SOFT CONDENSED MATTER

INTRODUCTION.

WHAT IS IT?

DEFORMABLE.

ELASTIC MODULUS : WEAK.

↳ $\frac{\text{ENERGY}}{\text{VOLUME}}$ → $kT \rightarrow eV$

→ VOLUME / 'PARTICLE'

VOLUME :

HARD ~ $\mathring{A}^3$

SOFT ~ $nm^3 \rightarrow \mu m^3$

REDUCTION 10^{-3} 10^{-12}

⇒ LARGER LENGTH SCALES

KEY PHYSICS:

PHYSICS OF LARGER LENGTH SCALE OBJECTS.

EXAMPLES

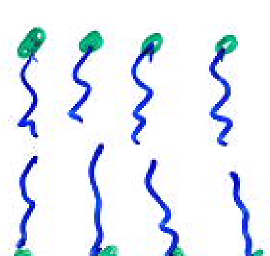
1. LIQUID CRYSTALS

LARGER MOLECULES

2. POLYMERS

VERY LARGE MOLECULES

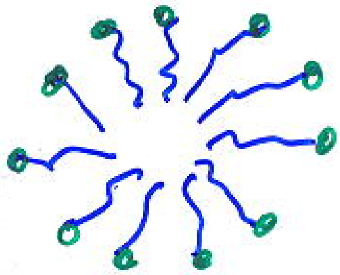
3. SURFACTANTS



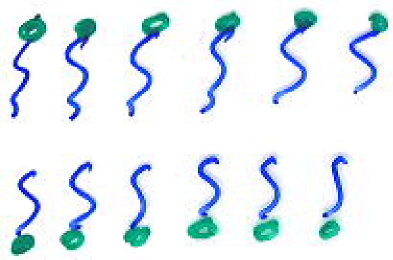
→ HALF HYDROPHILLIC
HALF HYDROPHOBIC

→ SELF ASSEMBLY.

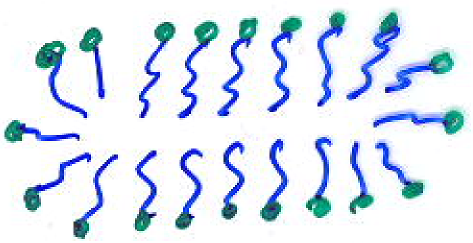
3a SELF-ASSEMBLED SURFACTANT STRUCTURES.



MICELLE

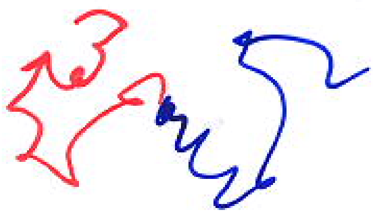


LAMELAE



RODS
– HEXAGONAL PACKING

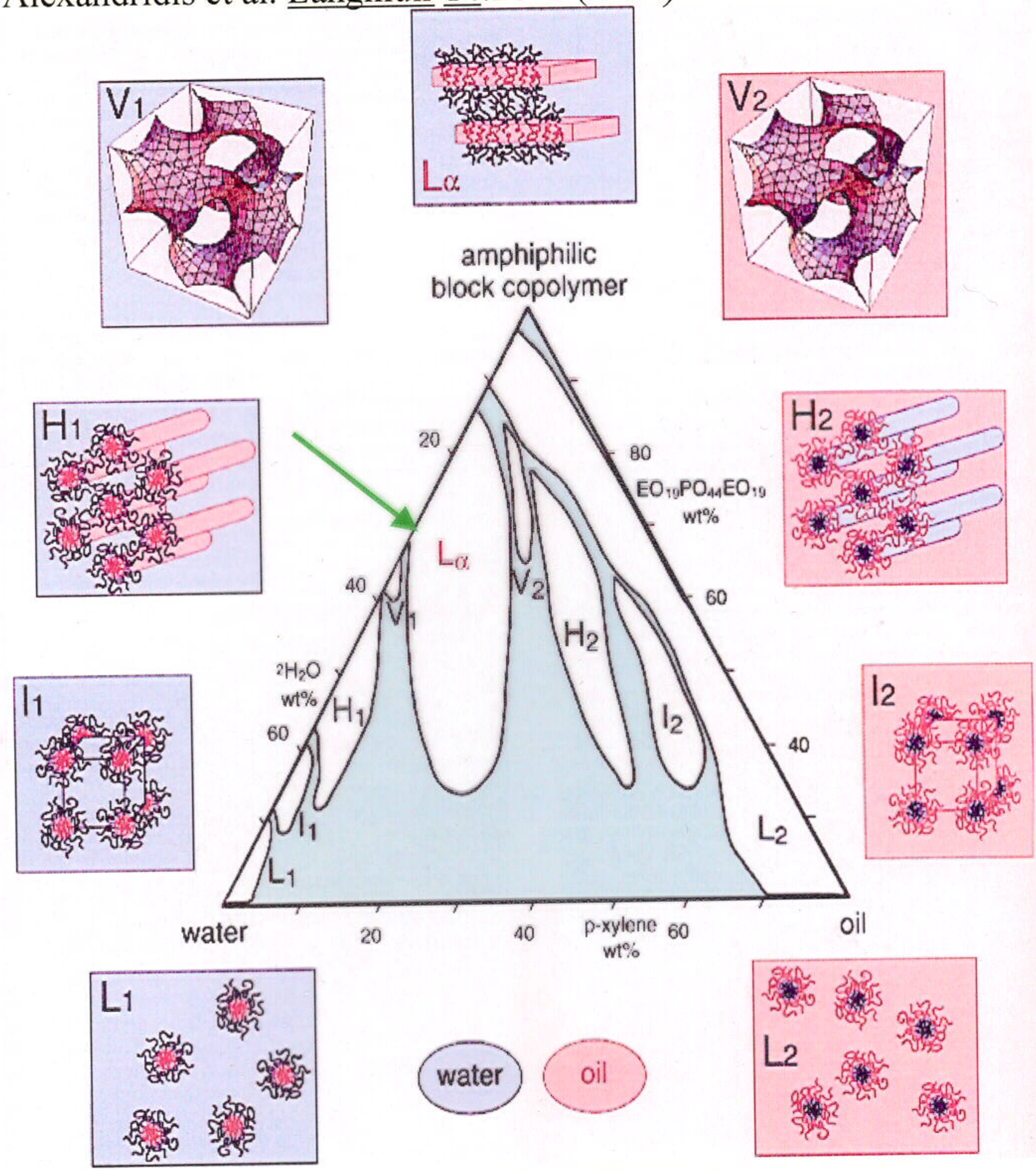
3b BLOCK CO-POLYMERS



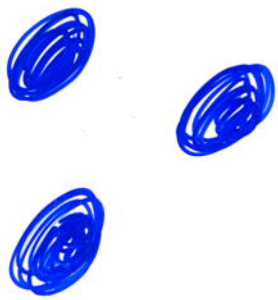
Block copolymers can form lamellar phases in water

- Biological membranes are often lipids in L_α

Alexandridis et al. Langmuir 14:2627 (1998)

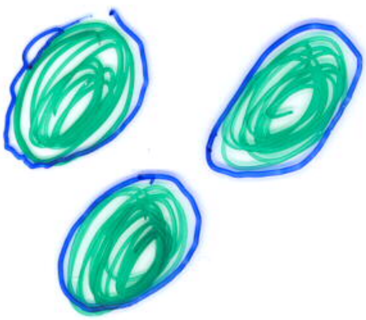


(4) COLLOIDS



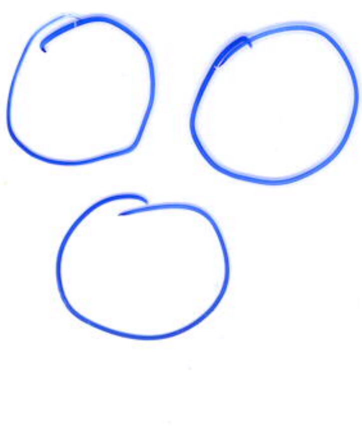
SOLID PARTICLE SUSPENSION

(5) EMULSIONS



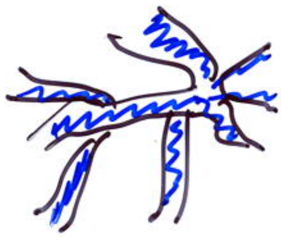
LIQUID DROPLET SUSPENSION

(6) FOAMS



GAS DROPLET SUSPENSION.

⑦ FLUIDS IN CONFINED SPACES

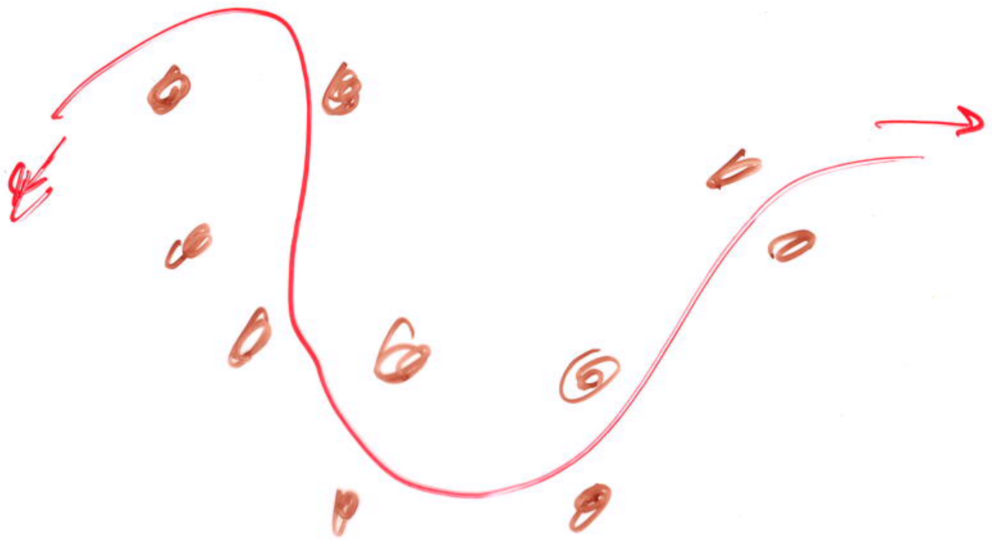


ROCKS, VYCOR

⑧ GRANULAR MATERIAL (?)

PACKED SOLID PARTICLES.

POLYMER RELAXATION



REPTATION

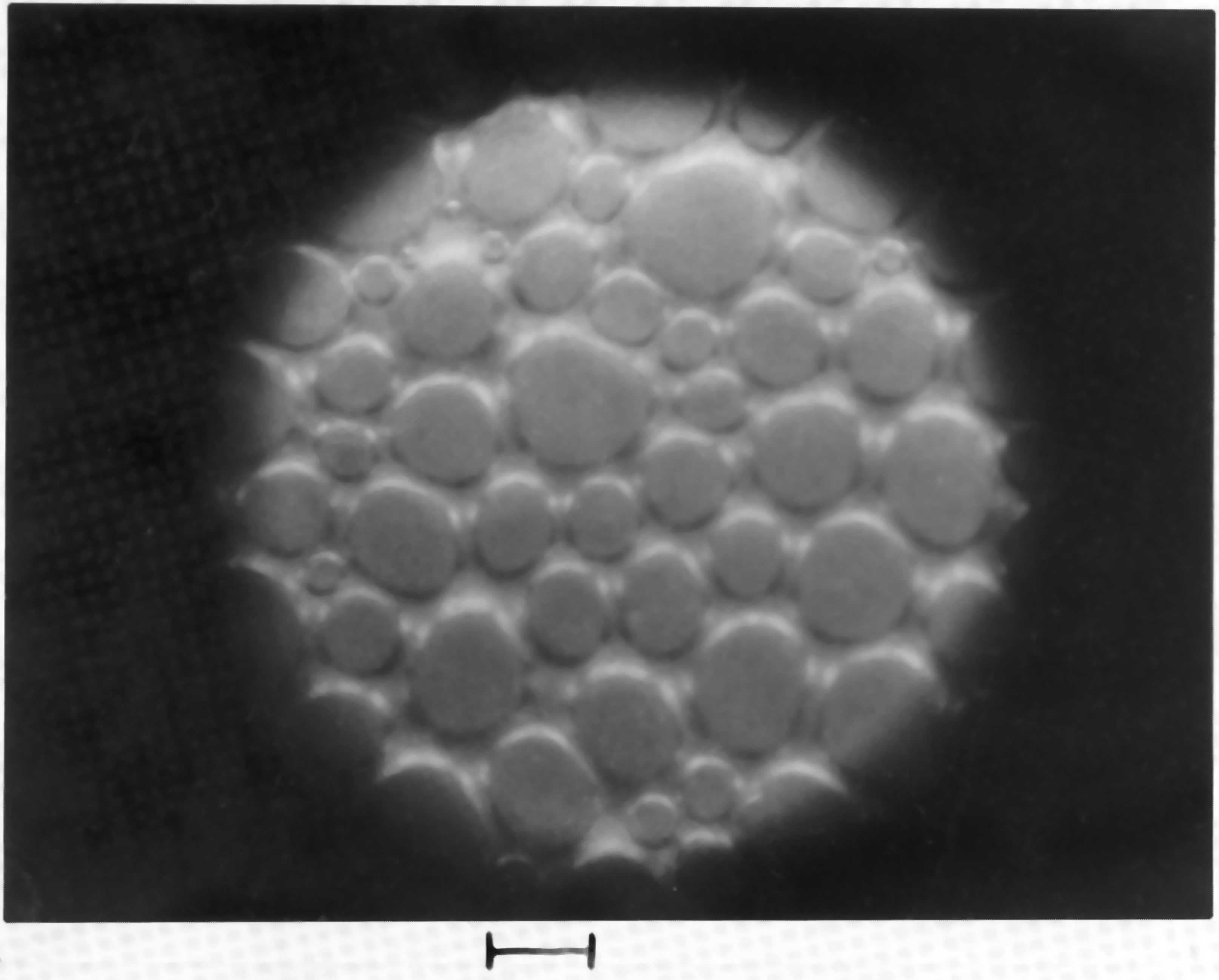
$$D \sim \frac{D_0 a}{L}$$ ← CONTOUR LENGTH

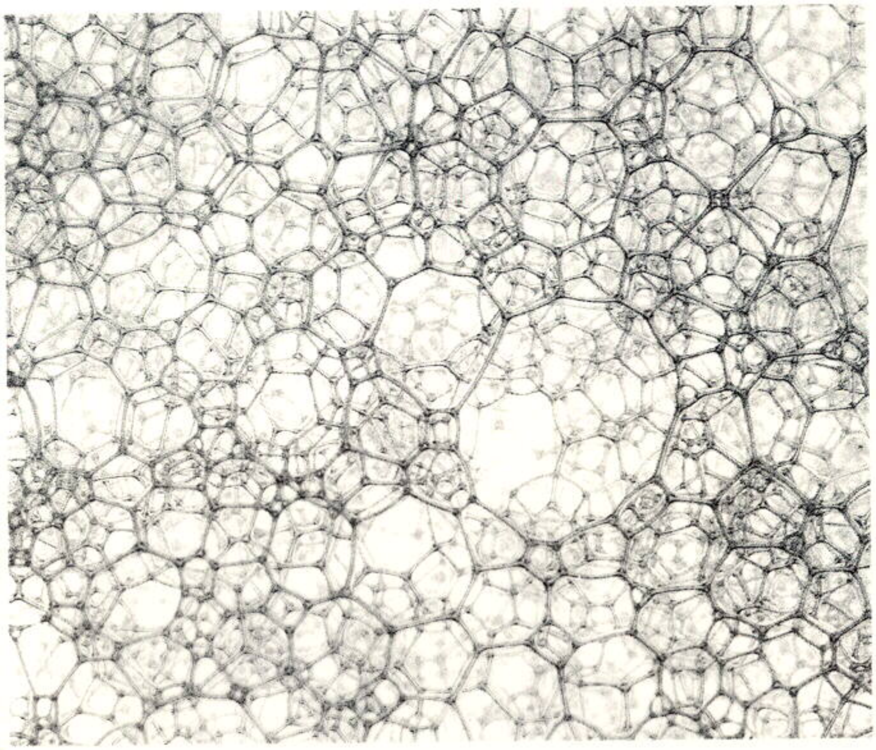
$$\tau = \frac{L^2}{D} \sim \frac{L^3}{a D_0} \sim \frac{N^3}{D_0}$$

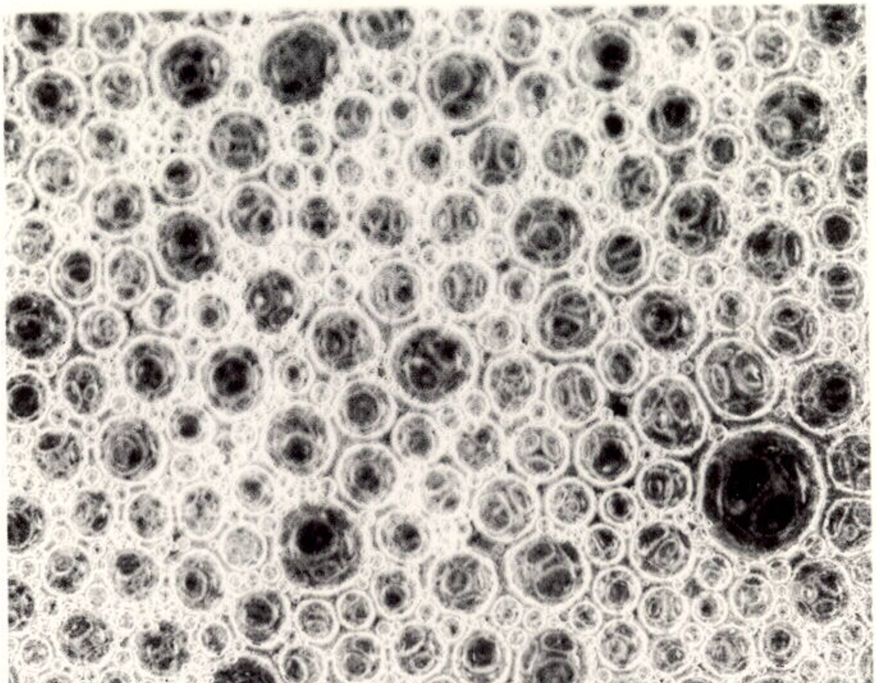
$$L^3 \sim a D_0 \tau \sim 10^{-7} \times 10^{-6} \times 10^{3} \sim 10^{-10}\ cm^3$$

(↑ 1 nm, ↑ D_0, ↑ 20 min)

$$L^3 \sim 100 \times 10^{-12} \Rightarrow 5 \times 10^{-4}\ cm \sim 5\ \mu m!$$

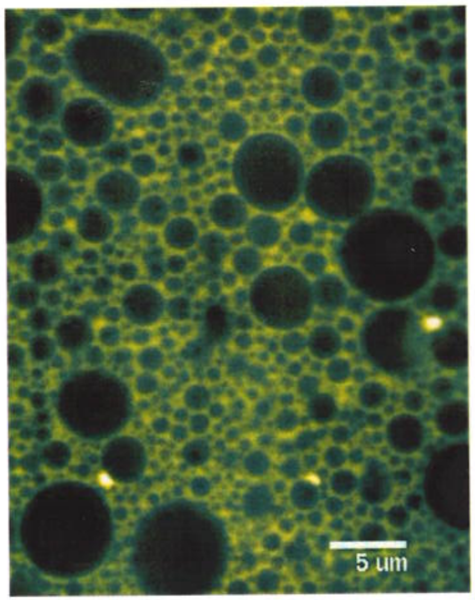

20μm



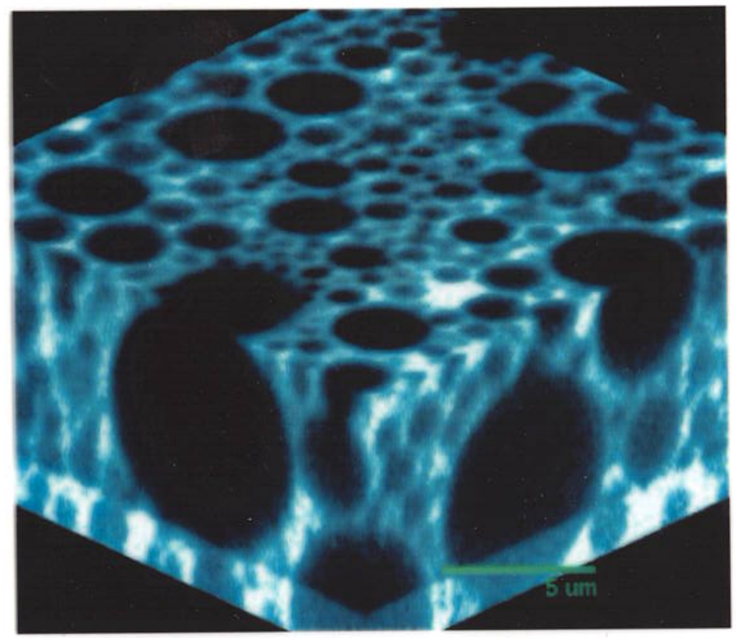


Compressed Emulsion

Confocal Microscope Images



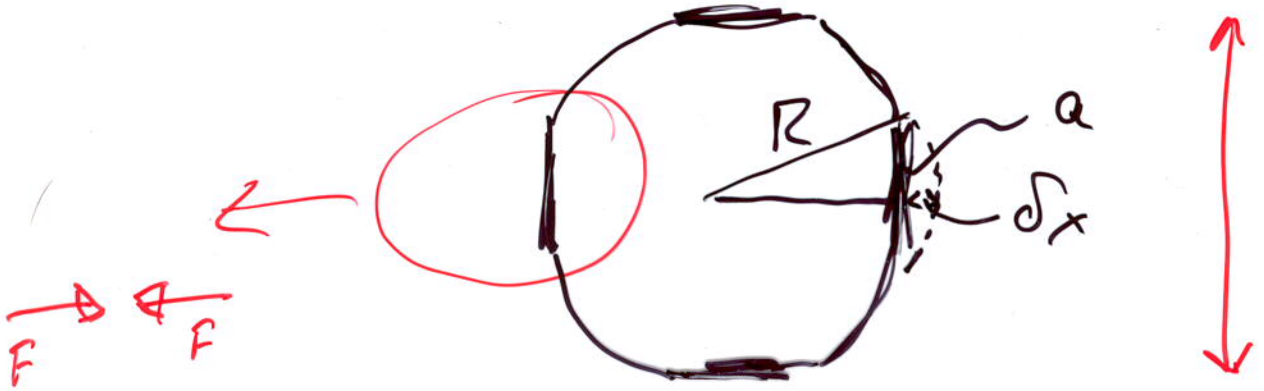
2D Slice



3D reconstruction

ELASTICITY OF FOAM

$a^2 = R^2 - (R - \delta x)^2 \simeq R\delta x$



DEFORM DROPLET.

$$\Pi = \frac{F}{A} = \frac{\gamma}{R}\frac{a^2}{R^2} \sim \frac{\gamma}{R}\frac{R\delta x}{R^2}$$

$$\sim \frac{\gamma}{R}\frac{R^2\delta x}{R^3} = \frac{\gamma}{R}\frac{\Delta V}{V}$$

$$\sim \frac{\gamma}{R}(\phi - \phi_c)$$

SCALE : $\Pi \sim \dfrac{\gamma}{R}$

FOAM ELASTICITY

SCALE SET BY $\frac{\gamma}{R}$

γ: SURFACE TENSION

ESTMATE

$$\gamma \sim \frac{kT}{A} \sim \frac{4 \times 10^{-14}}{60 \times 10^{-16}} \sim \frac{4}{.6} \sim 10 \ \frac{\text{dynes}}{\text{cm}}$$

$$\Pi \sim \frac{\gamma}{R} \sim \frac{10}{10 \times 10^{-4}} \sim 10^4 \ \frac{\text{dynes}}{\text{cm}^2}$$

- high by ~ 1 decade

$\Rightarrow$ Φ dependent term.