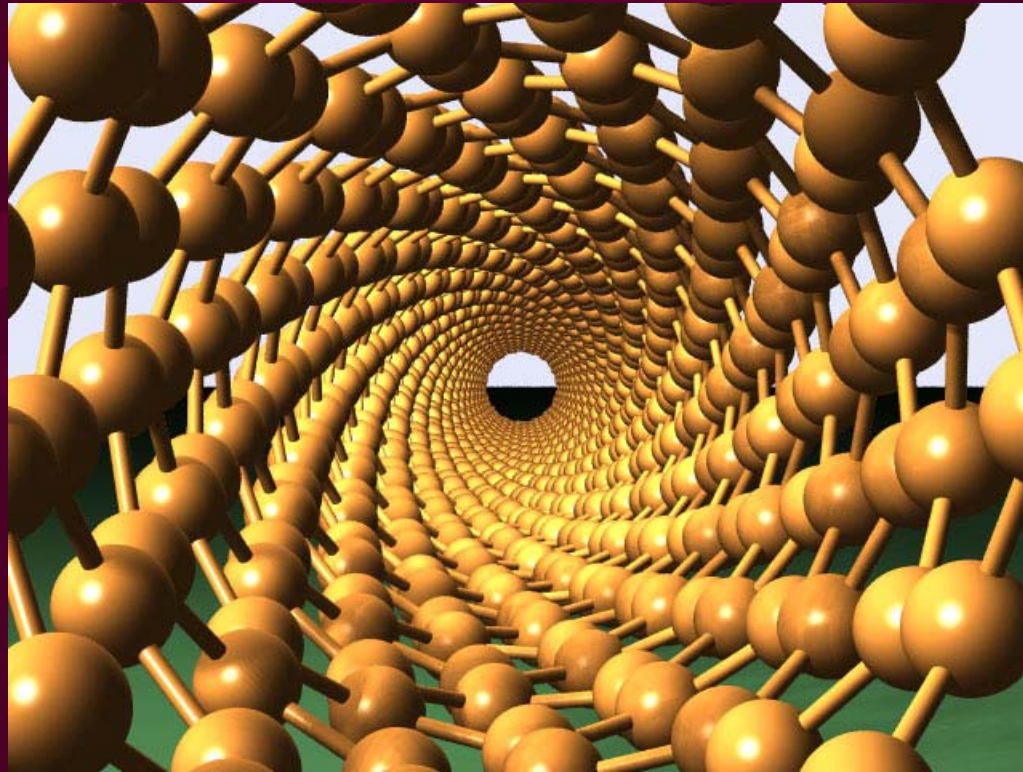
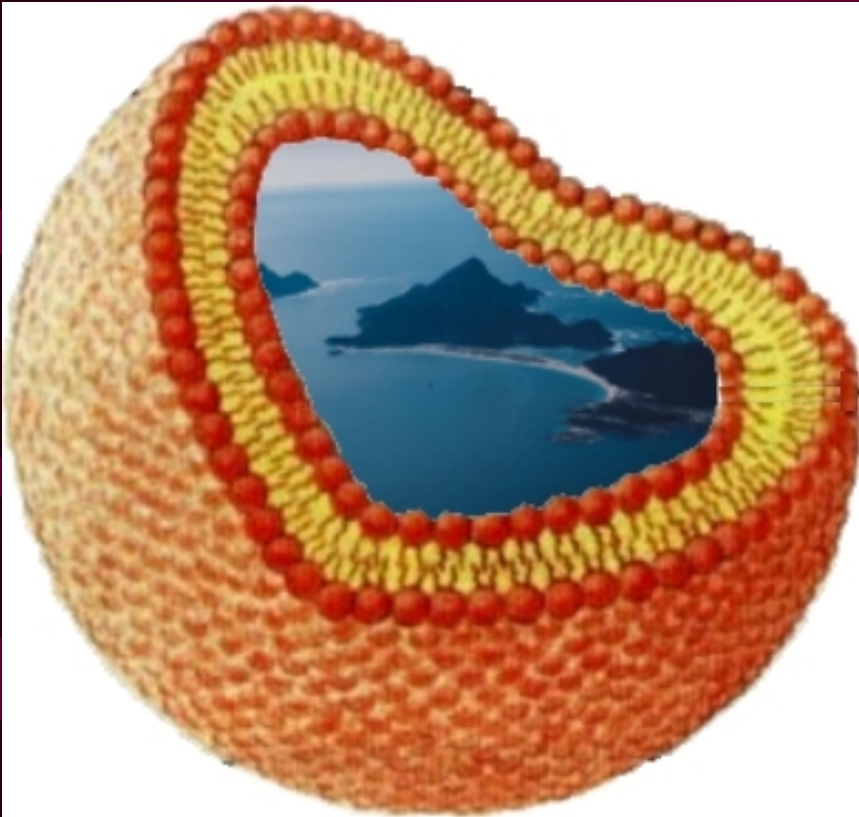


Forming Vesicles From Carbon Nanotubes



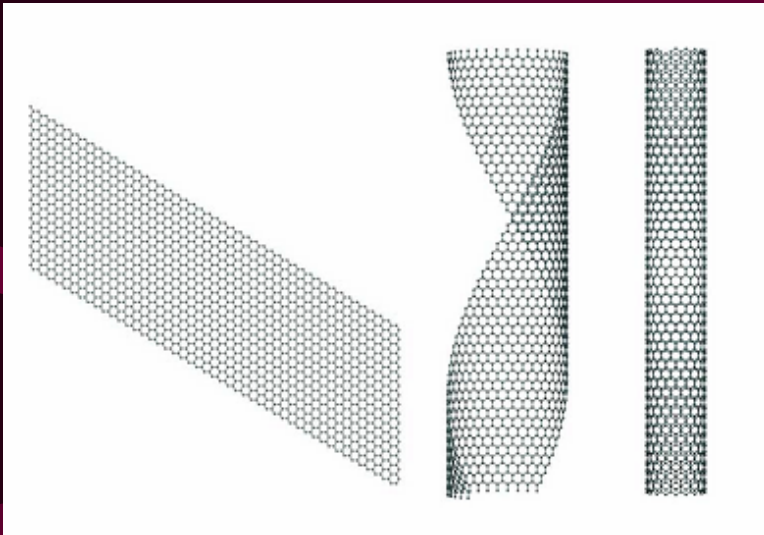
Alexsandra Fridshtand – BioE
Mentor – Dr. Jennifer Lukes

Vesicles



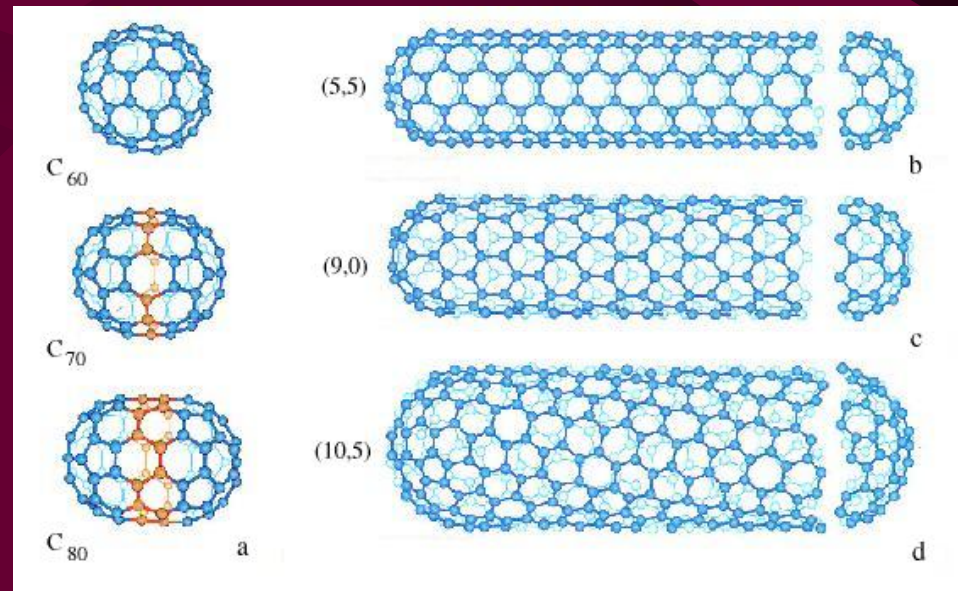
- Spherical containers
- Found in animal cells
- Made of a phospholipid bilayer
- Liposome = artificial vesicle

Carbon Nanotubes (CNTs)



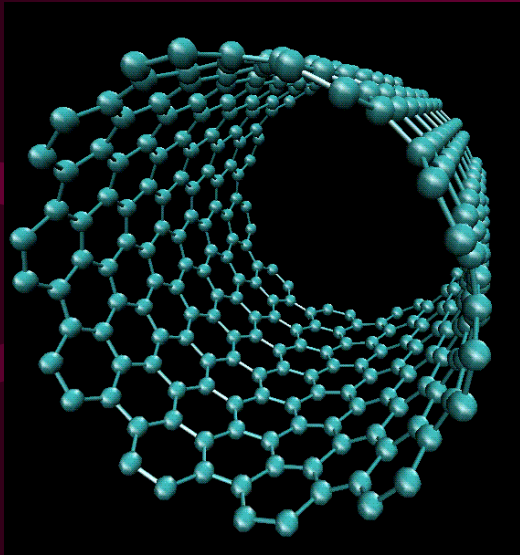
- Graphene sheet rolled into a cylinder

- Can be “capped” on the ends



Types of CNTs

- SWNT



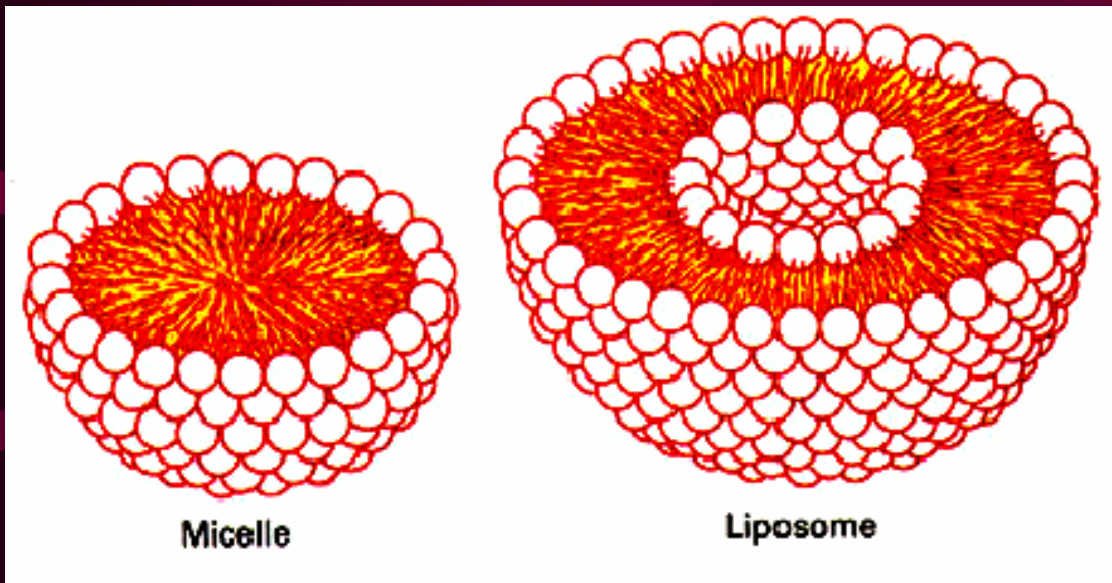
- One cylinder
- Diameter ~ 1.4 nm

- MWNT



- Concentric cylinders
- Interlayer dist $\sim .34$ nm

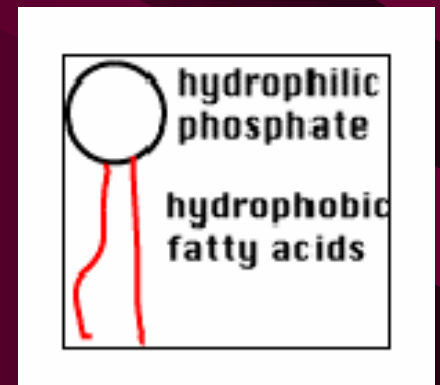
Micelles and Vesicles as Drug Carriers



- Monolayer
- Hold hydrophobic drugs

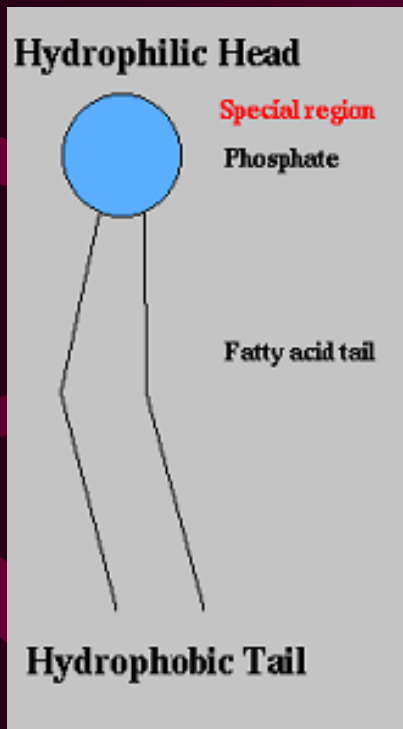
- Bilayer
- Hold hydrophilic drugs

Phospholipid

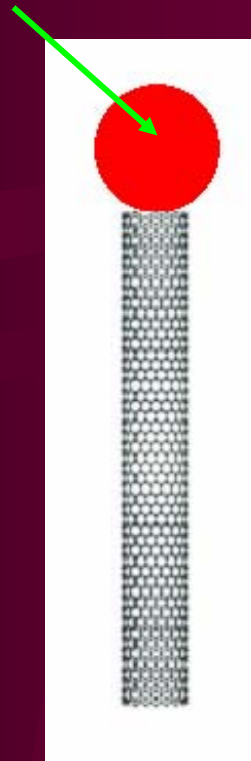


Functionalization of CNTs

attached hydrophilic region



Phospholipid



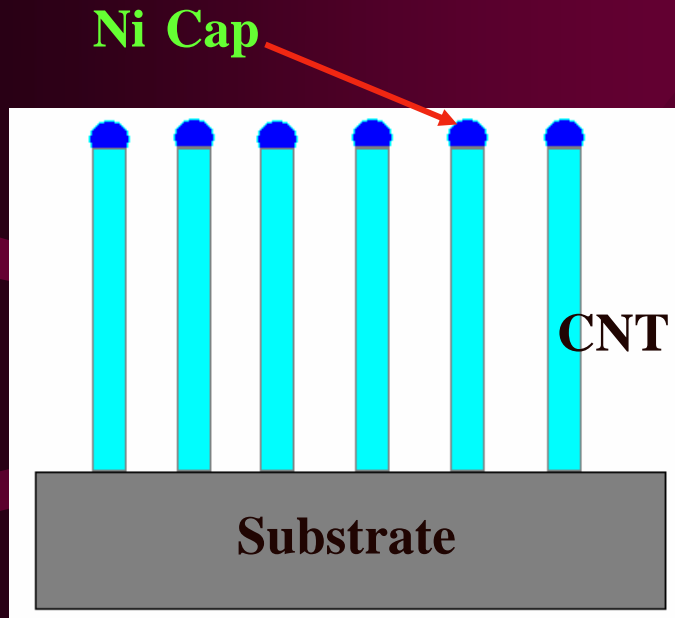
CNT

- Functionalize one end of the CNT with a hydrophilic molecule
- Mimics phospholipid in order to form vesicle

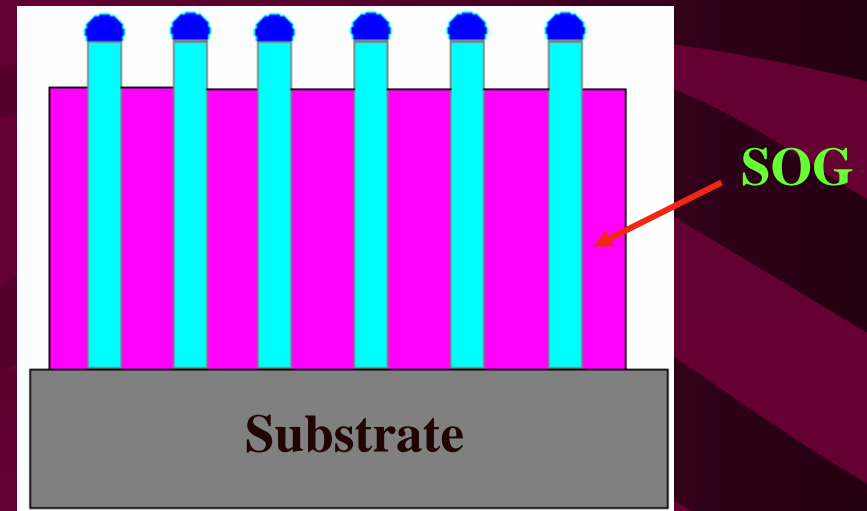


vesicle

Functionalization Process



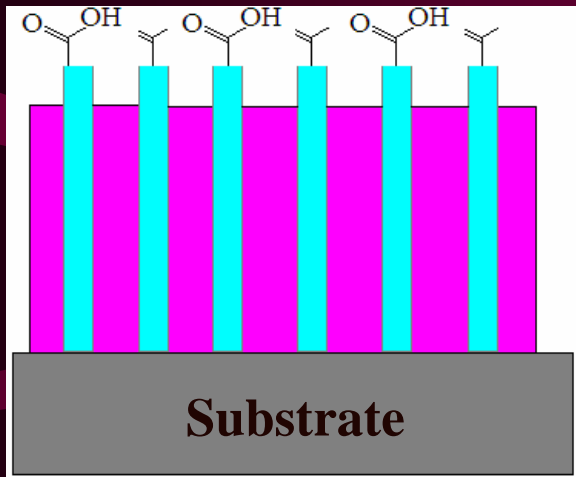
1. Grow nanotubes aligned on a substrate



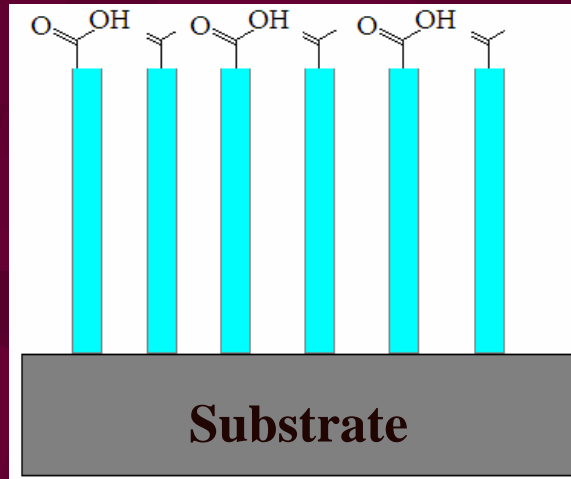
2. Fill in matrix between the CNTs, leaving only tips exposed

Functionalization Process

COOH groups

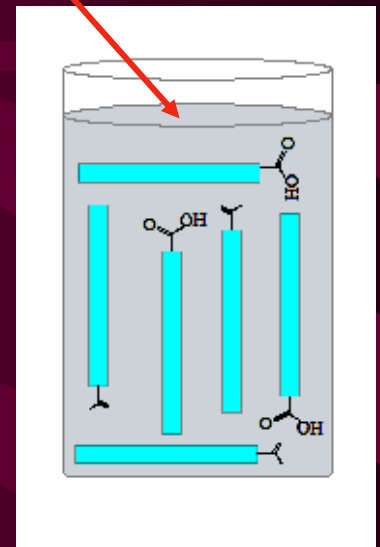


3. Add COOH to the tips



4. Dissolve the SOG matrix

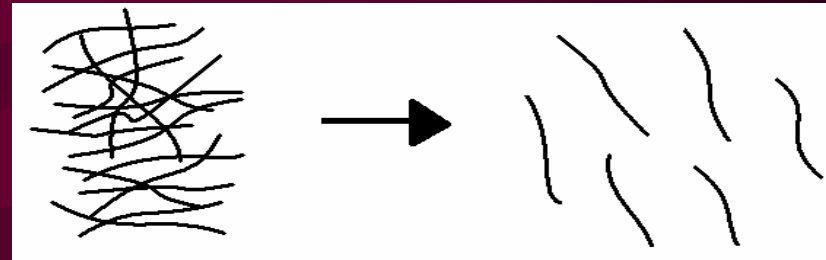
DiH₂O



5. Strip from substrate

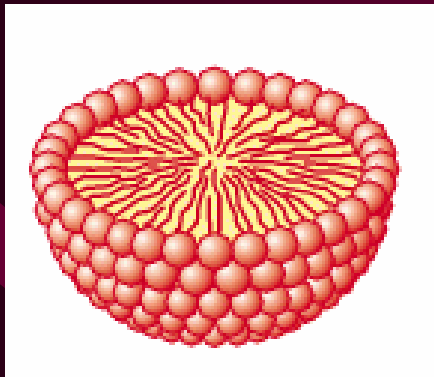
Conditions for Self-Assembly

- Dispersion
 - Ultrasonication
 - Surfactants

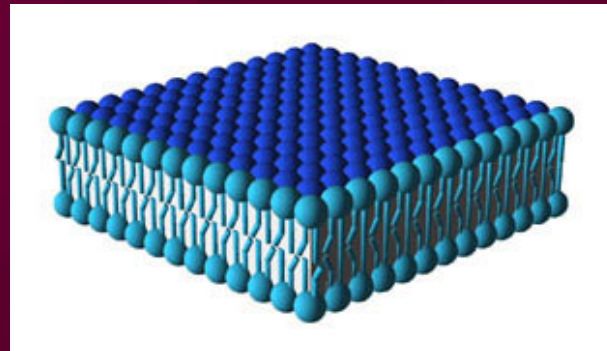


CNTs naturally bundle together

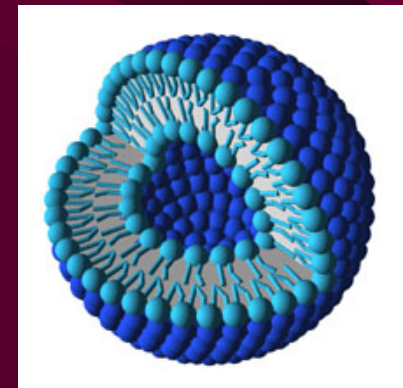
- Phase Determination



Micelle



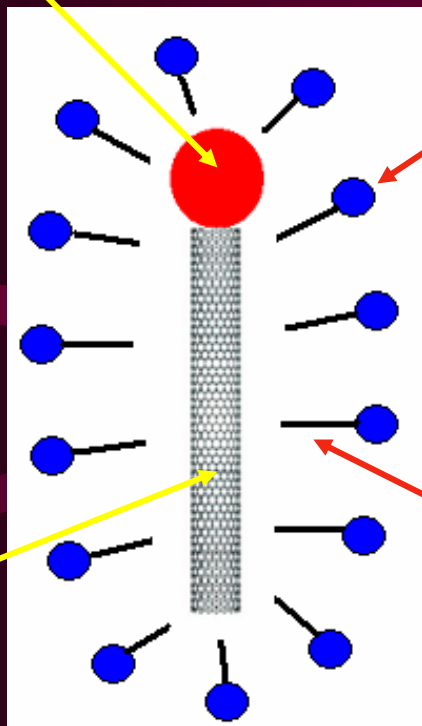
Bilayer



Vesicle

Surfactants

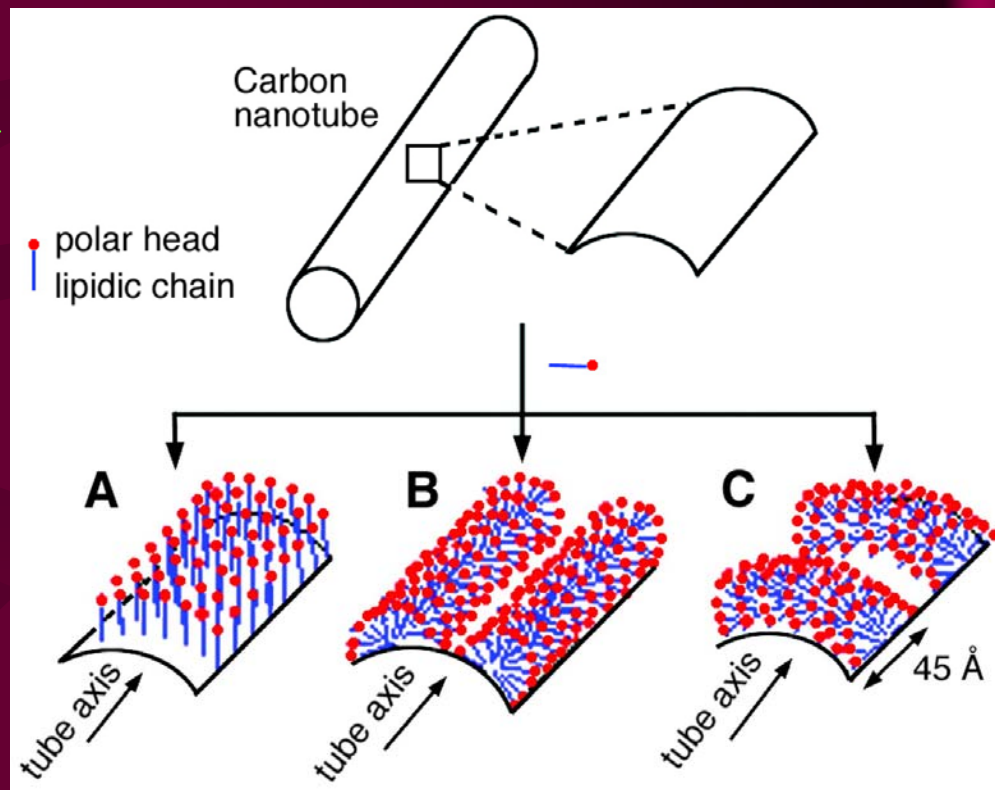
polar COOH groups



polar head

nonpolar tail

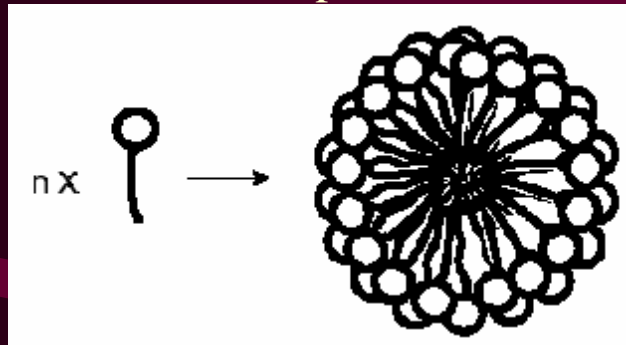
nonpolar CNT



Surfactants can coat nanotubes in various ways, so it is not clear whether they will help or interfere with nanotube self-assembly

Concentration Determining Phase

Spherical micelle

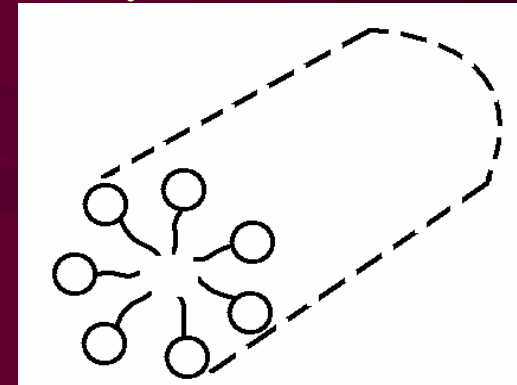


At critical micelle conc. (CMC)

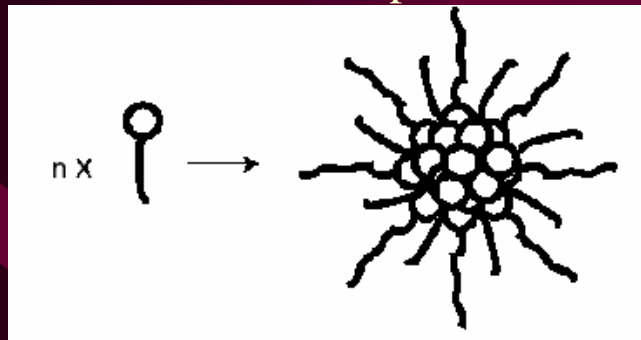
Increase conc.



Cylindrical micelle



Inverted spherical micelle

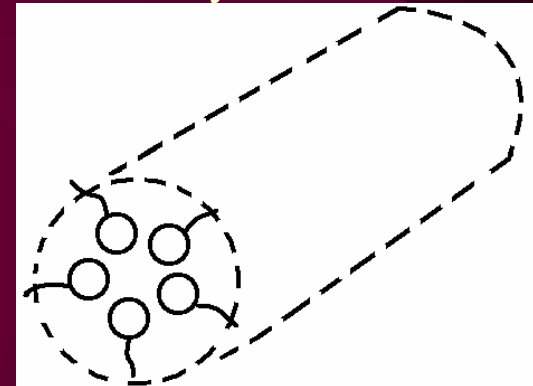


At very high concentrations

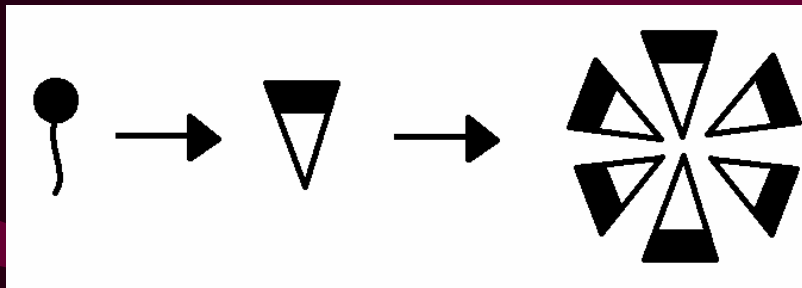
Increase conc.



Inverted cylindrical micelle



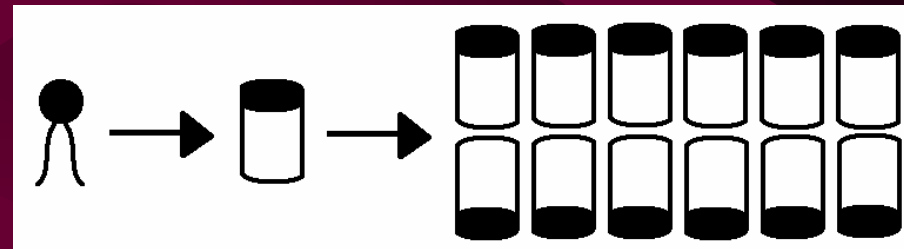
Molecule Shape Determining Phase



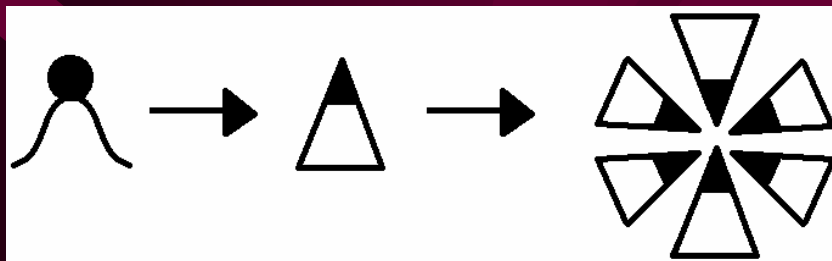
micelle

Polar region is bigger than nonpolar region

Polar and nonpolar regions are about the same size



bilayer

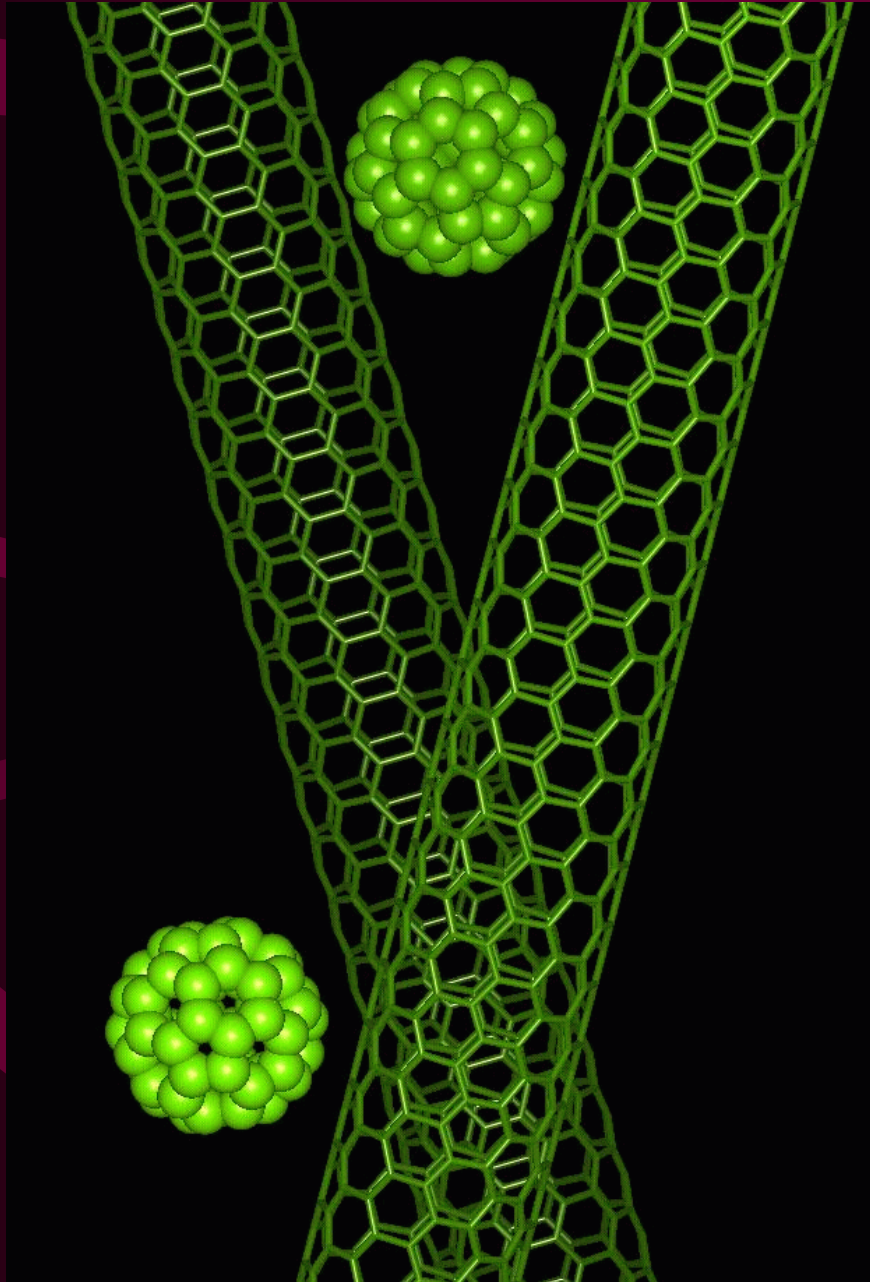


inverted micelle

Nonpolar region is bigger than polar region

Conclusions

- Experiment with:
 - Nanotube Concentration
 - Different dimensions of nanotubes
 - Various types and amounts of surfactant (if sonication is not sufficient)
- Develop recipes for each type of phase
 - Can then be replicated easily



Any
Questions?