

## Question Set 6

### Membrane Biophysics

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#### Questions for Cell membranes models & paper (Singer & Nicolson).

- 1) Describe the evolution of Cell Membrane Models until our currently most accepted model proposed by Singer & Nicolson.
- 2) Lipidic nanoparticles have assumed major role on the mRNA vaccines development. Based on the paper of Jayesh A. Kulkarni, please describe the role of four lipid component based on their characteristics.
- 3) What is the difference between a lipid molecule and detergent molecule? How would the structure of a lipid molecule need to change to make it detergent?
- 4) Lipid molecules exchange places with their lipid neighbor every 10<sup>-7</sup> sec. A lipid molecule diffuses from one end in a 2 $\mu$ m long bacterial cell to another in about 1 second. Are these two numbers in agreement (assume that a lipid head group is about 0.5 nm)? If not, can you think of a reason for the difference?
- 5) To get an appreciation for the speed of molecular motions, assume a lipid head group is about a size of ping-pong ball (4cm diameter) and that the floor of your living room (6 m x 6 m) is covered wall to wall with these balls. If two neighboring balls exchange position every 10<sup>-7</sup> sec, what would be the speed in kilometers per hour? How long would take a ball to move from one end of the room to another?
- 6) What role does water play in determining the molecular organization of cell membranes?
- 7) How do vesicles are formed? How can we define their size?
- 8) What are the main differences between Langmuir and Langmuir-Blodgett membranes?

### Questions for Probing Membrane Models at molecular Level

9) What are the main differences between FTIR and Raman Spectroscopies techniques?

Fundamentally, what are the processes involved in both methods since they can probe exactly the same information (defined frequencies of the molecular vibrations)?

10) Describe what are the selection rules for a vibrational mode be active in FTIR spectroscopy. Also, describe the same selection rules for Raman Spectroscopy.

11) The vibrational frequency of a harmonic oscillator formed by two spheres of mass  $m$  can be calculated by  $v_m = \frac{1}{2\pi} \sqrt{\frac{\kappa}{\mu}}$  where  $\mu = \frac{m_1 m_2}{m_1 + m_2}$ . Please explain how we can use these equation to understand how different molecules like H<sub>2</sub>, O<sub>2</sub>, CO, HF have their well-defined and unique fundamental frequencies of vibration. Remember to consider the strength of the bonding between the atoms.

12) Given the phospholipid 1,2-Dipalmitoyl-sn-glycero-3-phosphocholine ( **DPPC** ), please find some of the fundamental vibrations associated with (a) POx group, (b) NH<sub>3</sub>, CH<sub>3</sub> and CH<sub>3</sub>. State your answers in cm<sup>-1</sup> and then convert it to eV.

### Questions for sensing with SPR and QCM

13) What is a plasmon? Which metals are most commonly used to support Plasmon's? What are the essential characteristics of these metals?

14) Please, describe the main differences between Quartz Crystal Microbalance and Surface Plasmon Resonance techniques in terms of their uniqueness when probing the adsorption of proteins to the a biosensor surface from solution containing biomolecules.

15) In the paper J. Am. Chem. Soc. 2000, 122, 4177-4184, please describe how phospholipid vesicles were used to build a SPR sensing unit to monitor the amount of PLA<sub>2</sub> which bound to these vesicles. Please, describe the main strategy of the authors, and not the details.

## References

The Fluid Mosaic Model of the Structure of Cell Membranes, S. J. Singer and Garth L. Nicolson, **Science**, Vol. 175, No. 4023 (Feb. 18, 1972), pp. 720-731

On the role of helper lipids in lipid nanoparticle formulations of siRNA, Jayesh A. Kulkarni, Dominik Witzigmann, Jerry Leung, Yuen Yi C. Tama and Pieter R. Cullis **Nanoscale**, 2019, 11, 21733

Surface Plasmon Resonance Sensors for Detection of Chemical and Biological Species, Jiri Homola, **Chem. Rev.** 2008, 108, 462-493.

Quantification of Tight Binding to Surface-Immobilized Phospholipid Vesicles Using Surface Plasmon Resonance: Binding Constant of Phospholipase A2, Linda S. Jung et al. **J. Am. Chem. Soc.** 2000, 122, 4177-4184.