Biological Physics

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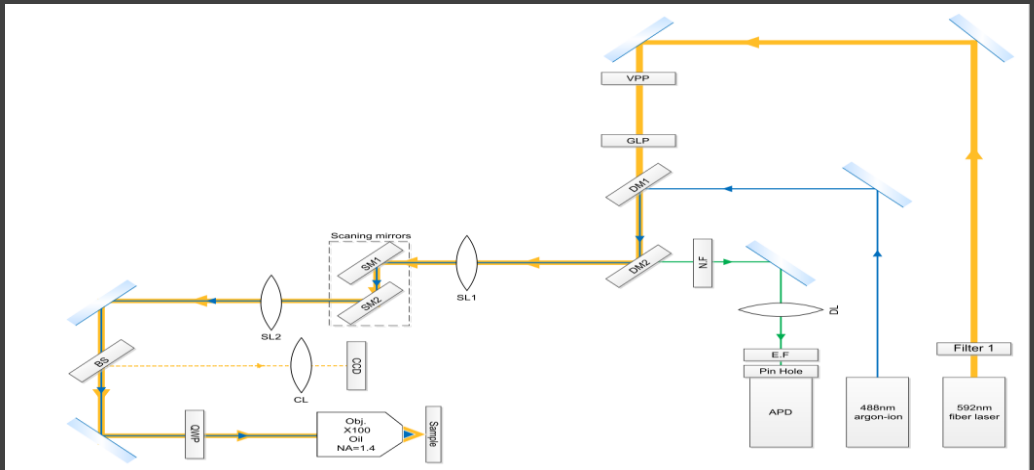
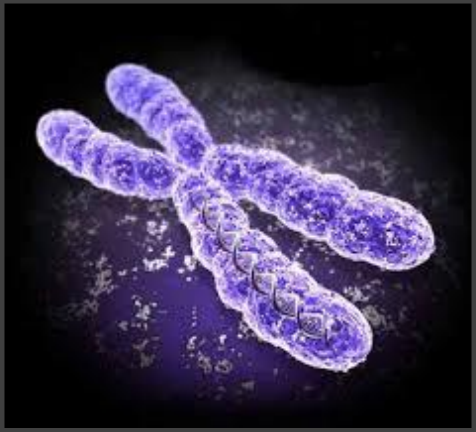
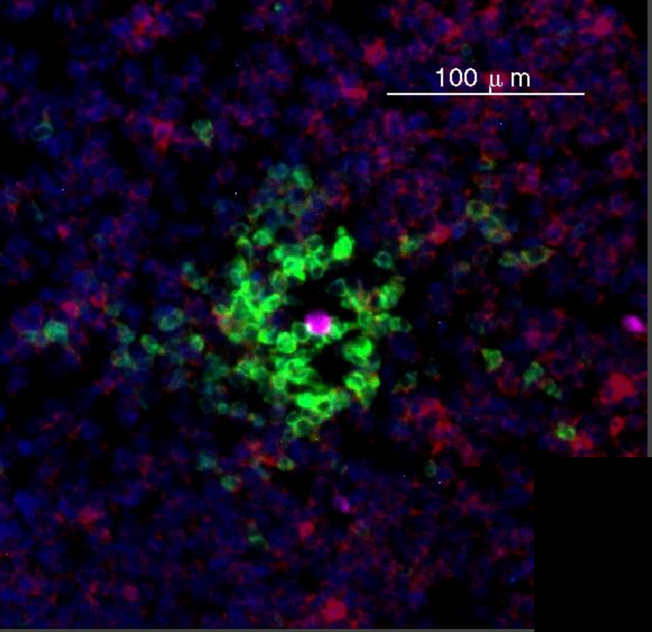
1) DNA polymer structure+dynamics
   moving towards Chromatin structure/dynamics

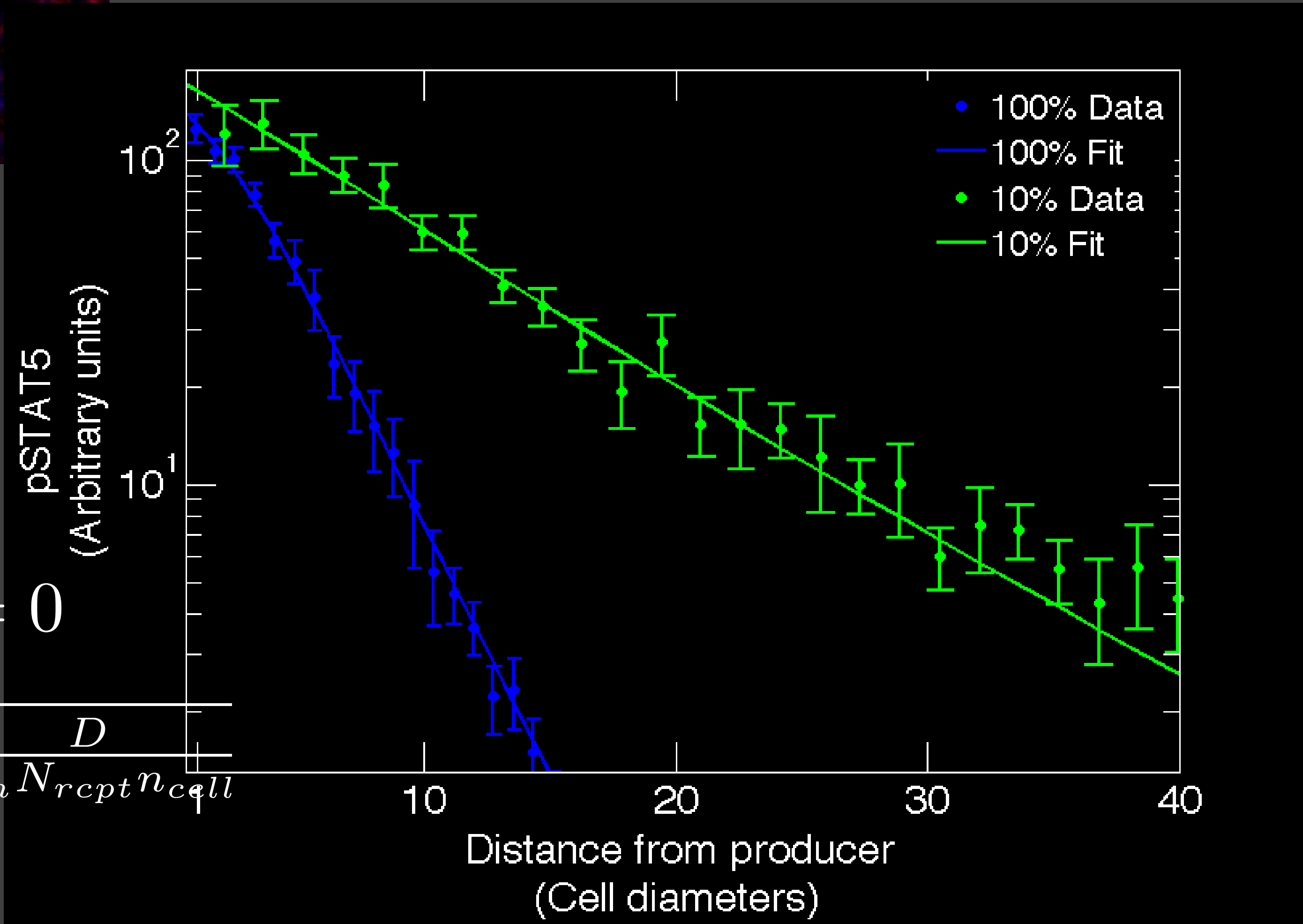
Techniques:
Fluorescence-Correlation Spectroscopy
Super-resolution (STED) microscopy
Microfluidics





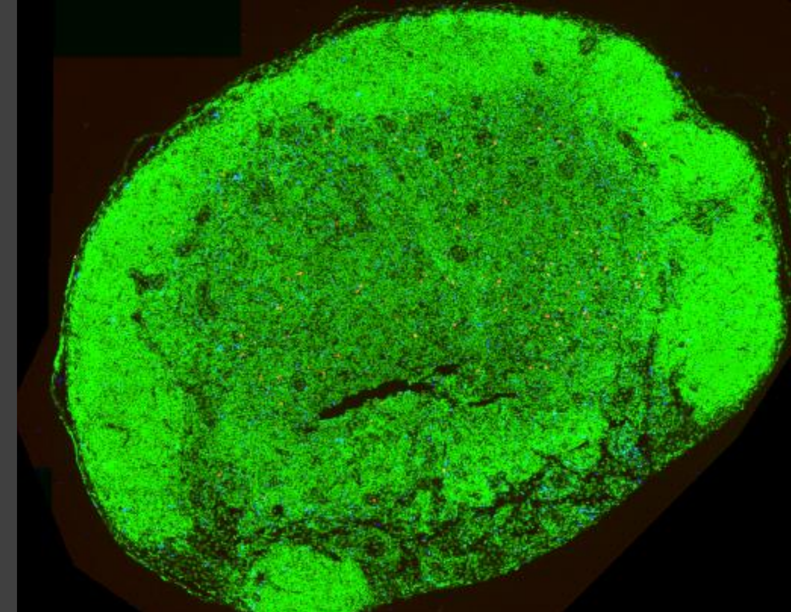
2) Quantitative immunology

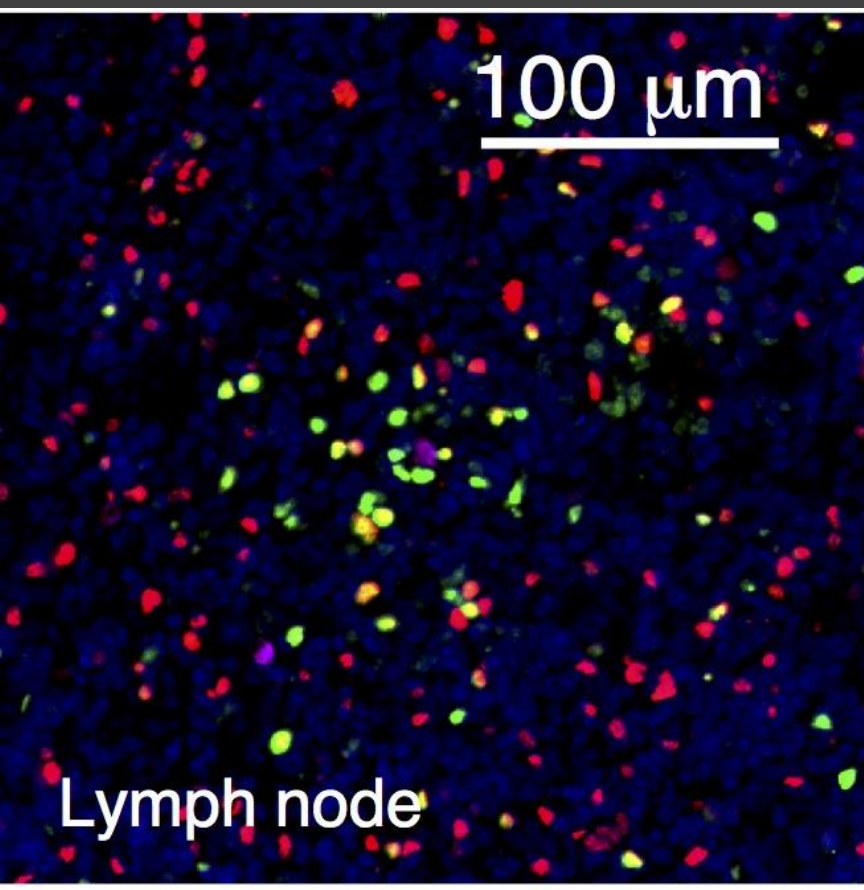


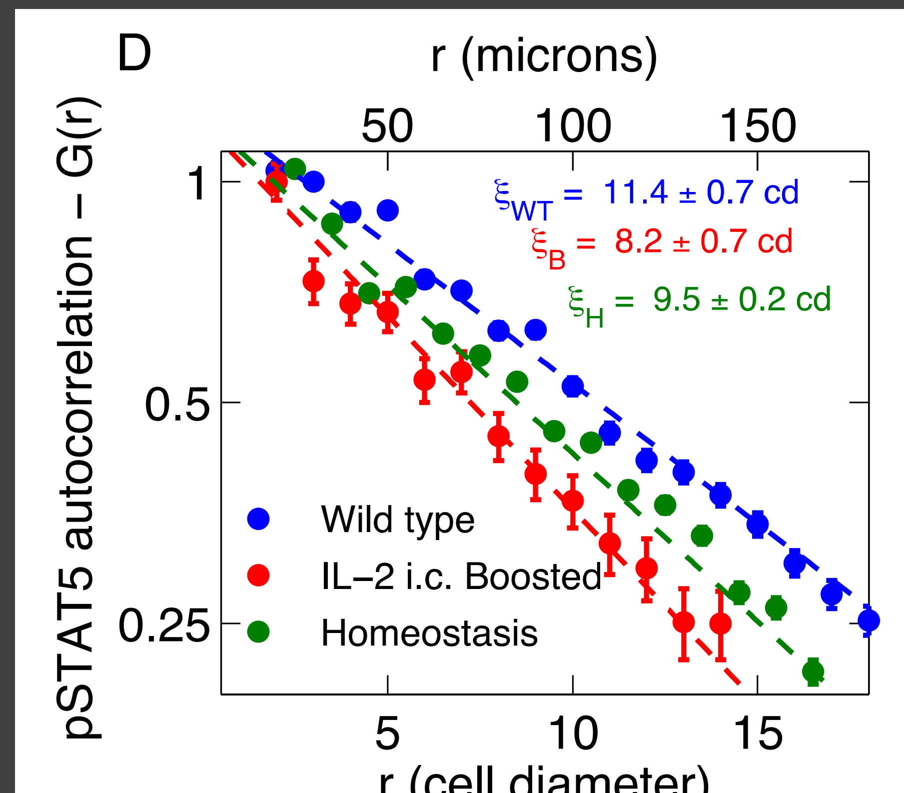


$$\nabla^2 c - \xi^{-2} c = 0$$

$$\xi \sim \sqrt{D\tau} = \sqrt{\frac{D}{k_{on} N_{rcpt} n_{cell}}}$$




100 µm
Lymph node


D
r (microns)
50
100
150
pSTAT5 autocorrelation – G(r)
1
0.5
0.25
ξWT = 11.4 ± 0.7 cd
ξB = 8.2 ± 0.7 cd
ξH = 9.5 ± 0.2 cd
Wild type
IL−2 i.c. Boosted
Homeostasis
5
10
15
r (cell diameter)

Talk to students:

Graduate students

Dotan Davidovich (Ph.D)
Ido Moskovich (Ph.D)
Elad Benjamin (M.Sc.)
Ido Michaelovich (M.Sc.)
Yuval Friedman (M.Sc.)

Undergrads:

Barak Azulay
Yuval Tsedek
Sapir Duany

Statistical Physics of Chocolate Mousse

Oleg Krichevsky

Recipe:

1) Mix 3 egg yolks with 50g of sugar. Warm in water bath (bain-marie) to 80^{o}C. Then whip.
2) Melt 200g of chocolate in water bath at 35^{o}C (careful: allow no water into chocolate!). Mix in the whipped yolks.
3) Alternatively whip egg white
4) Gently (!!!) add whipped cream to chocolate/yolk mix.

How comes $A + B \neq B + A$?

H_2O + NaCl = NaCl + H_2O

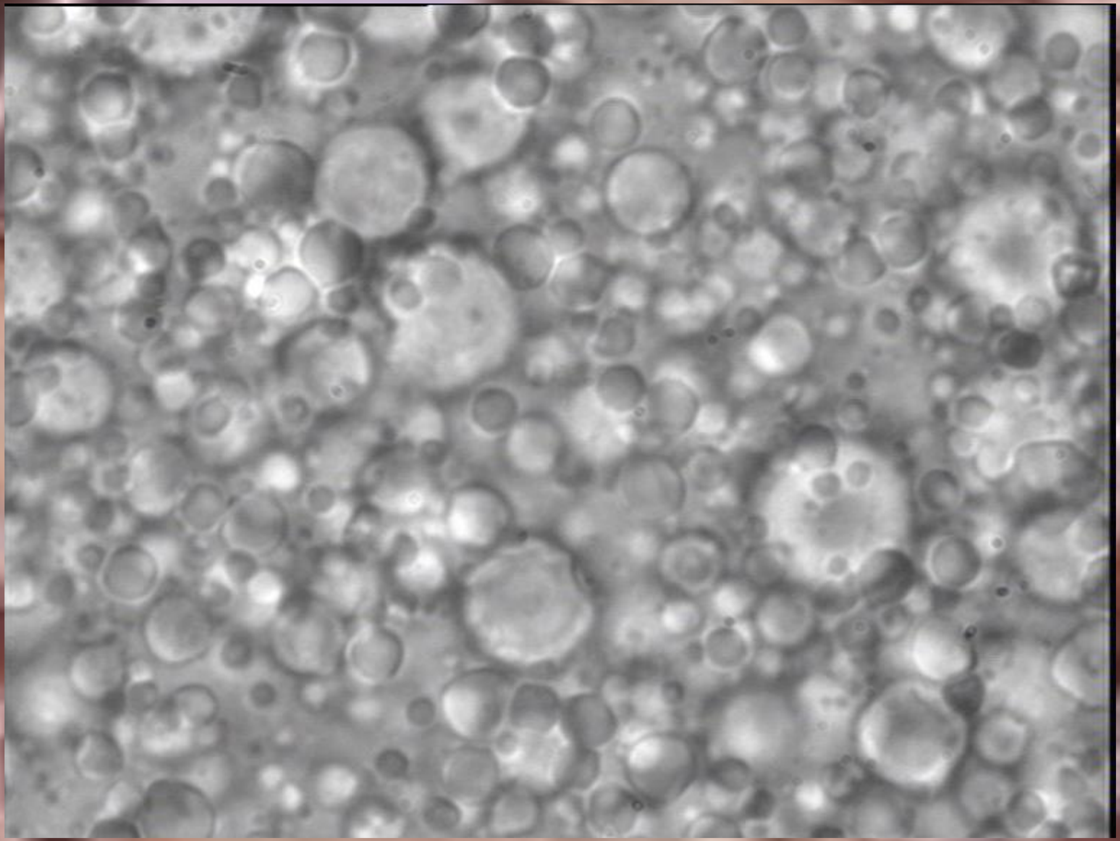
Why not the same with

Chocolate + Whipped Cream ?

For true equilibrium should not matter: obviously we are not dealing with true thermodynamic equilibrium

Both are emulsions: dispersion of droplets of one phase in another phase

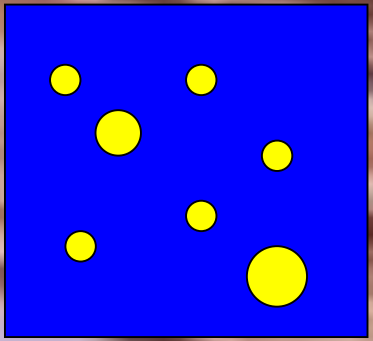
Metastable structures

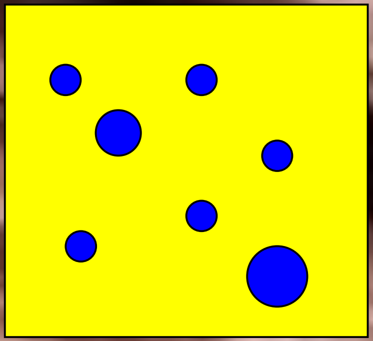


Food emulsions

Oil droplets in Water (milk, cream, mayonnaise)

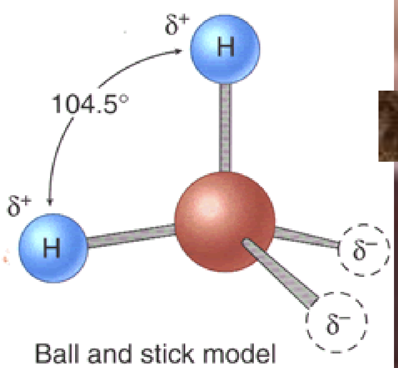
Water droplets in Oil (butter)





Water (H_2O): polar

Dielectric constant ε ~80

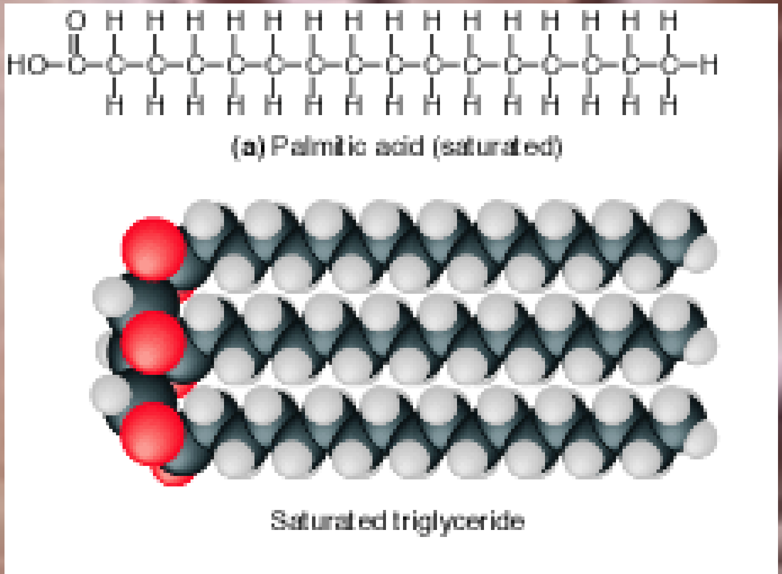


http://www.coolschool.cal

http://instruct.westvalley.edu/svensson/Cells/07molecules.htm

Oil (…-CH_2-CH_2-…): nonpolar

Dielectric constant ε ~3



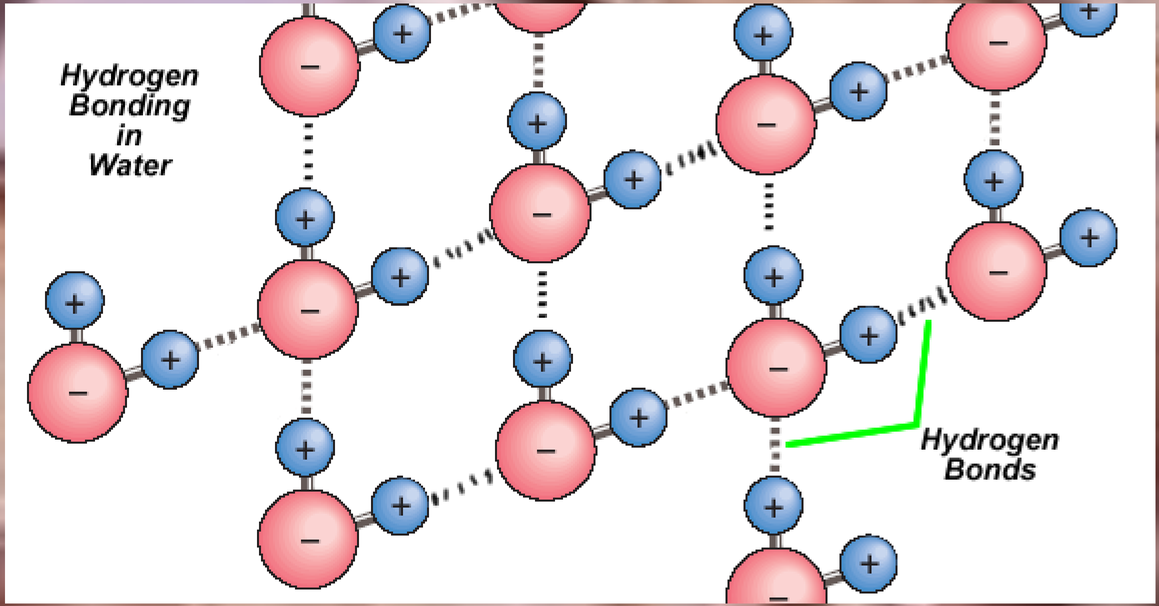
Van der Waals interaction ~ - $\alpha_1 * \alpha_2$

favors phase separation (no mixing between water and oil)

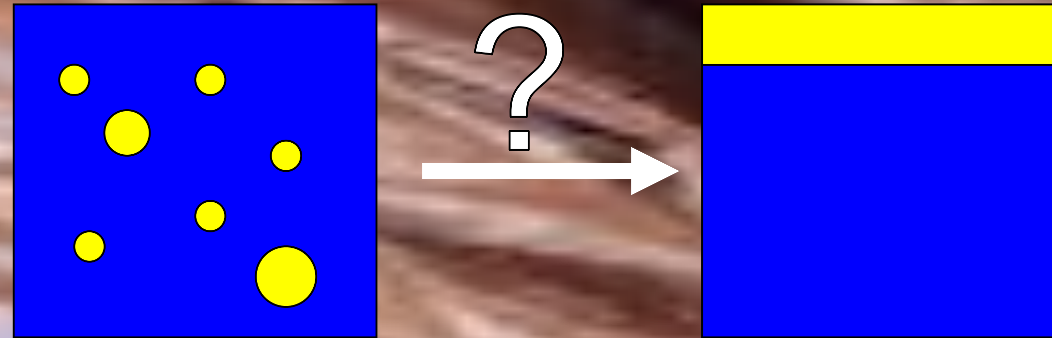
$\varepsilon_1 * \varepsilon_1 + \varepsilon_2 * \varepsilon_2 > 2 * \varepsilon_1 * \varepsilon_2$

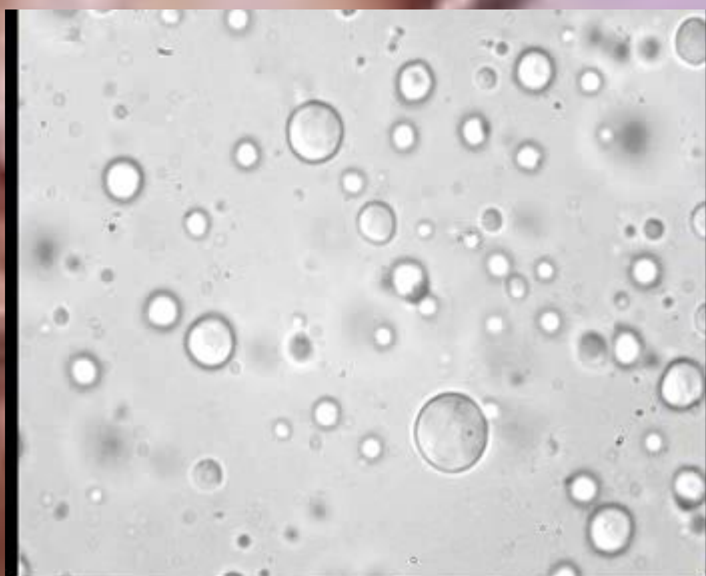
Even more important is water structure through hydrogen bonds

Oil molecules disrupt it: therefore mixing is unfavorable



Why water and oil do not separate completely? This would decrease surface energy.



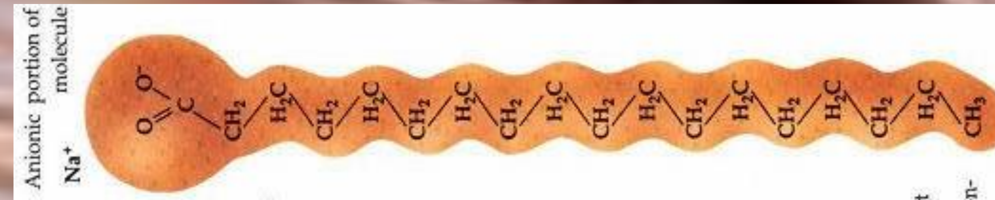


Light scattering.

http://www.chemistry.nus.edu.sg/2500/soap.htm

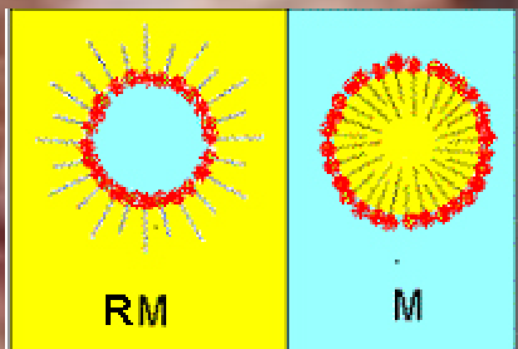
Surface Active agents (surfactants):

Like soap molecules



Charged (hydrophilic) head

Oily (hydrophopic) tail



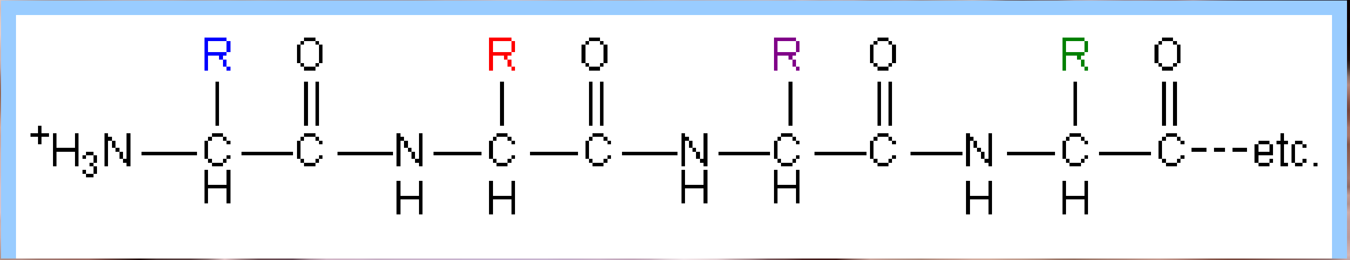
http://www.fisica.unam.mx/grupos/liquids/tutorials/microemulsions.htm

Charge prevents coagulation (but there are other mechanisms as well)

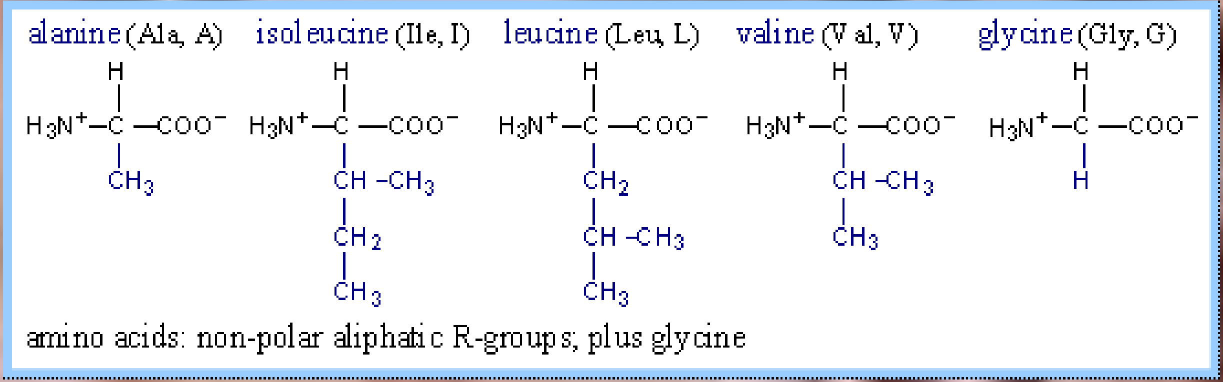
Metastable, but can be very stable

In natural products surfactants are proteins and phospholipids

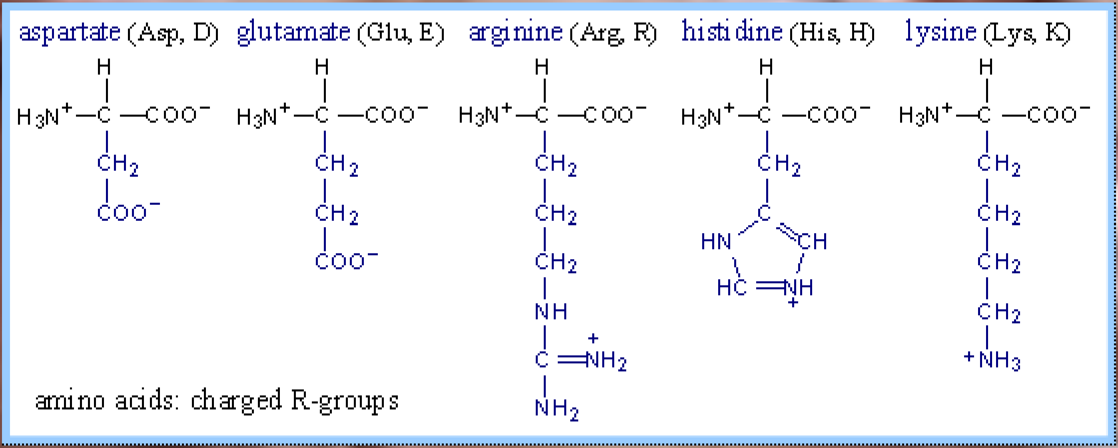
Proteins:



Hydrophobic aminoacids

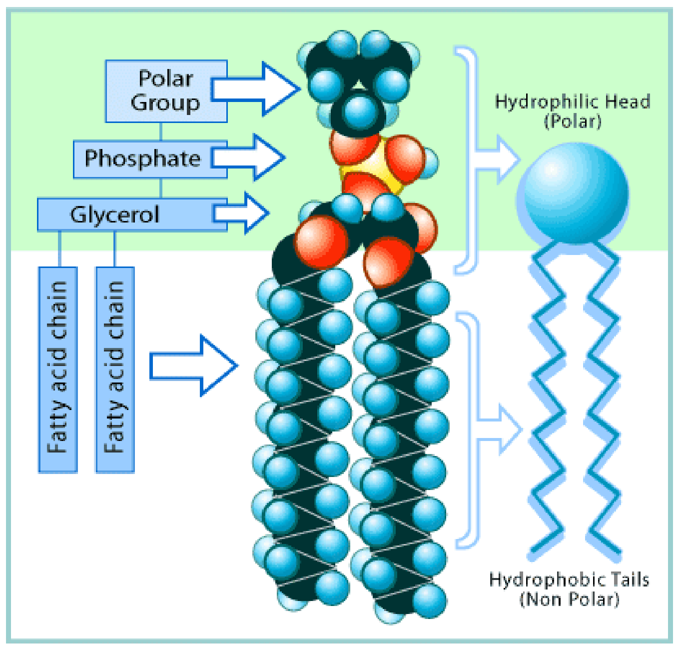


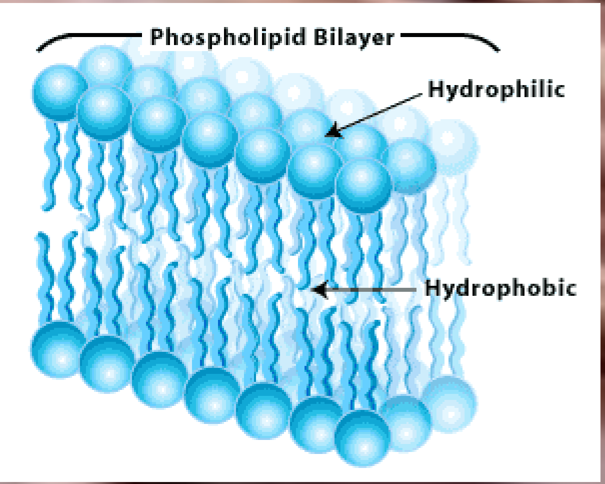
Hydrophilic (charged) aminoacids

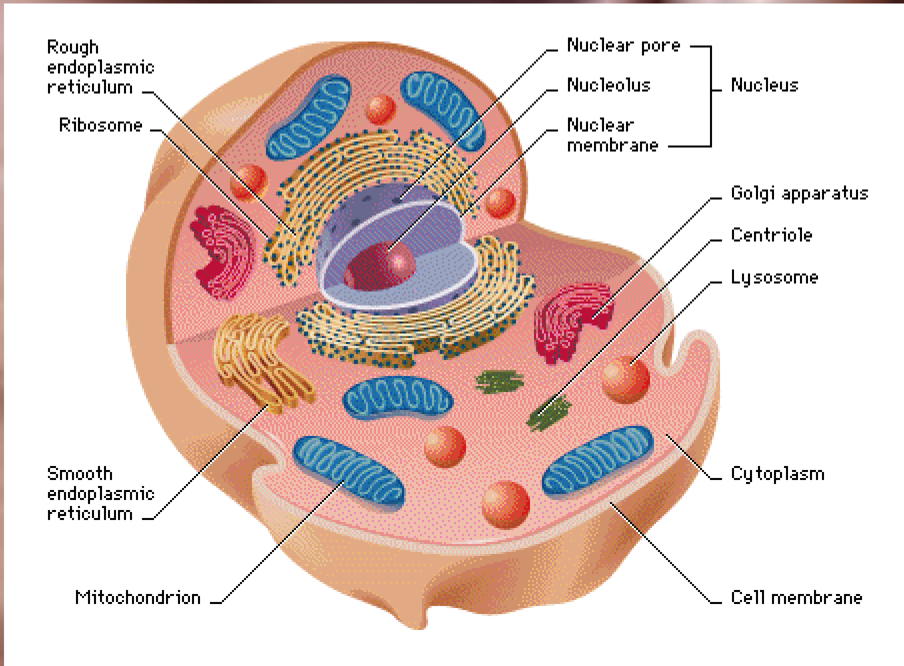


http://www.bioteach.ubc.ca/Bio-industry/Inex/

Phospholipids:

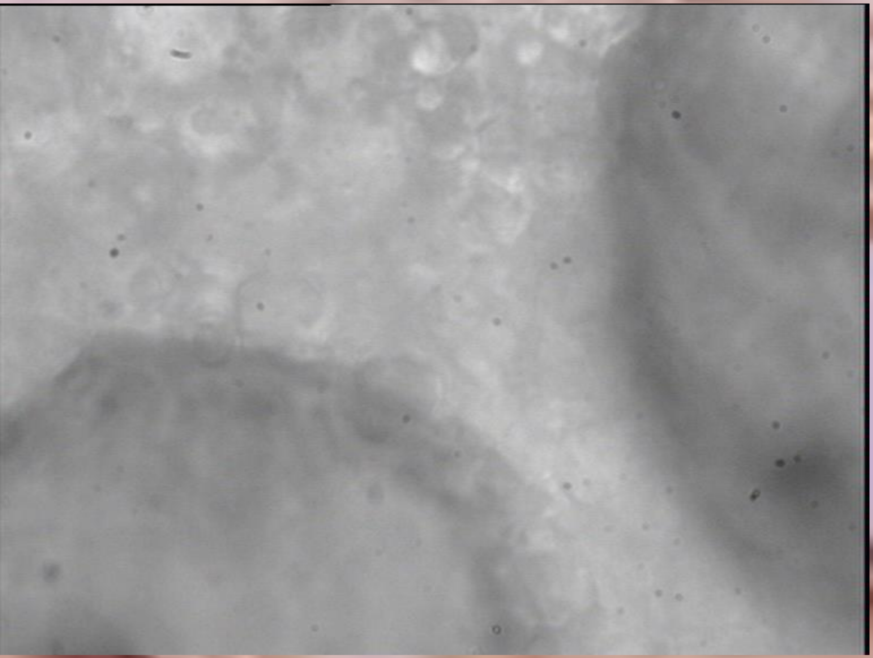


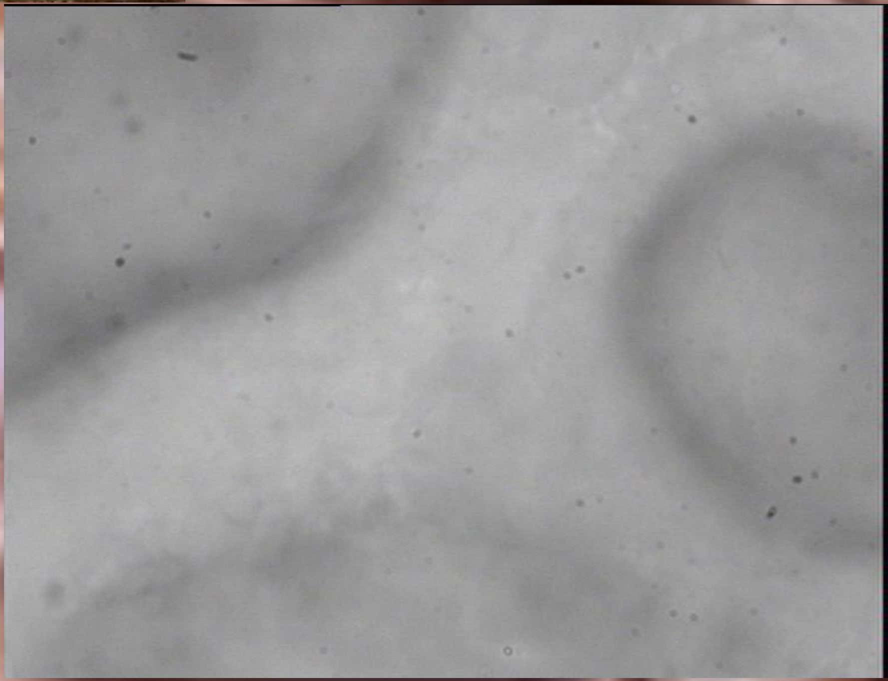


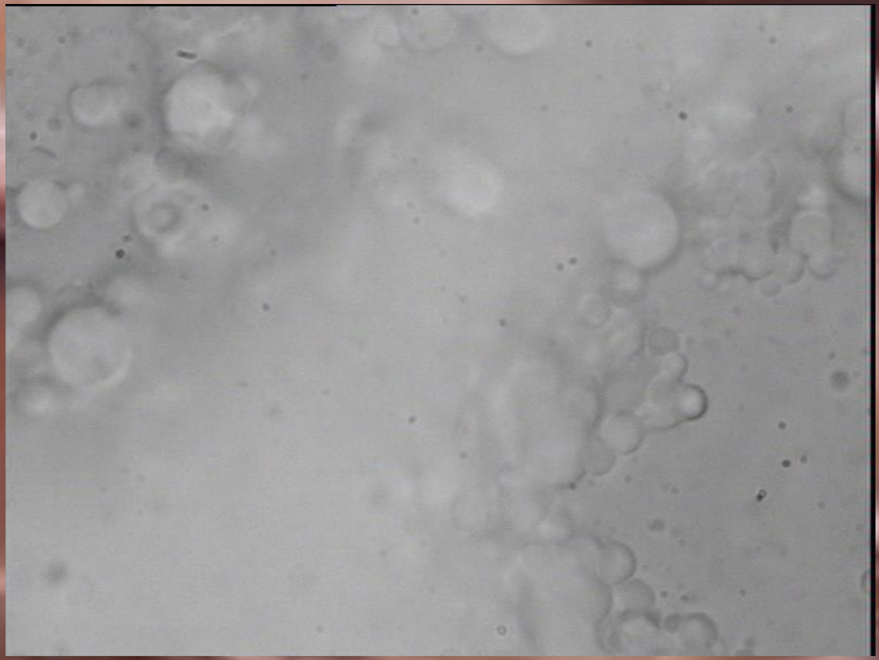


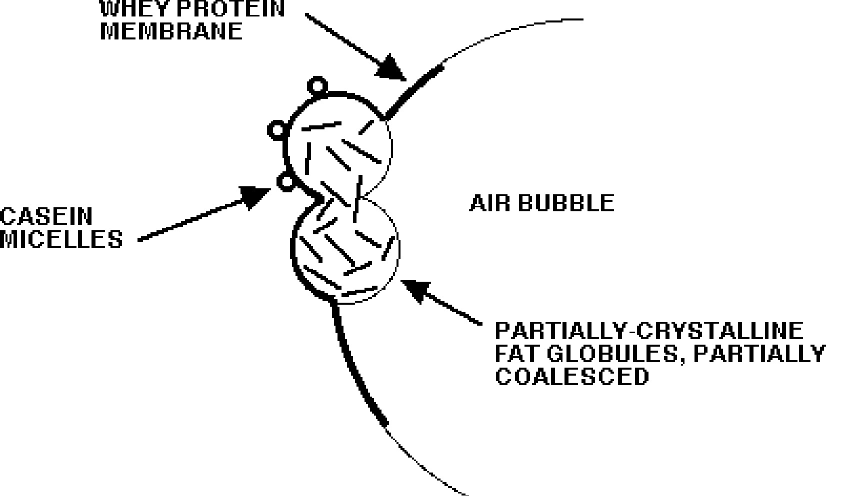
http://coolcell.blogspot.com/2004/10/animal-cell.html

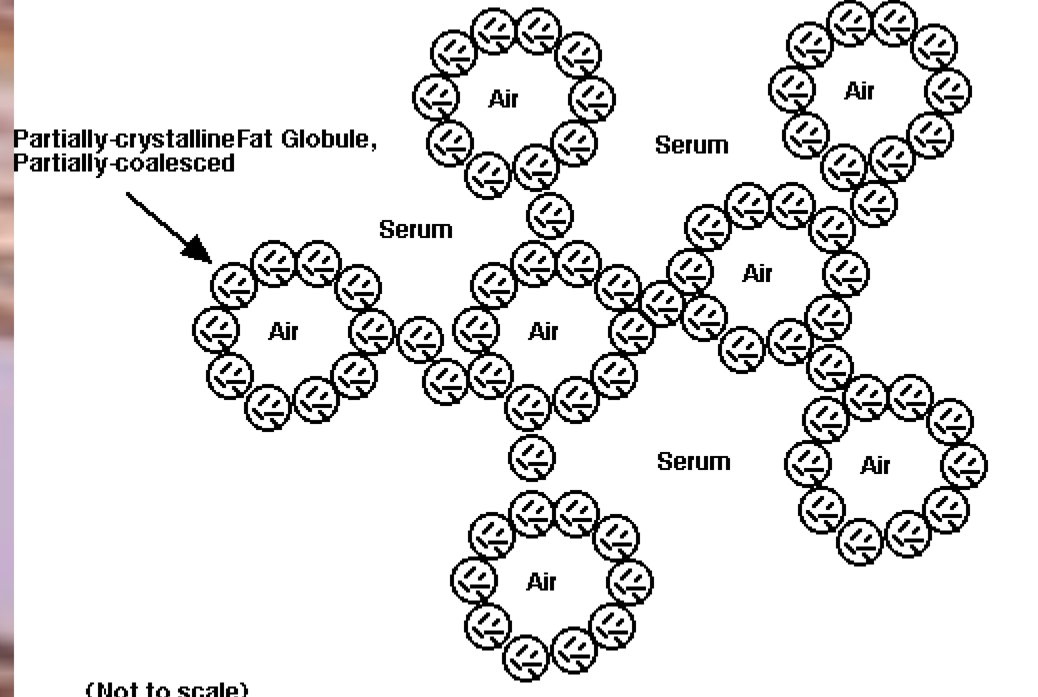
What happens to the cream upon whipping?

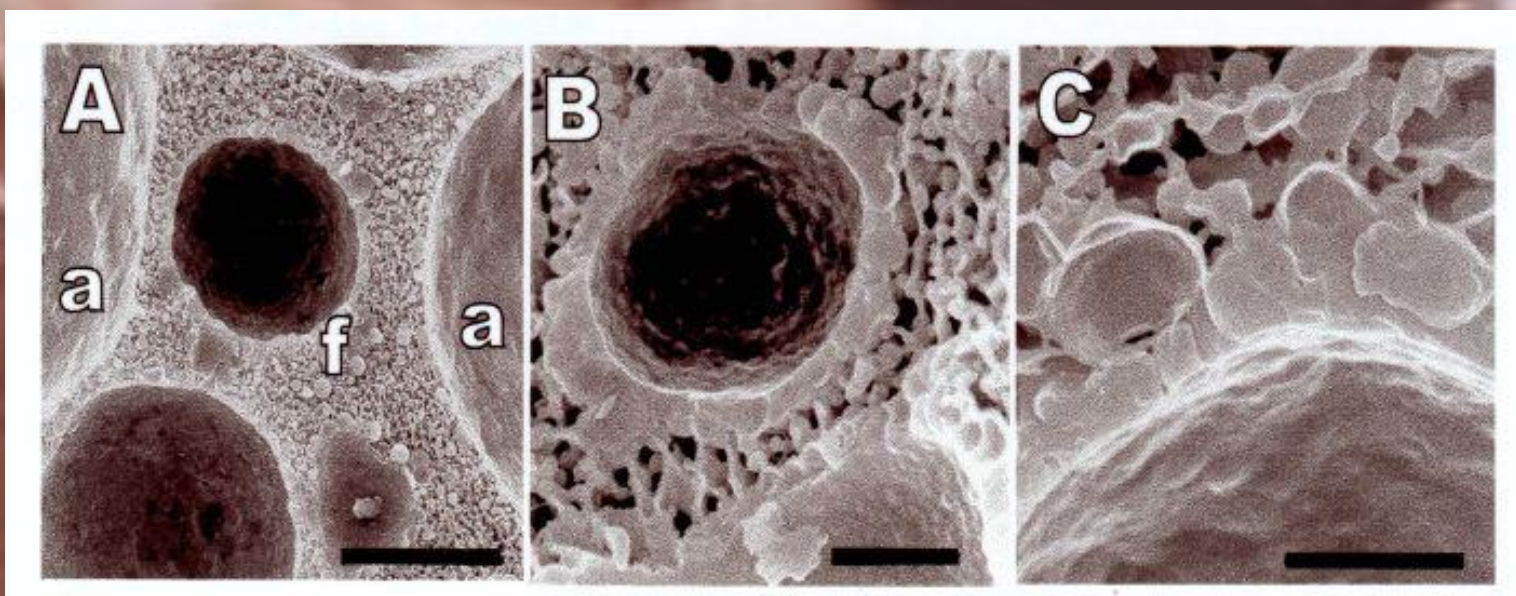












http://www.energymanagertraining.com/dairy/Whipped%20Cream%20Structure.htm

So to make mousse one needs

1) Fats (oil droplets) - come from creme
2) Water – from creme
3) Surfactants – crème and egg yolk
4) Chocolate

But in fact chocolate contains already

1) Fats – cocoa butter
2) Some surfactants
3) No water

So it must be possible to make chocolate mousse just out of pure chocolate and water: original idea by Hervé This