

A close-up photograph of a dark brown water bug with long, thin legs walking on a green water lily leaf. The bug's reflection is clearly visible on the surface of the water below the leaf. The background is a soft-focus view of the water and other lily pads.

Fenomeni di Trasporto Biologico: La Tensione Superficiale

15/11/2019

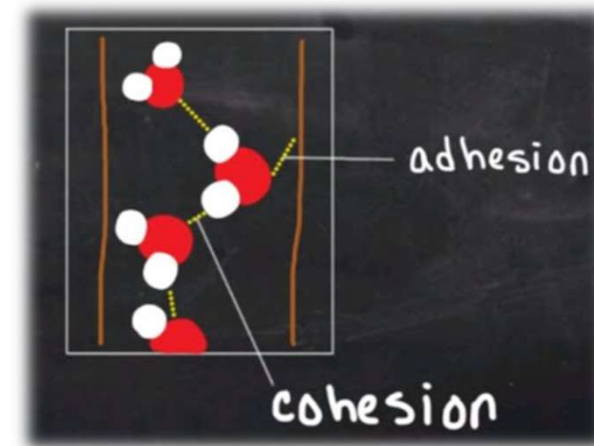
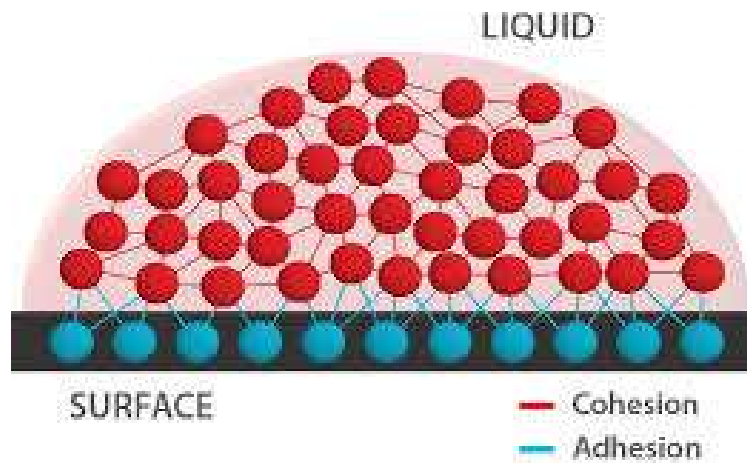
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Prova Sperimentale

- Contare n gocce che rompono la goccia su moneta
- Fotografie per angolo di contatto

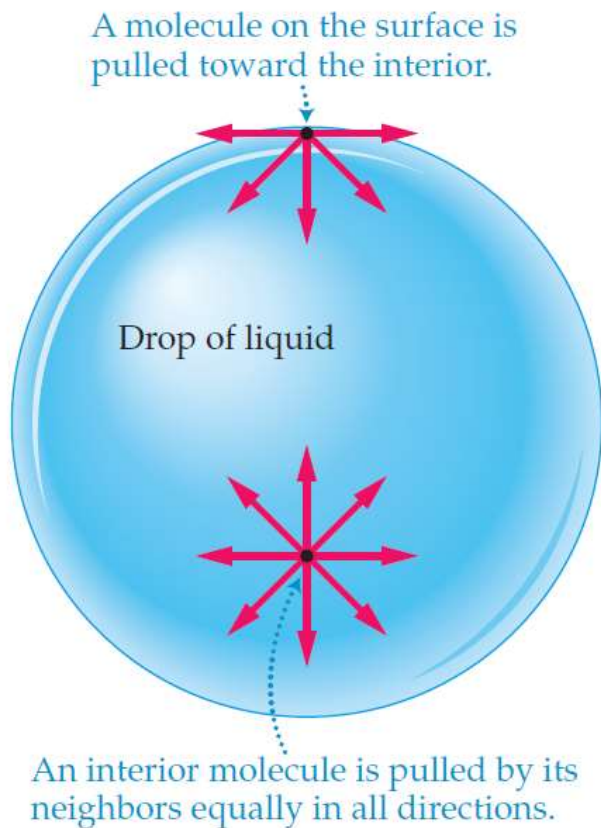
	Gruppo 1	Gruppo 2	Gruppo 3	Gruppo 4	Gruppo 5	Gruppo 6
N acqua	23	35	40	26	35	
	25	20	25	31	22	
	31	21	24	14	23	
N acqua e sapone	14	16	10	16	18	
	12	15	13	10	25	
	13	20	12	17	14	

Adesione e Coesione



- Legami deboli di natura elettrostatica
- Per la **COESIONE**: tra molecole dello stesso tipo
- Per l'**ADESIONE**: tra molecole di tipo diverso

Tensione Superficiale



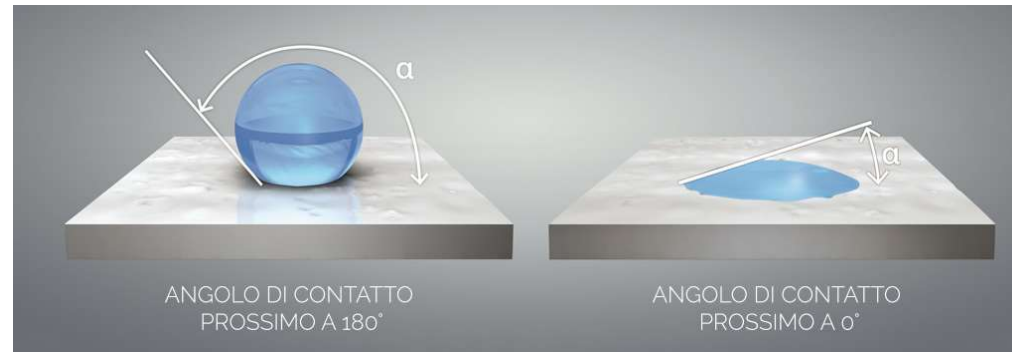
$$\gamma = \frac{\text{FORZA}}{\text{LUNGHEZZA}} \quad \left[\frac{\text{N}}{\text{m}} \right]$$

$$\gamma = \frac{\text{ENERGIA}}{\text{AREA}} \quad \left[\frac{\text{J}}{\text{m}^2} \right]$$

$$\text{ACQUA} \quad 72 \frac{\text{mN}}{\text{m}}$$

$$\text{MERCURIO} \quad 487 \frac{\text{mN}}{\text{m}}$$

Angolo di Contatto: interfaccia aria/solido/liquido



Adesione < Coesione

$$90^\circ < \theta < 180^\circ$$

NON BAGNABILE

@ H₂O

IDROFOBA

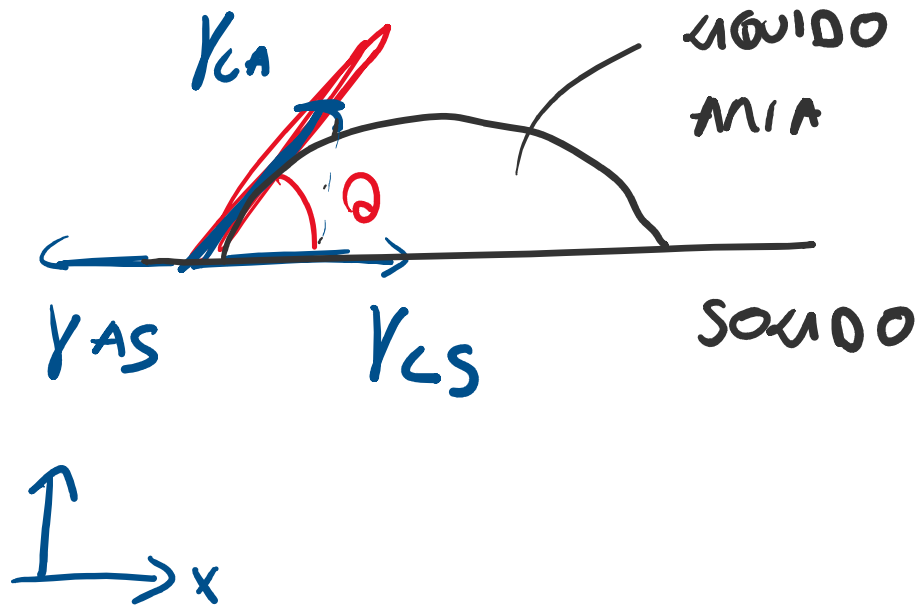
Adesione > Coesione

$$0 < \theta < 90^\circ$$

BAGNABILE

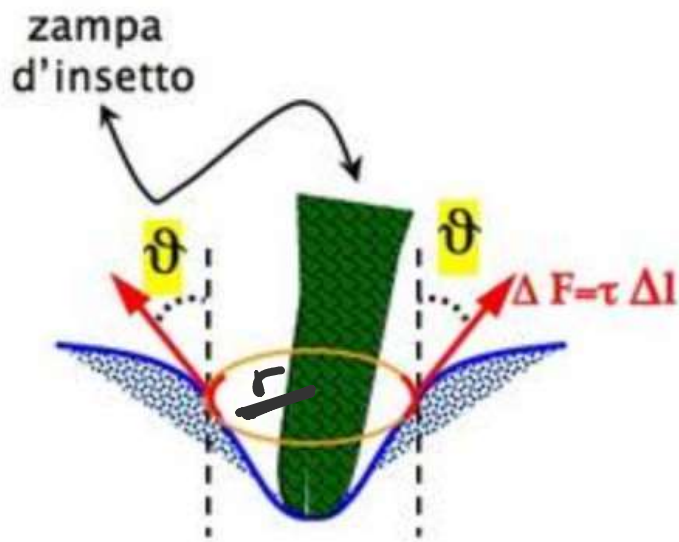
IDROFILO

Equazione Young-Dupree



$$\gamma_{AS} = \gamma_{CS} + \gamma_{LA} \cos \theta \quad @ \ x$$

Esempio: camminare sull'acqua



$$\bar{F}_p = \bar{F}_\gamma$$

$$mg = (\gamma \underbrace{2\pi r}_{L} \cos \theta) 6$$

$$mg = 12 \gamma \pi r \cos \theta$$

$$\cos \theta = \frac{mg}{12 \gamma \pi r} = 0.55$$

$$\bar{F}_p = 3 \times 10^{-3}$$

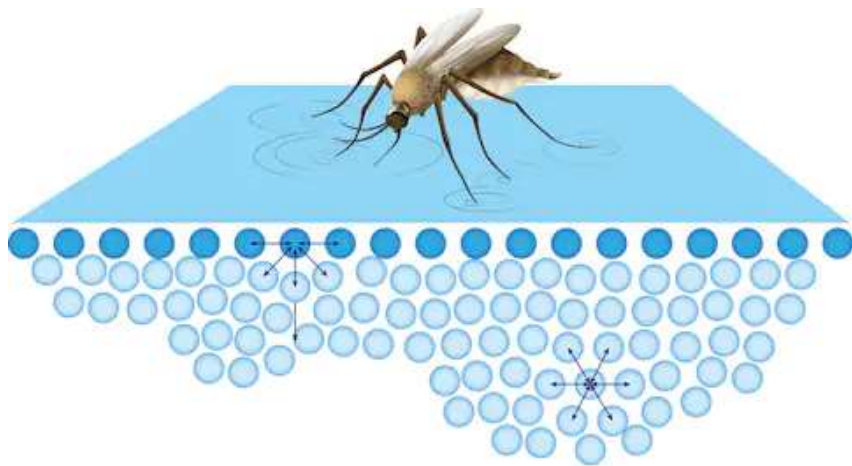
$$\bar{F}_\gamma = 12 (72 \times 10^{-3}) \pi (2 \times 10^{-3}) 0.55 = 7.9 \times 10^{-3}$$

$$r = 2 \times 10^{-3} \text{ m}$$

$$m = 0.3 \text{ mg}$$

$$\gamma = 72 \text{ m} \frac{\text{N}}{\text{m}}$$

Numero di Bond e Jesus



$$\text{Bond} = \frac{F_z}{\frac{F_y}{L}} = \frac{mg}{\gamma} = \frac{\rho L^3 g}{\gamma} = \frac{\rho g L^3}{\gamma}$$

$$\text{Bond} > 1$$

$$\bar{F}_z > F_y$$



$$\text{Bond} \leq 1$$

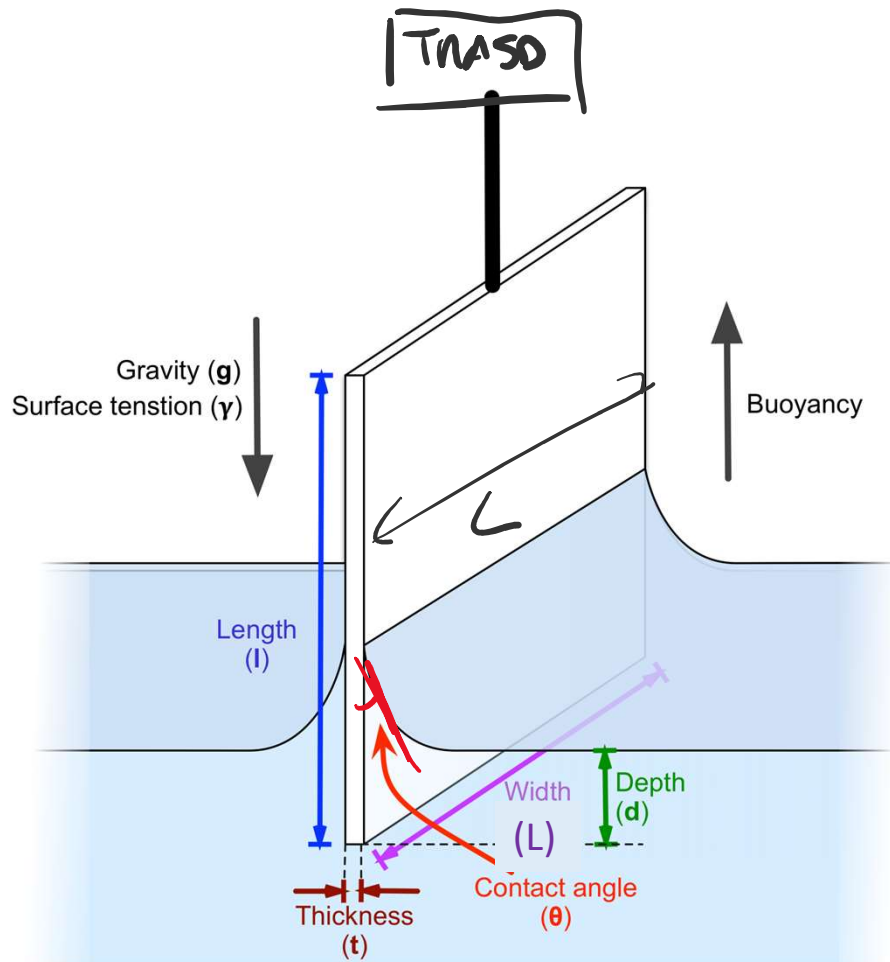
$$F_z \leq F_y$$



$$(\text{Jesus} > 1)$$

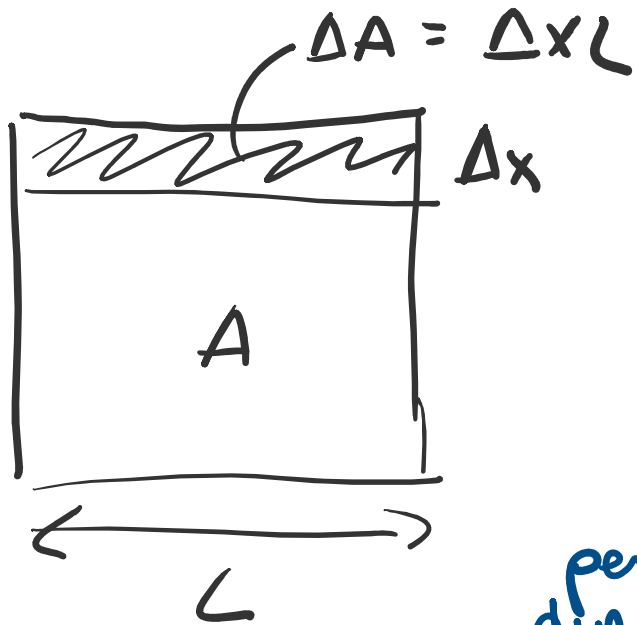
$$\bar{\text{Jesus}} = \frac{1}{\text{Bond}}$$

Misura Sperimentale



$$\bar{F}_\gamma + \bar{F}_A - \bar{F}_p = 0$$
$$\gamma 2L = (\bar{F}_p - \bar{F}_A) \bar{F}_{\text{misurata}}$$

$$\gamma = \frac{\bar{F}_{\text{mis}}}{2L}$$



Lavoro

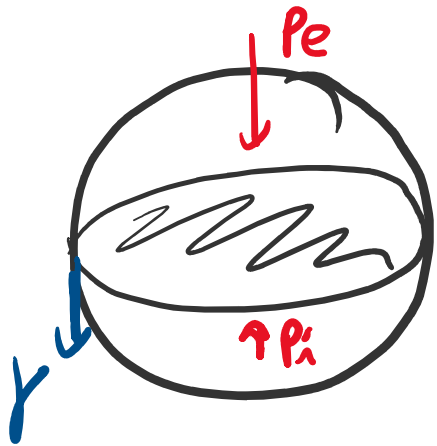
$$\frac{\Delta K}{\Delta A} = \frac{F \Delta x}{\Delta A} = \frac{F \Delta x}{\Delta x L} = \gamma$$

per le due facce $\rightarrow 2\gamma = \frac{F_{tens}}{L}$

$$\gamma = \frac{F_{tens}}{2L}$$

per una faccia della lamina

Legge Laplace per le gocce



SEZIONE A METÀ DELLA STERNA

$$P_e A + \gamma L = P_i A$$

$$P_e \pi r^2 + \gamma 2\pi r x = P_i \pi r^2$$

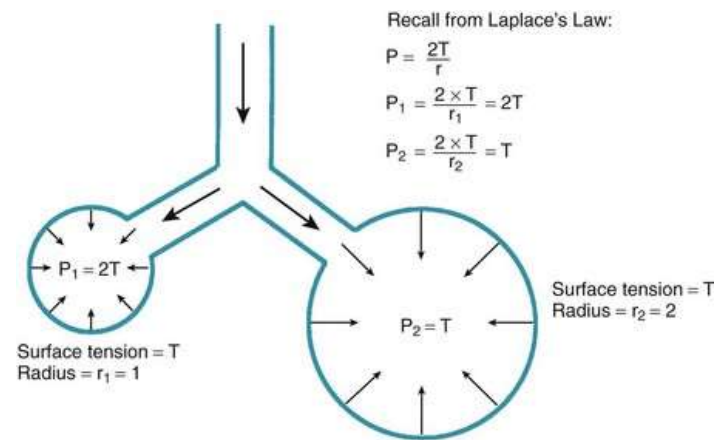
$$\underbrace{P_i - P_e}_{\Delta P} = \frac{2\gamma}{r}$$



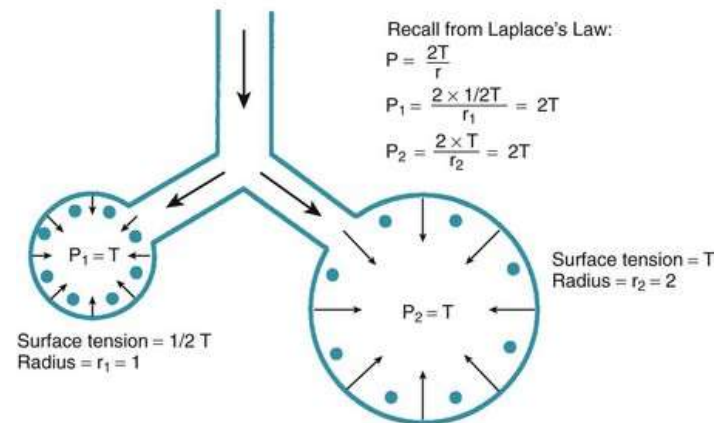
Spherical Vessel

$$T = \frac{PR}{2}$$

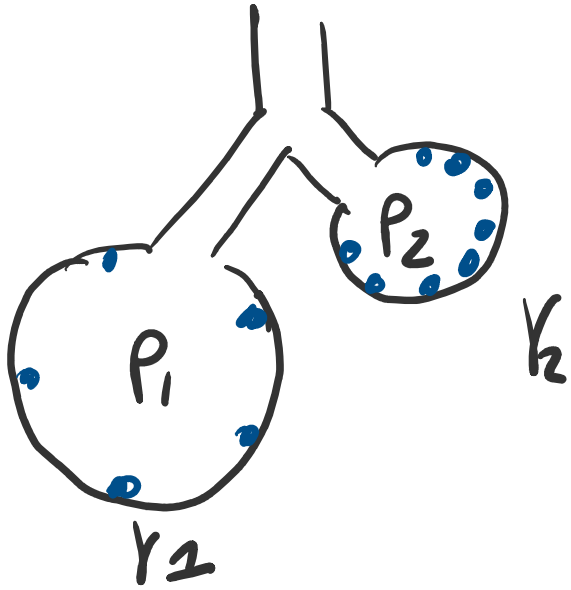
Esempio: Alveoli



A Ideal alveoli: $P_1 > P_2$



B Real alveoli: $P_1 = P_2$ with pulmonary surfactant



$$R_1 = 2R, R_2 = R$$

• = surfactante

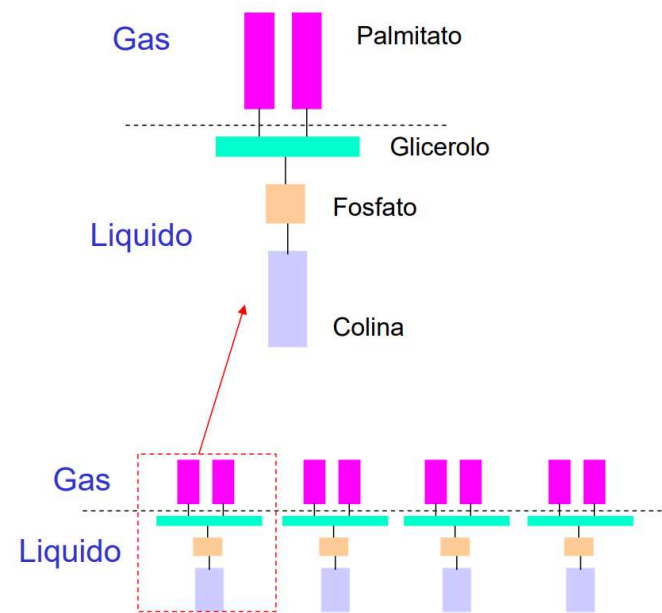
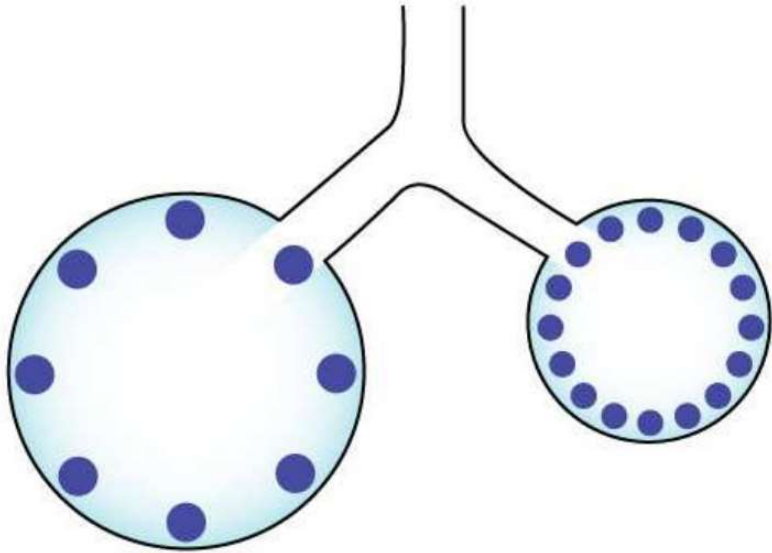
$$\frac{2\gamma}{2R} < \frac{2\gamma}{R}$$

$$@ \gamma_1 = \gamma_2 = \gamma$$

$$\frac{\gamma}{R} = \frac{2\gamma}{2R}$$

$$@ \gamma_2 = \frac{1}{2}\gamma, \gamma_1 = \gamma$$

Esempio: Alveoli

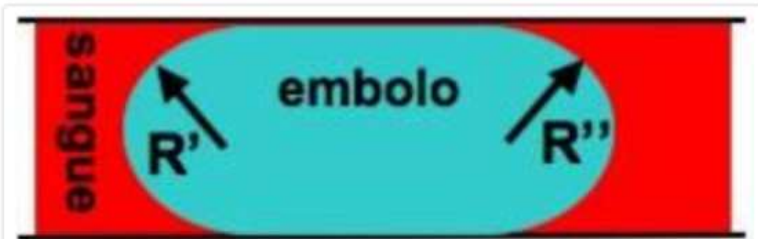


- Il surfattante è un fosfolipide: **Dipalmitoil-fosfatidilcolina (DPPC)** prodotto dai pneumociti di II tipo.

- Si dispone sulla superficie alveolare con la parte polare, idrofila, immersa nella fase liquida e la parte non polare, idrofoba, rivolta verso la fase gassosa.

- Le molecole di tensioattivo sono compresse durante la deflazione polmonare ed espanse durante l'insufflazione

Esempio: Embolia gassosa



Embolo simmetrico: $R' = R''$



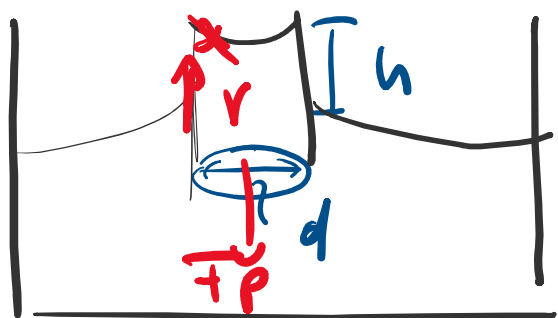
Embolo asimmetrico: $R' > R''$

$$\frac{(P_3 - P_4)}{R_2} - \frac{(P_2 - P_1)}{R_1}$$

$$P_2 - P_4 = 2\gamma \left(\frac{1}{R_2} - \frac{1}{R_1} \right)$$

$$P_1 = P_4 \quad R_2 = R_1$$

$$P_1 > P_4 \quad R_2 < R_1$$



$$F_a = F_r$$

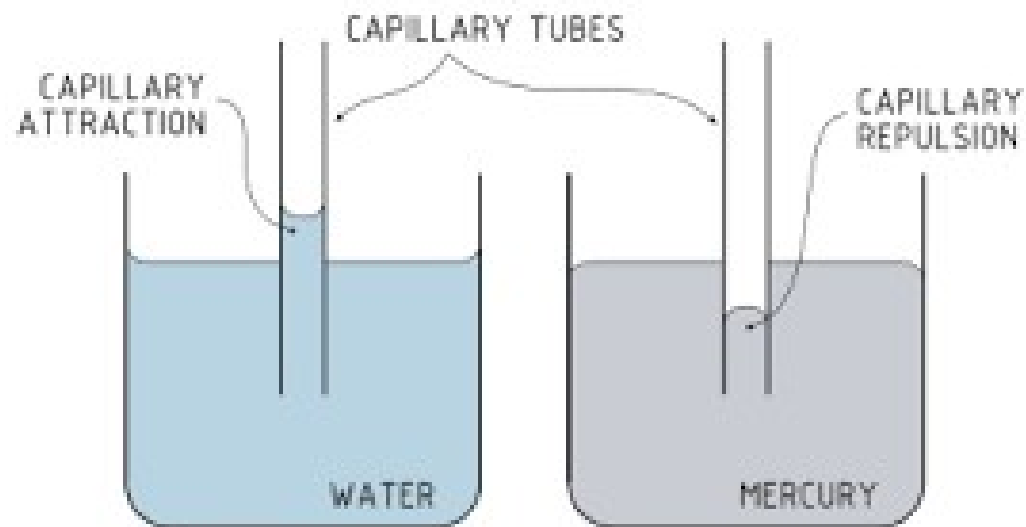
$$mg = \gamma L \cos \theta$$

ρV circ

$$\rho \pi \frac{d^2}{4} h = \gamma \pi d \cos \theta$$

$$h = \frac{4 \gamma \cos \theta}{d \rho g}$$

$$P = \rho g h = \frac{4 \gamma}{d} \cos \theta$$



$$\theta = 90^\circ$$
$$(\cos \theta = 0)$$
$$h = 0$$

$$\theta < 90^\circ$$
$$h > 0$$

$$\theta > 90^\circ$$
$$h < 0$$

Capillarità: esercizio

$$d = 300 \mu\text{m}$$

$$\gamma = 72 \text{ mN}$$

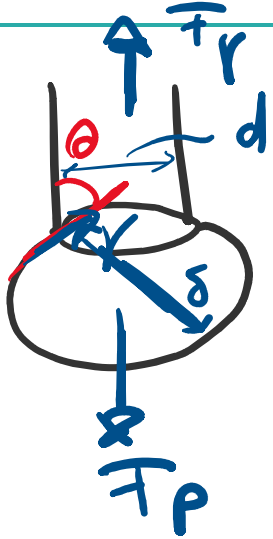
$$\rho = 1000 \text{ kg/m}^3$$

$$= 1 \quad (\theta = 0^\circ)$$

$$h = \frac{4\gamma \cos\theta}{d\rho g} = \frac{4 \times 72 \times 10^{-3}}{300 \times 10^{-6} \times 10 \times 1000} = 96 \text{ mm}$$

$$\frac{\text{N}}{\text{m}} \quad \left[\frac{\text{kg} \cdot \text{m}}{\text{m}^3 \cdot \text{s}^2} \right] \cdot \text{m} \quad \text{N} \quad [\text{m}]$$

Caduta gocce da capillare



$$F_p = M_{\text{goccia}} g = \rho g V = \rho g \frac{4}{3} \pi \left(\frac{\delta}{2}\right)^3$$

$$= \rho g \frac{\pi}{6} \delta^3$$

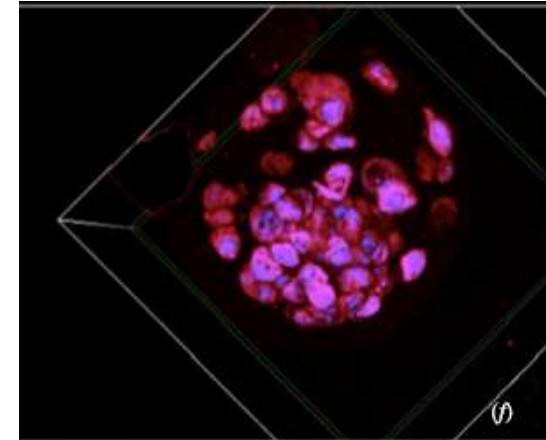
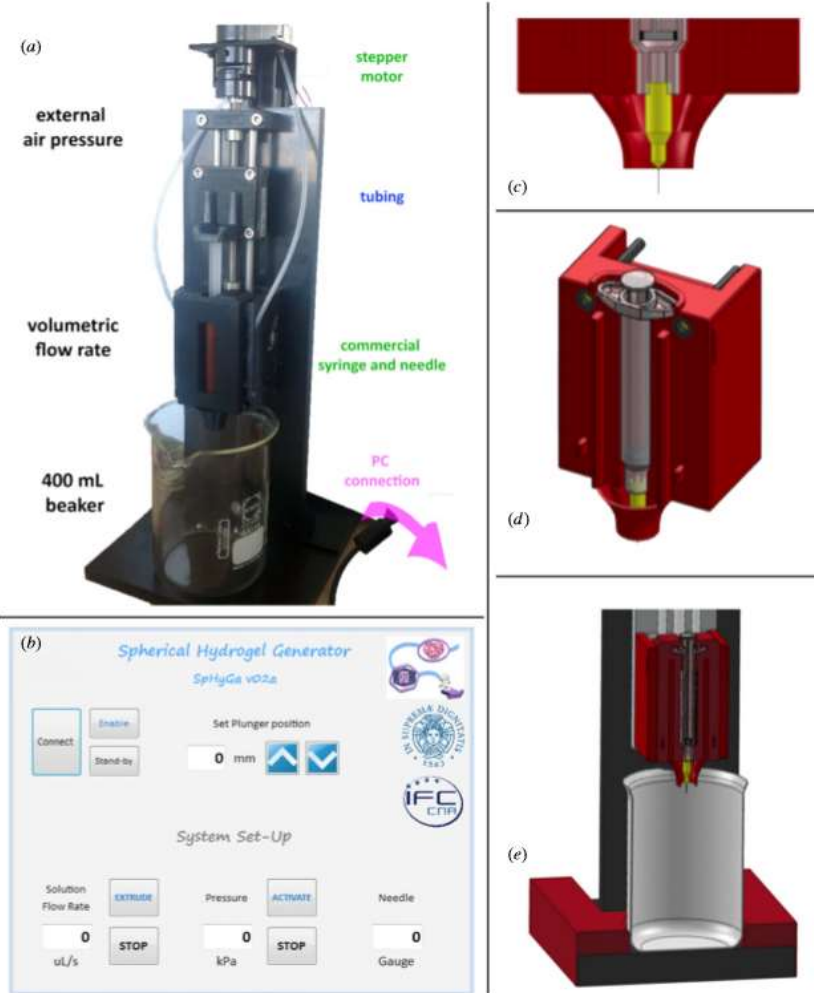
$$F_\gamma = \gamma L \cos \theta = \gamma \pi d \cos \theta$$

@ $\theta = 0$ (GOC CIA SI STACIA)

$$\rho g \frac{\pi}{6} \delta^3 = \gamma \pi d$$

$$\delta = \sqrt[3]{\frac{6 \gamma d}{\rho g}}$$

Esempio: incapsulatore cellulare



$$\bar{F}_p + P = F_Y$$

$$\Downarrow$$

$$\delta = \frac{\sqrt[3]{(rd - \frac{Pd^2}{s})^6}}{L^2}$$