Lipid rafts and their contribution to the cell membrane

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INTRODUCTION

Figure 1. Journal cover – Nickels *et al. J. Phys. Chem. B* (2019)

I am a biology student, I research various biological cell membranes and their lipid extracts. Extracts from *Escherichia coli*, porcine brain, bovine heart and liver, and *Bacillus subtilis* have served as an example as to why the cell membrane is more than a typical fluid mosaic model. Lipid rafts can act as buffer or aid for many cell membranes. Change in temperature allows the lipid raft to become more or less fluid, which ultimately has an effective on the cell membrane's structure. The experimental technique, Small Angle Neutron Scattering (SANS) was used to observe the structure and composition of the sample. SANS uses elastic neutron scattering at small scattering angles to examine the structure of various substances at a mesoscopic scale of about 1–100 nm.

THE CELL MEMBRANE

- What is the function and structure of the cell membrane?
  - To control the movement of substances in and out of cells and organelles, it is selectively permeable to ions and organic molecules.
  - The cell membrane's structure is composed of a phospholipid bilayer and other various molecules
  - The phospholipid bilayer contains a hydrophilic ('water loving') head and a hydrophobic ('water fearing') tail.
  - The phospholipid bilayer functions to provide structural support for the cell membrane

Figure 2. Cell membrane model

LIPID RAFTS

- What are lipid rafts?
  - Lipid rafts are subdomains of the plasma membrane that contain high concentrations of cholesterol and glycosphingolipids. In these small regions of the cell membrane proteins are recruited based on bilayer thickness and other physical properties
- Why are lipid rafts important?
  - This allows the partitioning of proteins into rafts, which establishes a platform where many biochemical process can be facilitated. This includes;
    - Cytoskeleton organization and adhesion
    - Signal transduction
    - Endocytosis and exocytosis

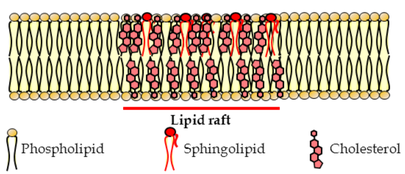

Figure 3. A lipid raft model

SMALL ANGLE NEUTRON SCATTERING

- The objective is to observe the angle at which neutrons are scattered from the sample.
- Neutron scattering length, *b*, is an atomic property that varies by element and isotope.
- Neutrons are especially sensitive to the isotopes of hydrogen.
- Scattered intensity is related to the structure and composition of the sample
- Lipids are hydrogen rich and have good internal contrast

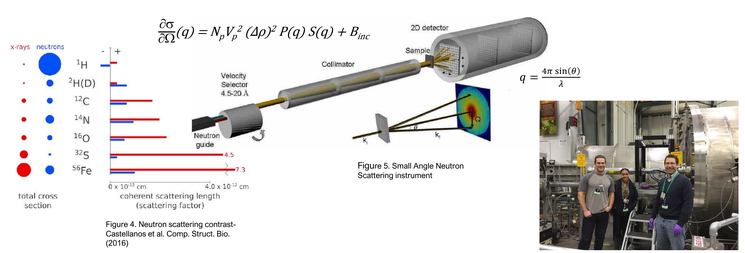

Figure 4. Neutron scattering contrast- Castellanos et al. Comp. Struct. Bio. (2016)

$$\frac{\partial\sigma}{\partial\Omega}(q) = N_p V_p^2 (\Delta\rho)^2 P(q) S(q) + B_{inc}$$

$$q = \frac{4\pi \sin(\theta)}{\lambda}$$

Figure 5. Small Angle Neutron Scattering instrument

LIPID EXTRACTS

- Lipids are insoluble in water and are frequently extracted from tissue, cells, or fluids using organic solvents.
- The efficiency of lipid extraction depends on the separation of different lipids into the organic phase and lipid composition of the sample.
- Natural lipid extracts are a favored choice as a membrane mimic for a wide range of structural, biochemical, and biophysical studies.
- Lipid extracts provide the diverse composition of natural bilayers

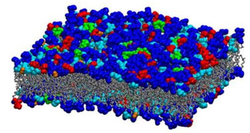

Figure 7. Lipid Extract- Nickels *et al. J. Phys. Chem. Lett.* 2017

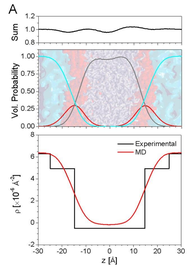

Figure 8. 3. Experimental and computational characterization of the extract Nickels *et al. J. Phys. Chem. Lett.* 2017

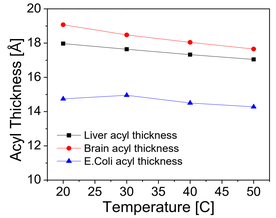

Figure 9. SAS fitting for Brain, Liver and E.Coli Acyl (tail) thickness with increasing temperatures.

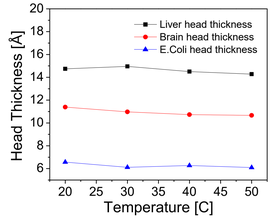

Figure 10. SAS fitting for Brain, Liver and E.Coli Head thickness with increasing temperatures.

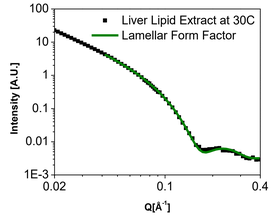

Figure 11. A lamellar fit model for Liver at 30C

LIPIDS RAFTS ACTING AS A BUFFER

- Membrane composition defines the mechanical and viscous properties of the bilayer. The composition also fluctuates with temperature, and with systematic changes in the partitioning of high and low melting temperature membrane components. Due to the nature of this, rafts act like buffers, gradually counteracting environmental changes by means of compositional change. Changes such as; additional high melting lipids that separate to the fluid phase with rising temperatures, increase in the bending modulus and viscosity, as thermal effects that decrease these same properties, are the many examples as to why lipid rafts function as buffers of membrane physical properties.

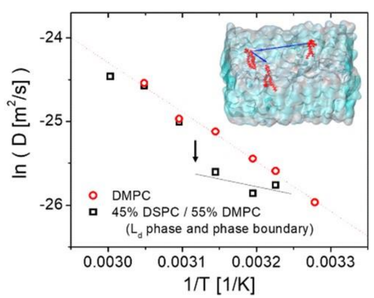

Figure 12. Nickels *et al. J. Phys. Chem. B* (2019)

ACKNOWLEDGEMENTS

- Department of Chemical and Environmental Engineering, University of Cincinnati, Cincinnati, Ohio 45221, United States
- Center for Molecular Biophysics, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830, United States