**LECTURE 1.1 - THE MEMBRANE BILAYER**

**AIM**

To introduce the basic structure of biological membranes. At the end of the lecture you should be familiar with the lipid bilayer model for membrane structure.

**General functions of biological membranes (cells and organelles)** 1. Continuous highly selective permeability barrier.

2. Allows control of the enclosed chemical environment

3. Communication - control the flow of information between cells and their environment

4. Recognition - signalling molecules, adhesion proteins, immune surveillance 5. Signal generation in response to stimuli - electrical, chemical

Different membranes have specialised functions

e.g. Plasma membrane - all of the above functions.

e.g. Mitochondrial membrane - energy conservation by oxidative phosphorylation

**Membrane Composition -** Varies with source but generally membranes contain approximately: 40% lipid, 60% protein and 1-10% carbohydrate (dry weight). N.B. the membrane bilayer is a hydrated structure and hence 20% of total membrane weight is water.

**Membrane lipids -** amphipathic molecules - i.e. they contain both hydrophilic and hydrophobic moieties. Distribution varies depending on cell type 13

**Phospholipid** - predominant lipids - e.g. phosphatidylcholine

Head groups

- a range of polar head groups are employed - choline, amines, amino acids, sugars Fatty acid chains

- enormous variety, C16 and C18 most prevalent

- unsaturated fatty acid side chains (double bonds) in the cis conformation introduce a kink in the chain which reduces phospholipid packing. 3

**Plasmalogens**

**Sphingomyelin** - the only phospholipid not based on glycerol. In the membrane the

conformation of sphingomyelin resembles other phospholipids. 14

**Glycolipids** - sugar containing lipids

- Cerebrosides - head group sugar monomers

- Gangliosides - head group oligosaccharides (sugar multimers) Similararity of membrane lipid structures

Figure above taken from http://en.wikipedia.org/wiki/File:Membrane\_lipids.png, with permission

**Cholesterol** - plasma membrane lipid, 45% of the total membrane lipid.

Distribution of different lipids is tissue specific and related to function

**Lipid Bilayer**

Amphipathic molecules form one of two structures in water, ***micelles*** and ***bilayers***. Bilayers are the favoured structure for phospholipids and glycolipids in aqueous 15

media. Bilayer formation is spontaneous in water driven by the van der Walls

attractive forces between the hydrophobic tails. The co-operative structure is stabilised by non-covalent forces; electrostatic and hydrogen bonding between hydrophilic moieties and interactions between hydrophilic groups and water.

Pure lipid bilayers have a very low permeability to ions and most polar molecules.

**Dynamics in lipid bilayers**

Membranes are fluid structures. Lipid molecules possess four permitted modes of mobility in a lipid bilayer.

1. Intra-chain motion - kink formation in the fatty acyl chains 2. Fast axial rotation.

3. Fast lateral diffusion within the plane of the bilayer.

4. Flip-flop - movement of lipid molecules from one half of the bilayer to the other on a one for one exchange basis.

Unsaturated double bonds in the fatty acid side chains disrupt the hexagonal packing of phospholipids and so increase membrane fluidity. Cholesterol plays an important role in stabilising the plasma membrane. (You will consider this again as part of the work session)

**Membrane proteins**

Membrane proteins carry out the distinctive functions of membranes which include enzymes, transporters, pumps, ion channels, receptors, and energy transducers. Protein content can vary from approximately 18% in myelin (nerve cell „insulator‟) to 75% in the mitochondria. Normally membranes contain approximately 60% dry weight of protein. 16

**Mobility of proteins in bilayers**

Three modes of motion permitted – conformational change, rotational and lateral - NO

FLIP-FLOP Restraints on mobility

- lipid mediated effects - proteins tend to separate out into the fluid phase or cholesterol poor regions.

- membrane protein associations

- association with extra-membranous proteins (peripheral proteins) e.g. cytoskeleton.