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ICB N05

Describe the structure and properties of phospholipids

Phospholipids belong to the lipid family and are the most abundant type of lipid, which make up an extremely important structure known as the phospholipid bilayer in Eukaryotic cells (SparkNotes Editors, 2014). Lipids are insoluble in water and are a key component in the membrane of a cell as they affect a cell's permeability to water. Phospholipids have a distinct structure, they are comprised of a hydrophilic head and a hydrophob 1 fatty acid chain. The hydrophilic head groups are exposed on both sides of the cell membrane as they can interact with water. The hydrophobic fatty acid chains are attached to the hydrophobic head groups. Being hydrophobic, they are not attracted to water and remain on the inside of the membrane connecting with other hydrophobic fatty acid chains. In eukaryotic cells, it is this arrangement that forms the phospholipid bilayer (Bradley and Calvert, 2013). A detailed description of the structure and some of the major properties of phospholipids will now be discussed in this paper.

The first phospholipid; lecithin was identified by the French chemist, Theodore Nicolas Gobley in 1847 (Sourkes, 2004). As previously mentioned, phospholipids are specially arranged to make up the phospholipid bilayer in eukaryotic cells. The hydrophilic head group is polar; a molecule with a net dipole as it has both negative and positive charges and can therefore interact with aqueous mediums; solutions in which the solvent tends to be water. The hydrophilic head consists of a phosphate group which can bind with another polar molecules, such as choline; phosphatidyl-choline, serine; phosphatidylserine or inositol; phosphatidylinositol (Cooper and Hausman, 2009). The hydrophobic tails are non-polar as they only contain Carbon-Hydrogen (C-H) bonds which are unable to interact with the hydroxyl (OH) groups in water, and so are insoluble in aqueous mediums. The hydrophobic group of phosphol 8 ds are their fatty-acid chains. Fatty acid chains are the simplest form of lipids consisting of long hydrocarbon chains (usually 16-18 carbons long), with a carboxyl group attached at the end of it (Cooper and Hausman, 2009). As phospholipids have both hydrophilic and hydrophobic properties, they are described as amphipathic molecules.

The majority of phospholipids are derived from glycerol and are synthesised in the smooth endoplasmic reticulum membrane by cytosolic precursors (Cooper and Hausman, 2009). In glycerol phospholipids, the two fatty acid chains form covalent bonds with glycerol to create a di-glyceride. The third carbon in glycerol is bound to the phosphate group forming a phosphatidic acid. On the other hand, Sphingomyelin is the only non-glycerol phospholipid in cell membranes, in which serine replaces the glycerol and choline is bonded to the phosphate group (Cooper and Hausman, 2009).

The cell membrane is an essential structure in eukaryotic cells, which do not have a cell wall, unlike plant and fungi cells (Bradley and Calvert, 2013). The eukaryotic cell membrane is crucial in the separation of the cell's intercellular environment from the extracellular environment. The phospholipid bilayer's amphipathic properties ensures that the cell's polar hydrophilic heads are exposed to the water 1 nd the non-polar hydrophobic tails are buried on the inside of the cell, forming a strong and stable barrier between the two aqueous mediums.

The fluidity of the membrane is a crucial property and is determined by two factors, temperature and the composition of lipids in the membrane. Saturated fatty acid chains which have short hydrocarbon chains, have less interactions along the chain, as they have less C-H bonds than longer chained fatty acids. The chain therefore is weaker, making membranes with short chains less rigid and remain fluid at lower temperatures. Longer chained fatty acids or unsaturated fatty acid chains increase membrane fluidity, as there are more interaction 1 due to the longer chain length. The longer hydrocarbon fatty acid chains have more freedom in the interior end of the phospholipid bilayer, making the membrane soft and flexible. The presence of the double bond in unsaturated

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fatty acid chains produces more kinks in the hydrocarbon thus making it more difficult to pack together. As a consequence the membrane is more fluid (Cooper and Hausman, 2009)

Cholesterol also plays an important role in the cell membrane due to its hydrocarbon ring structure. Cholesterol interacts with certain areas of the hydrophobic fatty acid chains. As a result this relationship decreases the mobility of these areas of the fatty acid chain, making this part of the cell membrane more rigid. This interaction between cholesterol molecules and fatty-acids highly influences the cell's membrane fluidity. At high temperatures, cholesterol interferes with the phospholipid bilayer making it less fluid and reducing its permeability to small molecules. On the other hand, at lower temperatures, cholesterol has a different effect its interaction with the fatty acid chains prevents the membrane from freezing thus ensuring the cell membrane remains fluid (Cooper and Hausman,2009).

The hydrophobic tails of phospholipids are non-polar, making the plasma cell membrane impermeable to water soluble molecules including ions and most biological molecules. The phospholipid bilayer is semi-permeable to small particles with no charge that can freely pass through the bilayer, such as carbon dioxide and oxygen. In order for molecules to successfully pass across the plasma membrane, there are number of specialised proteins embedded in the phospholipid bilayer. The type of proteins vary, some act as channel proteins, allowing specific molecules to pass through the membrane by diffusion. An example of an integral membrane protein is Aquaporin. Aquaporin acts as a channel which primarily allows water pass through the membrane by osmosis (Takata, Matsuzaki and Tajika, 2004).

Movement across the membrane whether it is passive or active requires a concentration gradient. As long as this concentration gradient is maintained the cell remains intact. For example, osmosis is the movement of water across the membrane to balance solute concentrations (Brooker *et al.,* 2014). Cells tend to be in an isotonic medium so the concentration of solutes on both sides of the phospholipid bilayer is equal. On the other hand, if the concentration of solutes outside the cell is greater than inside the cell it is said to be hypertonic. During osmosis, water diffuses out of the cell to balance the solute concentration. The cell may undergo crenation as a lot of water has exited the cell. The reverse of this would be if the cell is in a hypotonic medium; the concentration of solutes is greater in the cell than outside. In this case water moves into the cell by osmosis. Therefore, in extreme cases as the cell has taken up too much water it can explode; osmotic lysis. These results differ for cells with a cell wall such as plant and fungal cells. When placed in a hypertonic solution, the plasma cell wall shrinks and pulls away from the cell wall; plasmolysis, when a large volume of water leaves the plant cell by osmosis. On the other hand, in a hypotonic solution, the contractile vacuole takes up the bulk of the water (Brooker *et al.,* 2014). The ridged plant cell wall then prevents the cell from rupturing.

Another type of protein found embedded in the bilayer are carrier proteins. Carrier proteins may be gated, displaying protein specific binding sites on their surface, therefore only allowing specific molecules to pass through it. Molecules which contain sites specific to carrier proteins are able to bind to it which opens the channel, allowing small molecules to pass through by facilitated diffusion or active transport (Alberts *et al.*, 2002). GLUT1 is an example of a carrier protein which is present in the cell membrane of most animal cells and facilitates the transport of glucose across the bilayer (Deng *et al.*, 2014).

The specialised proteins mentioned above are integral membrane proteins and are permanently fixed into the phospholipid bilayer. Furthermore, peripheral proteins are dissociated from the membrane and indirectly bonded by protein to protein interactions. These two types of membrane

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proteins were distinguished by Jonathan Singer and Gareth Nicolson. It was in 1972 that Singer and Nicolson proposed the idea of the fluid mosaic model in reference to plasma cell membranes in eukaryotic mammalian cells (Cooper and Hausman, 2009).

To conclude, the phospholipid bilayer is a key feature of eukaryotic cells. The phospholipid bilayer is semi-permeable; meaning that only certain substances can pass through the bilayer, unless there are specific protein channels embedded or associated with the phospholipid bilayer. One feature of living cells is their ability to maintain a constant internal environment that differs from its external environment with the help of the phospholipid bilayer (Brooker *et al.,* 2014). The plasma cell membrane acts as a barrier in eukaryotic cells. Its amphipathic structure helps arrange the phospholipid bilayer into its specific structure of hydrophilic heads on the outside and hydrophobic tails on the inside. Erythrocytes do not contain nuclei or internal membranes, so they act as a source from which pure plasma membranes can easily be isolated for biochemical analysis and it was due to them that evidence was provided that biological membranes consist of lipid bilayers (Cooper and Hausman, 2009).

References:

Alberts B, Johnson A, Lewis J, Raff,M Roberts, K Walter, (2002). Carrier Proteins and Active Membrane Transport. In: Alberts B, Johnson A, Lewis J, et al *Molecular Biology of the Cell*. 4th Edition. New York: Garland Science. Chapter 11.

Bradley and Calvert. (2013). *Biology*. 2nd Edition. Banbury: Scion (pages 19-20)

Brooker et al. (2014). *Biology*. 3rd Edition. New York: McGraw Hill Education (pages 106-108)

Deng, D Xu, C Sun, P Wu, J Yan, C Hu, M & Yan, N. (2014). Crystal structure of the human glucose transporter GLUT1. *Nature*. 1 (510), 121–125.

Cooper and Hausman. (2009). *The Cell: A Molecular Approach*. 5th Edition. (s.l.). (s.n.) (pages 6, 47-49, 59, 63, 402, 530-533)

Burkes. (2004). *The Discovery Of Lecithin, The First Phospholipid* [online]. 29 (1), 9-15. Available at: http://www.scs.illinois.edu/~mainzv/HIST/bulletin_open_access/v29-1/v29-1%20p9-15.pdf [Accessed 1st October 2014]

SparkNotes Editors. (2014). *SparkNote on Cell Membranes* [online]. Available at: http://www.sparknotes.com/biology/cellstructure/cellmembranes/section1.html [Accessed 9th Oct 2014]

Takata, K Matsuzaki, T Tajika, Y. (2004). Aquaporins: water channel proteins of the cell membrane.. *Prog Histochem Cytochem*. 39 (1), 1-83.