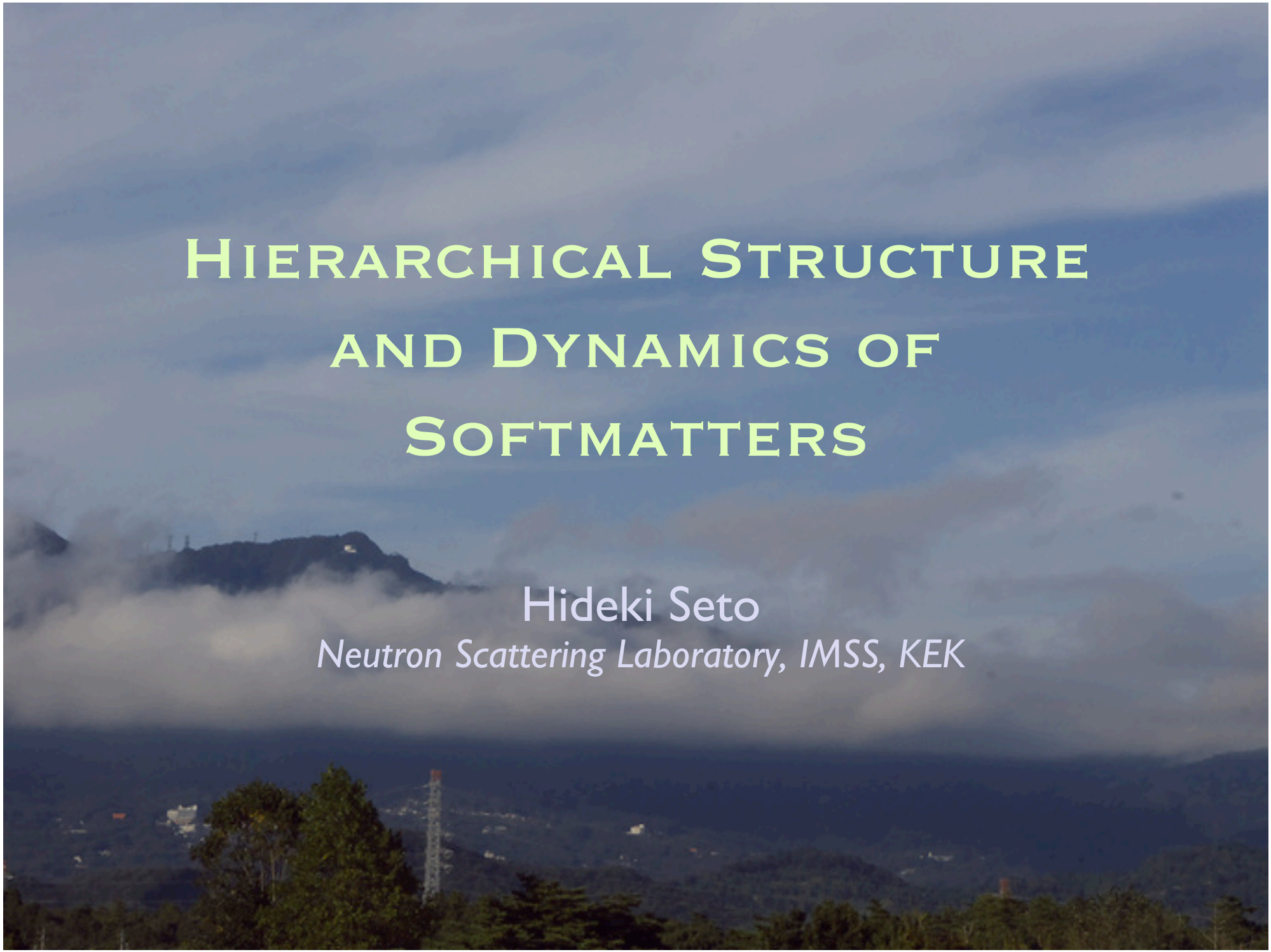


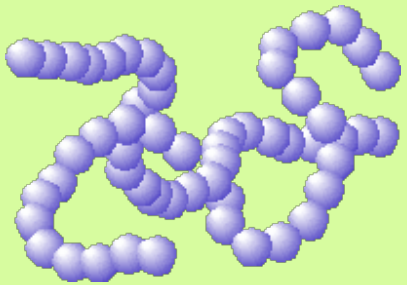
Hierarchical Structure and Dynamics of Softmatters

Hideki Seto

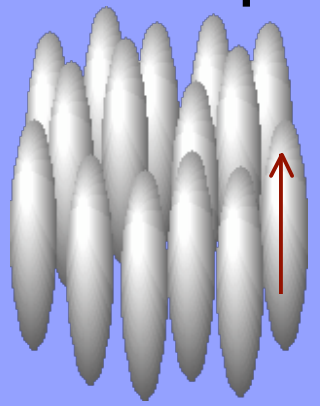
Neutron Scattering Laboratory, IMSS, KEK

SOFTMATTER (=SOFT CONDENSED MATTER)

Polymers



Liquid Crystals

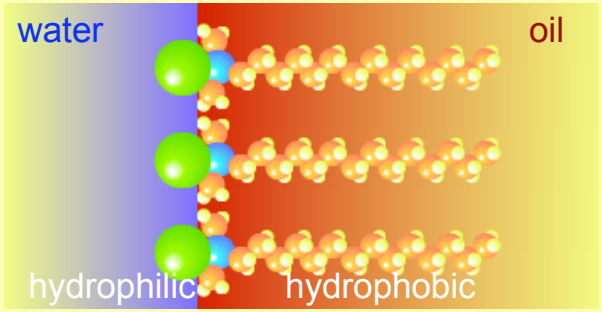


Polymer Liquid Crystal
Liquid Crystal Polymer

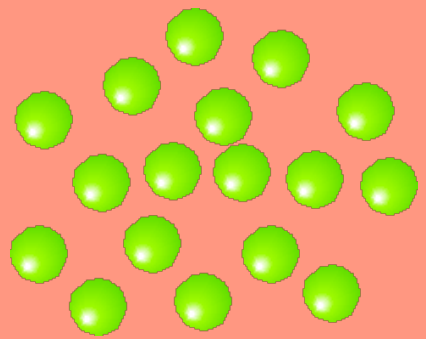
Amphiphilic Polymer

Lyotropic Liquid Crystal

Liquid Crystal Colloid



Emulsion



Amphiphilic molecules

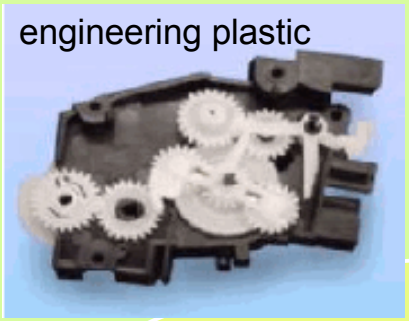
Colloids

Applications of Softmatters

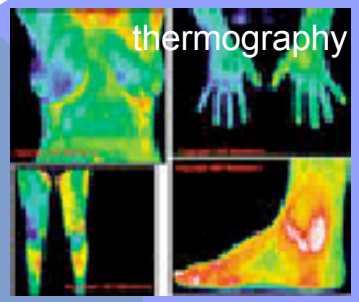
Polymers

Liquid Crystals

engineering plastic



film



thermography

display

detergent

soap

paint

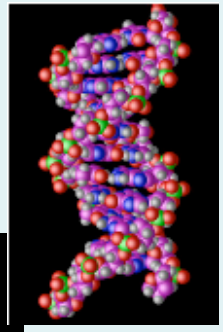
cosmetics

Amphiphilic molecules

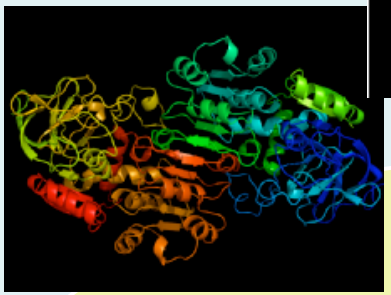
Colloids

Softmatters in Lives

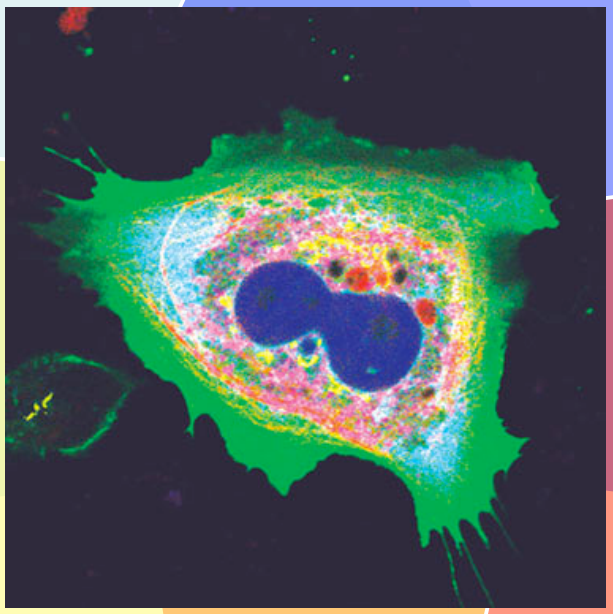
Polymers



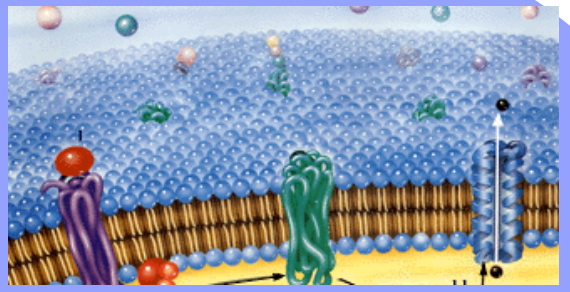
DNA



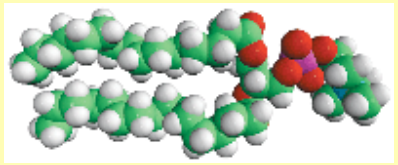
protein



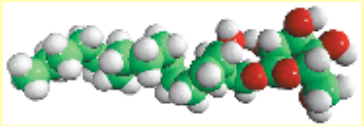
Liquid Crystals



bio-membrane

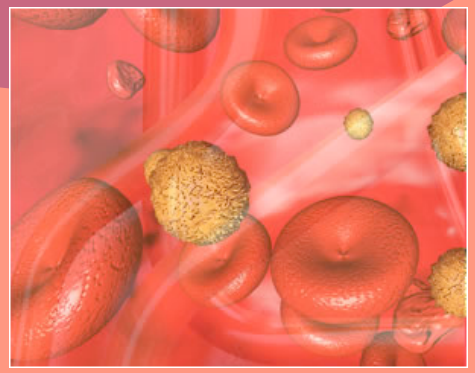


phospholipid



glycolipid

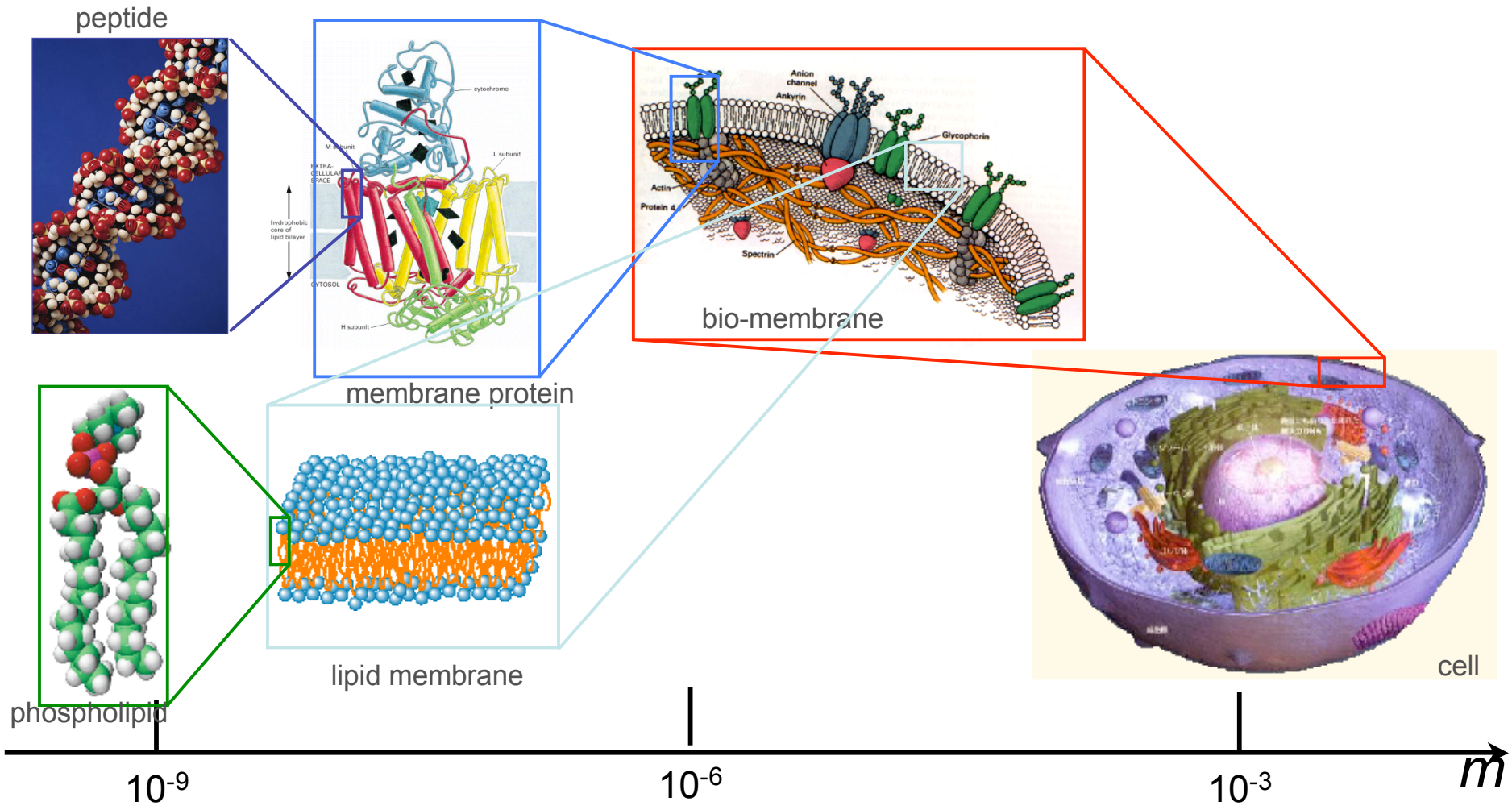
Amphiphilic molecules



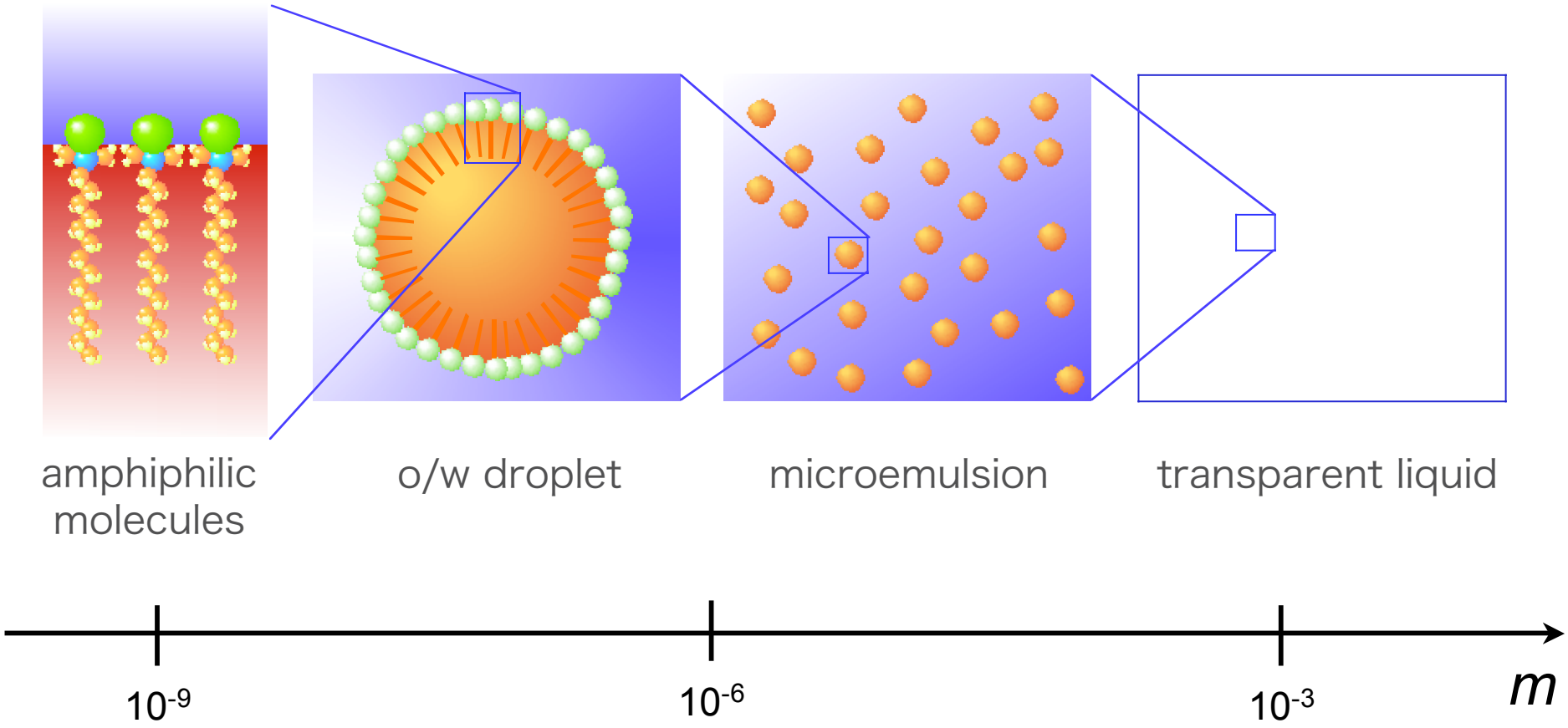
blood

Colloids

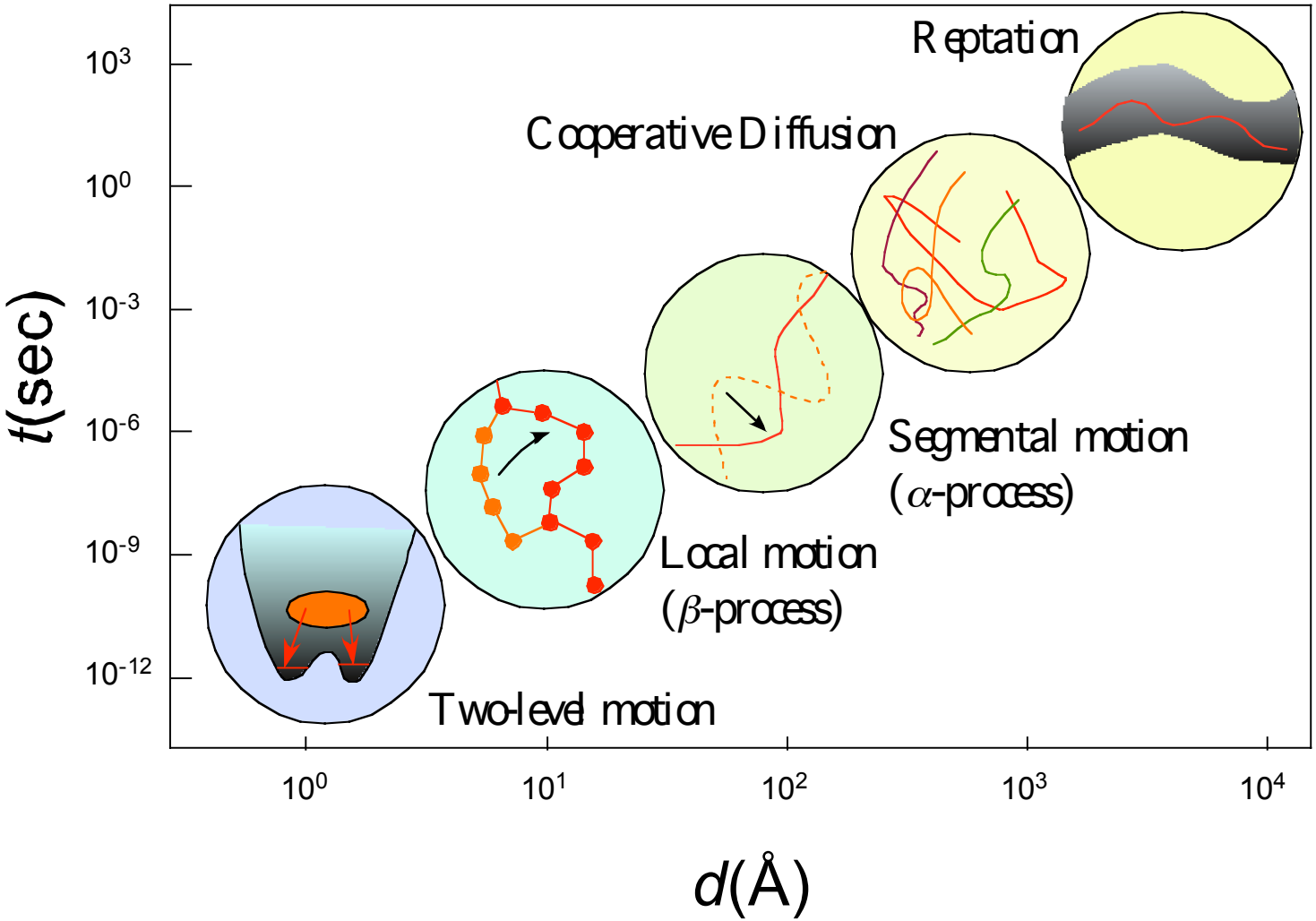
Hierarchical Structure of Biological System



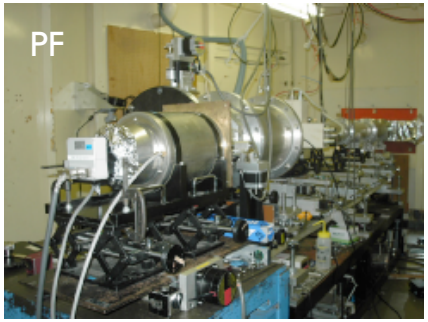
Hierarchical Structure of Softmatters



Hierarchical Structure and Dynamics

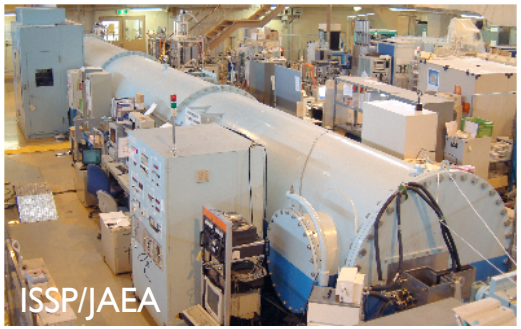


Methods to investigate Softmatters



Small-Angle X-ray Scattering

10<d<1000Å, time slice(Δt>10ms)



Small-Angle Neutron Scattering

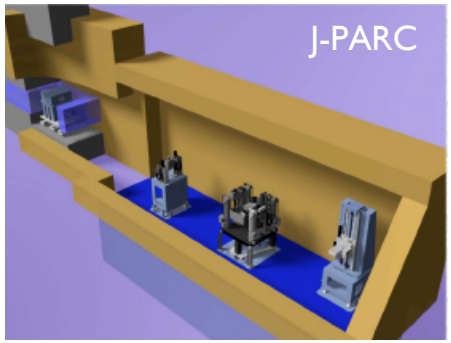
20<d<3000Å, contrast variation

Neutron Spin Echo

5<d<1000Å, quasi-elastic(ΔE~10neV)

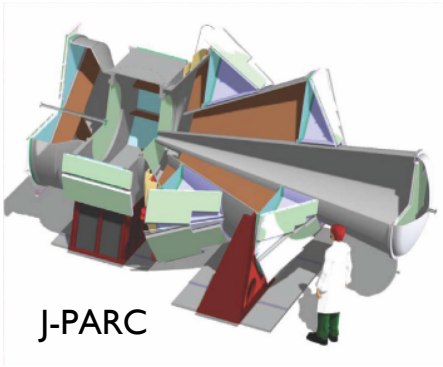
X-ray Reflectometer/GI-SAXS

10<d<1000Å, surface structure



Neutron Reflectometer

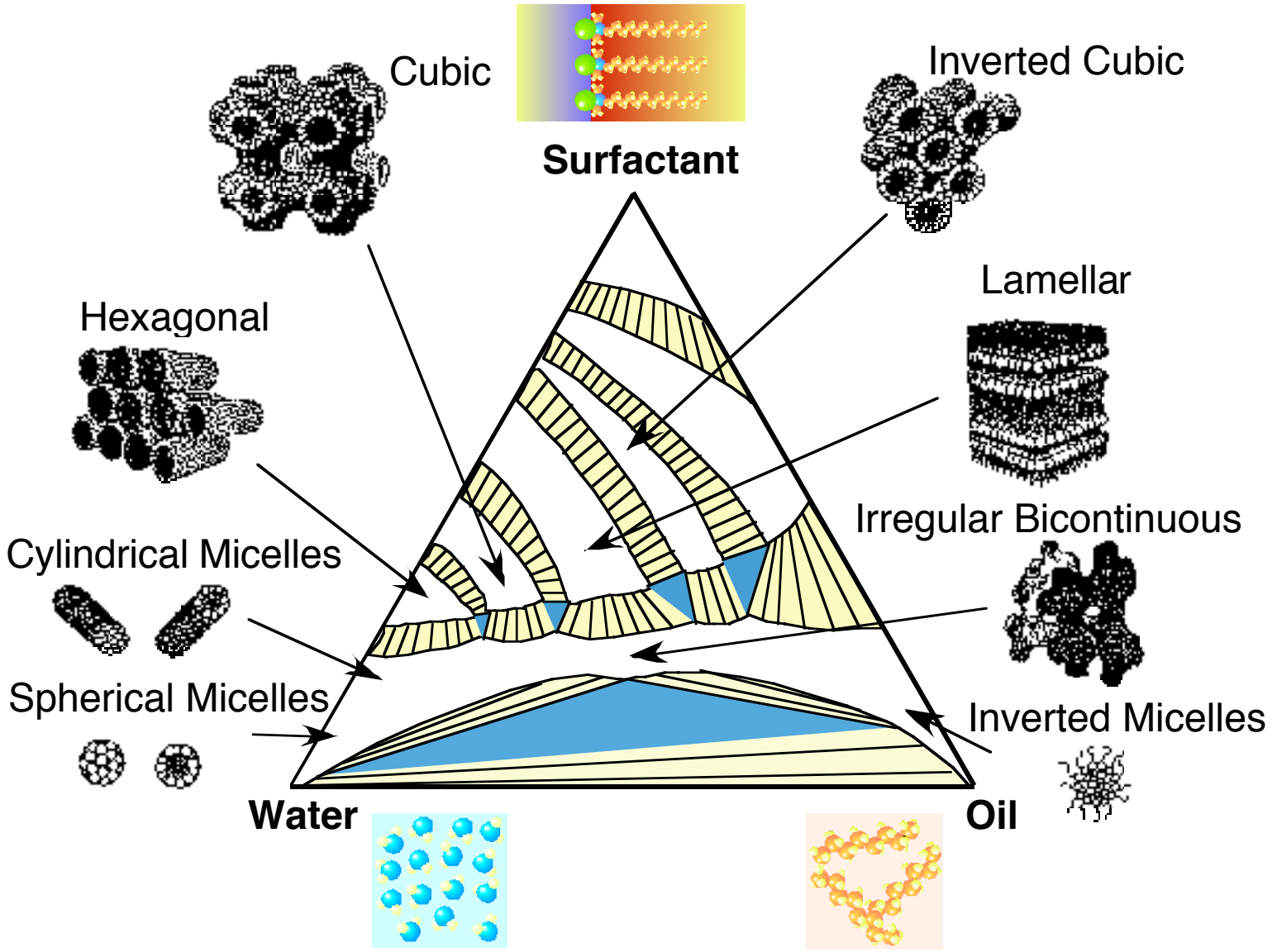
10<d<700Å, air/liquid interface



Neutron Total Scattering

0.06<d<800Å, wide Q-range

Structures of microemulsions

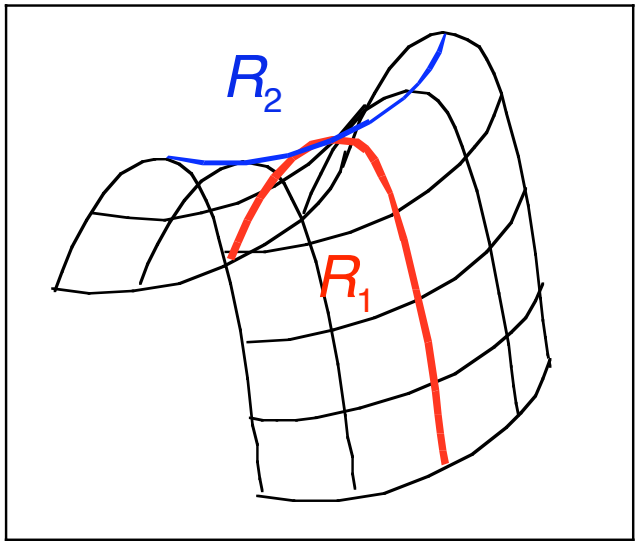


Bending energy

W. Helfrich, Z. Naturforsch. C28 (1973) 693

mean curvature $H = \frac{1}{2}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$

Gaussian curvature $K = \frac{1}{R_1}\frac{1}{R_2}$

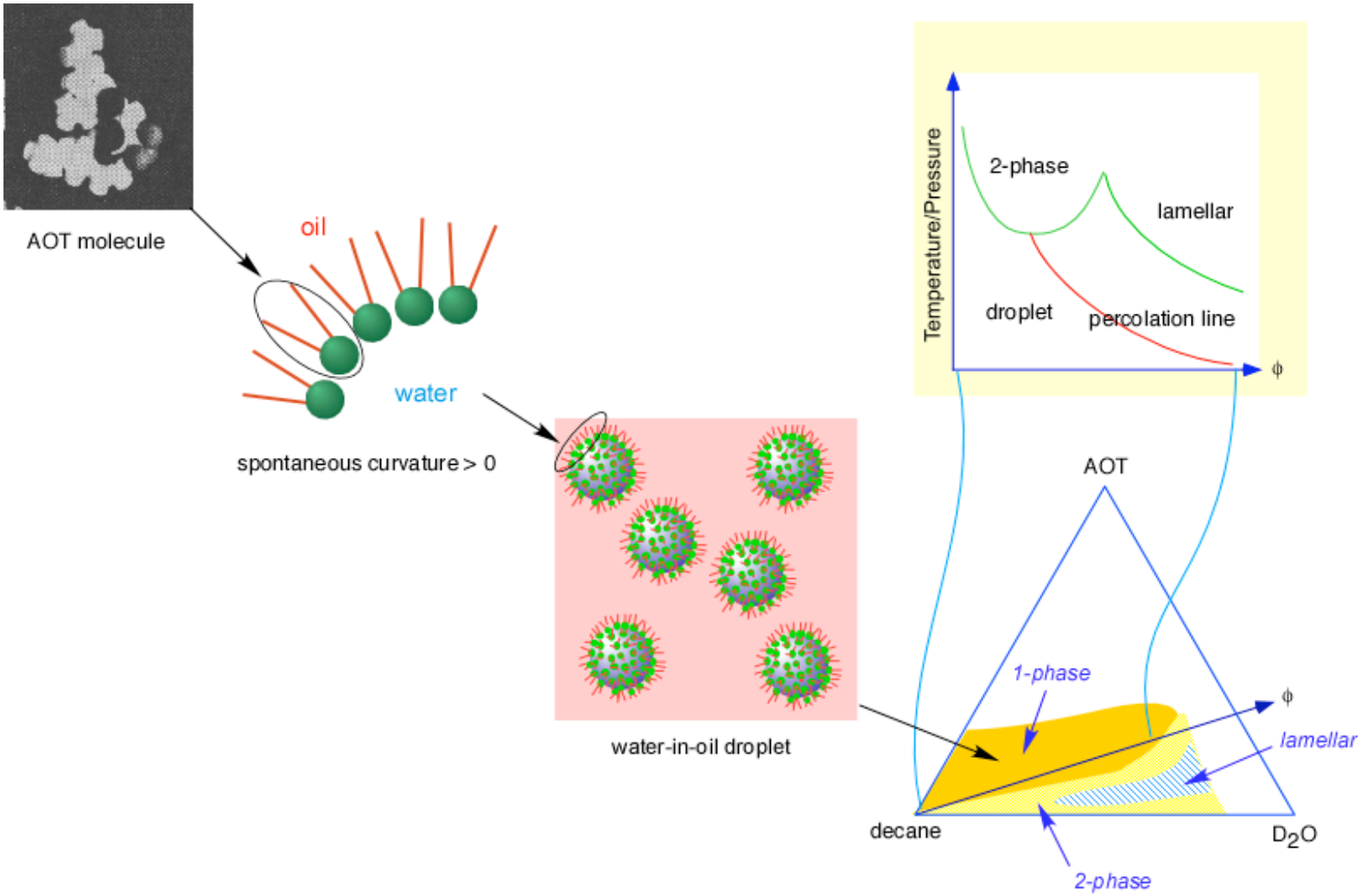


bending modulus *saddle-splay modulus*

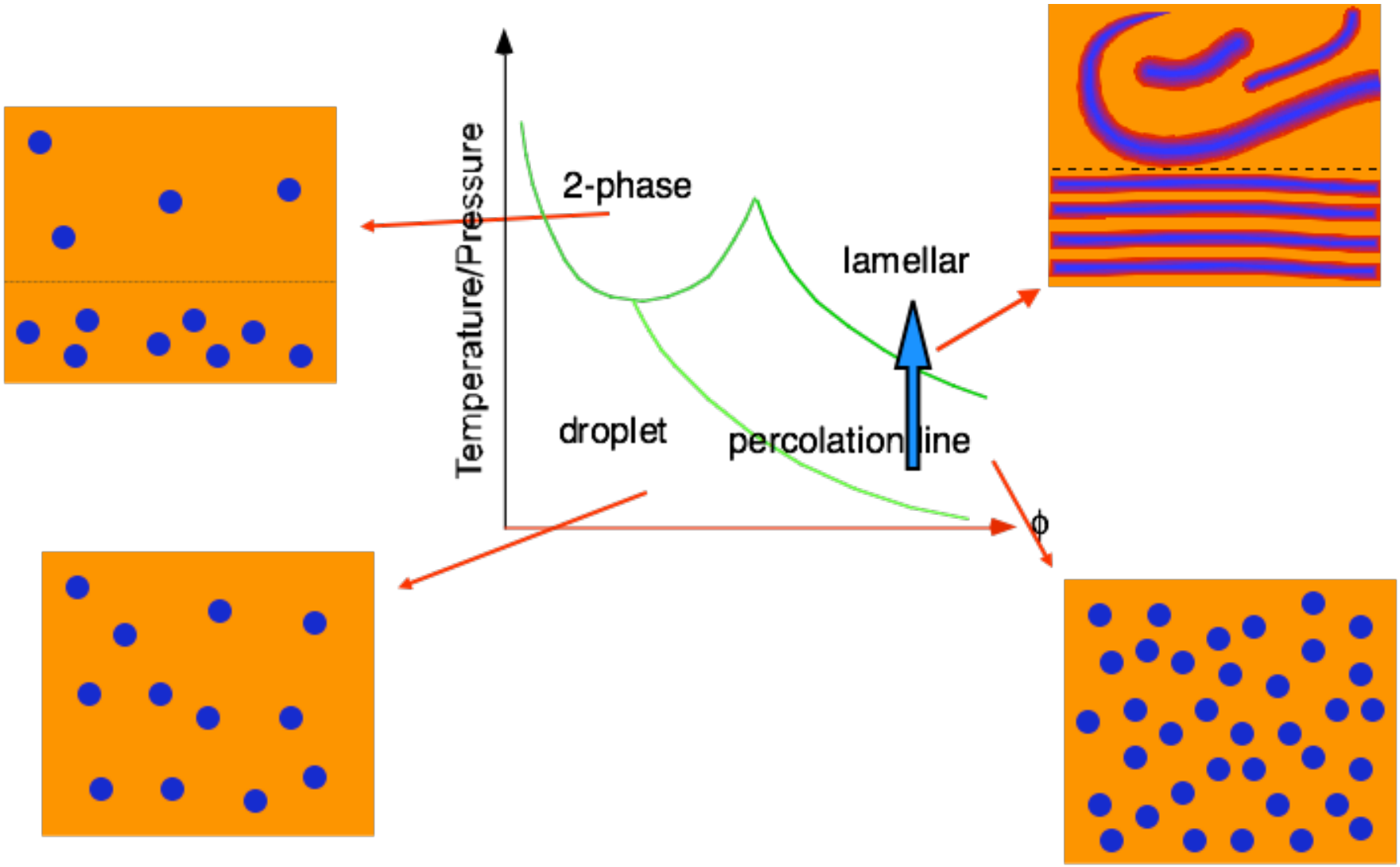
$$E_{bend} = \int \left[\kappa (H - \frac{1}{R_s})^2 + \bar{\kappa} K \right] dS$$

spontaneous curvature

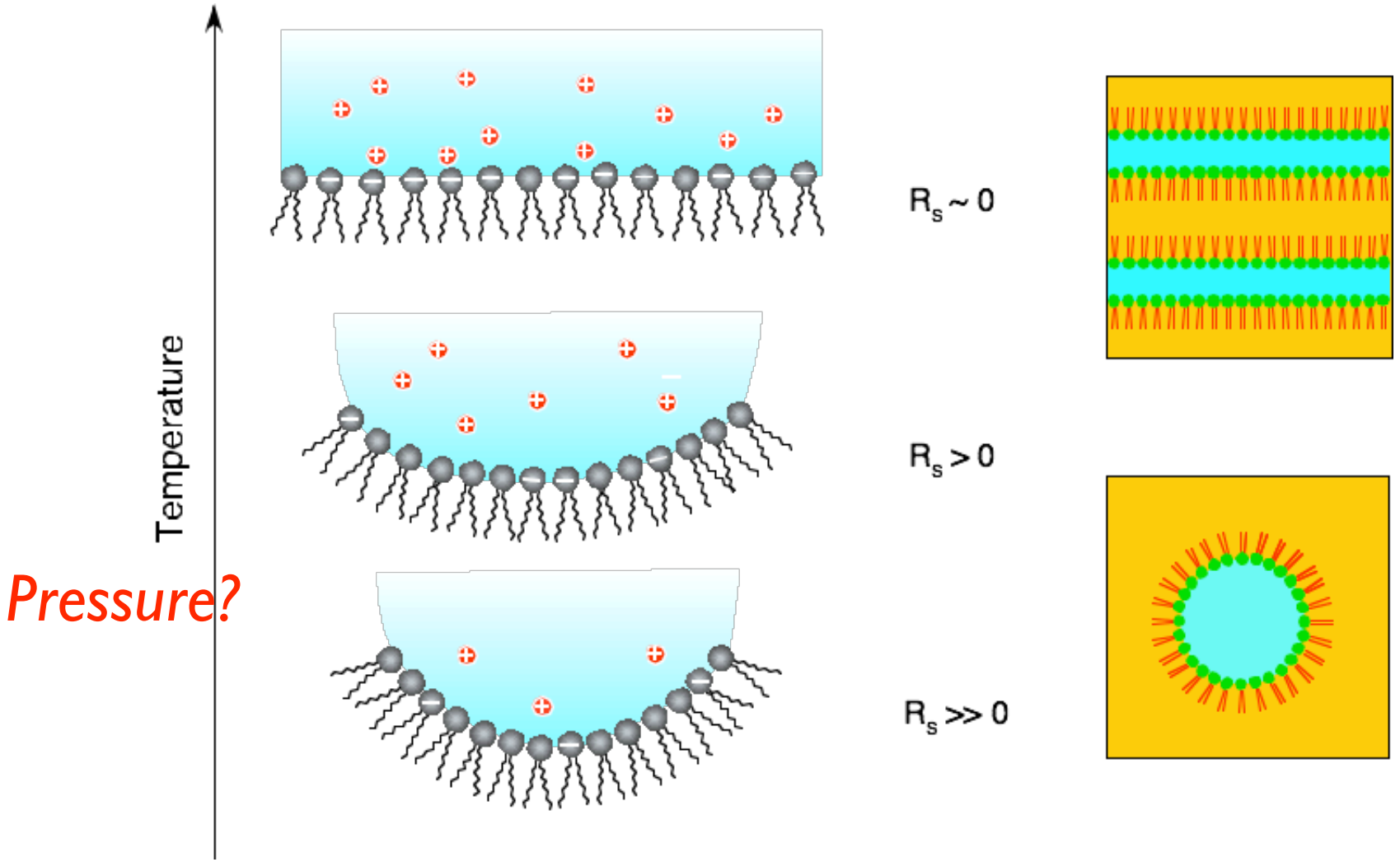
AOT+D_2O+decane



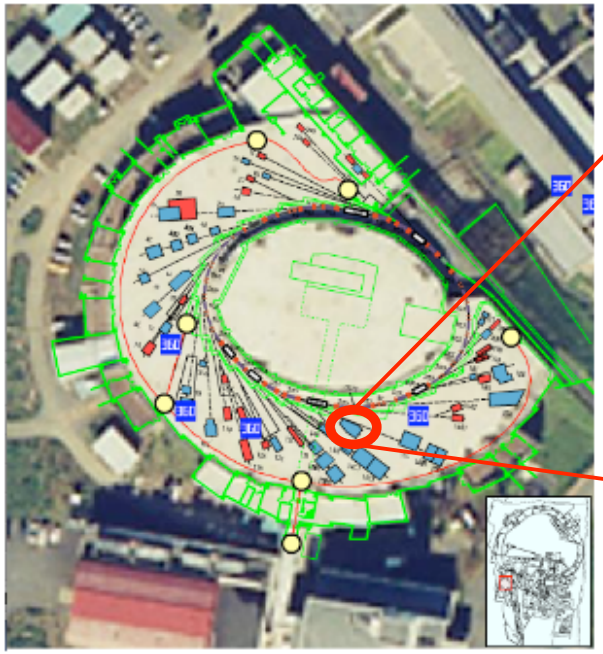
Effects of T and P seem to be the same

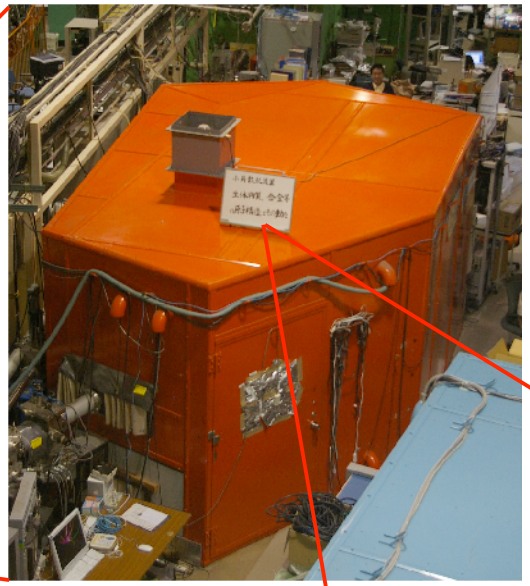


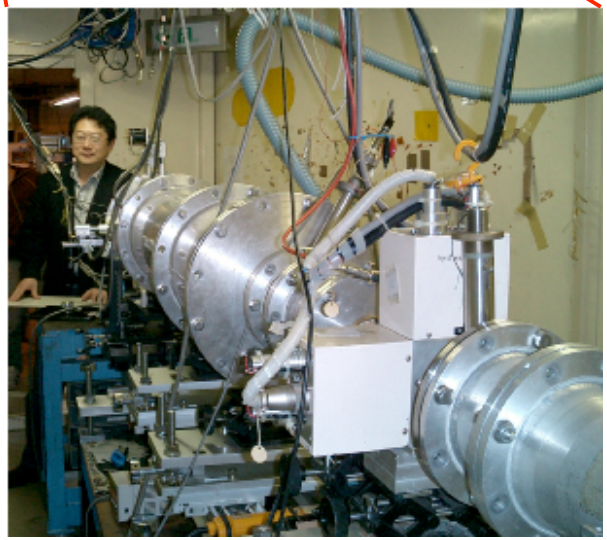
Temperature induced phase transition



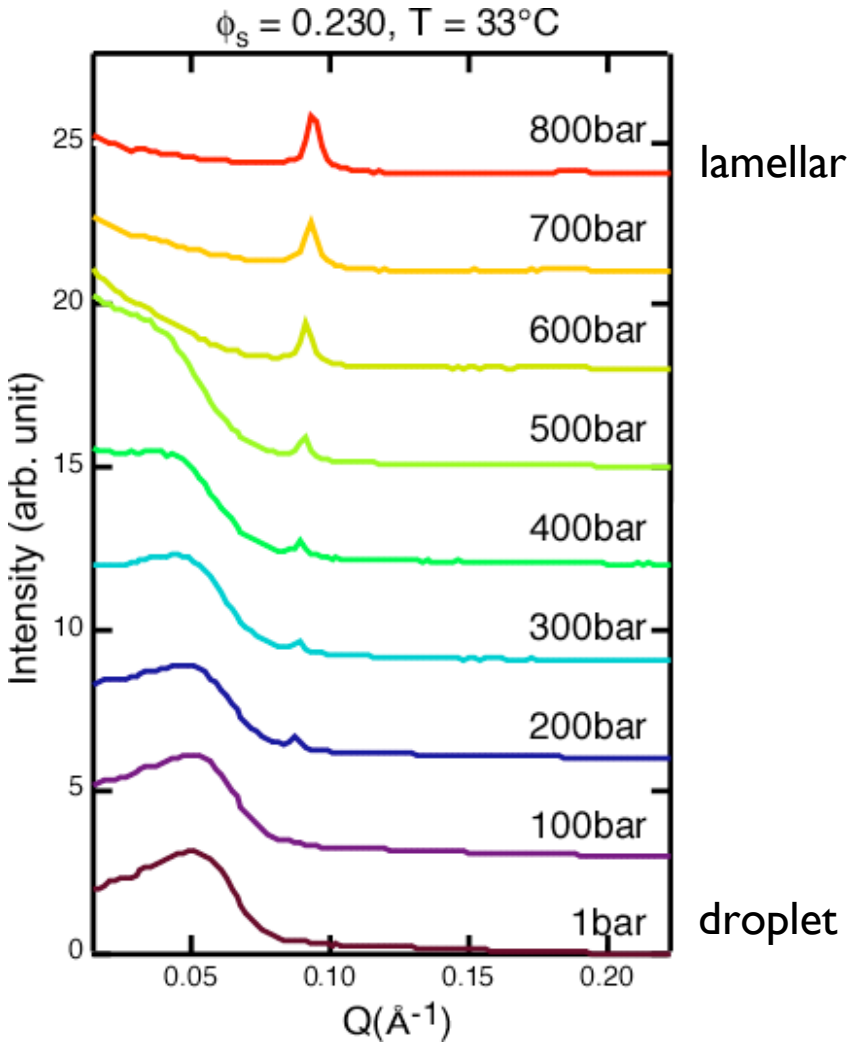
BL-15A, Photon Factory, KEK





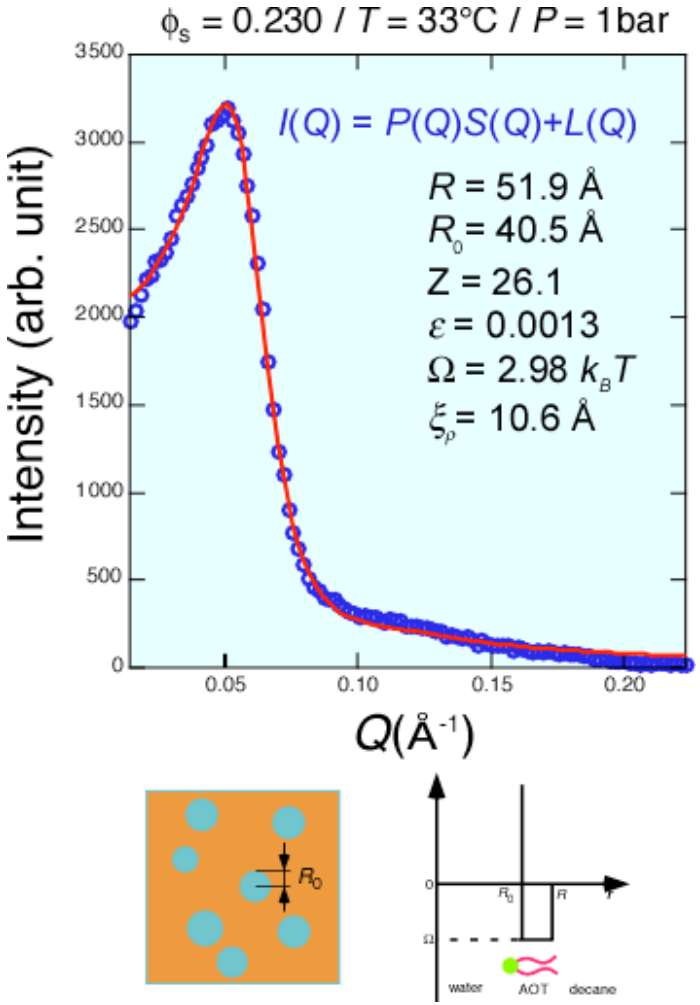


P-dependence of SAXS

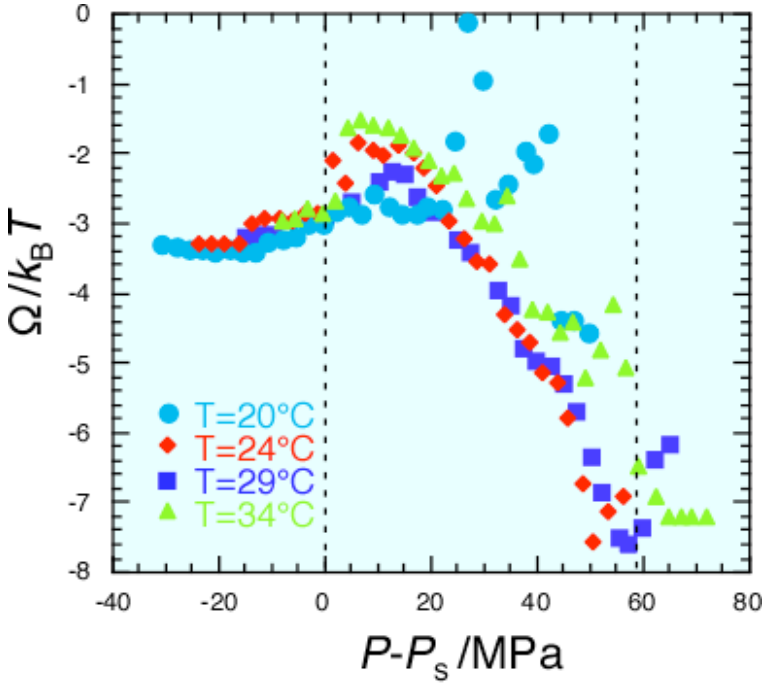


lamellar

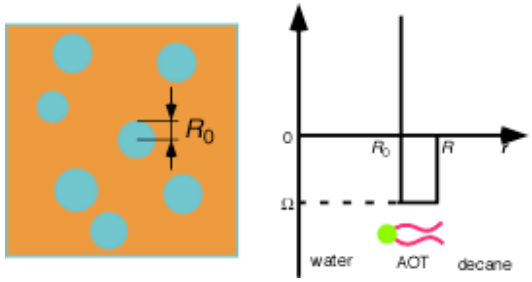
droplet



T- and P-dependences of inter-droplet potential



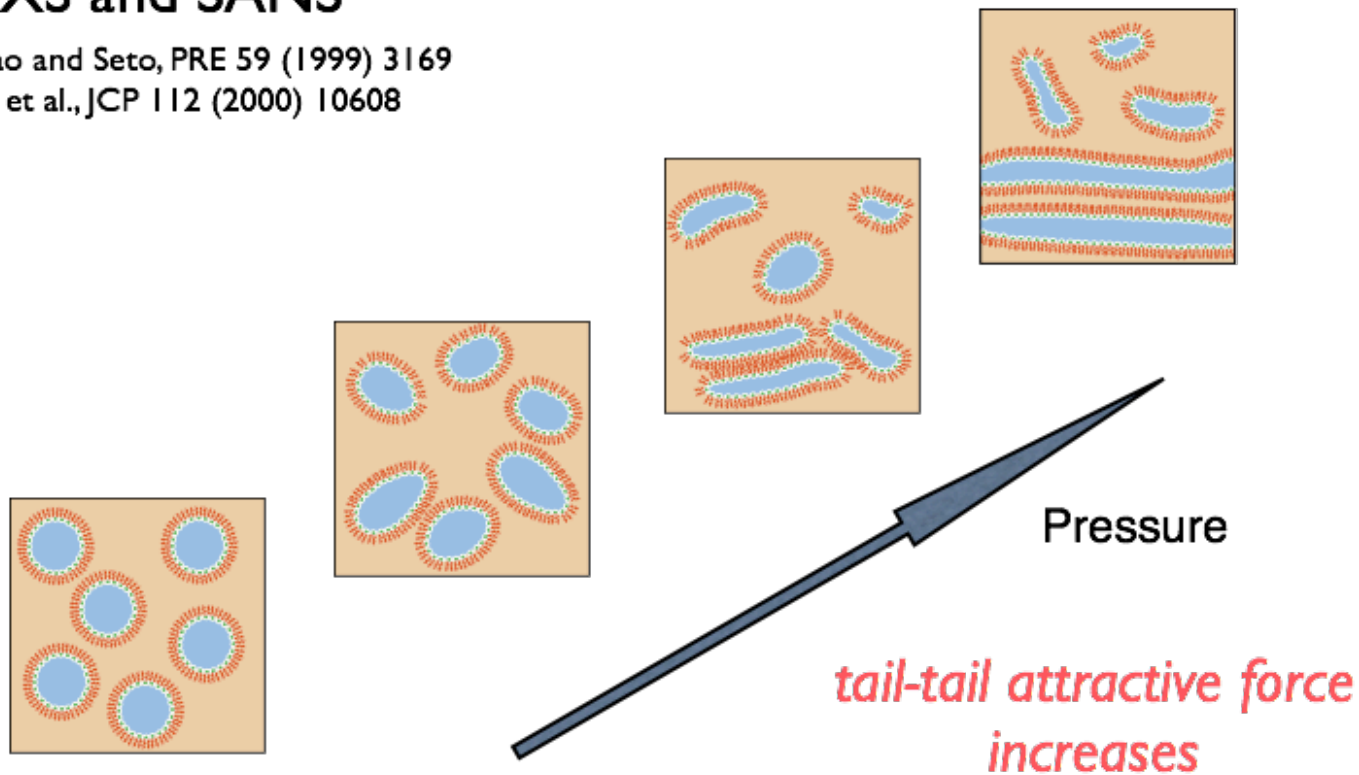
P_s : transition start pressure



Pressure-induced phase transition

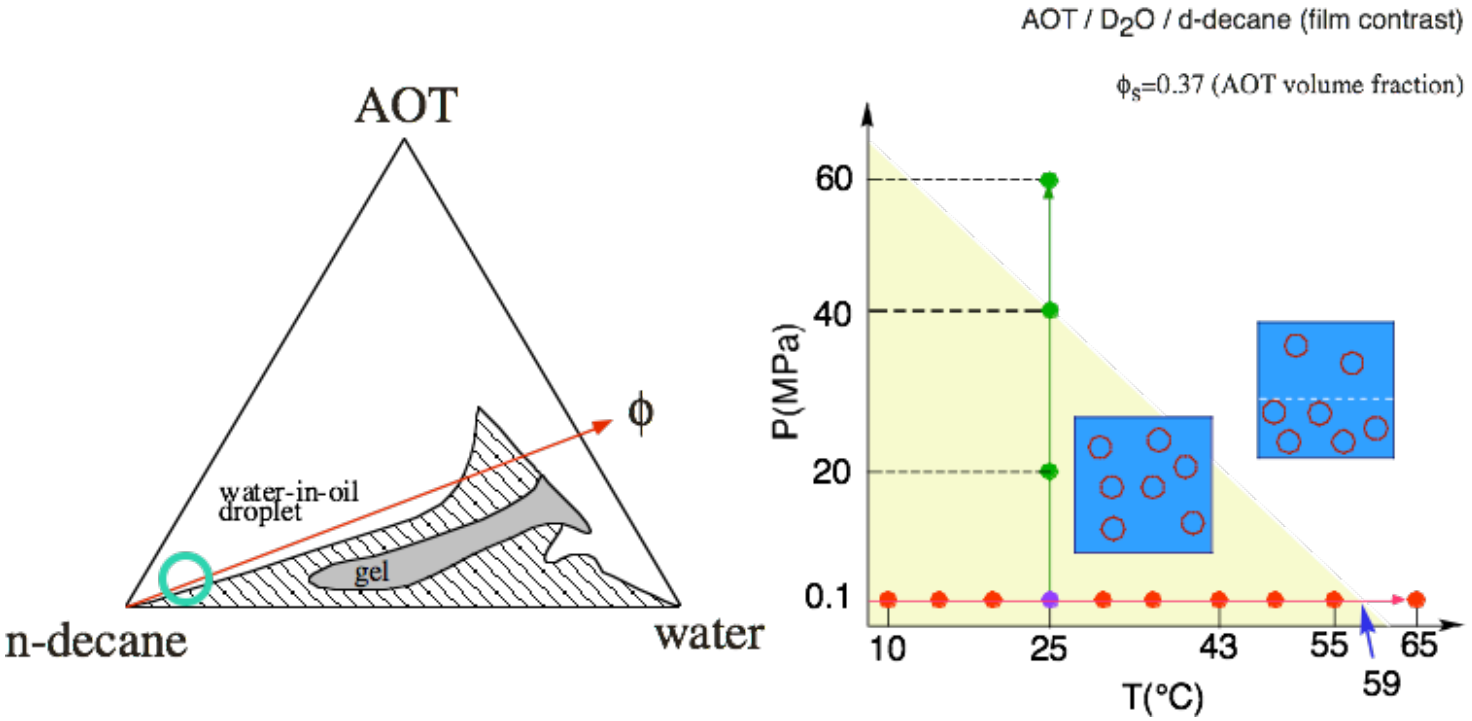
SAXS and SANS

Nagao and Seto, PRE 59 (1999) 3169
Seto et al., JCP 112 (2000) 10608

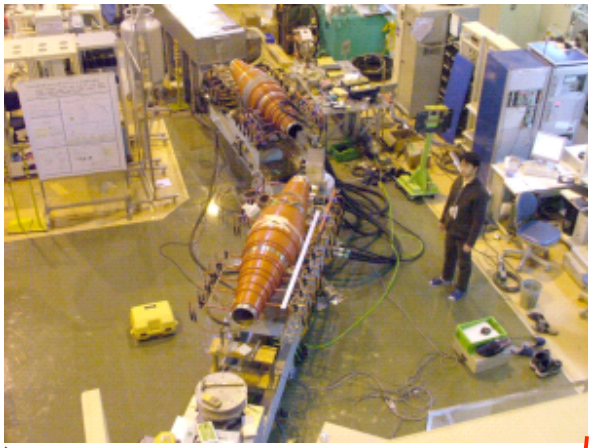


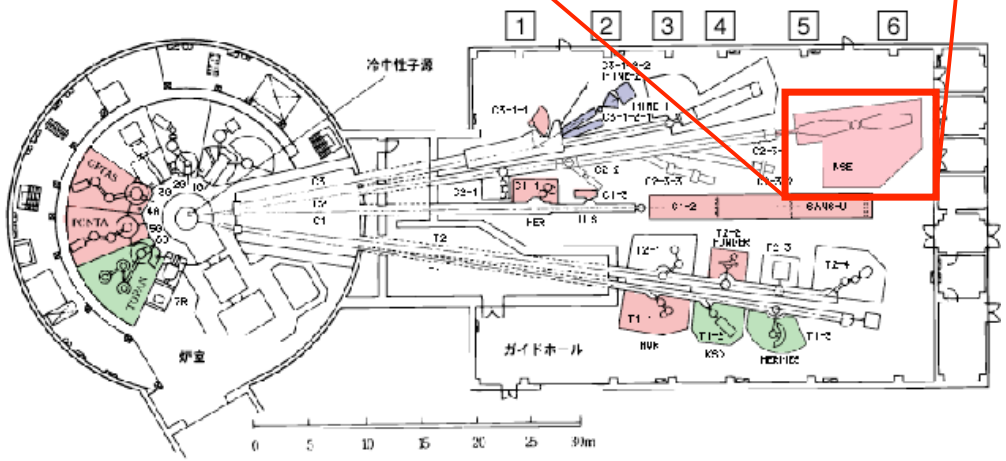
P- and T- dependence of membrane fluctuation were investigated by NSE

Kawabata, Seto et al., PRL 2004, JCP 2007



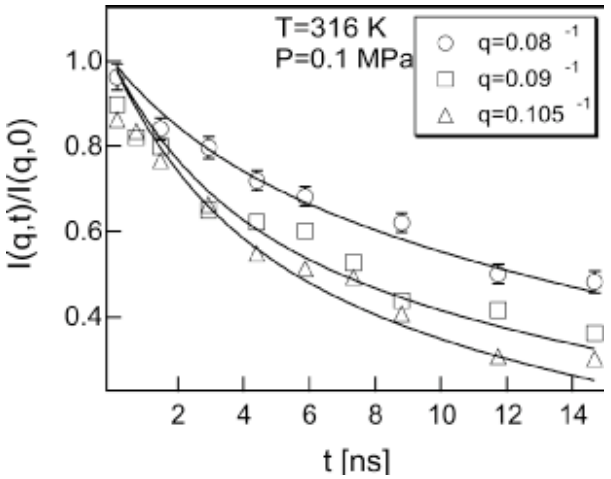
iNSE at JRR-3M, JAEA (ISSP)





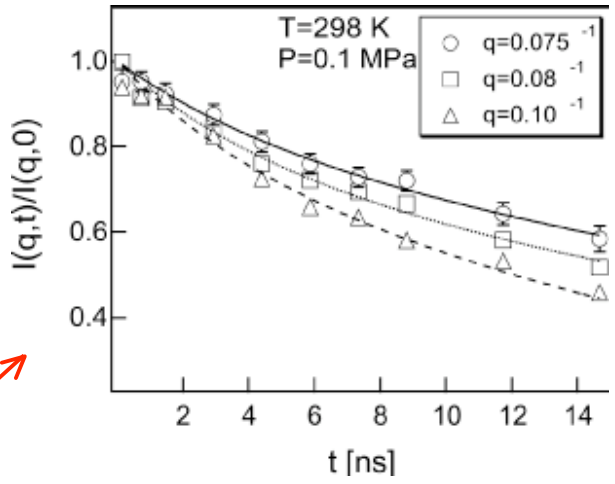
P- and T-variations of I(Q,t)

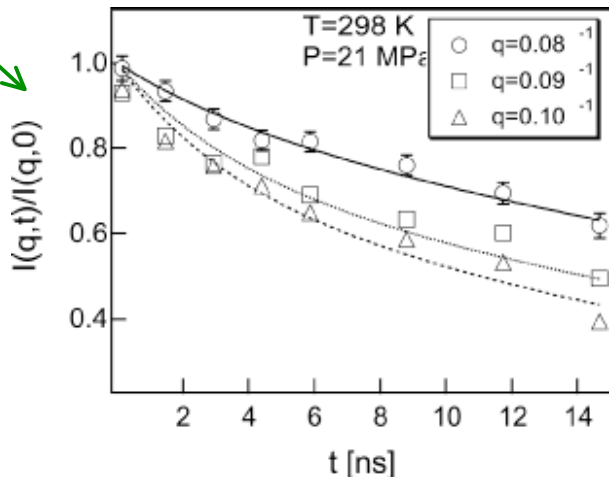
ambient temperature/pressure



T

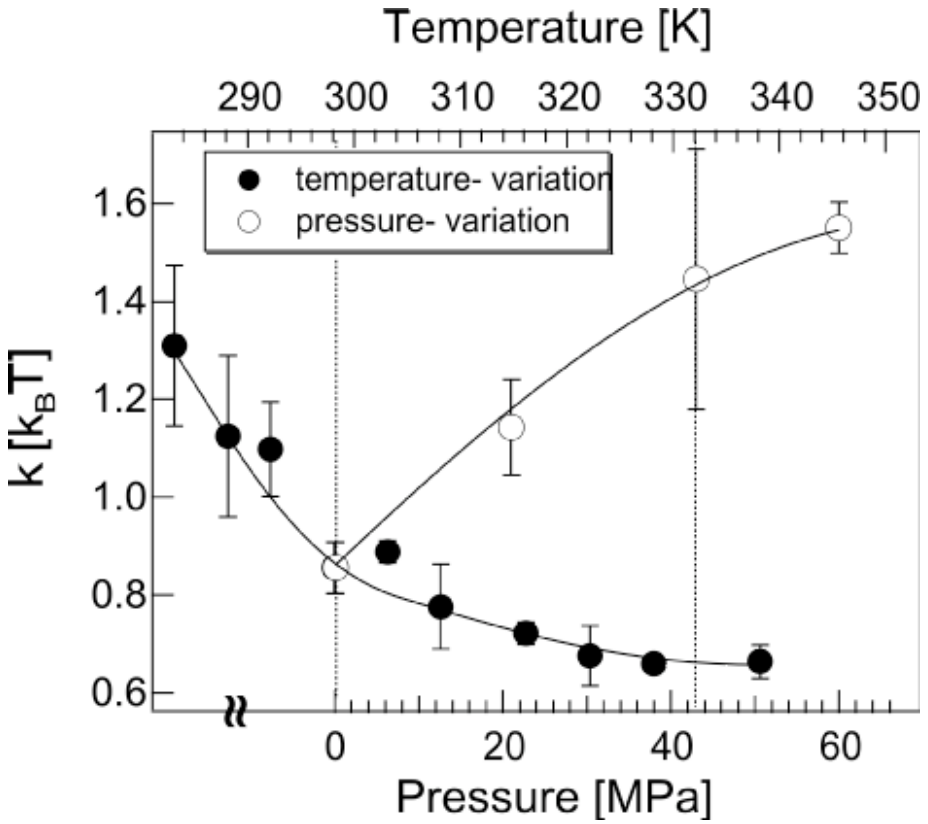
P



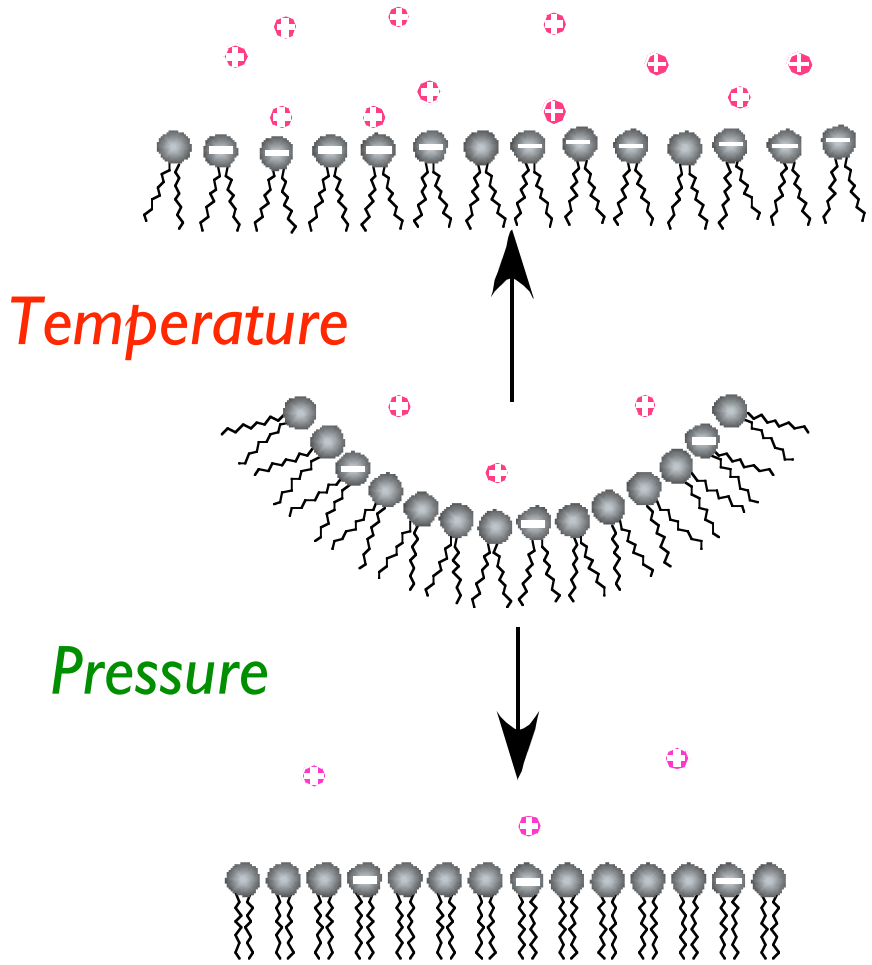


$I(Q,t)/I(Q,0)=\exp(-D_{eff}Q^2t)$

Bending modulus



Effects of Pressure and Temperature

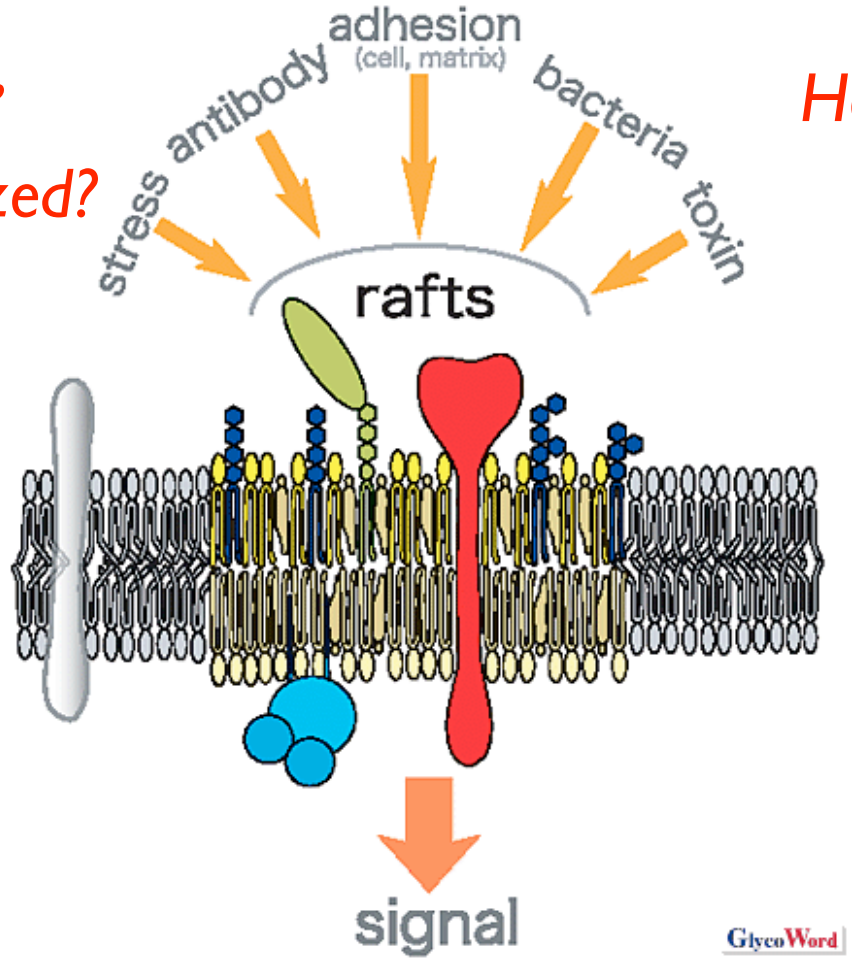


	R_s (spontaneous curvature)	κ (bending modulus)
Temperature	decrease	decrease
Pressure	decrease	increase

Future works to be investigated at CMRC?

for example: “raft” structure of bio-membrane

How the “raft” structure is organized?

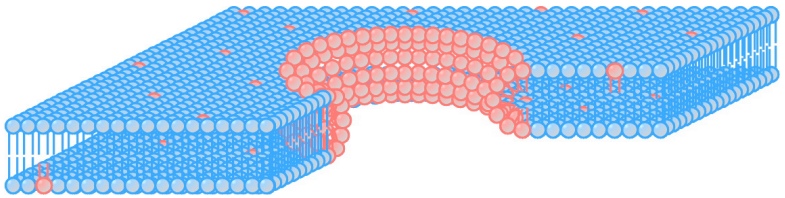


How the membrane proteins work?

Hybridization of softmatters

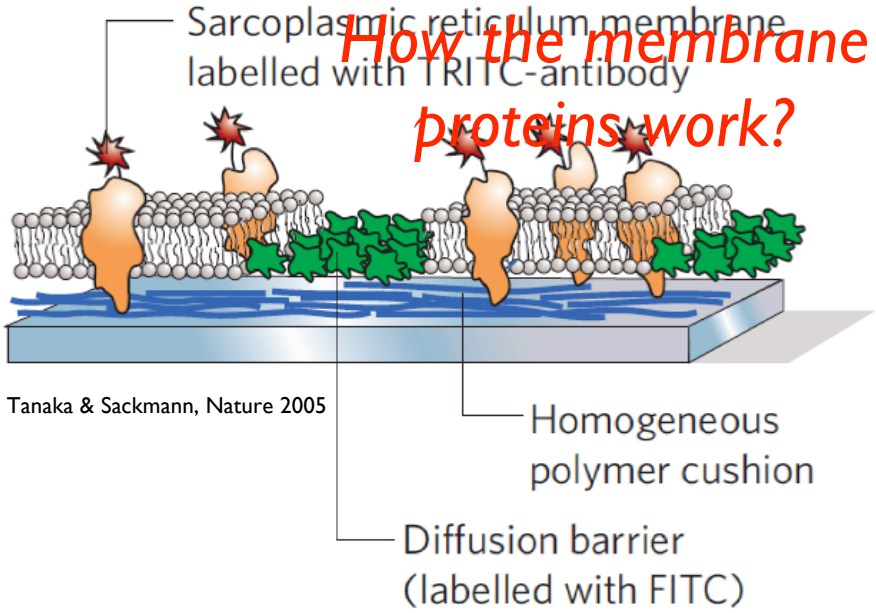
phase separation of a mixture of lipids

Vietch & Keller, PRL 2002



Yamada et al., submitted

polymer supported model bio-membrane



Tanaka & Sackmann, Nature 2005

SANS/SAXS/NSE

XR/NR/GI-SAS