PG1005

Lecture 3

Biological Membranes

Dr. Neil Docherty

My Teaching Objectives

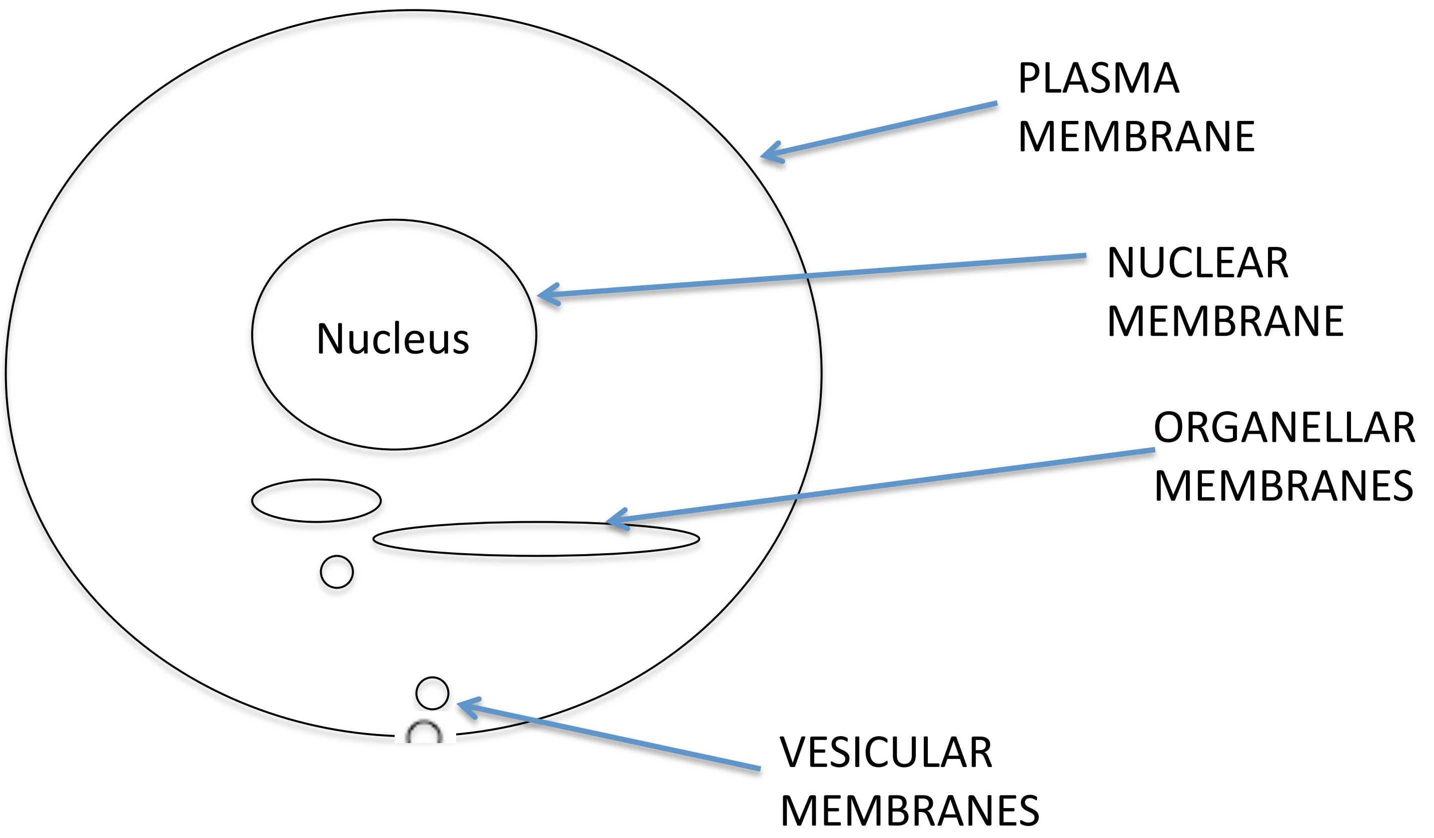
- To illustrate the key features of biological membranes; function, location and composition.

- To explain the fundamentals of phospholipid bilayer formation

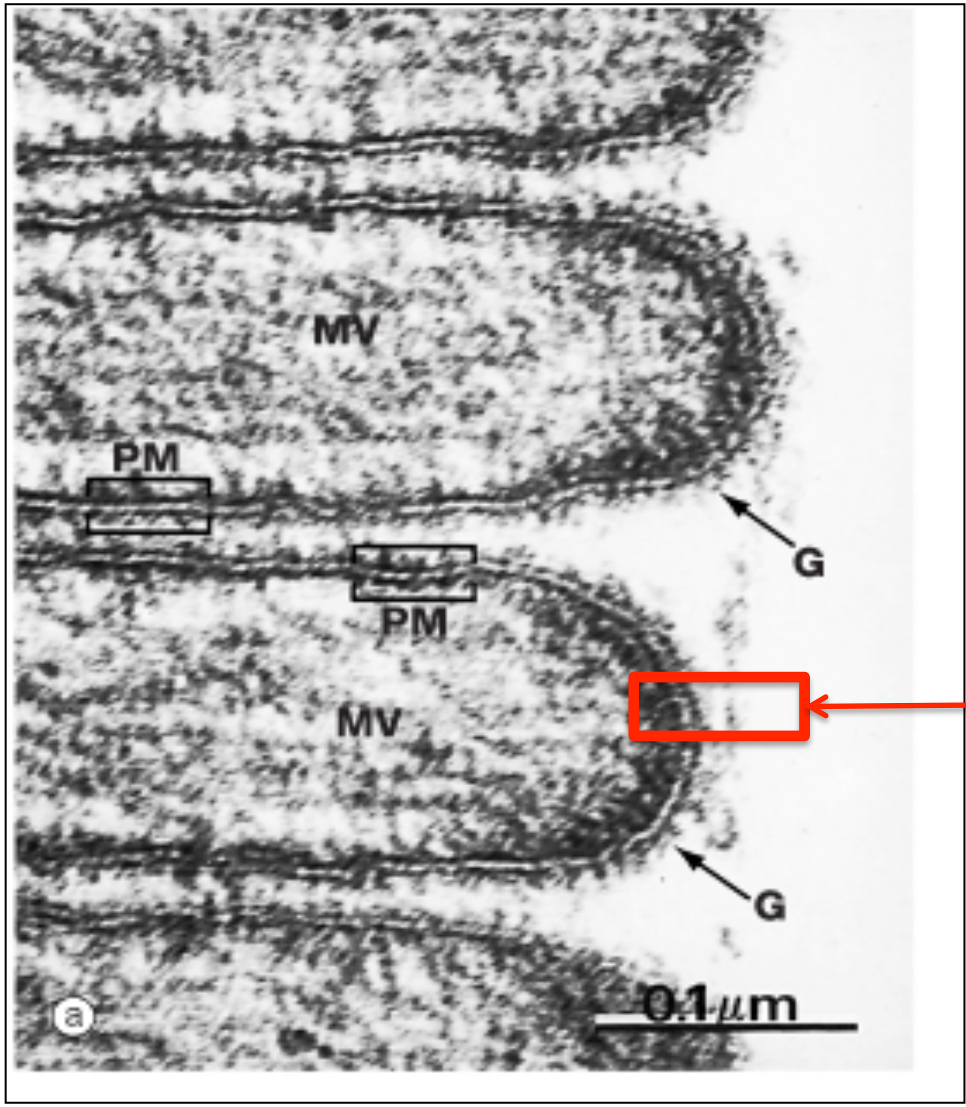
- To describe the biological membranes according to the the fluid mosaic model

Membranes
Fundamental Feature of Compartmentalisation

The cell requires to **compartmentalise intracellular activities**, maintain a **selective barrier to the exterior** and **transport** substances **in, out and around cell in packets**.



Trilaminate Appearance of Plasma Membrane on TEM

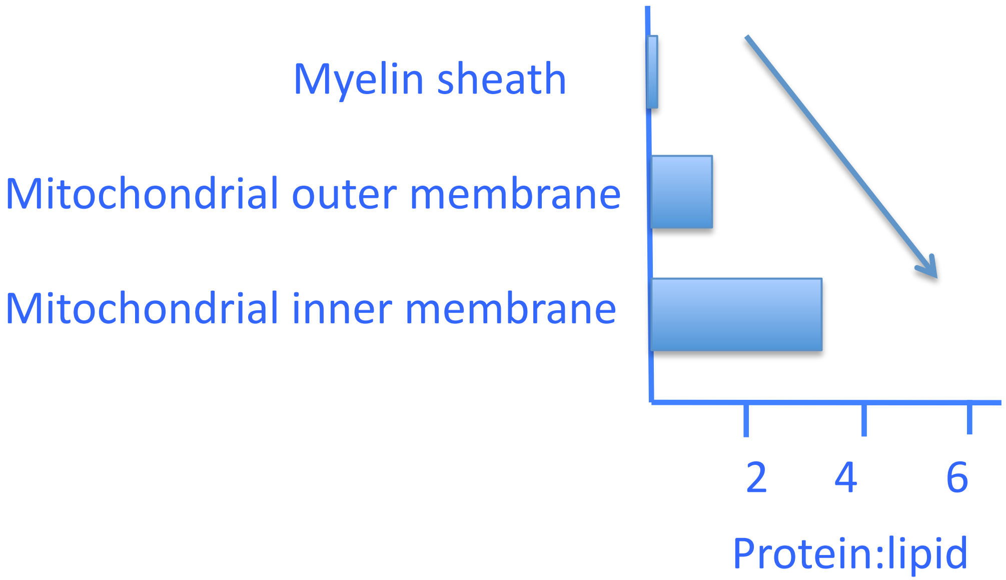


Central electro-luscent zone bounded by defined areas of electron density

Biological Membrane Composition

- Lipids (Phospholipids, glycosphingolipids and cholesterol)
- Proteins (integral, peripheral, membrane spanning)
- Carbohydrates (peripheral sugar moeities)

RATIOS VARY BETWEEN AND WITHIN MEMBRANES

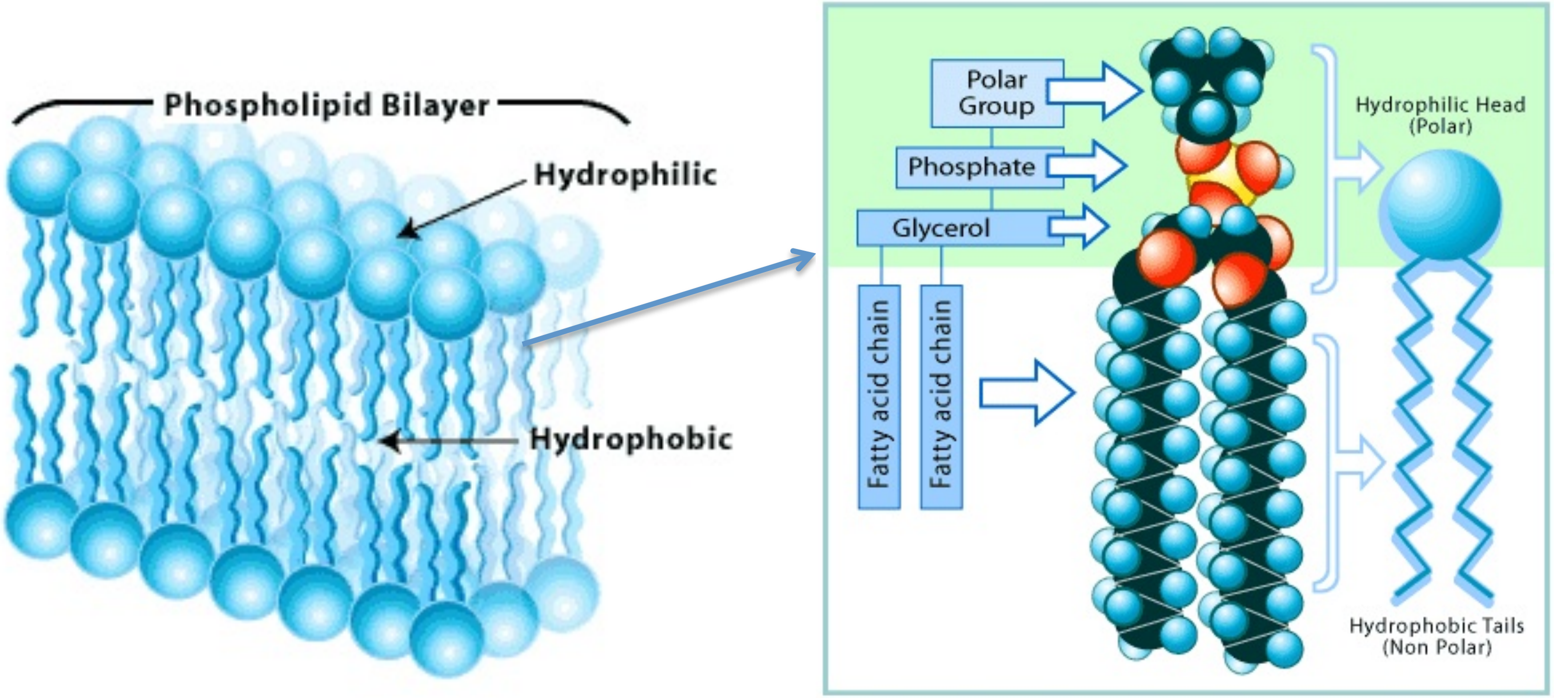


Increased protein reflects increased transport and/or enzymatic activities

INSULATION VERSUS TRANSPORT

Phospholipids

The fundamental unit of biological membranes is
an asymetric phospholipid bilayer.

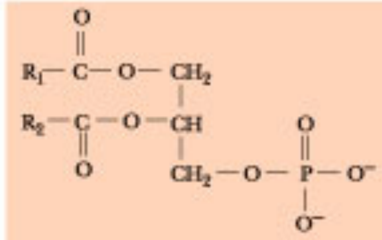


http://www.bioteach.ubc.ca/Bio-industry/Inex/

N.B. Sphingosine replaces glycerol in many phospholipids of neuronal membranes
What is glycerol? What is a fatty acid? What is a polar group?

Phosphoglycerides

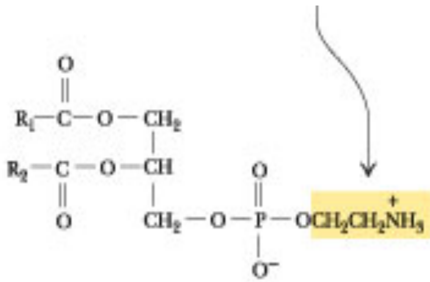
Phosphatidic acid



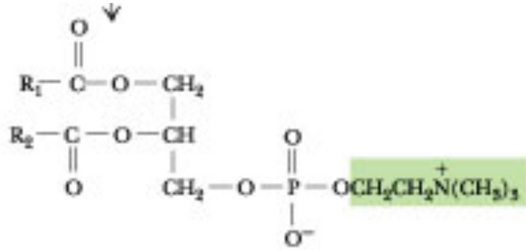
Phosphoglycerides are generally composed of the following
-glycerol backbone (poly-alcohol $C_3H_5(OH_3)$)
-two fatty acids linked to glycerol backbone at C1 and C2 in ester linkage
R-O<u>**H + HO**</u>OC-R=RCOOR
-A phosphorylated alcohol ester linkage on C3

R=fatty acid, see next slide

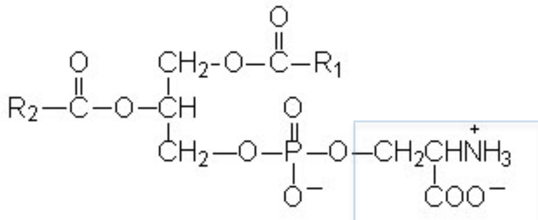
Phosphatidyl ethanolamine



Phosphatidylcholine
(most common)



Phosphatidylserine



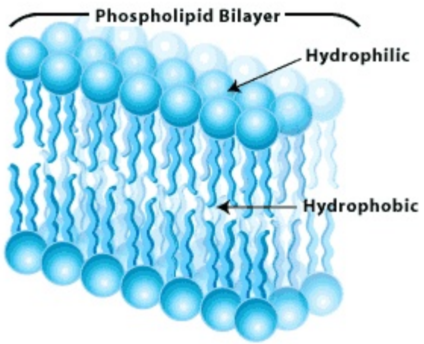
The **phosphorylated** alcohol ester provides the **polar hydrophilic** region
Will protrude towards the aqueous side of the bilayer

Fatty Acid Ester Linkages Provide for The Hydrophobic Core

Fatty acids are even numbered hydrocarbon chains of variable length which terminate in a carboxyl group and hence can be esterified in a reaction with the alcohol groups of glycerol

SATURATED FATTY ACIDS (anoic acids)=contain no double bonds-straight rigid
e.g. palmitic acid (C16), stearic acid (C18)

UNSATURATED (enoic acids)=mono or polyunsaturated, i.e. one or more C=C bonds
exist principally in a cis configuration which introduces a 120° kink in chain
Flexible, provide for membrane fluidity
e.g) oleic acid (C18 monounsaturated, one double bond)
eicosapentaenoic acid (EPA) (C20, five double bonds)



ϖ20:5, 5,8,11,14,17

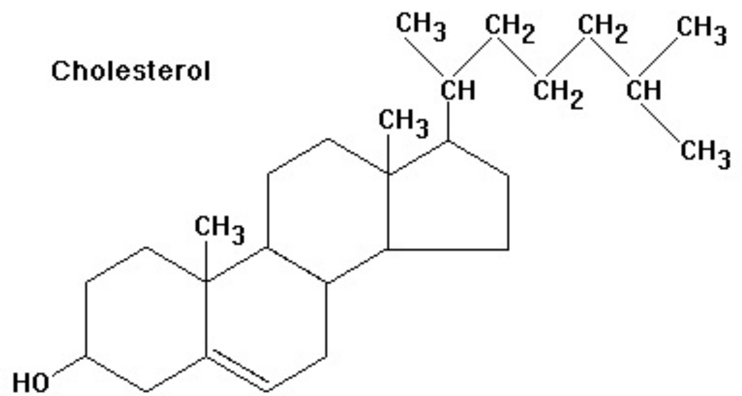
20-17=3, hence omega-3-polyunsaturated fatty acids

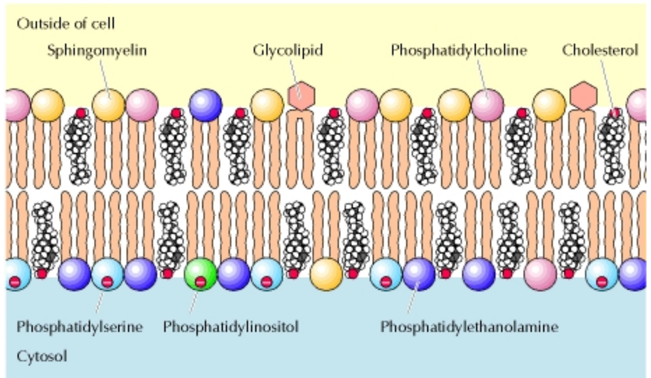
Cholesterol Aids Membrane Fluidity

Cholesterol is a steroid

3x 6 carbon rings linked to a cyclopentane ring

C3 of the first ring is hydroxylated,
A C=C double bond is inserted on ring 2
C17 of cyclopentane ring has a non-polar side chain attached





Membrane is **asymetric and fluid**
Cholesterol assists fluidity by limiting
Tail packing

Membrane Proteins

Integral

Transmembrane   Internal

Single spanning   multiple spanning

Hydrophilic N and C termini
Single or repeated stretches of hydrophobic amino acids arranged in an α-helix

Peripheral

No interaction with membrane core
Hydrophilic interaction with terminal regions of proteins and/or phospholipid or glycolipid heads

The Fluid Mosaic Model

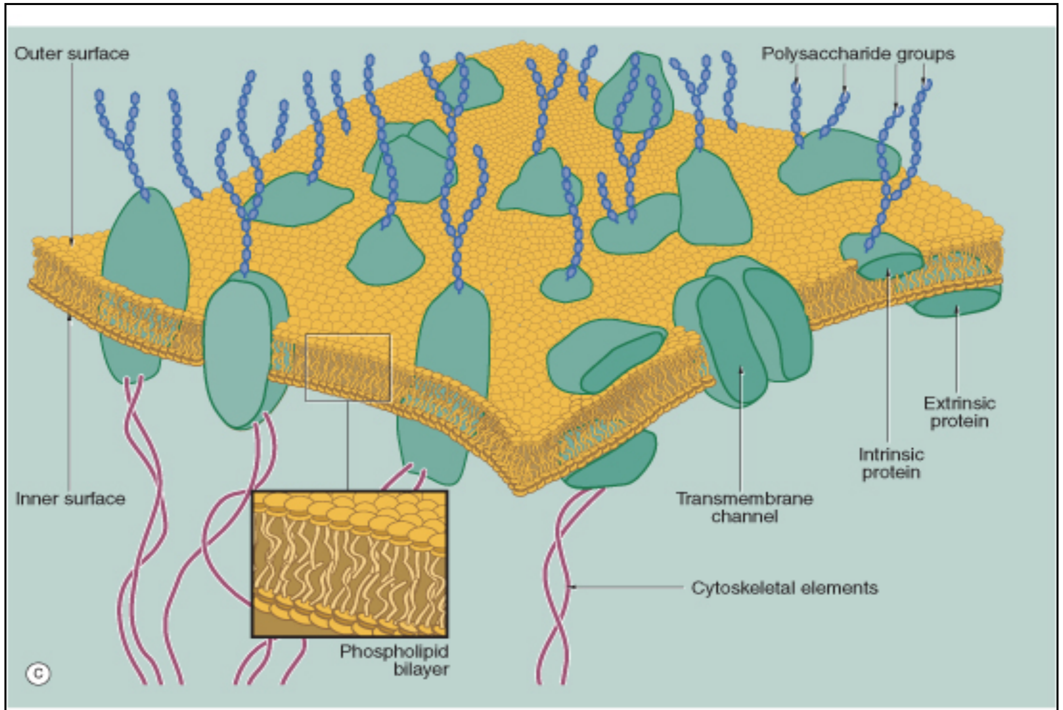
Singer and Nicolson (1972)

Lateral diffusion of proteins

Lateral diffusion of phospholipids

THE MEMBRANE IS NOT A RIGID STRUCTURE

Aided by;
Cholesterol
PUFA content
POSITIVE EFFECT ON PACKING AND FLUIDITY



This model underpins a lot of the theories about disease you hear about
Regarding healthy versus unhealthy fats and disease
e.g., diabetes, depression etc….

Your Learning From Today

Should focus on being able to;

•Explain the key roles played by biological membranes in achieving cell function

•Describe the biochemical constituents of membranes and how their differing chemistries allows for phase separation

•Outline the behaviour of biological membranes according to the the fluid mosaic model