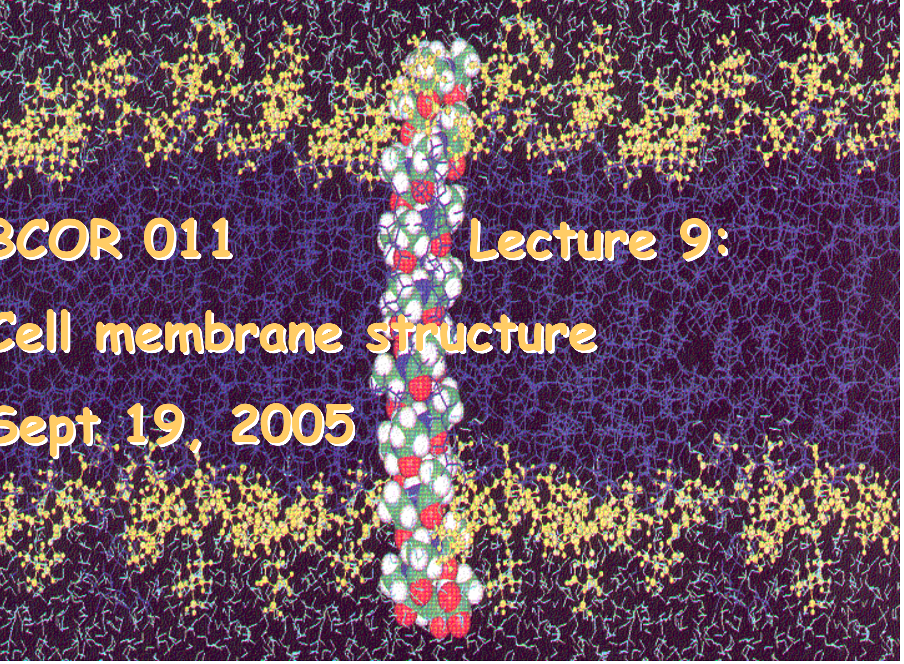
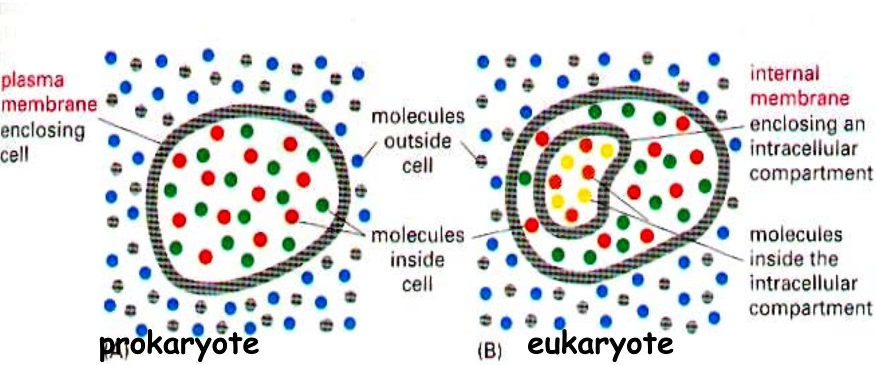


Cell membranes

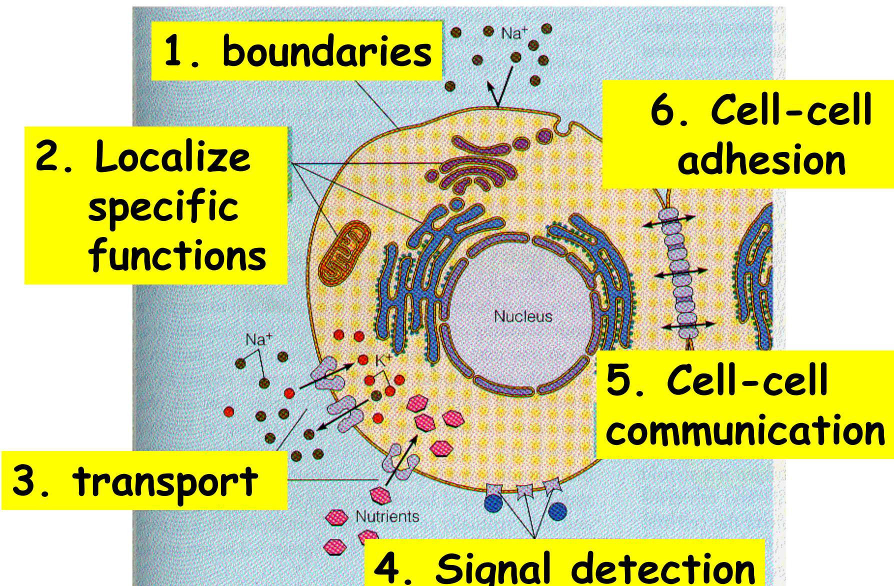
1. What are the functions of cell membranes?
2. What is the current model of membrane structure?
3. Evidence supporting the fluid mosaic model
4. How appropriate fluidity is maintained

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...** ance from ... Some of these proteins hydrolyze ATP as an energy ssource to actively pump substances across the membrane.

3. transport

(b)

E... the membrane m... posed to s... ome cases, s... ganized as a... of a m...

2. Localize specific functions

(c)

Signal transduction. A membrane protein may have ... hape ... he ... conformational change in the protein (receptor) that relays the message to the inside of the cell.

4. Signal detection

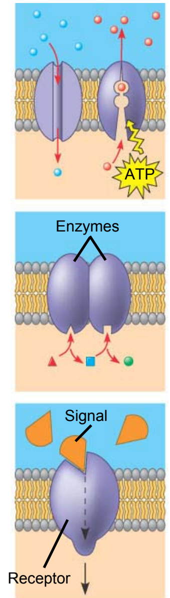


Figure 7.9

...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... stabilizes th... roteins that a... ular and intracellular changes (see Figure 6.29).

1. boundaries

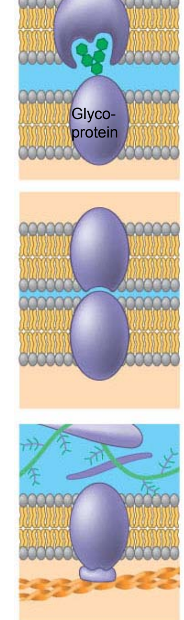


Figure 7.9

Transport – Lect 10
materials across membranes

Cell Signaling – Lect 11
external signals trigger internal events

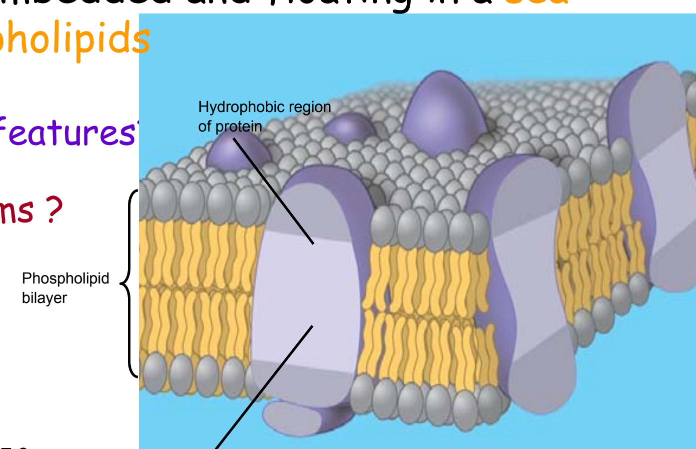
Biochemical functions – Lects 16-19
Oxidative Phosphor, Photosynthesis
Importance of Membranes in biochemical Rxns

Current Understanding of Membrane Structue: Fluid Mosaic Model
1972 Singer & Nicholson

Proteins embedded and floating in a sea of phospholipids

Familiar features

Problems ?



Integral Membrane proteins

Span the phospholipid bilayer – usually α-helices

Why do proteins cross membranes as α-helices?

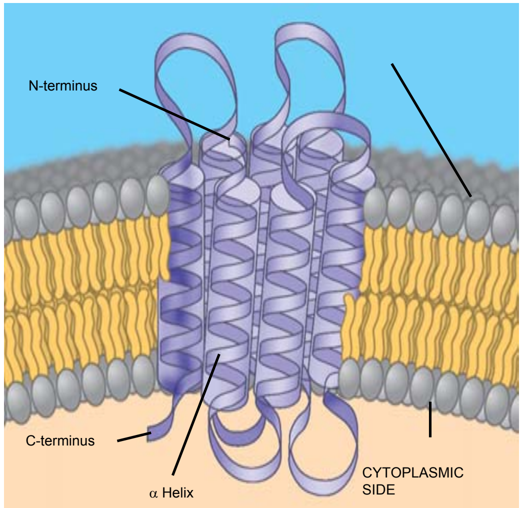
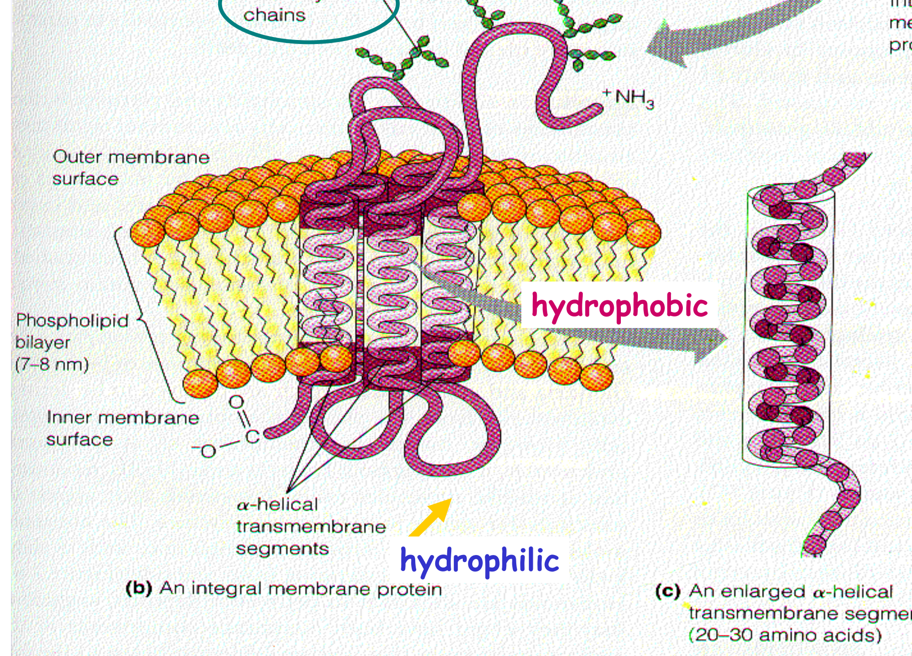
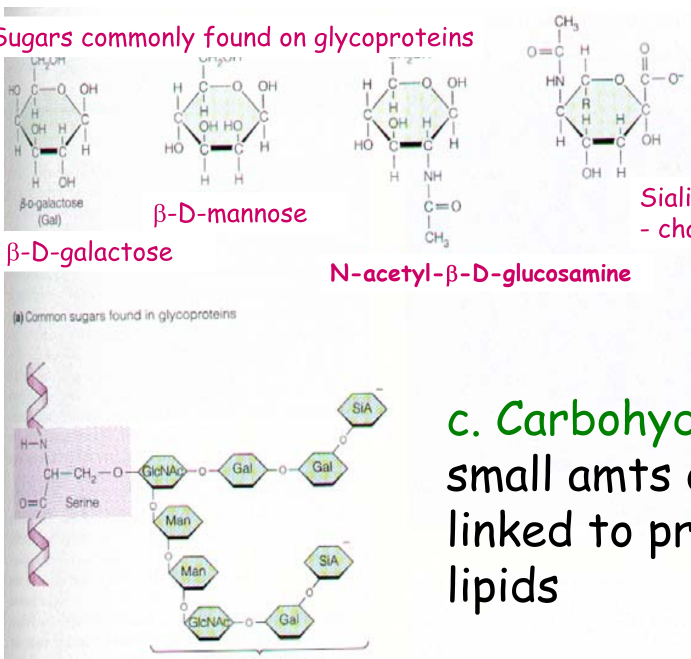


Figure 7.8

Must present hydrophobic surface



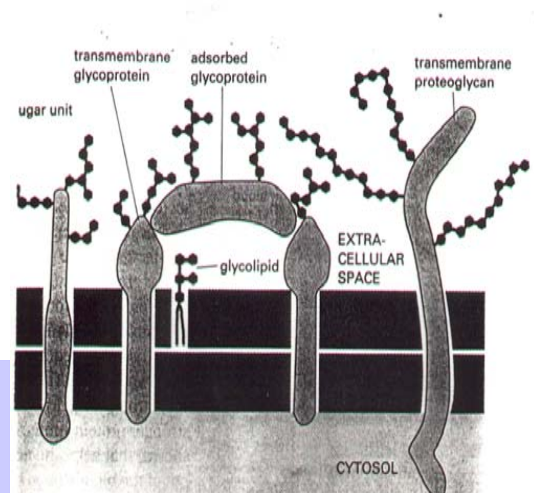
Sugars commonly found on glycoproteins

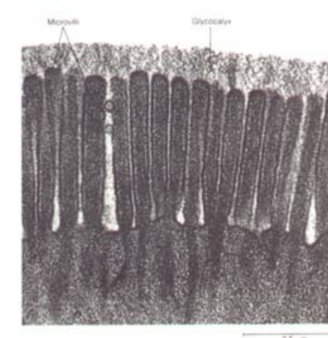


c. Carbohydrates – small amts often linked to proteins or lipids

Glycocalyx: *"sugar coat"*

Outside cell





Inside cell

Membrane proteins and lipids

- Are synthesized in the ER and Golgi apparatus

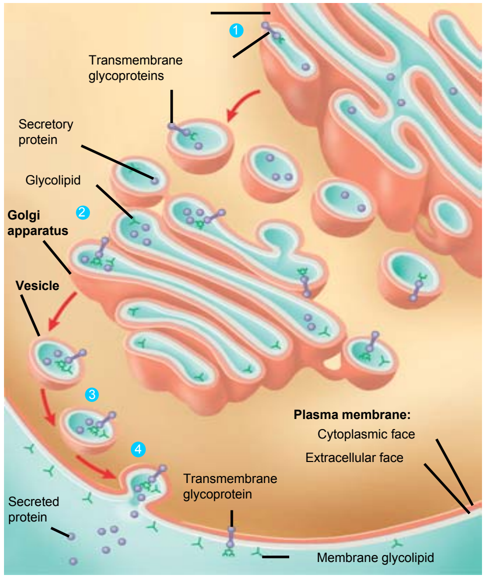
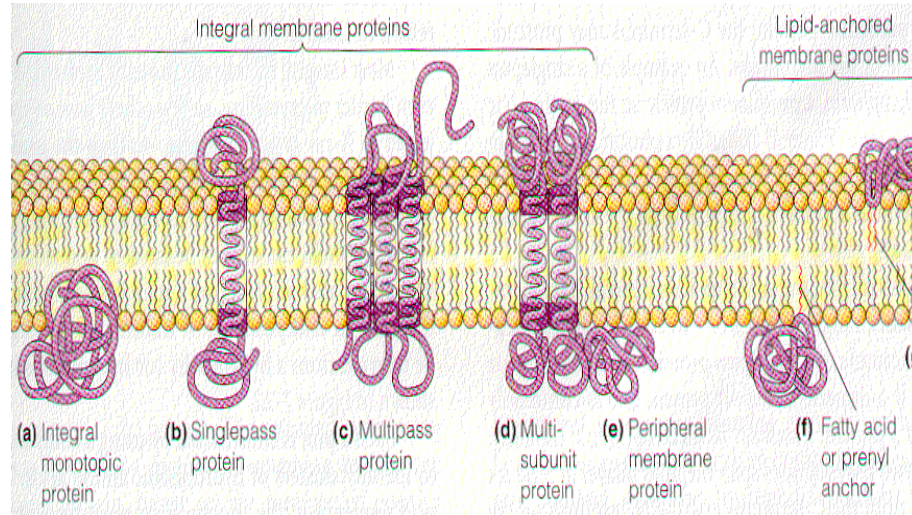


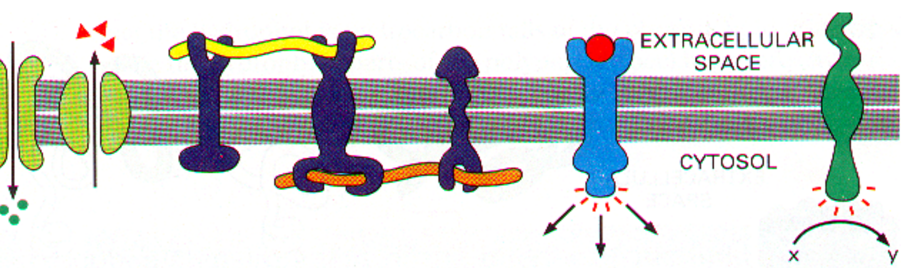
Figure 7.10

Membrane proteins

- Integral
- Peripheral
- Lipid-anchored



Roles of membrane proteins?

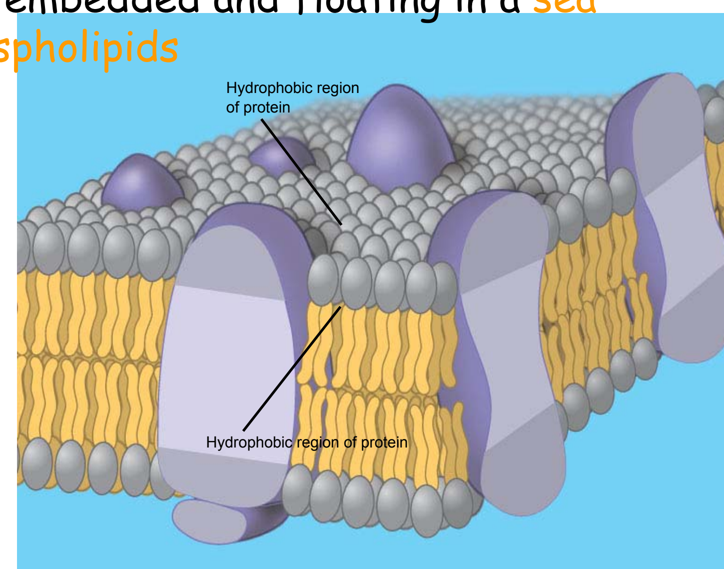


A. Transport – channels and pumps
B. Links to structural proteins
C. Receptors - doorbells
D. Enzymes – localized biochemical rxns
E. Energy Generation

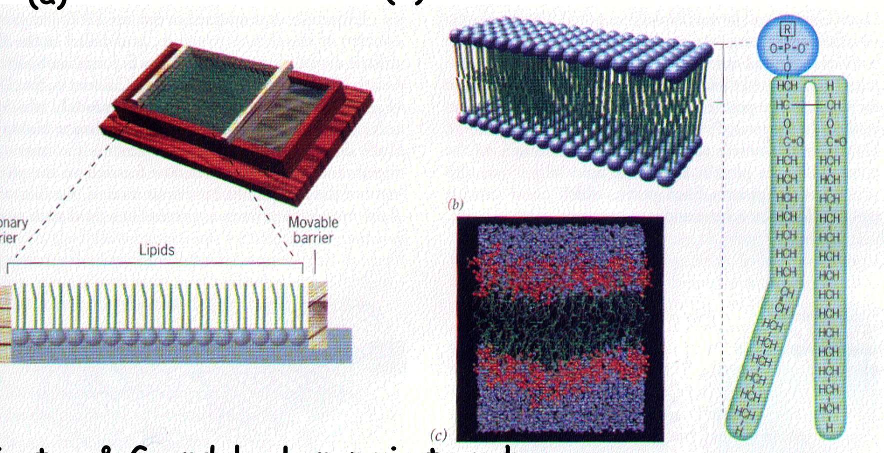
Fluid Mosaic Model

Proteins embedded and floating in a sea of phospholipids

Evidence?



vidence for Phospholipid

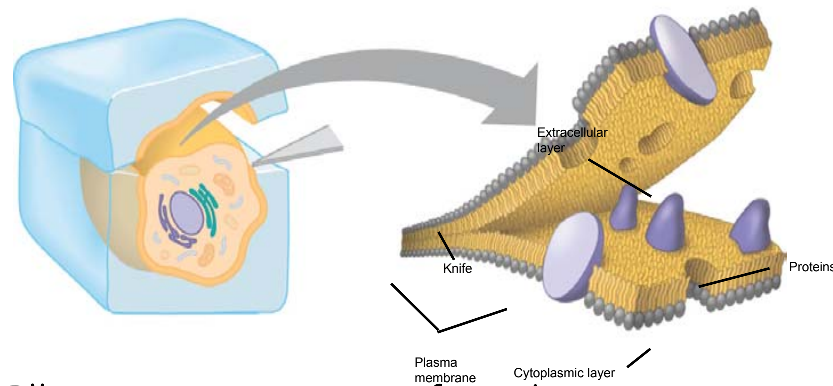


orter & Grendel – Langmuir trough

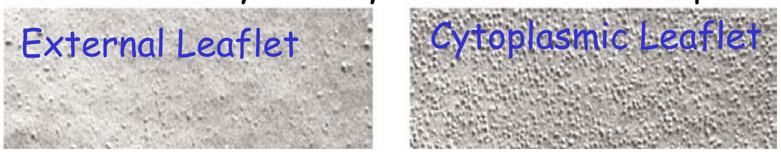
ed blood cells had enough lipid to <u>twice</u> cover their surface

onclude lipid is a <u>bilayer</u> – hydrophilic heads faced aqueous environment

Evidence for integral membrane proteins: Freeze-Fracture Electron Microscopy



Illustrates: asymmetry of membrane componets

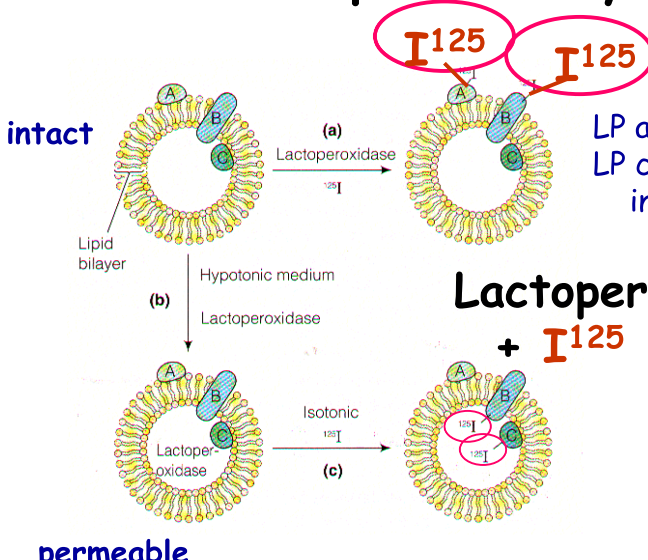


Fluid Mosaic Model predicts:

A. Membranes are <u>fluid</u>: lipids & proteins move in the plane of the bilayer

B. Proteins and lipids are <u>asymmetrically</u> distributed in the bilayers

Evidence for protein asymmetry



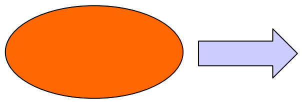
LP adds I to protein
LP can't pass thru intact membrane

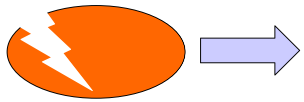
Lactoperoxidase (LP) + I^{125}

Evidence for lipid asymmetry?

Cut off head groups off of exposed lipids

Digested them with phospholipase

Intact red blood cells  SM, PC

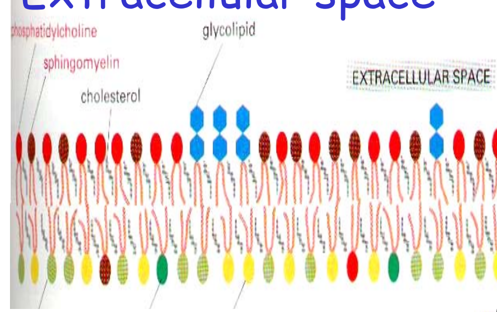
Broken red blood cells  PE, PS SM & PC

Results: *isolated different types of phospholipids suggesting lipids were distributed differently 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

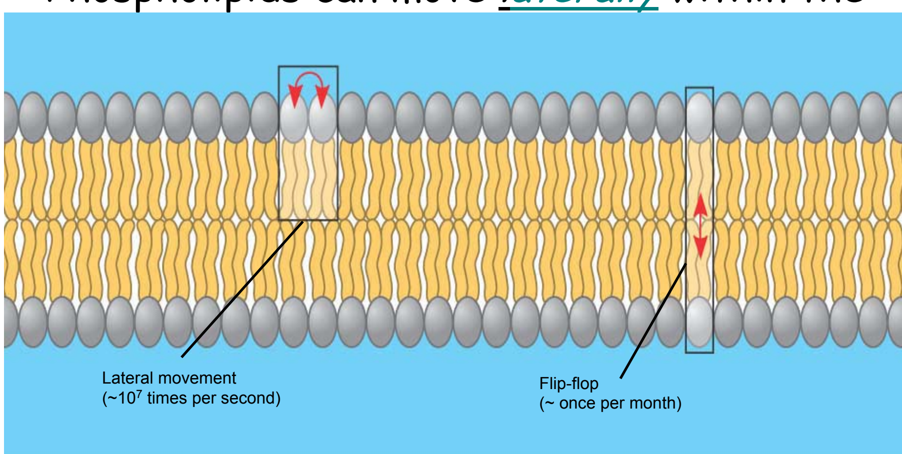
Fluid Mosaic Model predicts:

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

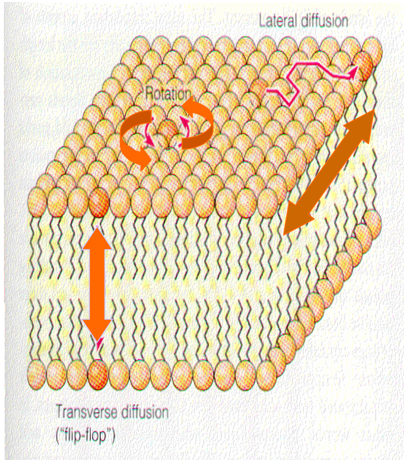
- Phospholipids can move *laterally* within the



(a) Movement of phospholipids

Movement of membrane phospholipids

1. Rotation about long axis



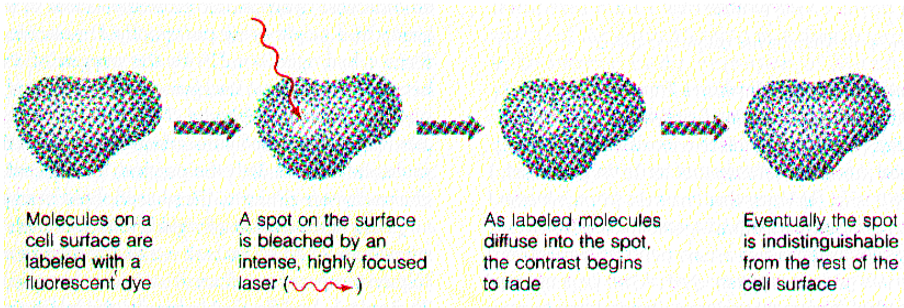
2. Lateral exchanges
1×10^7 times/sec.
moves several μm/sec

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

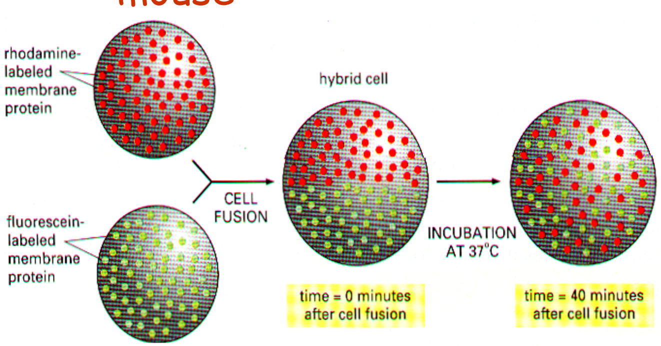


Figure 7.6

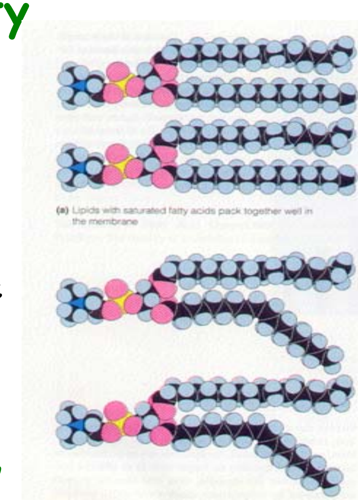
human

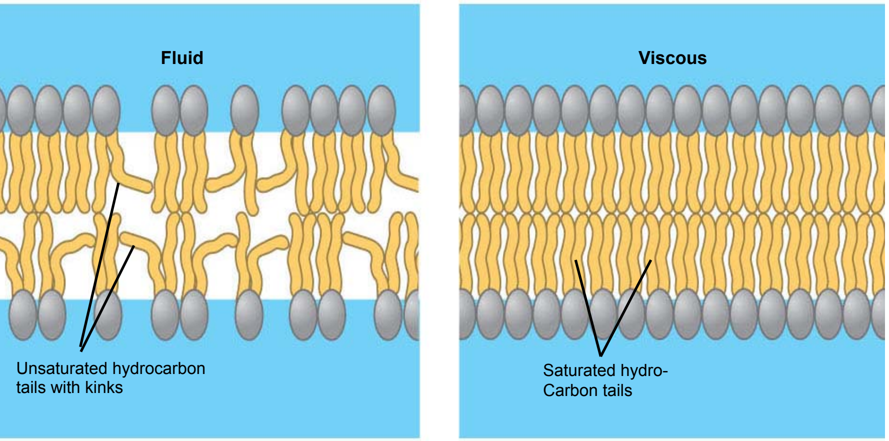
Lipids: critical role in maintaining membrane fluidity

- 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

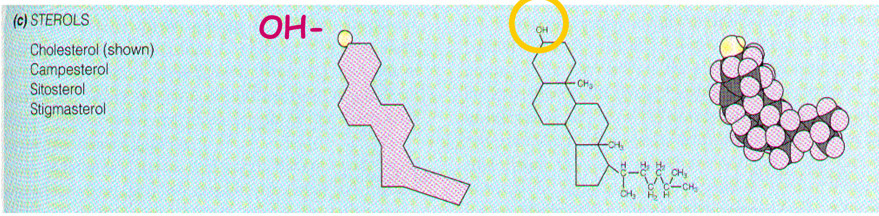


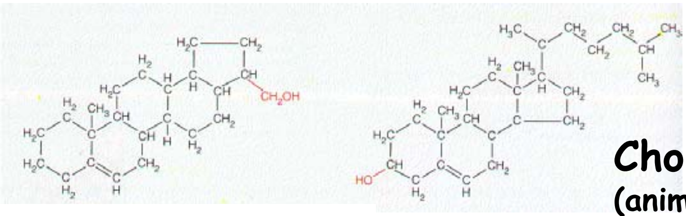


(b) Membrane fluidity

igure 7.5 B

Sterols –
affect membrane fluidity



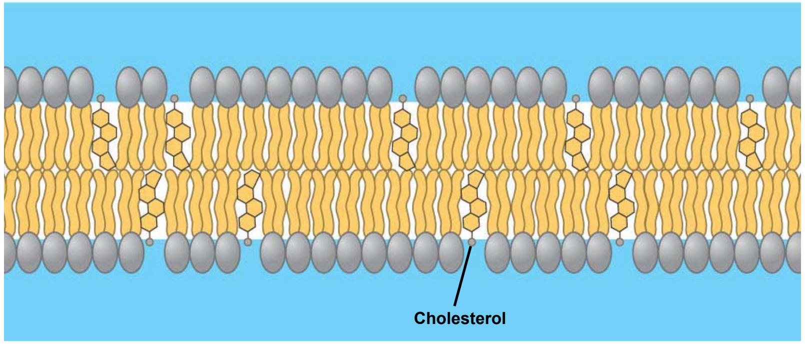


Hopanoid (prokaryotes)

Cholesterol (animal)

cholesterol

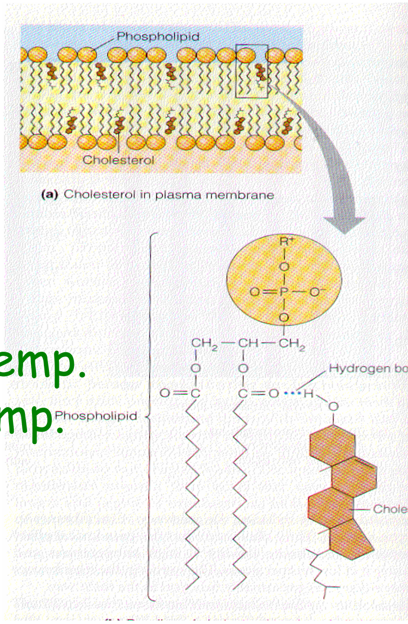
- At high temperature has a loosening effect
- At low temperature has a stiffening effect



gure 7.5 (c) Cholesterol within the animal cell membrane

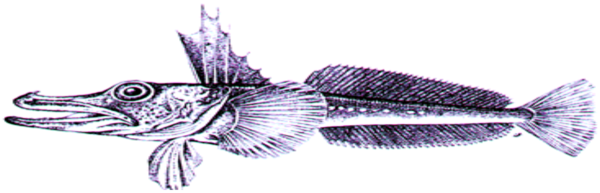
Cholesterol is common in animal cells

Paradox:
a) ↓fluidity at high temp.
b) ↑fluidity at low temp.



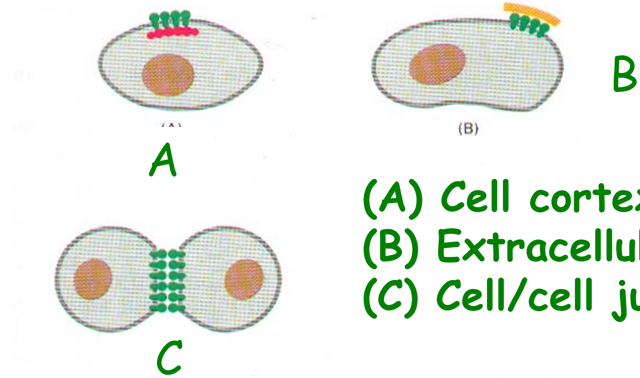
Most organisms regulate membrane fluidity

"Homeoviscous adaptation"



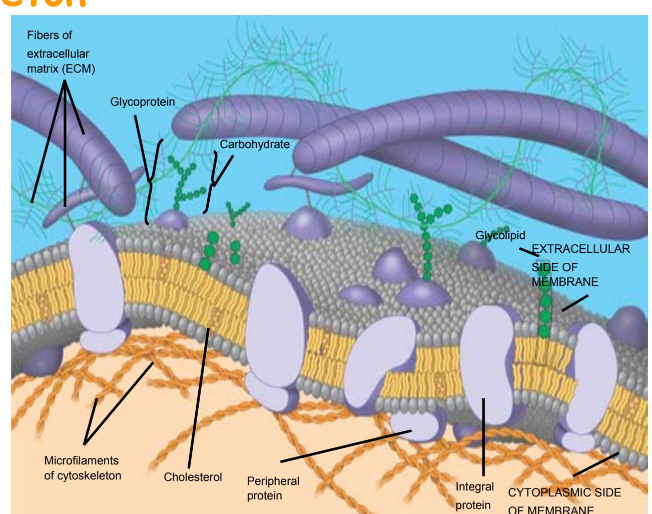
Fish, plants	Mammals, palm trees
0-20°C	30-37°C
Polyunsaturated F.A.	Saturated F.A.
Shorter chains	Longer chains
Cholesterol	cholesterol

Restricting movement of membrane proteins -> Membrane Domains



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

Tethering of membrane proteins to the Extracellular Matrix or The Cytoskeleton



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