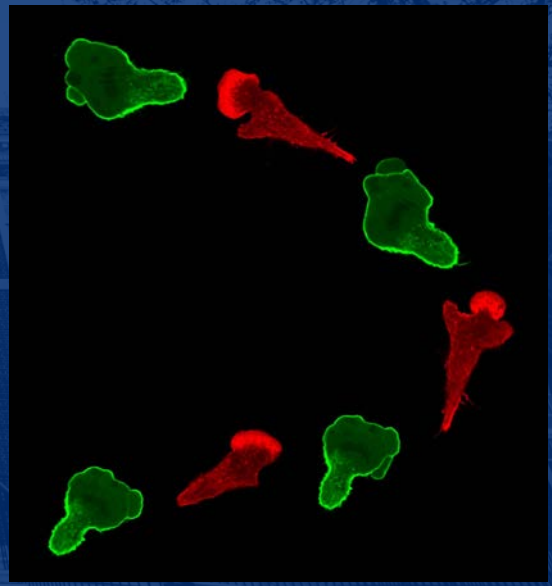
Cell and Tissue Engineering

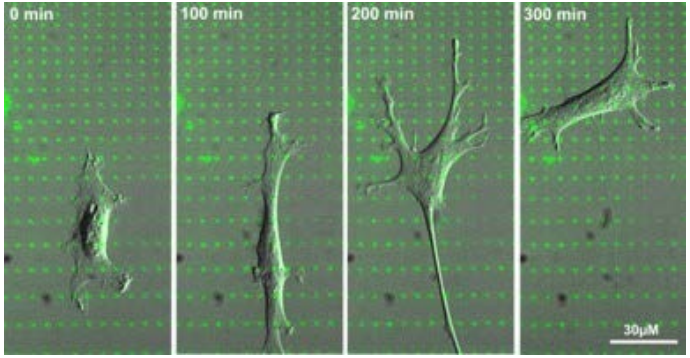
Cell Adhesion, Part 1



Martin Bergert,
Max Planck Institute for Molecular Cell Biology and Genetics

Why is cell adhesion so important?

Haptotaxis



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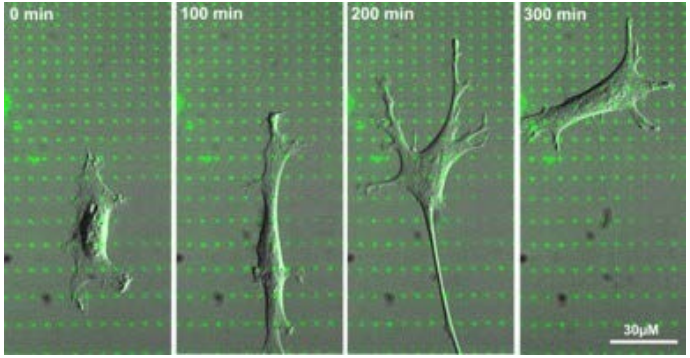
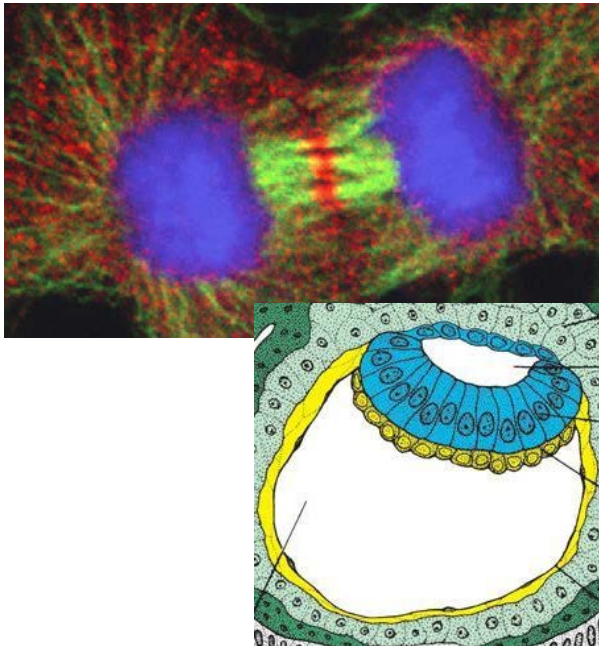
Haptotaxis

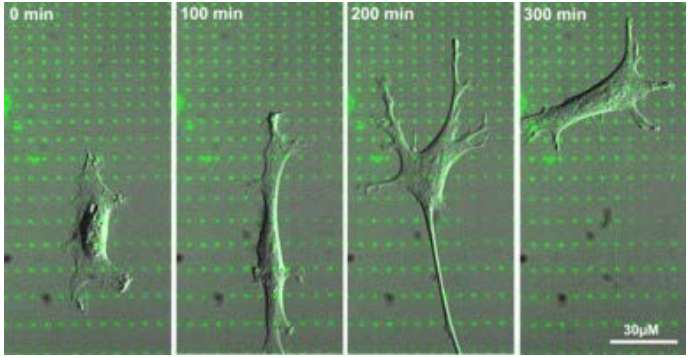


Cell-cell adhesion

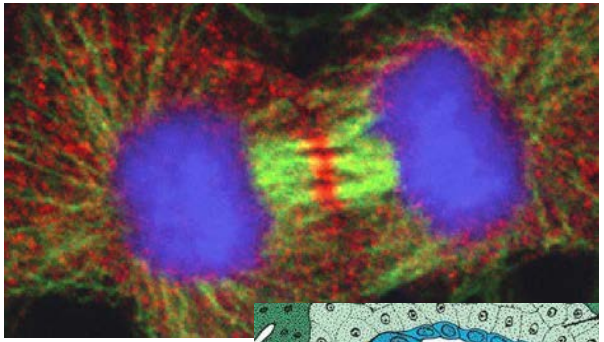


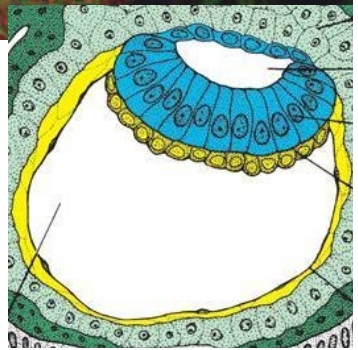
Why is cell adhesion so important?

Haptotaxis

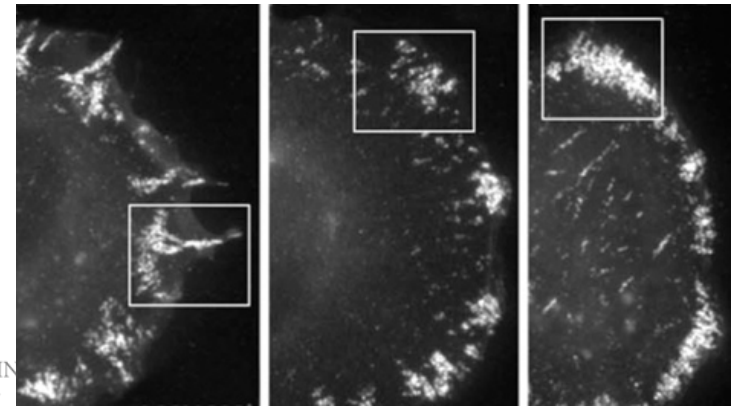


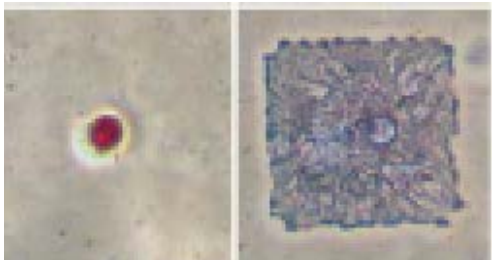
Cell-cell adhesion





Cell-matrix adhesion





McBeath, et. al., 2004

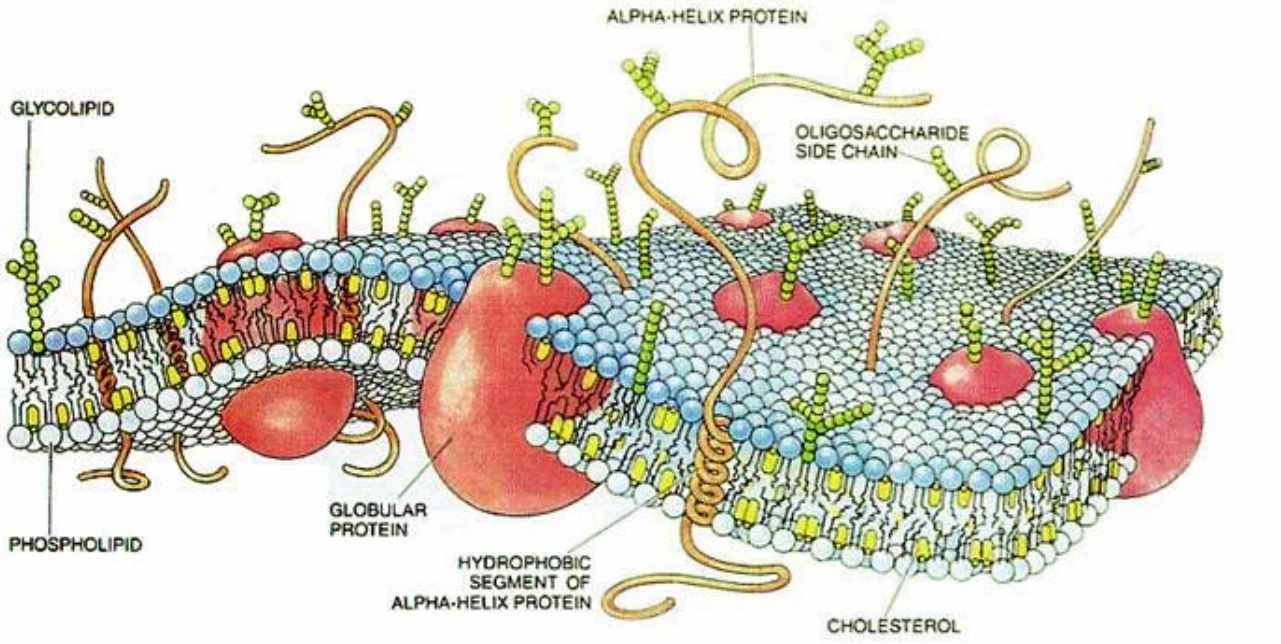
www.zi1.uni-karlsruhe.de; www.mayo.edu; studyblue.com

Cell adhesion happens near the cell membrane

5% carbohydrate

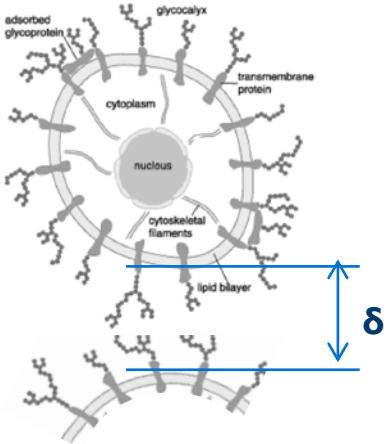
50% protein

45% lipid (abundant anionic phospholipid phosphatidylserine give the membrane a net negative charge)

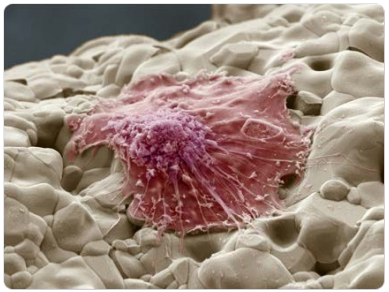


Wikipedia.org

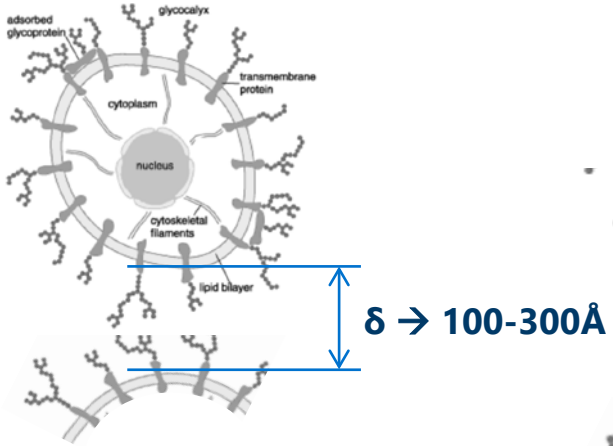
Mechanics of cell adhesion



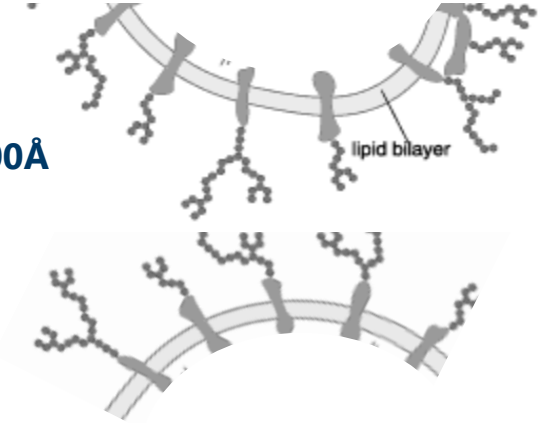
Poly(L-lysine)



Mechanics of cell adhesion



Repulsive forces
Charge
Osmotic imbalance
Compression of surface molecules



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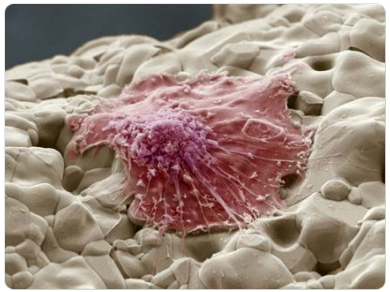
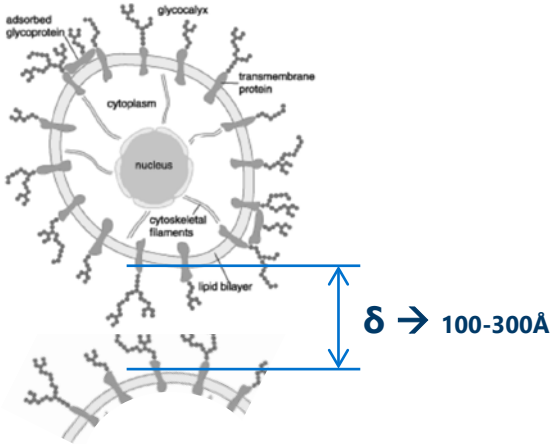


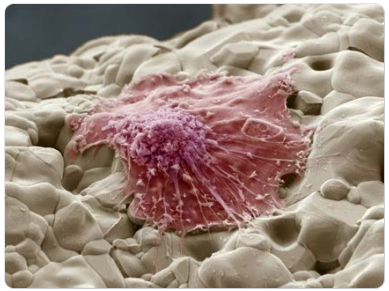
Attractive force
van der Waals (>200Å)
~1000dynes/cm^2

Mechanics of cell adhesion

Attractive force
van der Waals (>200Å)
~1000dynes/cm^2

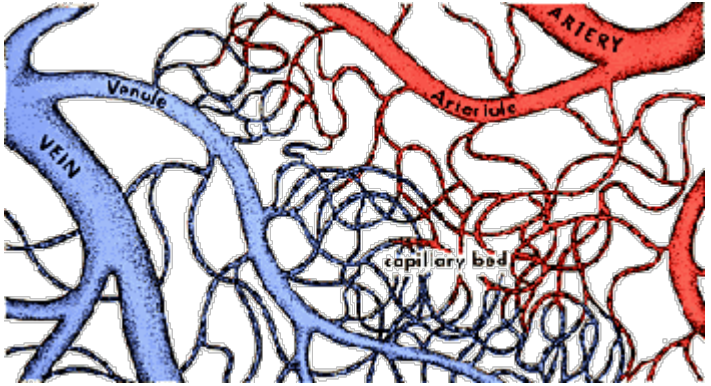


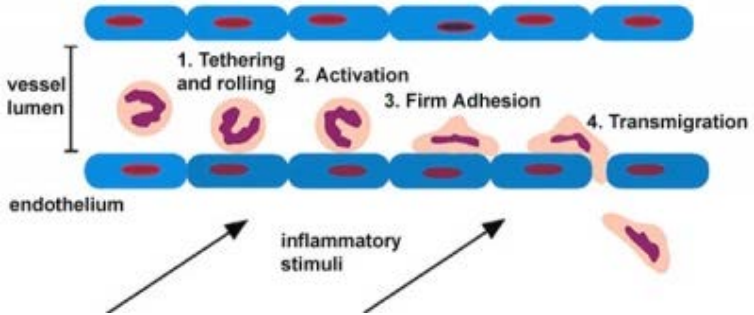
Poly(L-lysine)



Shear force in venule
~1-10dynes/cm^2

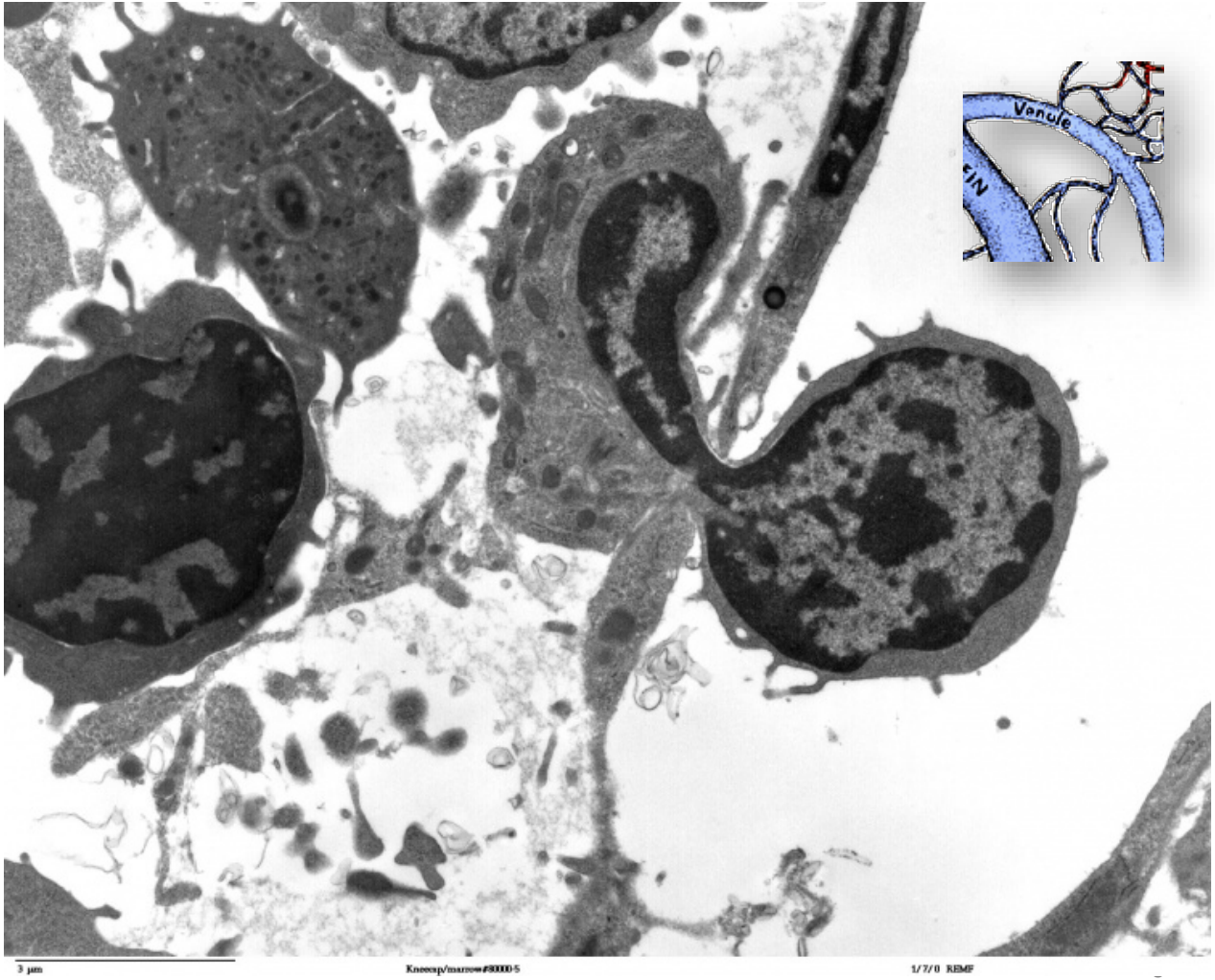
Shear force in arterioles
~10,000dynes/cm^2





Leukocyte adhesion cascade

Cell extravasation



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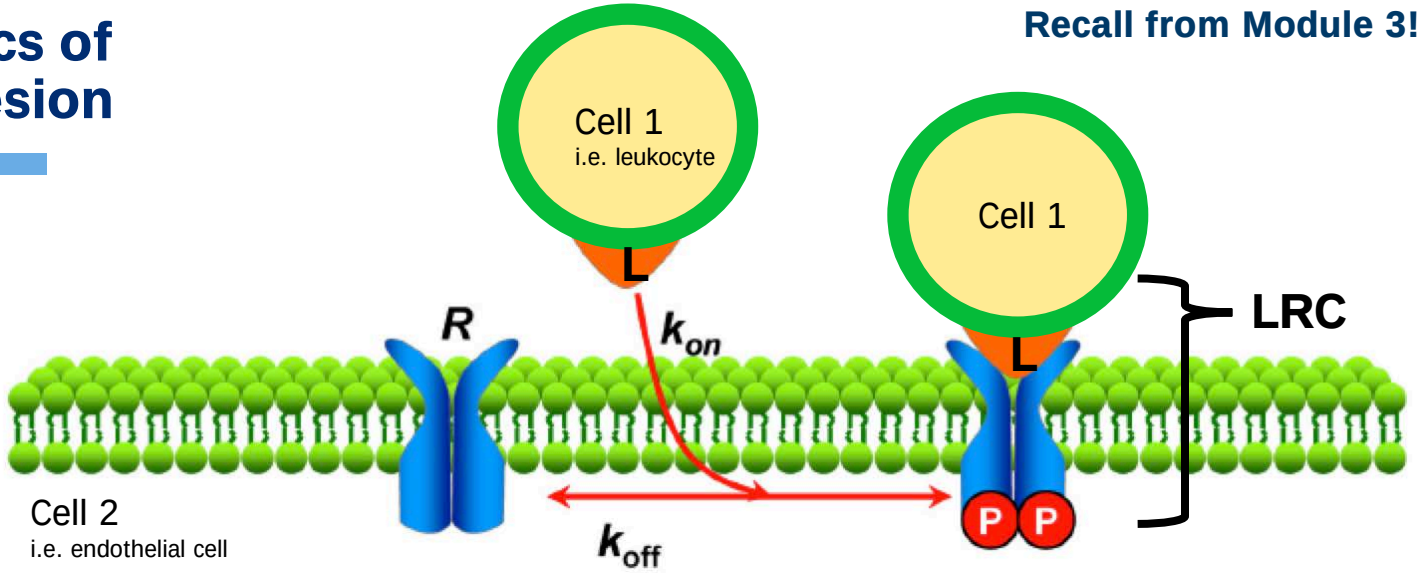
WHITING SCHOOL
of ENGINEERING

Mechanics of cell adhesion

Recall from Module 3!



$$L + R \underset{k_{off}}{\overset{k_{on}}{\Leftrightarrow}} LRC$$

$$\frac{[L][R]}{[LRC]} = \frac{k_{off}}{k_{on}} = K_d = \frac{1}{K_a}$$

k_{on} – forward rate constant
k_{off} – reverse rate constant
K_d – dissociation equilibrium constant
K_a – association equilibrium constant

Bond strength estimations

Tensile strength for affinity bonds

δ (Å)	K_d (M)	F (μdyn / molecule)
10	10^{-6}	6
1	10^{-12}	120

adapted from Tissue Engineering, Saltzman; livescience.com

Bond strength estimations

Tensile strength for affinity bonds

δ (Å)	K_d (M)	F (μdyn/molecule)
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Assume

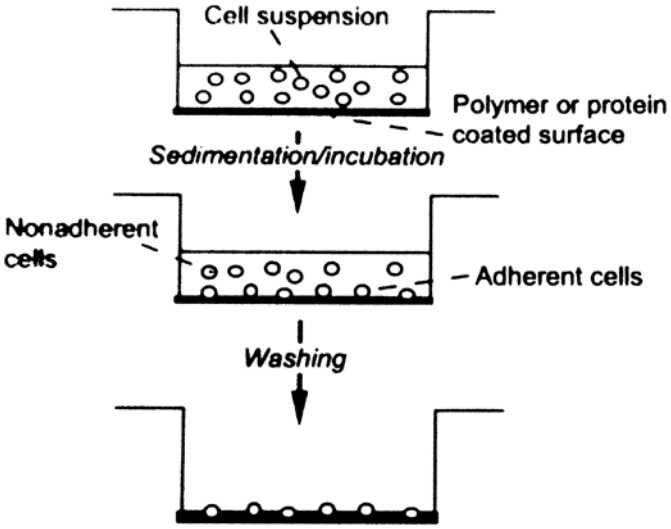
1) average bond of 40μdyne/molecule
2) Bonds spaced 1μm apart on the cell surface

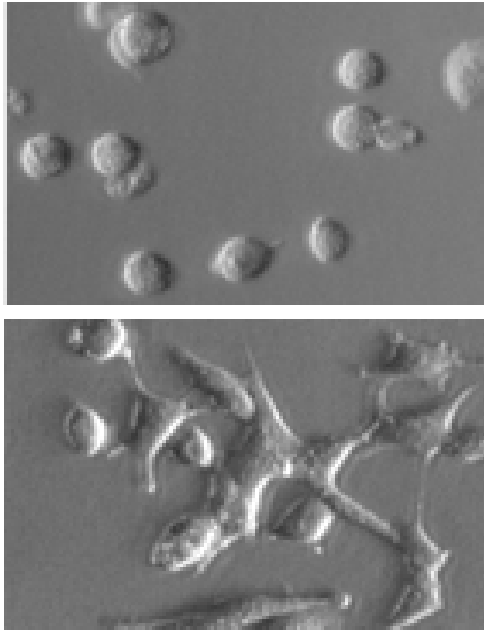
4,000dyn/cm^2 produced from specific binding

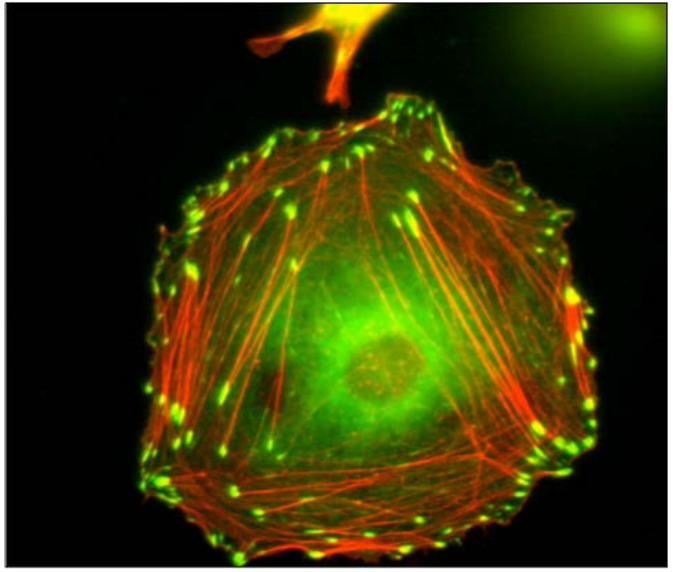
adapted from Tissue Engineering, Saltzman; livescience.com

Methods for measuring cell adhesion

Sedimentation-detachment



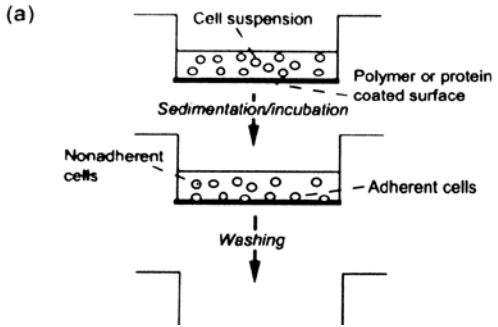




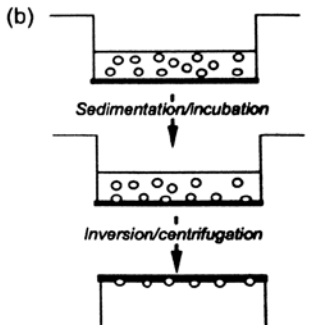
Tissue Engineering, Saltzman; Sithanandam, et. al., Nature Pediatrics.Wisconsin.edu

Methods for measuring cell adhesion

Sedimentation-detachment



Centrifugation



Tissue Engineering, Saltzman; Sithanandam, et. al., Nature; Cole Parmer, Eppendorf

Methods for measuring cell adhesion

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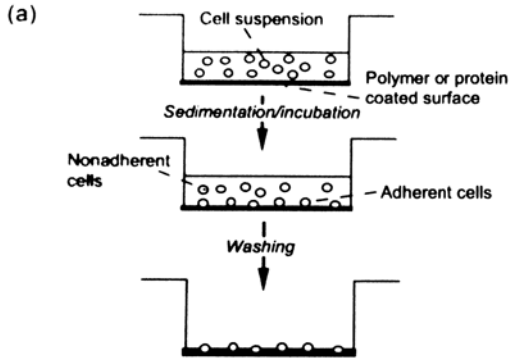
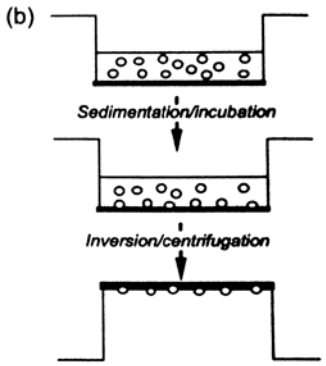
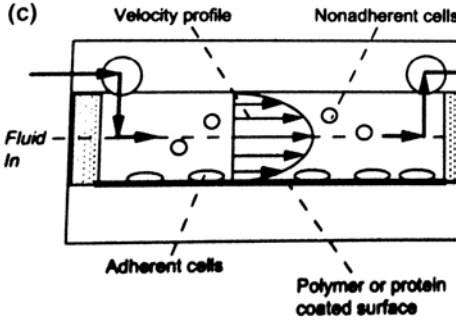
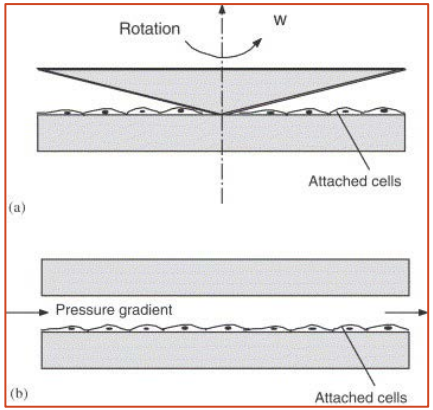


Centrifugation



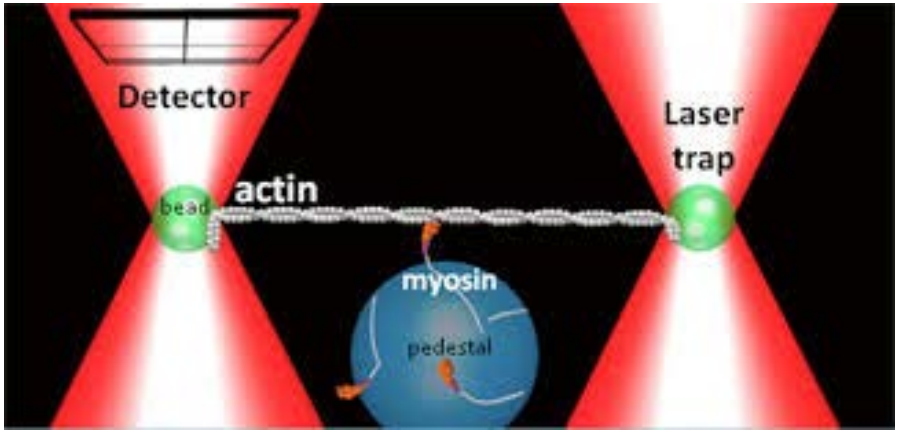
Fluid flow chambers





Tissue Engineering, Saltzman; Ohashi and Sato, 2005

Methods for measuring cell adhesion



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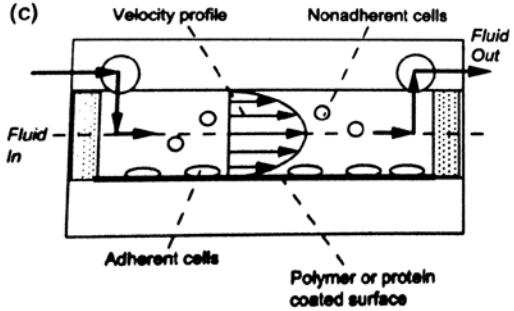
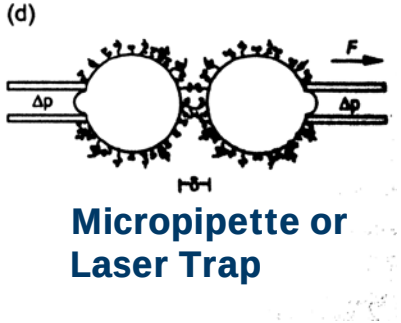
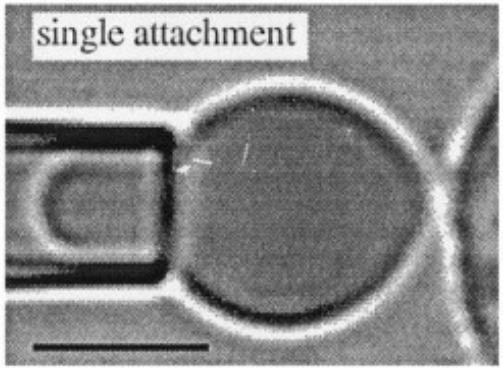
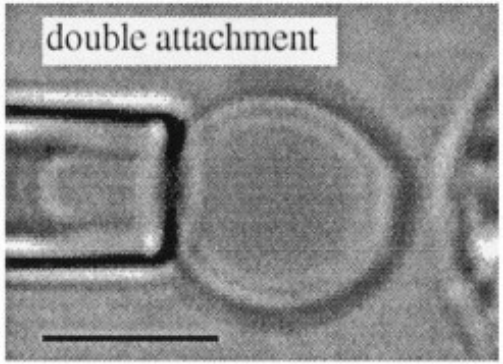




Micropipette or Laser Trap

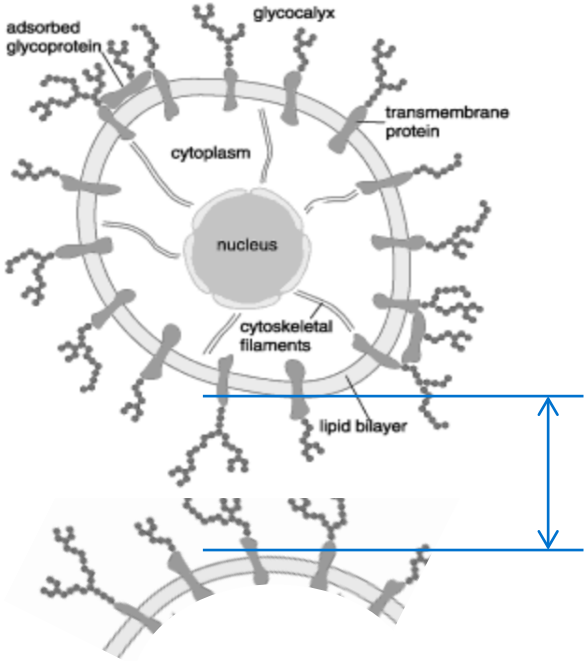




Tissue Engineering, Saltzman; Chesla, et. al., 1998; Debold 2012

Rewind and review

Forming a bond



Measuring adhesion and bond strength