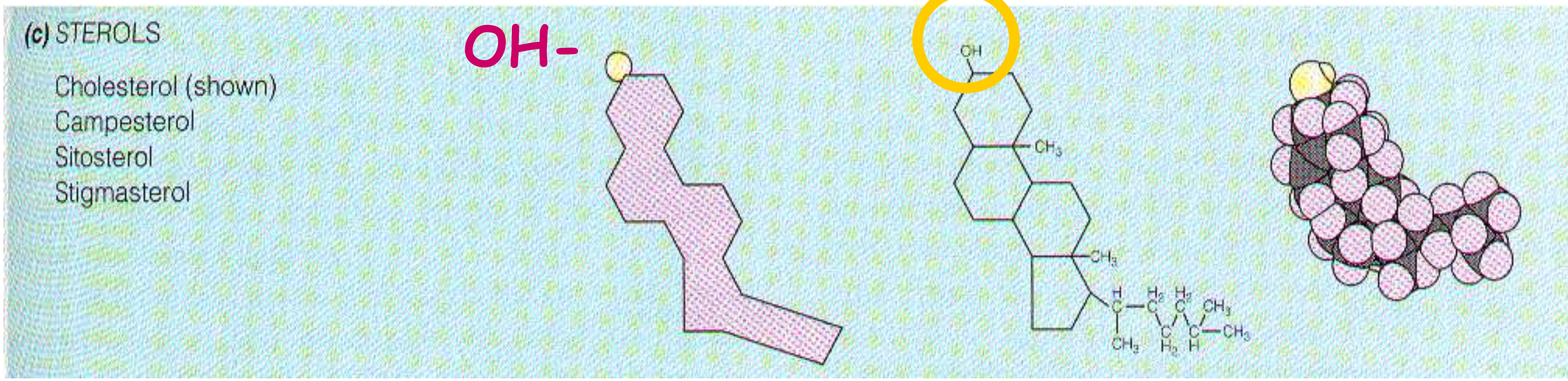


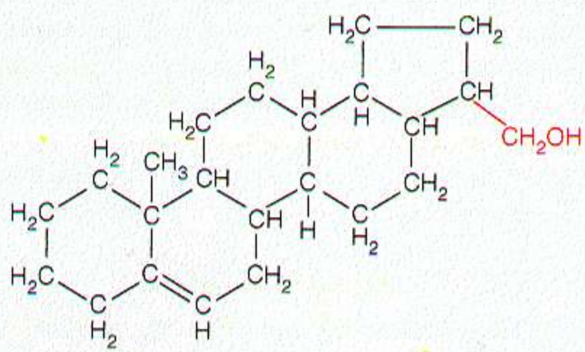


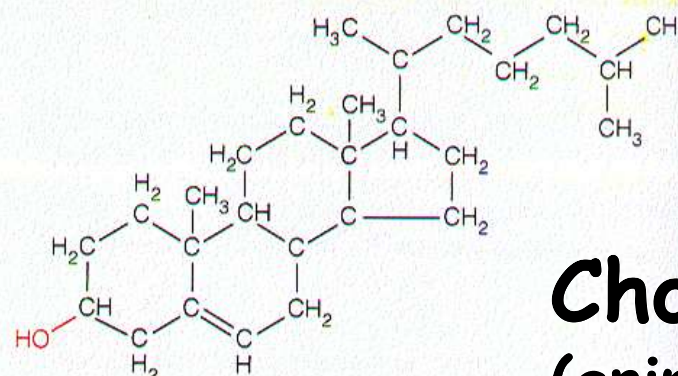
(b) Membrane fluidity

Figure 7.5 B

Sterols –
affect membrane fluidity







Cholesterol (animal)

Hopanoid (prokaryotes)

cholesterol

- At high temperature has a loosening effect
- At low temperature has a stiffening effect

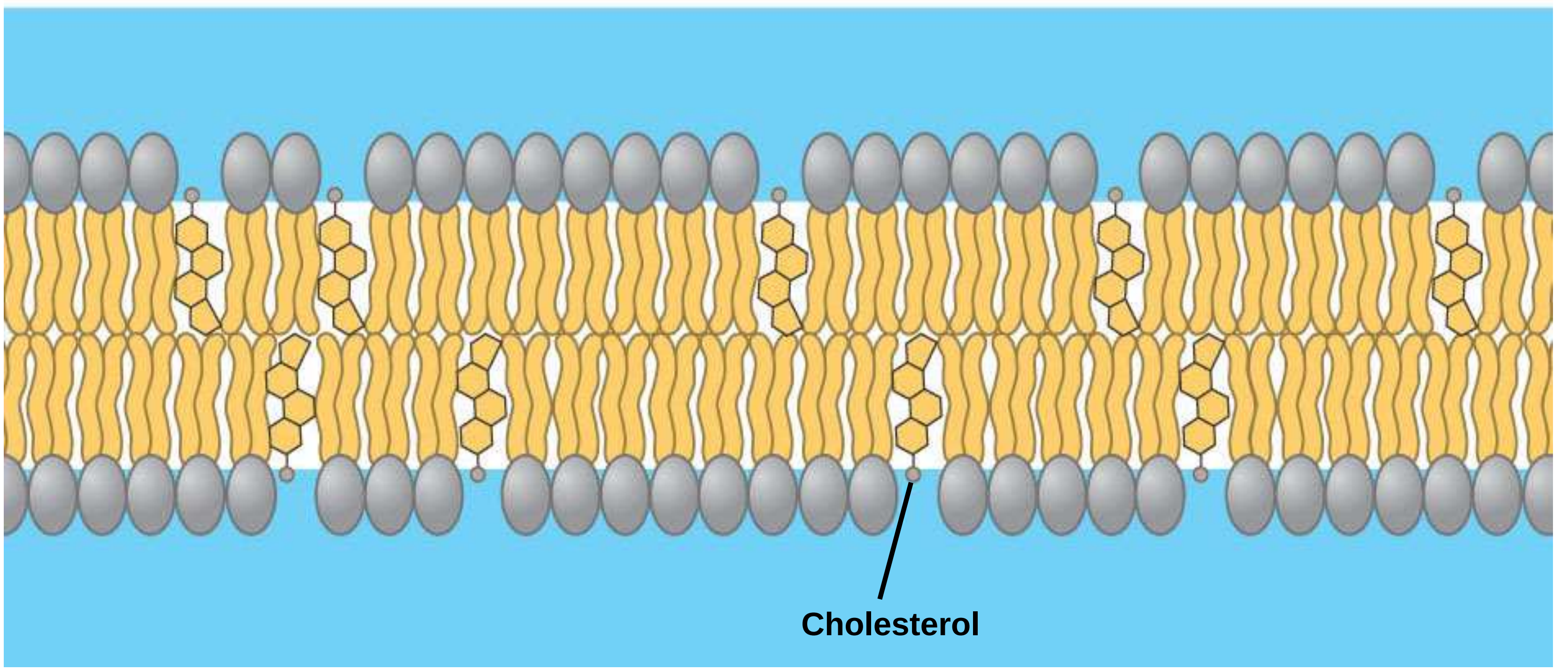


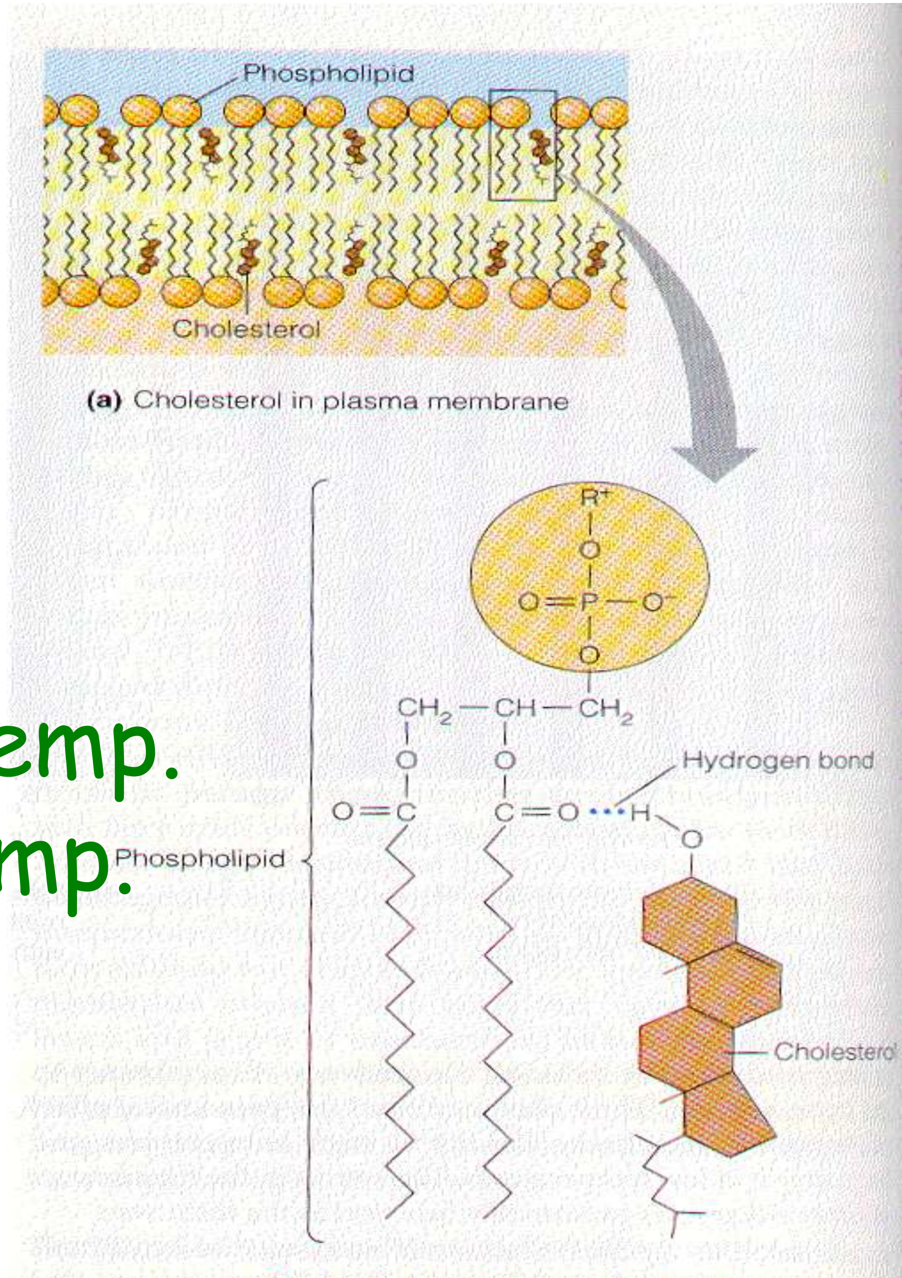
Figure 7.5 (c) Cholesterol within the animal cell membrane

Cholesterol is common in animal cells

Paradox:

a) ↓fluidity at high temp.

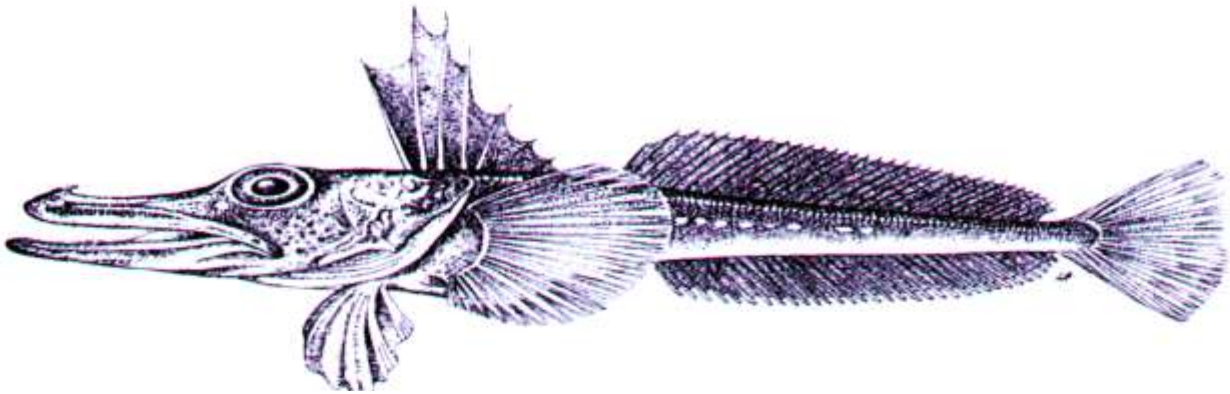
b) ↑fluidity at low temp.



(a) Cholesterol in plasma membrane

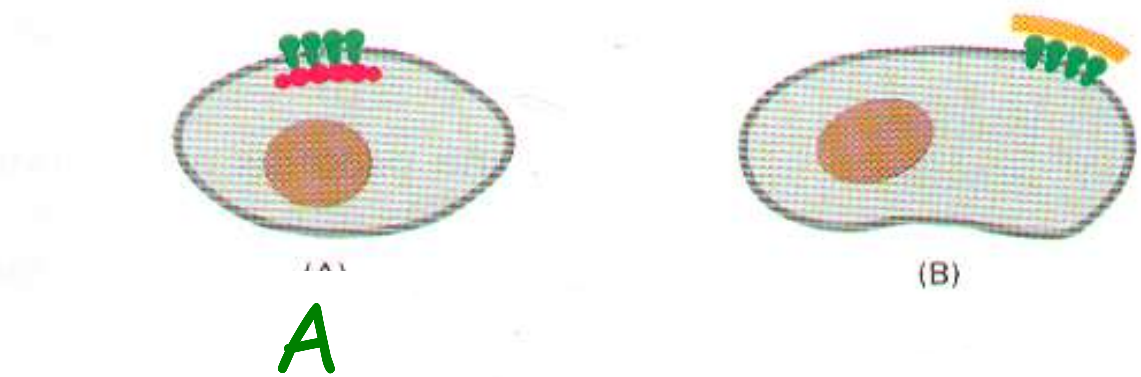
Most organisms regulate membrane fluidity

"Homeoviscous adaptation"

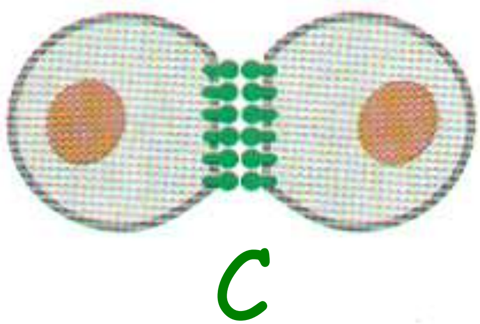


Fish, plants	**Mammals, palm trees**
0-20°C	30-37°C
Polyunsaturated F.A.	Saturated F.A.
Shorter chains	Longer chains
Cholesterol	cholesterol

Restricting movement of membrane proteins -> Membrane Domains



B



(A) Cell cortex
(B) Extracellular matrix
(C) Cell/cell junctions

Tethering of membrane proteins to the Extracellular Matrix or The Cytoskeleton

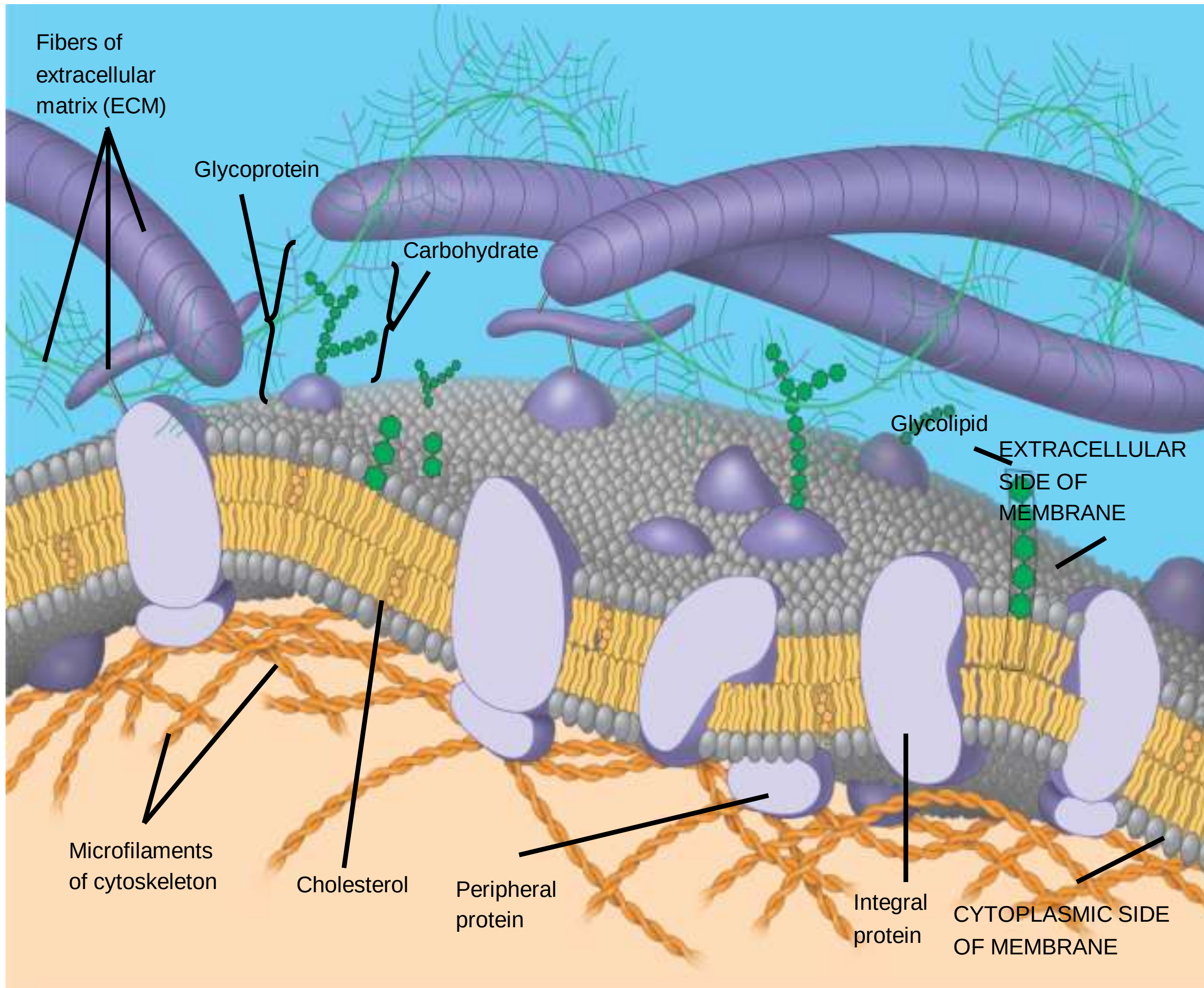


Figure 7.7

Summary: Membranes

1. **Fluid Mosaic Model**: **fluid** nature & **asymmetric** distribution of components

2. Components:
   - **Lipids** – phospholipids, sterols, glycolipids
   - Fluidity

   - **Proteins** – integral, peripheral, lipid-linked
   - transport, receptors, enzymes, structural support, electron transport, specialized functional domains

   - **Carbohydrates** – as glycolipids & glycoproteins external glycocalyx