



ભારતીય સૌંકેલિક વિજ્ઞાન સંસ્કૃત હૈડ્રેબાદ
ભારતીય પ્રૌદ્યોગિકી સંસ્થાન હૈદરાબાદ
Indian Institute of Technology Hyderabad

Introduction of Bio-nanotechnology

BT1110

Lecture 8 : Lipid nanotechnology

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Course contents

- Introduction to nanotechnology and bionanotechnology,
- Biological self-assembly
- Biologically inspired nanostructures - introduction to biomimetics
- Nucleic acid nanotechnology
- DNA origami
- Protein engineering
- **Lipid nanotechnology**
- Chirality in biological systems
- Interaction of nanomaterials with biological systems
- Virology: viruses and vaccines

Vaccine technology

mRNA vaccines
Pfizer, moderna

Conventional vaccines

- Weakened pathogen



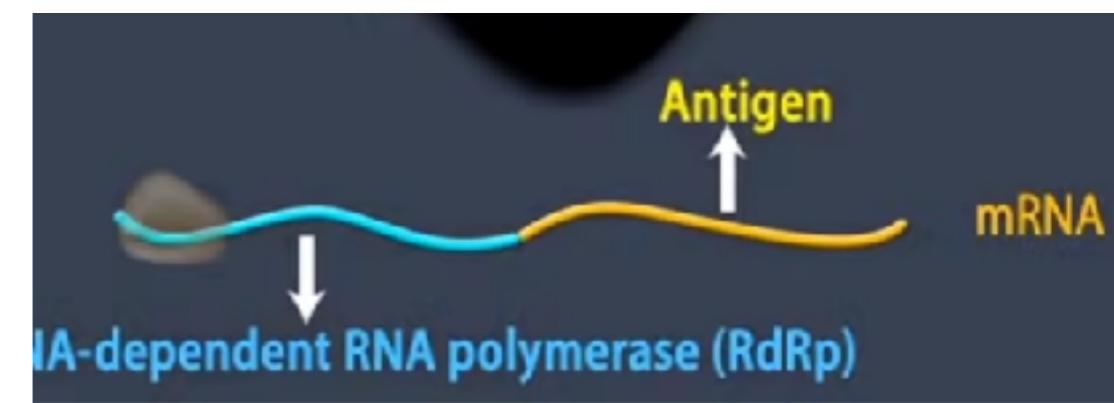
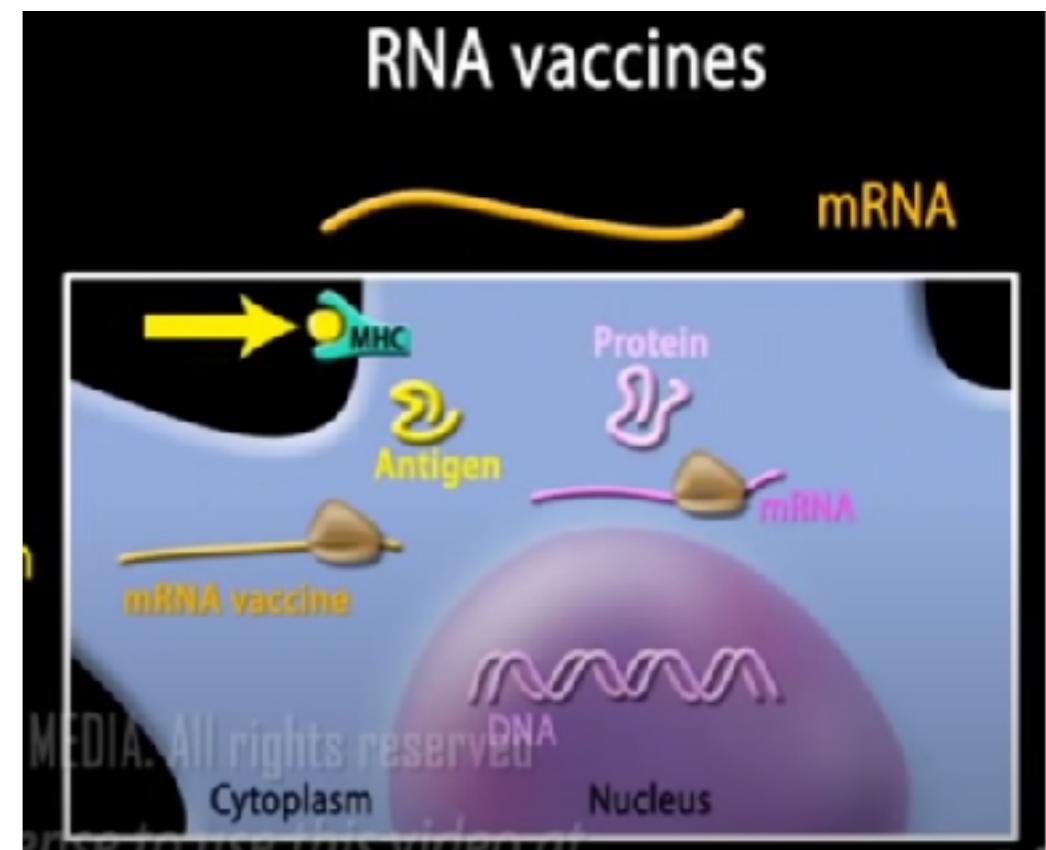
- Inactivated pathogen



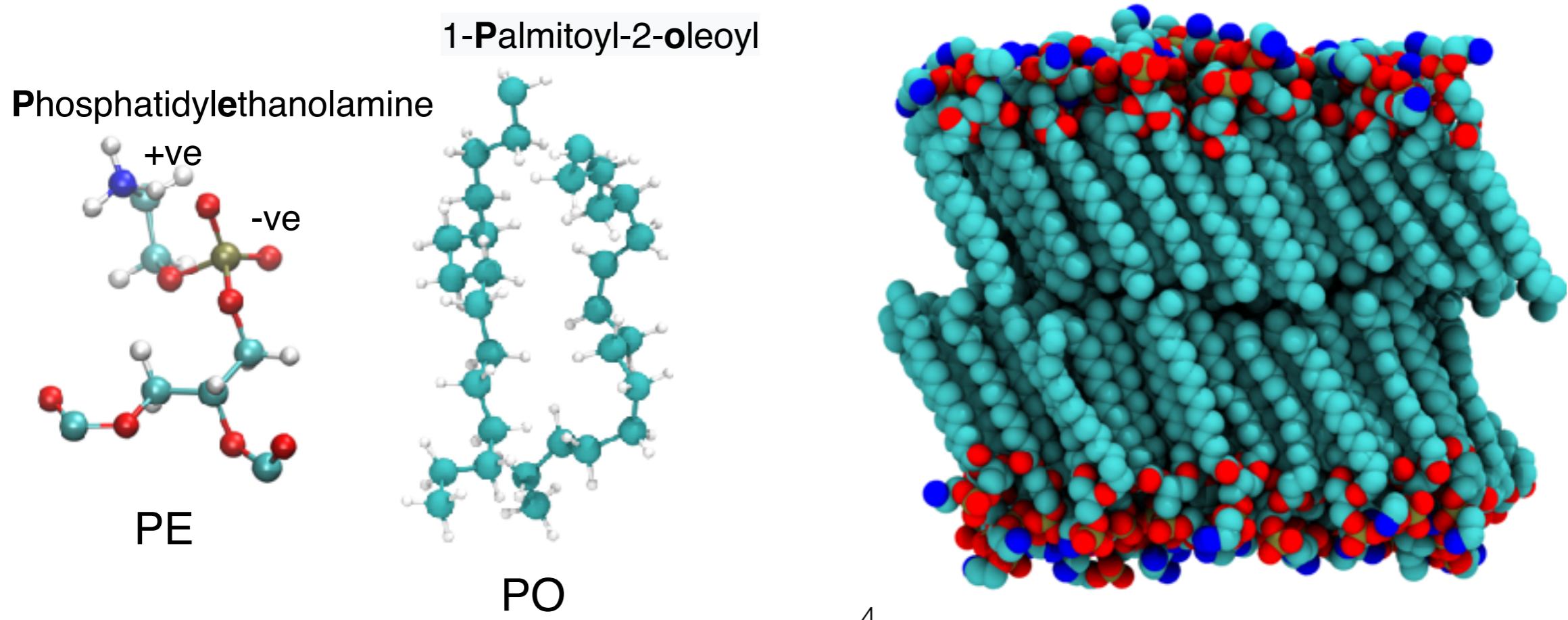
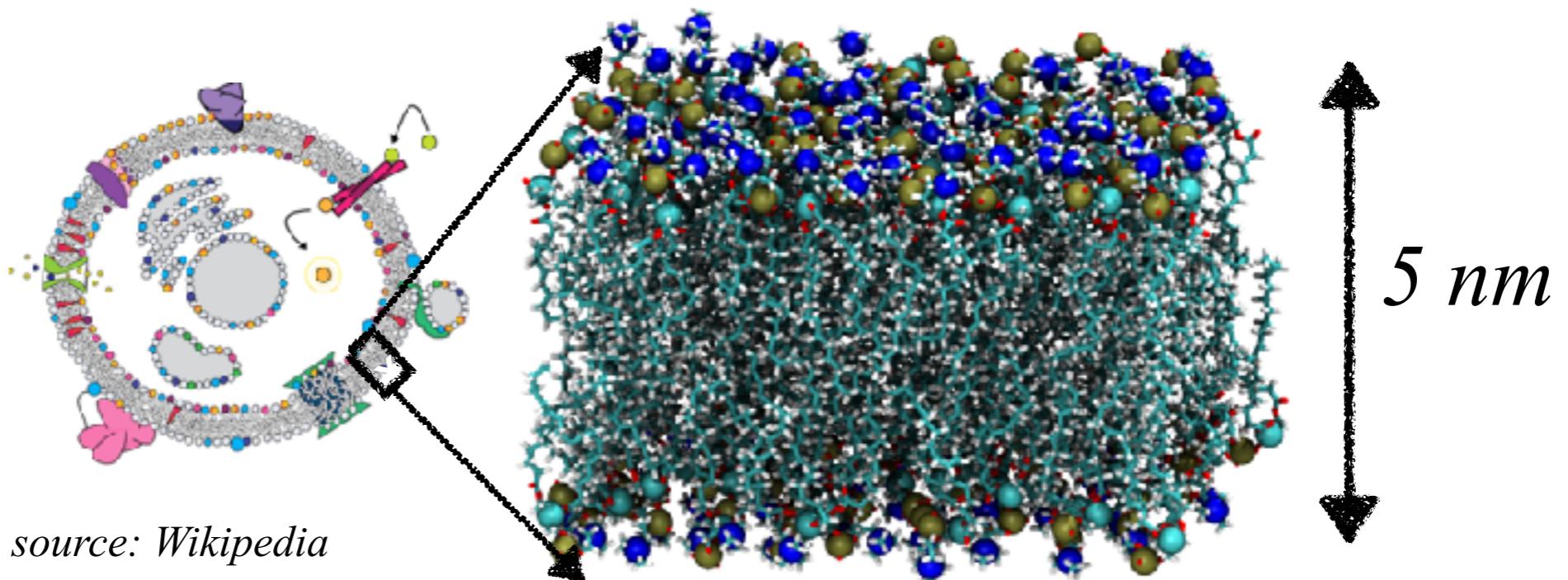
- Part of pathogen (antigen)



Antigen

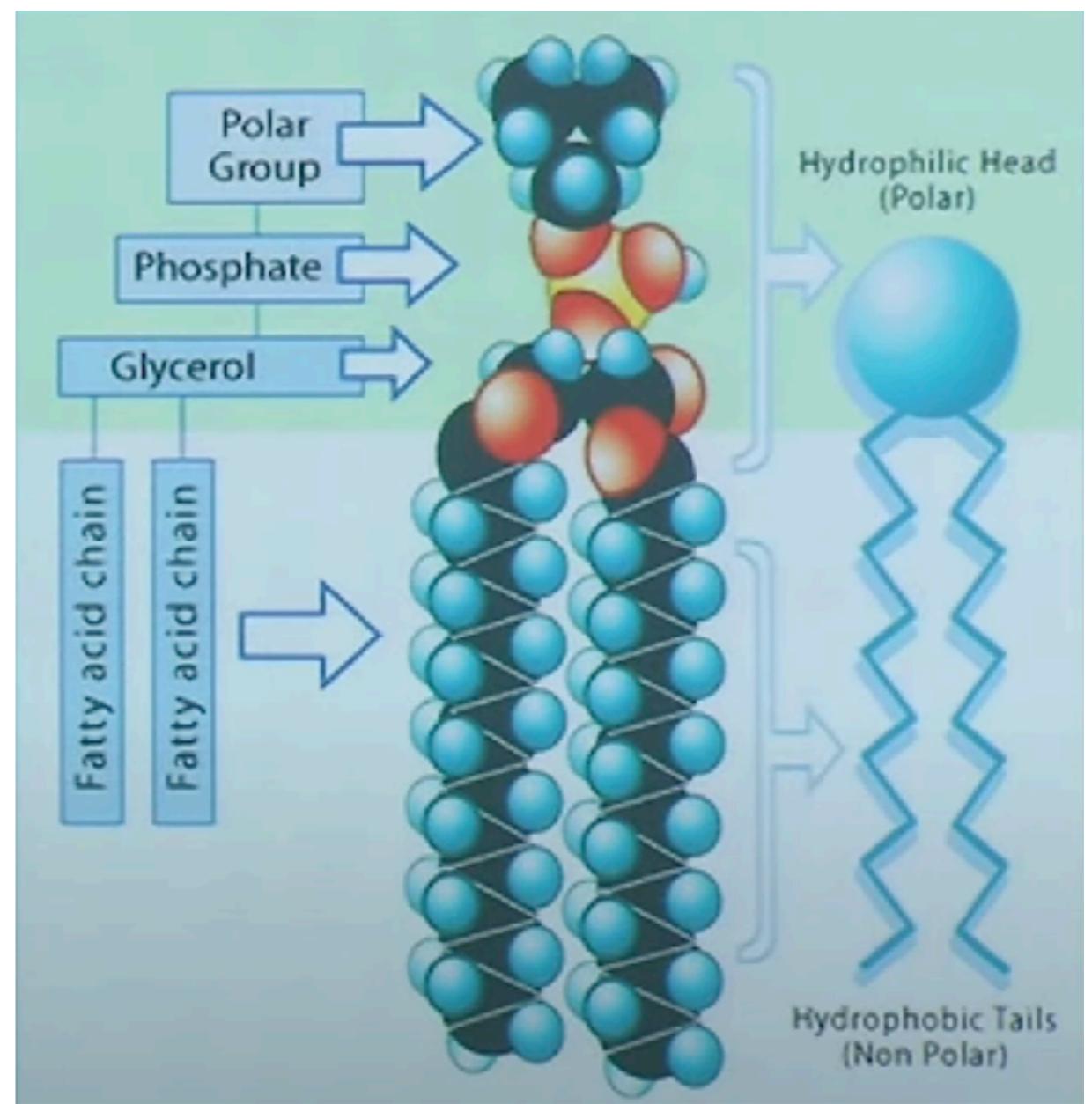
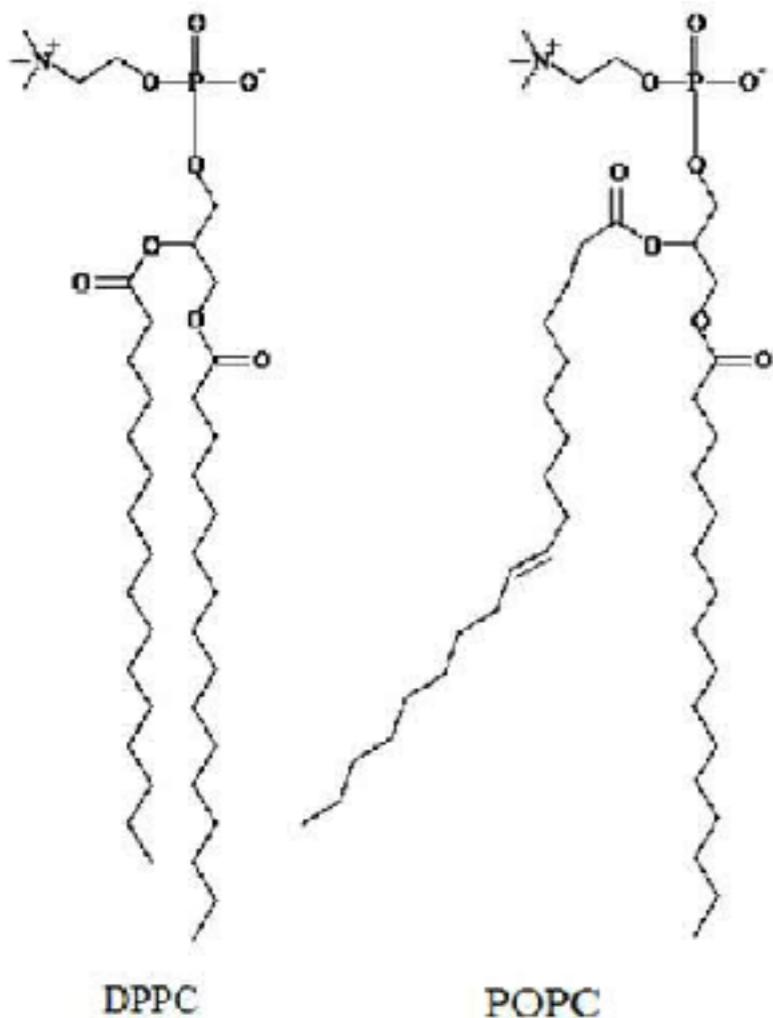


Structure of phospholipid bilayer membranes

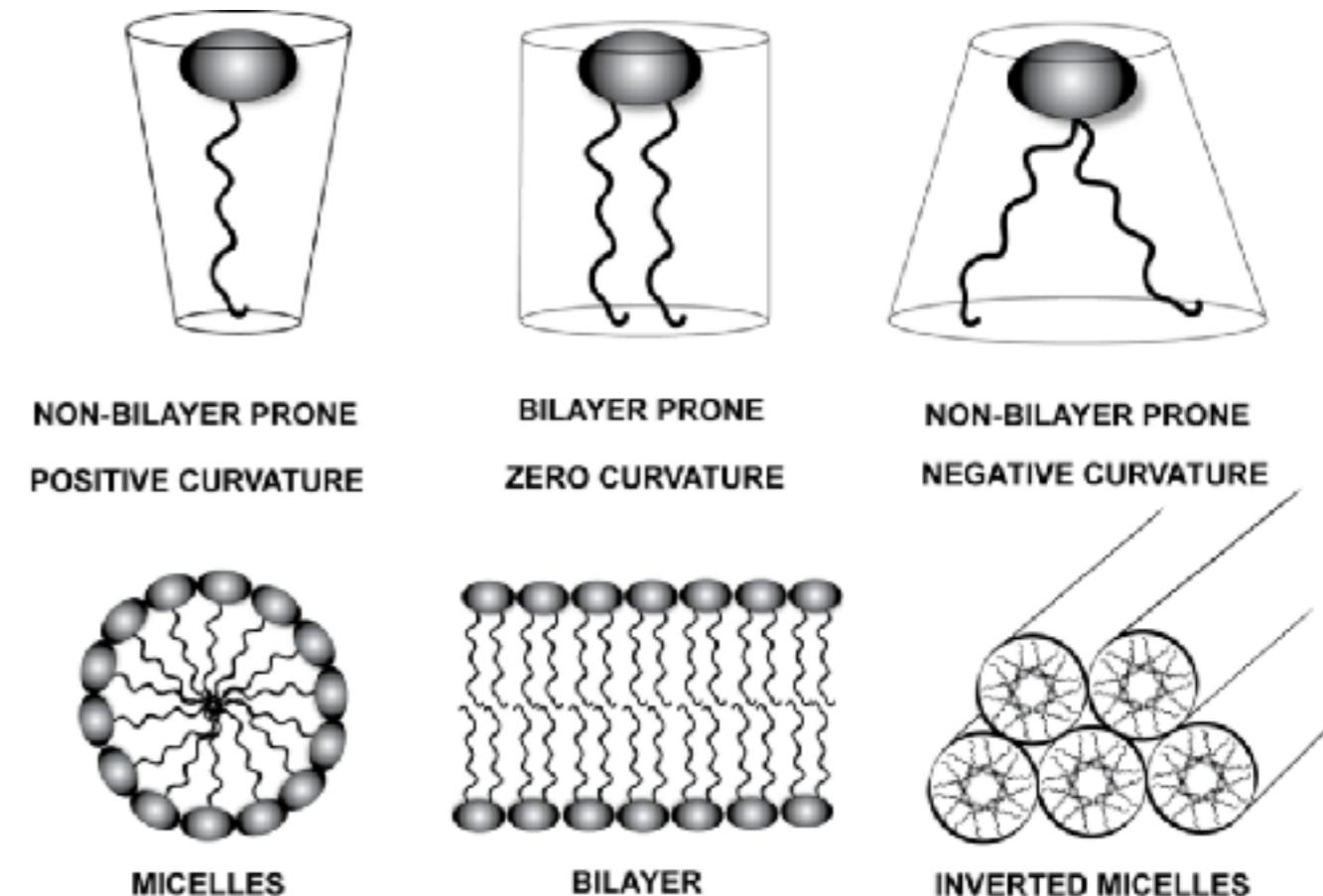
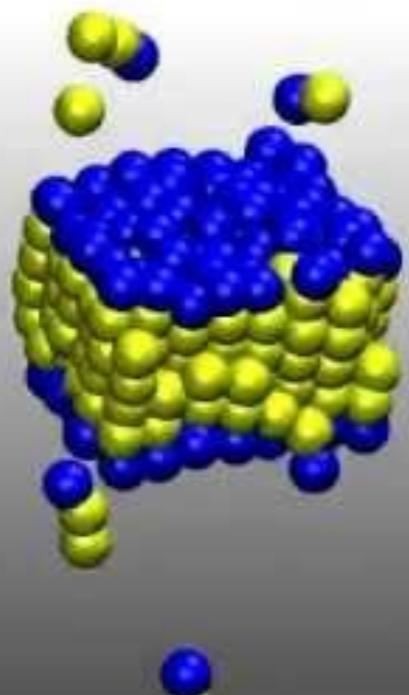


Lipid molecules

Lipids are a major class of biomolecules, made of fatty acids, cholesterol, triglycerols, even fat soluble vitamins (Vitamin A E K etc)

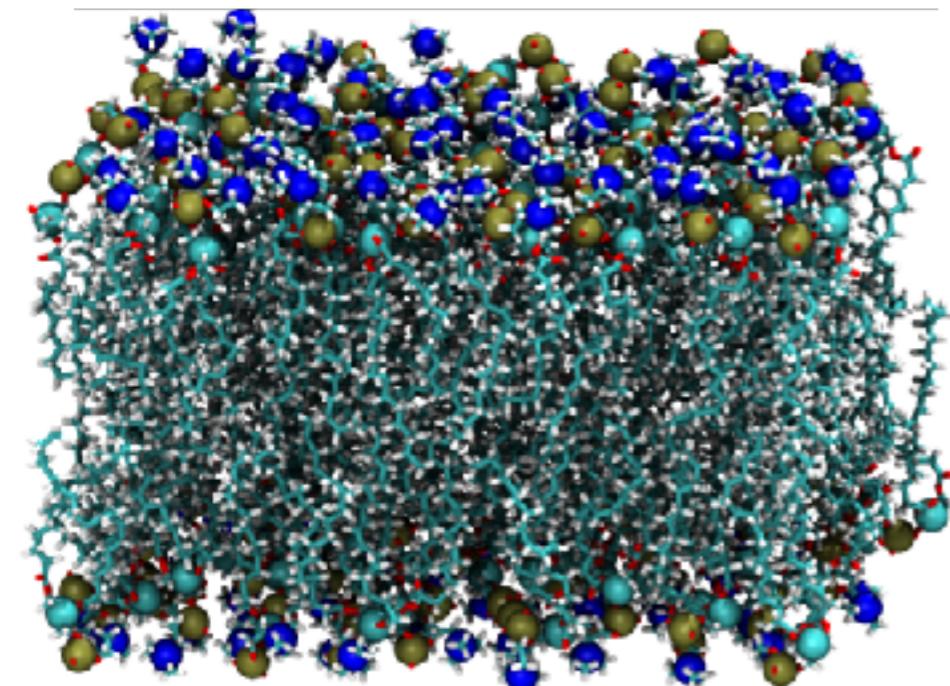
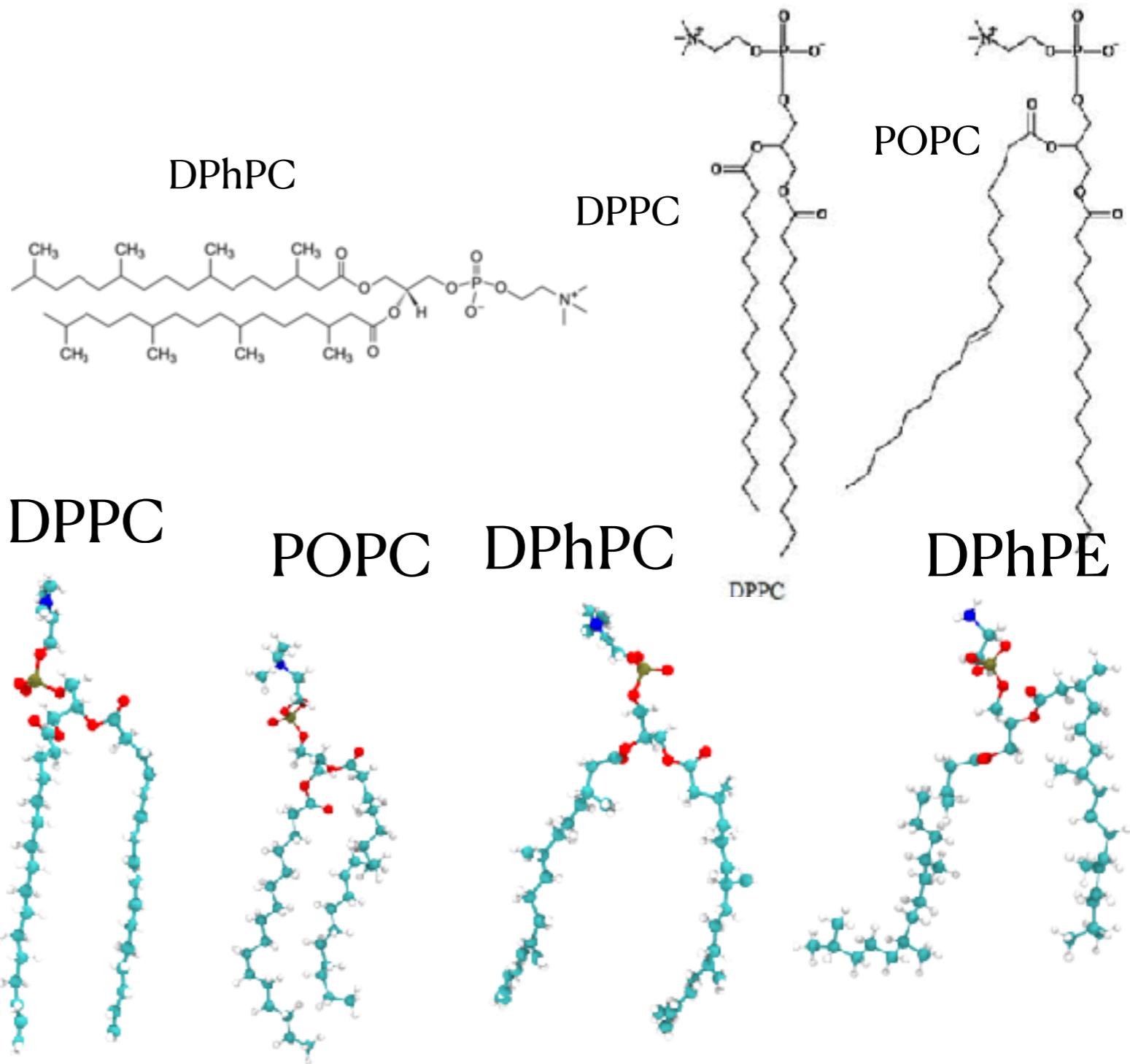
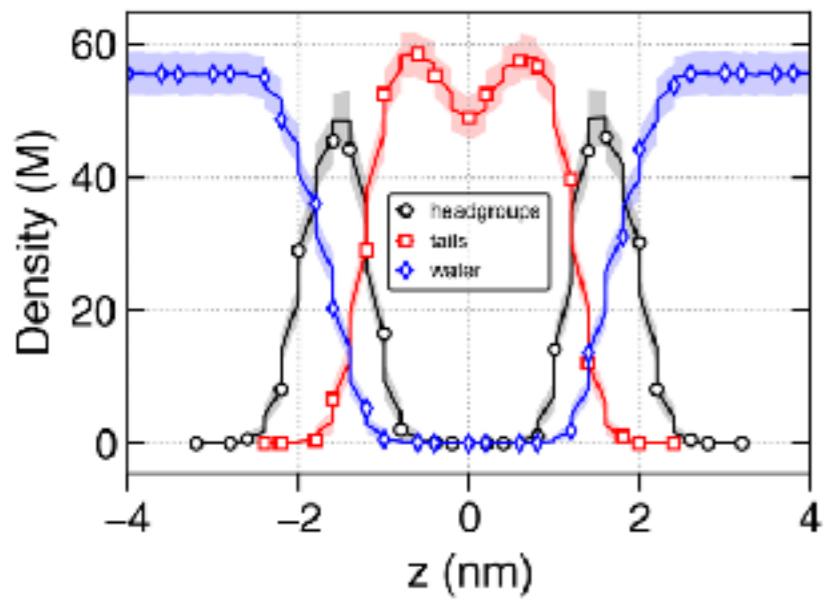


Various structure obtained by the self assembly of lipid membranes



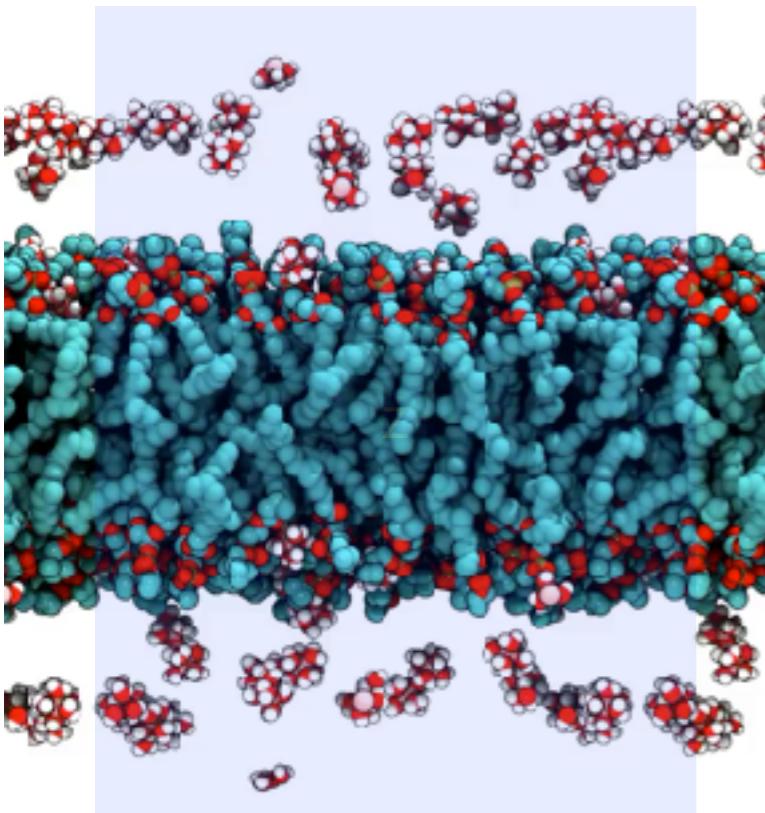
Reference
Thesis: Candan Ariöz

Commonly modeled glycerophospholipids

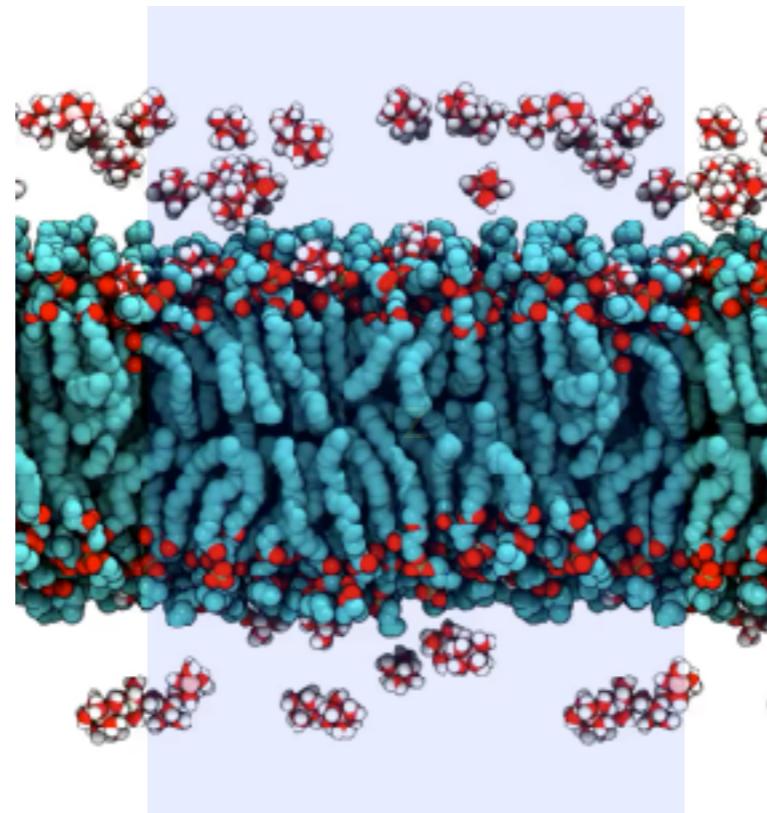


MD simulation movies of PC membranes in gel and fluid-phase

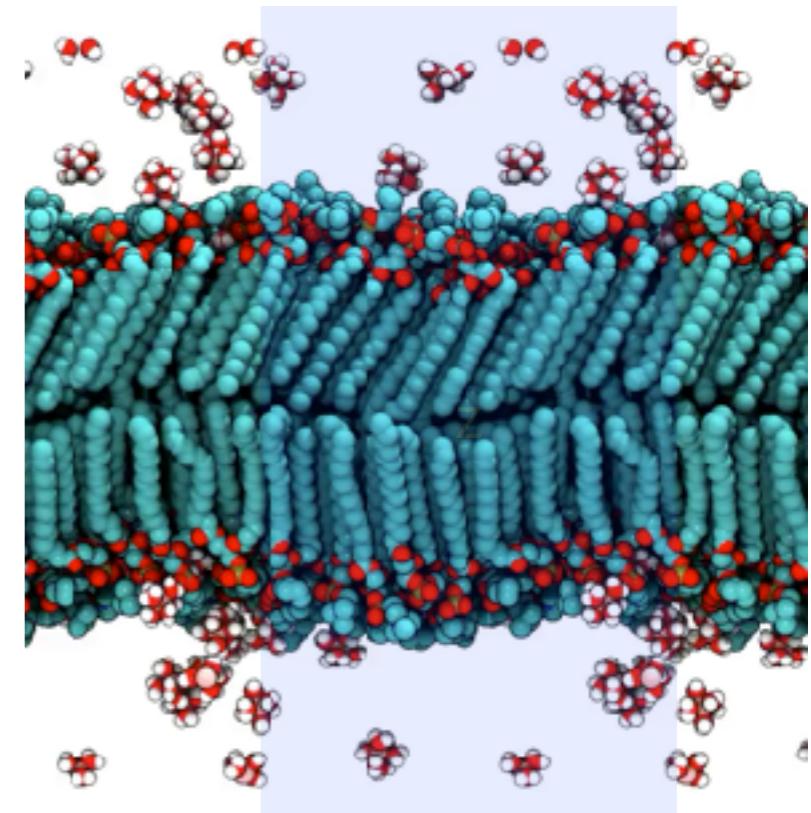
DPhPC (300 ns)



POPC (406 ns)



DPPC (448 ns)

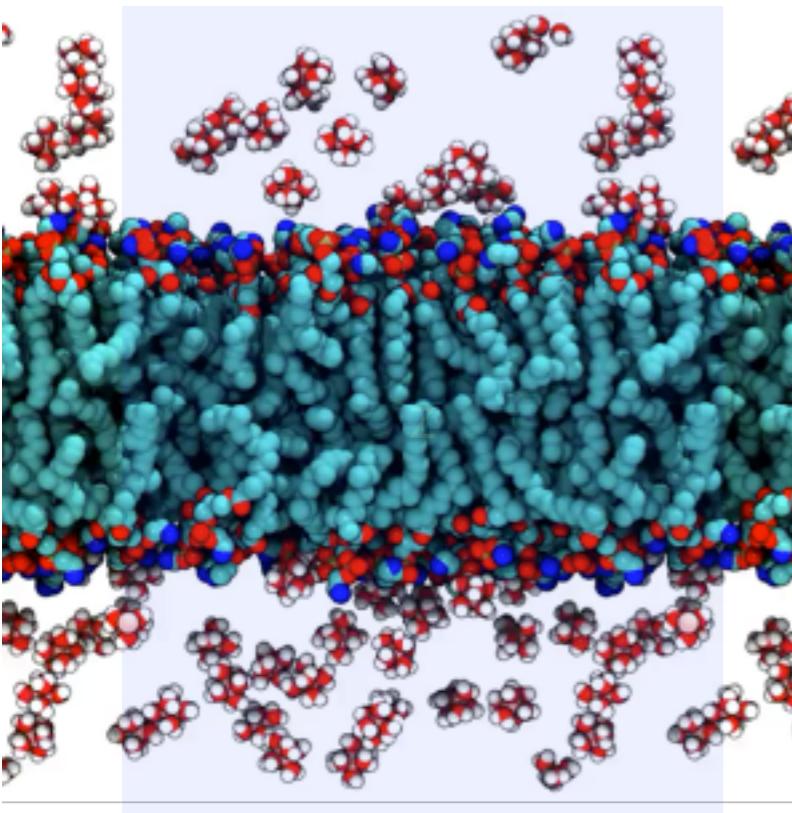


- As expected, the diffusion of lipids is very slower in gel phase as compared to liquid crystalline phase.
- A few (3) Mg²⁺ ions formed long lasting contacts with DPPC membrane.

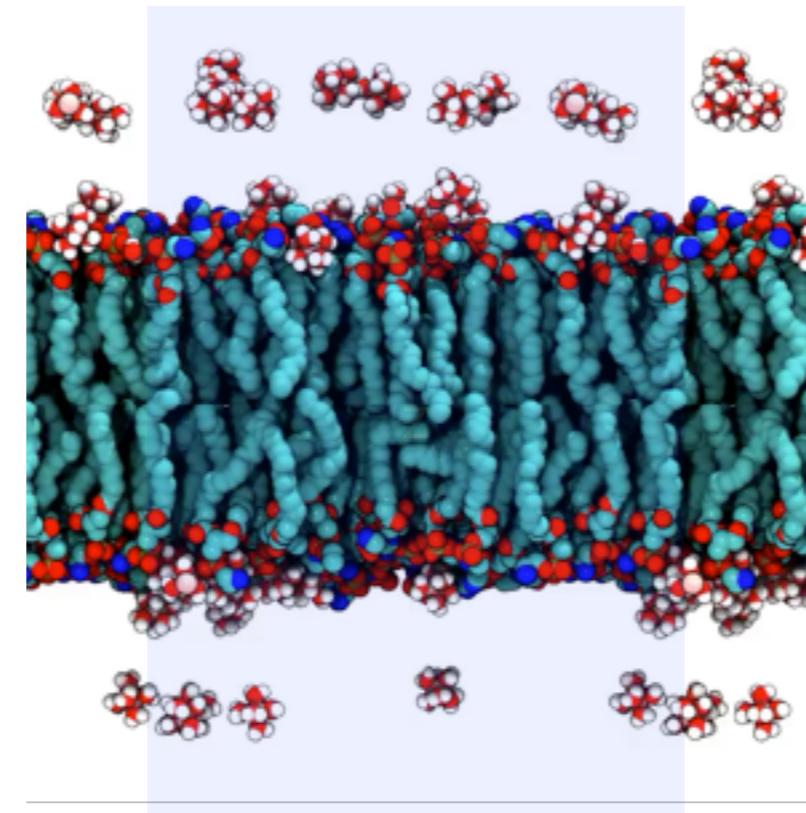
*Water and Cl⁻ ions are not shown, the transparent background approximately shows the unit of simulation.

MD simulation movies of PE membranes in gel and fluid phases

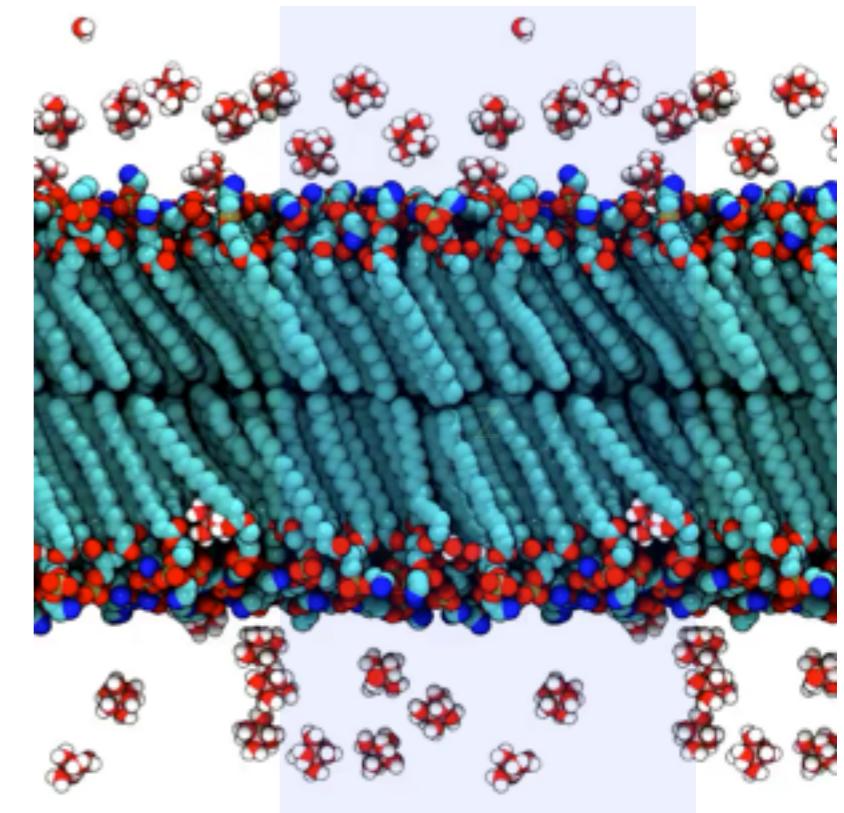
DPhPE (320 ns)



POPE (300 ns)

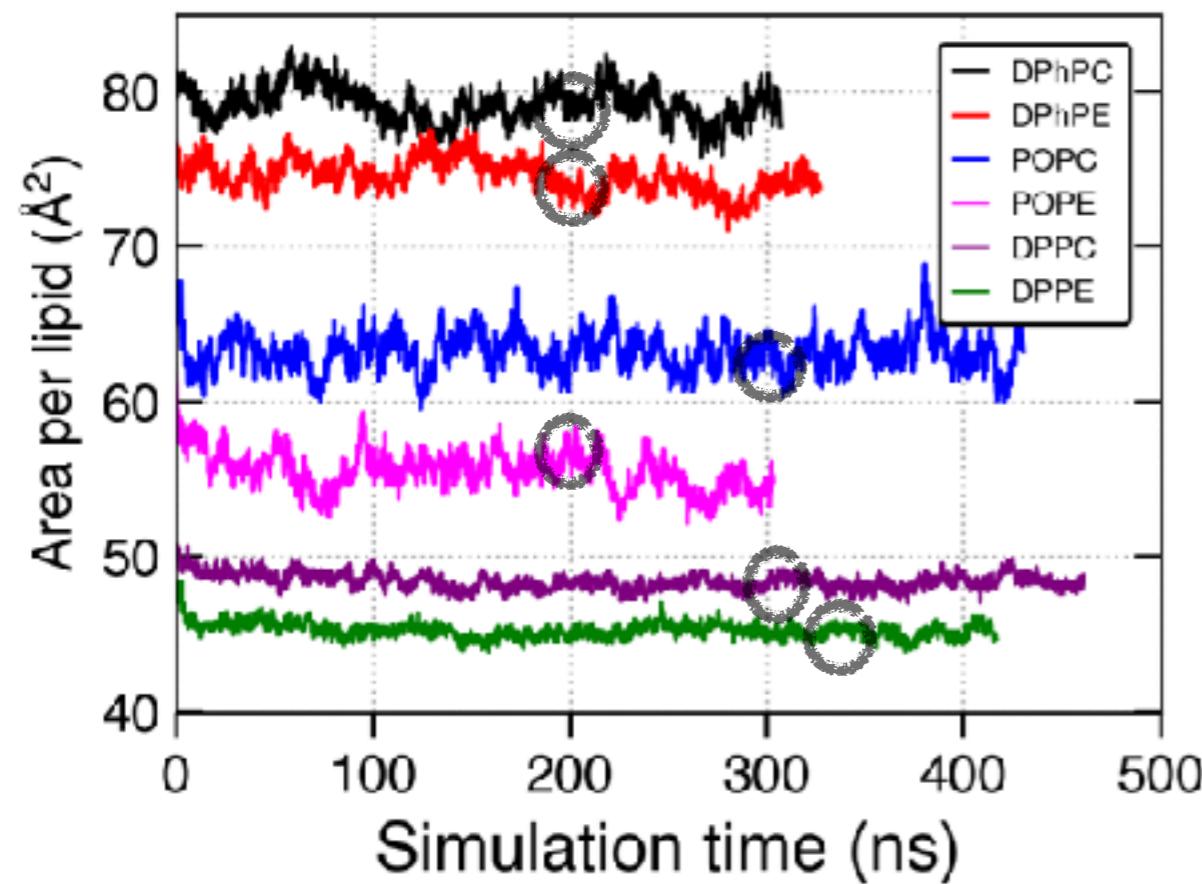


DPPE (412 ns)

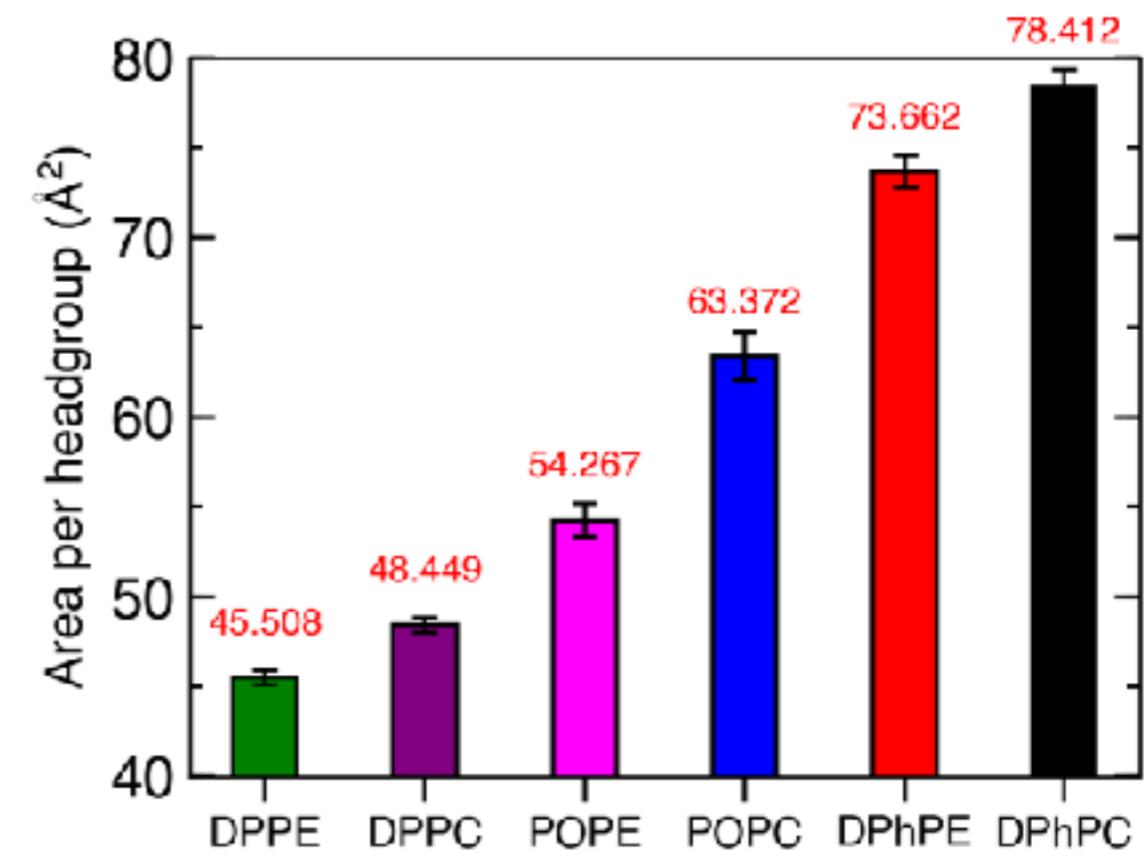


- Similar to DPPC, DPPE membrane also goes to gel-phase at room temperature, which can be easily characterized by slow diffusion of lipids.

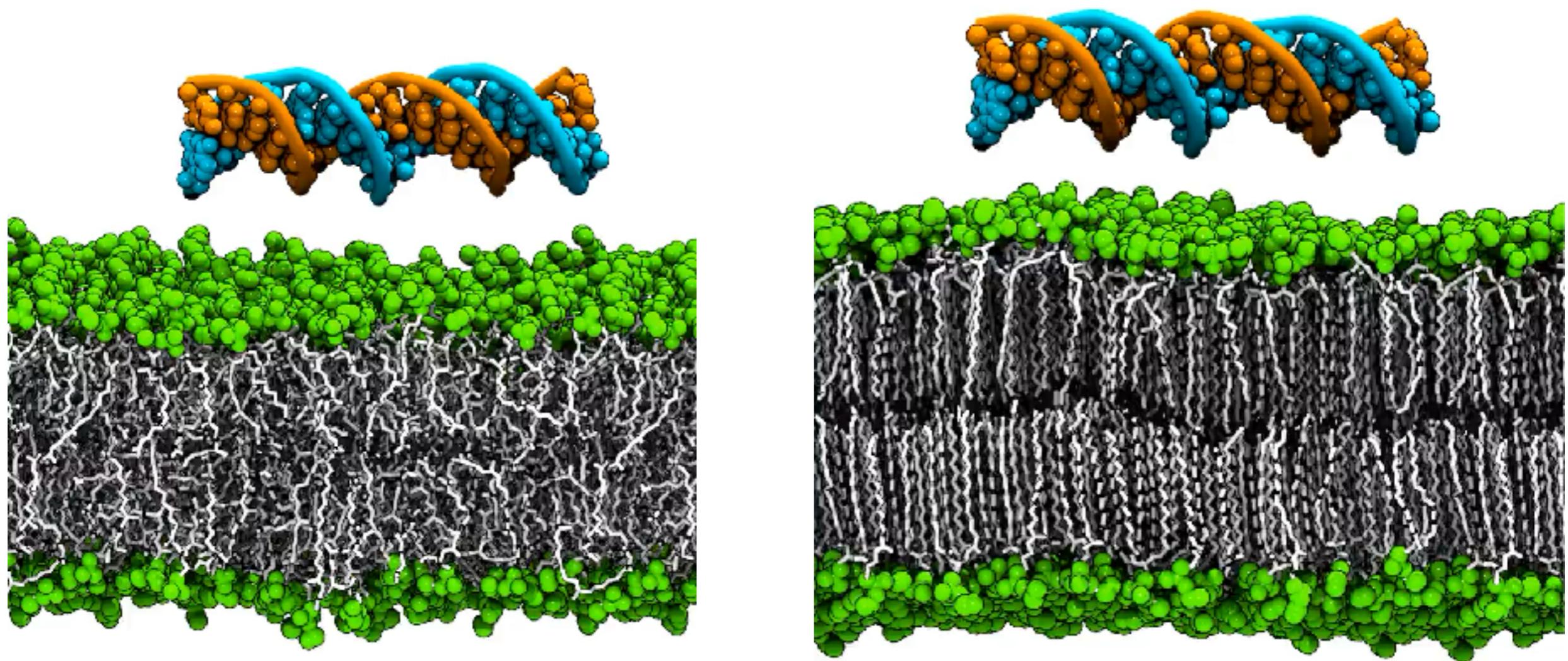
Area per head group



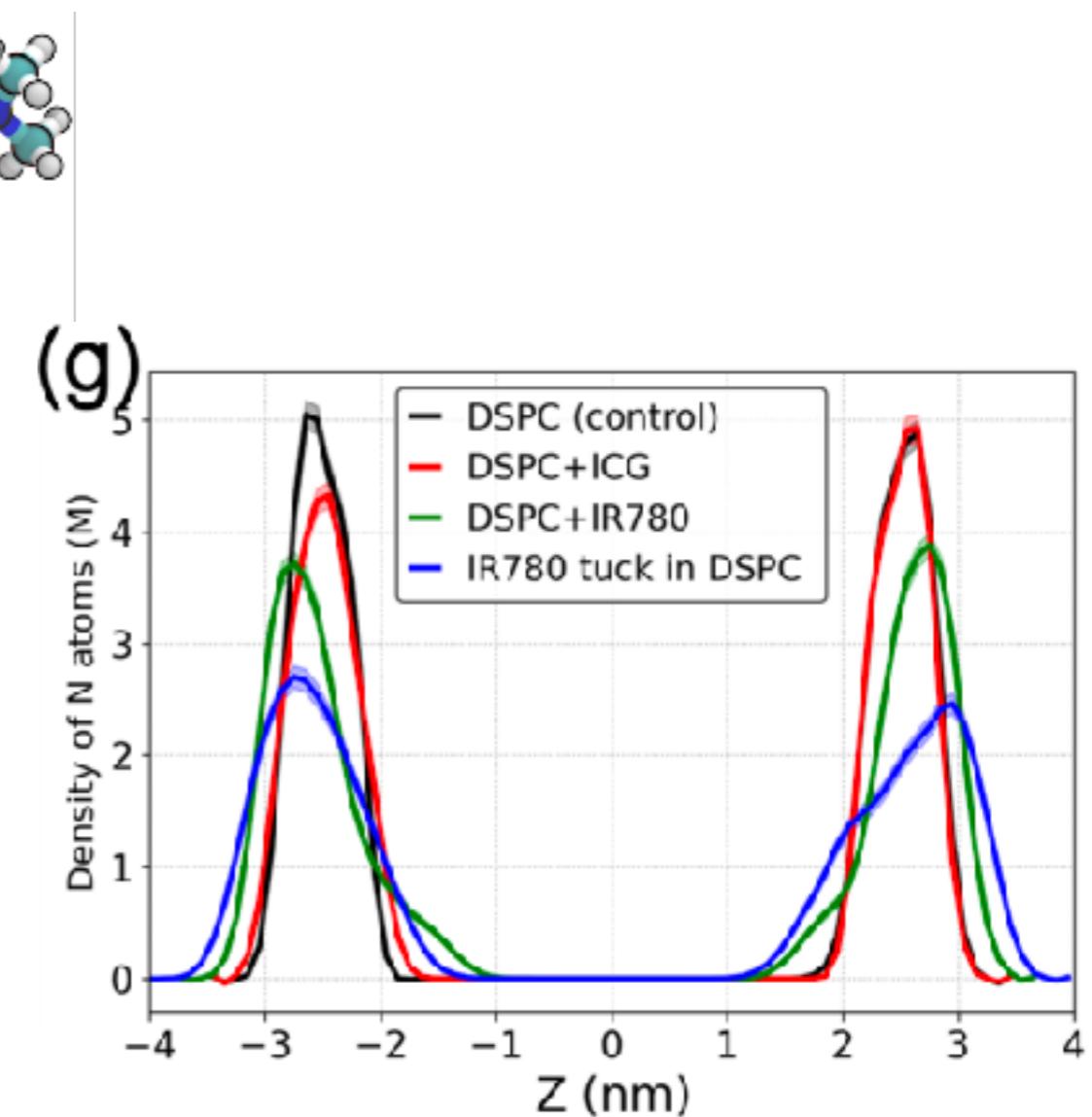
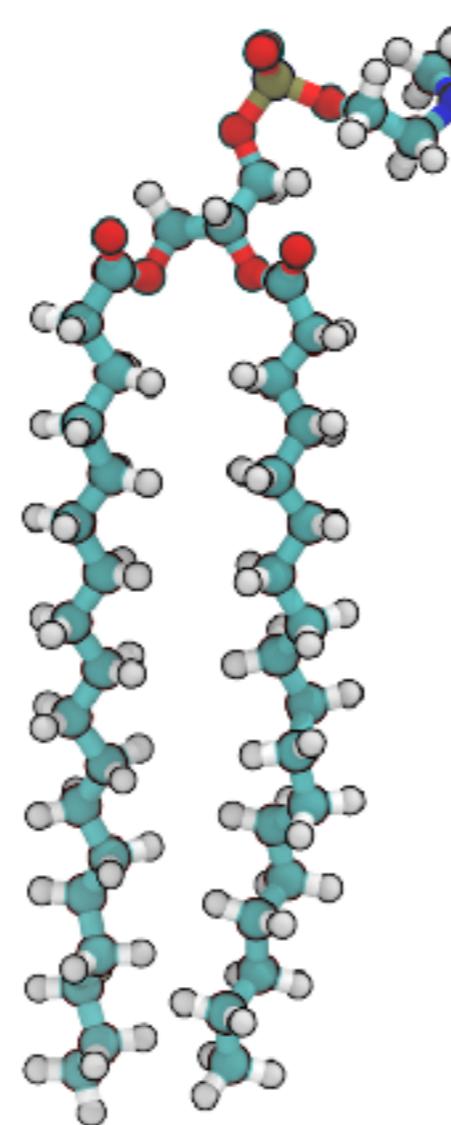
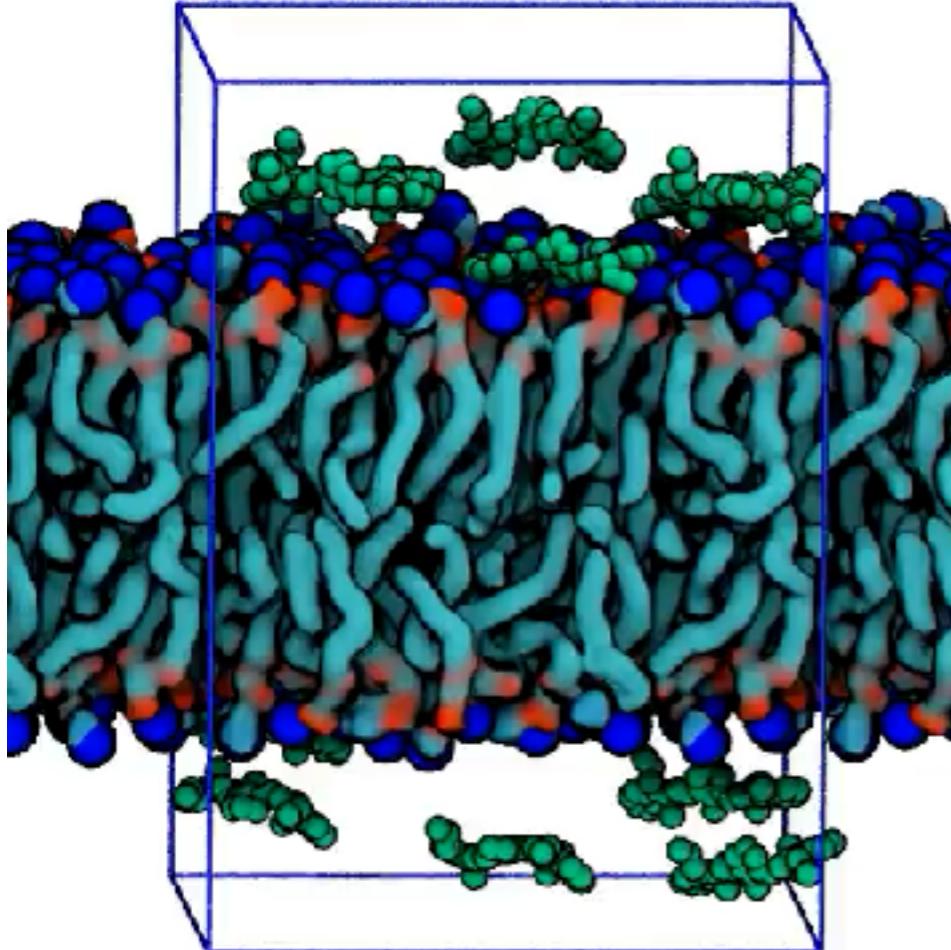
Average area



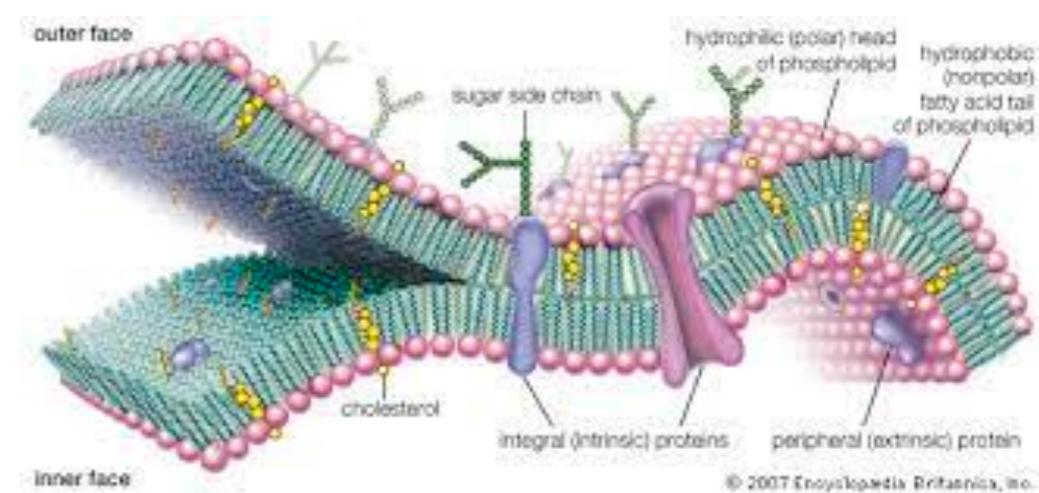
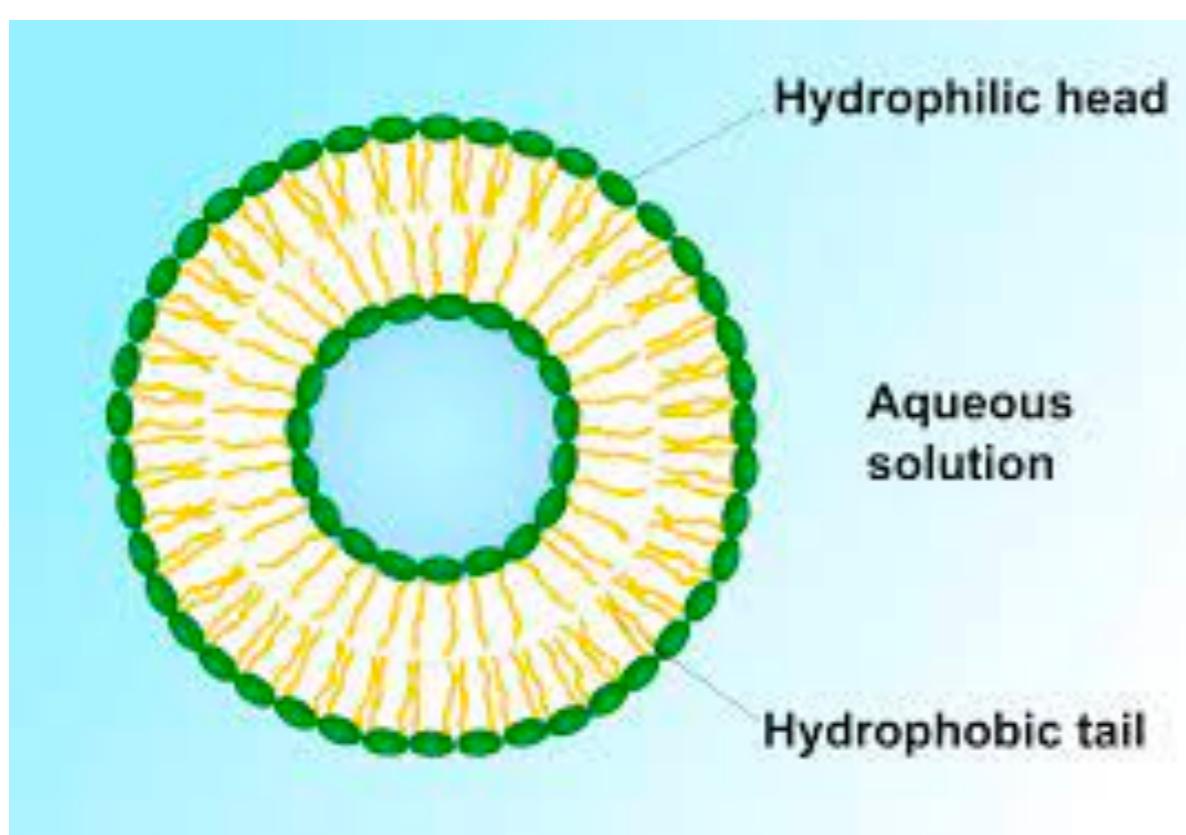
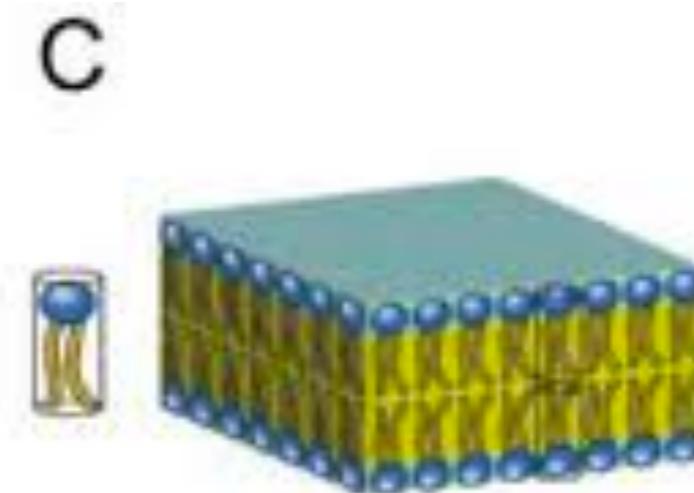
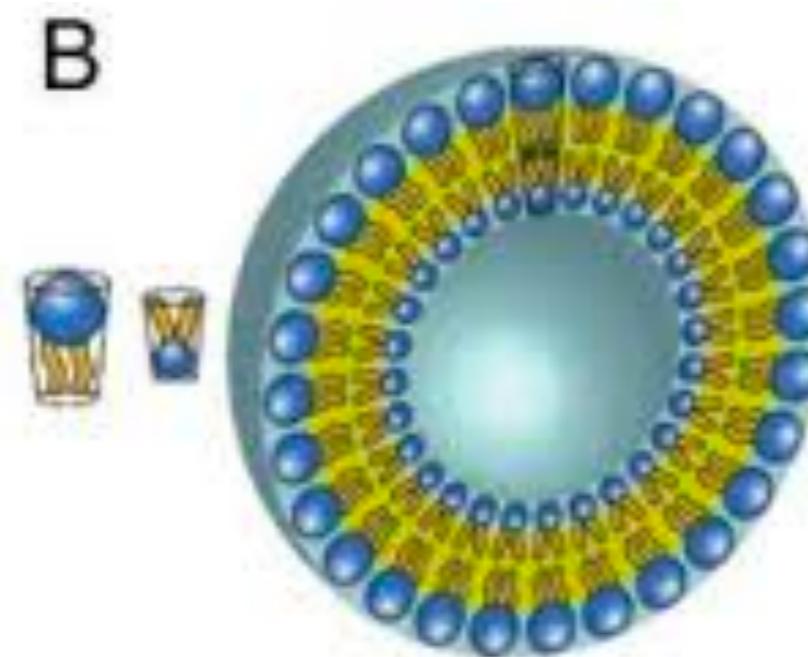
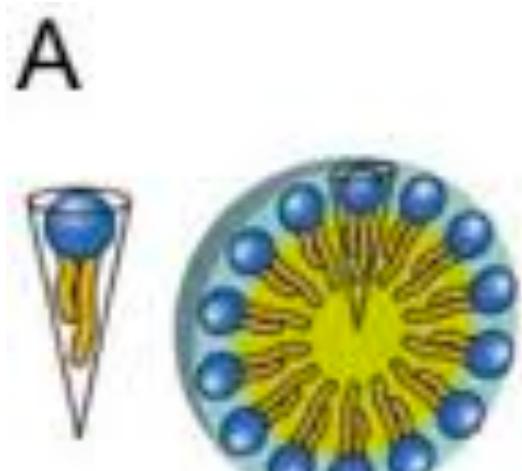
dsDNA on gel and fluid phase membranes



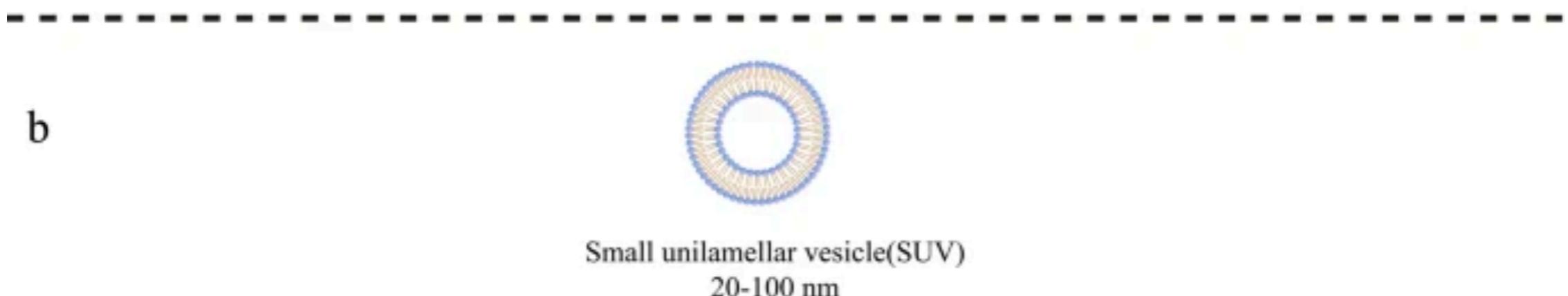
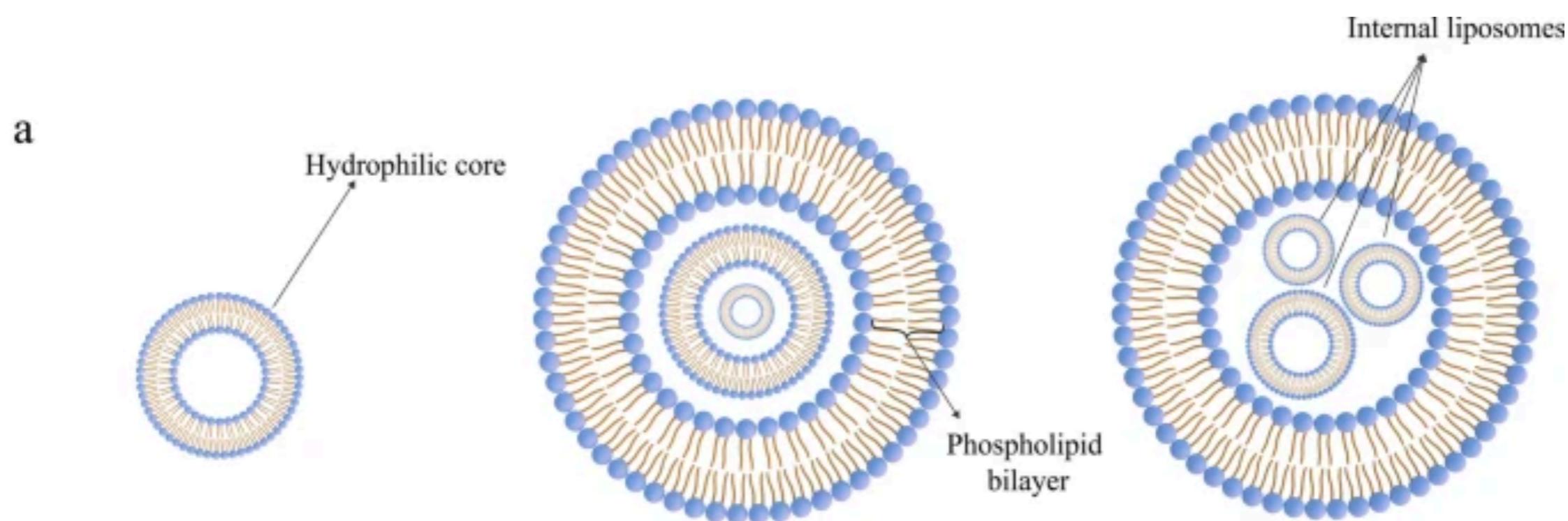
DSPC lipid bilayer membrane



Various structure obtained by the self assembly of lipid membranes



Source: Wikipedia



Reference
DOI:10.1186/s11671-021-03553-8

Surface tension

The tendency of liquid surfaces at rest to shrink into the minimum surface area possible.

72 dynes/cm is the surface tension of water

Simulation	Description	Simulation time (ns)	γ (dyn/cm)
R-A1	DLPE (60 bins)	1.4	34.2 (2.6)
R-A2	DLPE (120 bins)	2.1	21.8 (4.7)
R-B	DLPC	1.6	40.36 (4.7)
R-C1	POPE (48.5\AA^2)	1.9	-24.1 (8.5)
R-C2	POPE (53.3\AA^2)	1.9	46.6 (7.0)
R-C3	POPE (59.1\AA^2)	1.9	43.9 (1.3)
R-C4	POPE (64.9\AA^2)	1.9	48.8 (4.3)
R-D1	POPC (64.0\AA^2)	2.4	37.2 (6.0)
R2-D1	POPC (64.0\AA^2)	5.5	39.6 (1.8)
R-D2	POPC (67.24\AA^2)	2.6	27.6 (10.2)
R-D3	POPC (70.56\AA^2)	2.5	35.7 (2.4)
R-D4	POPC (73.96\AA^2)	2.5	38.2 (7.4)