Chapter 2. Cell-Matrix Interactions. [that determine biomaterials function in vitro and in vivo]

A. How cells pull onto and deform the matrix to which they attach themselves.

B. Cell-matrix interactions control the spontaneous closure of wounds in organs.

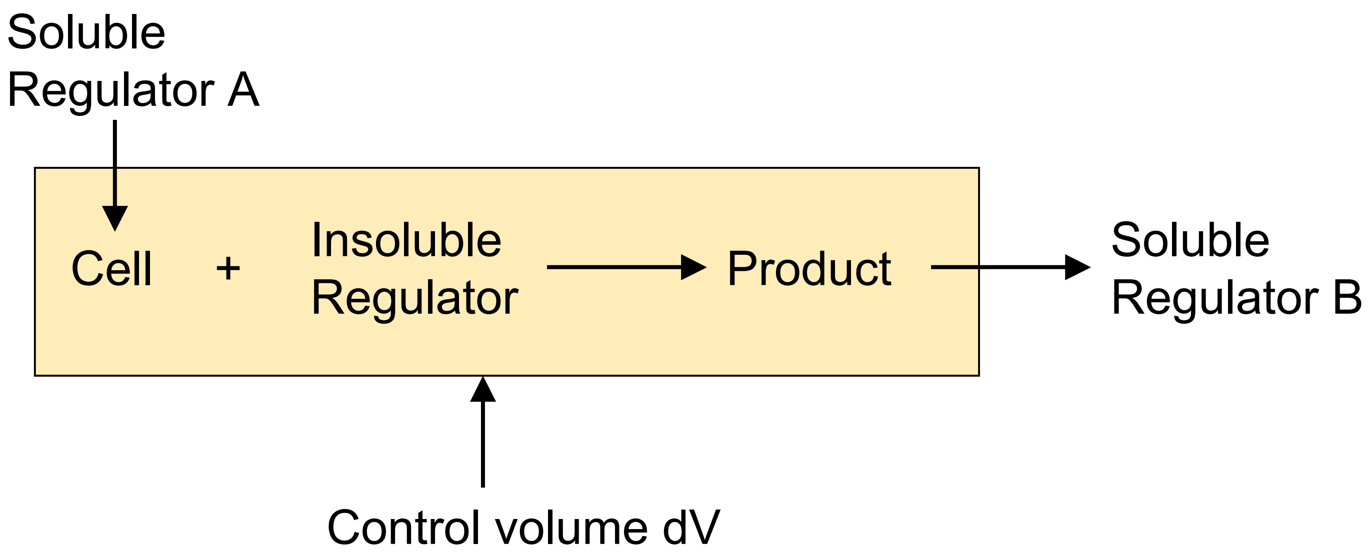
C. What happens when regeneration is induced?

A. How cells pull onto and deform the matrix to which they attach themselves.

- Cells develop contractile forces individually, not cooperatively.
- Cell elongation, not contraction, eventually leads to matrix deformation.
- Contractile forces are force-limited, not displacement-limited.

A brief review or relevant structures: cell membrane, transmembrane proteins, cell receptors (integrins), cytoplasm, matrix

Definition of unit cell process

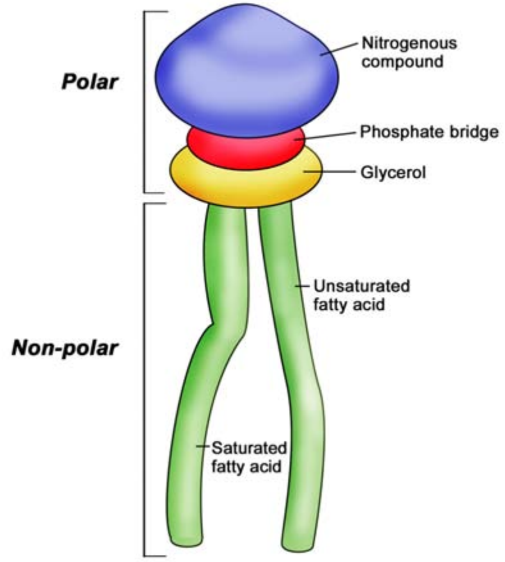


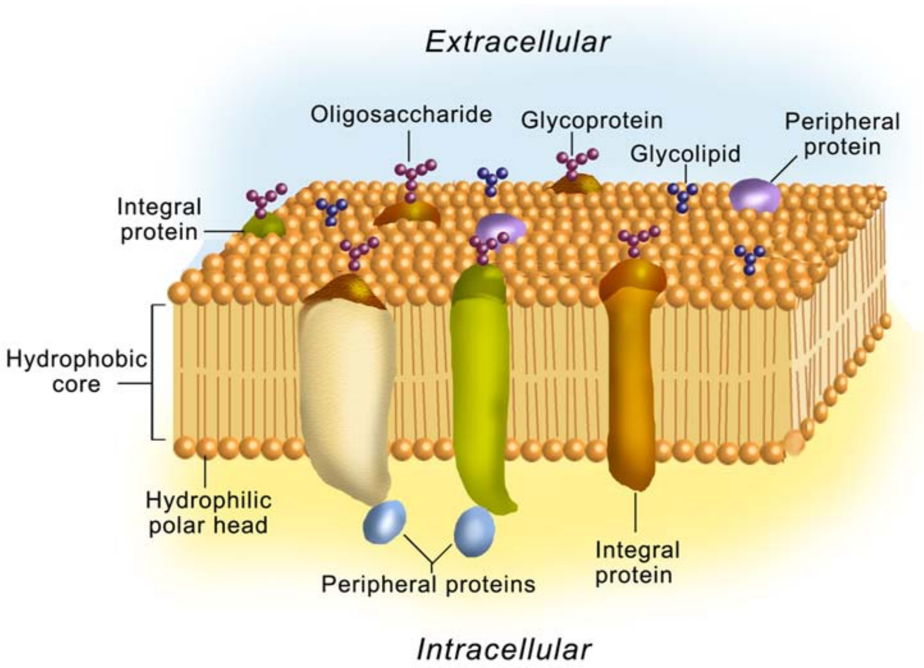
Unit cell process confined conceptually in a control volume dV

A typified cell diagram showing cell-cell binding

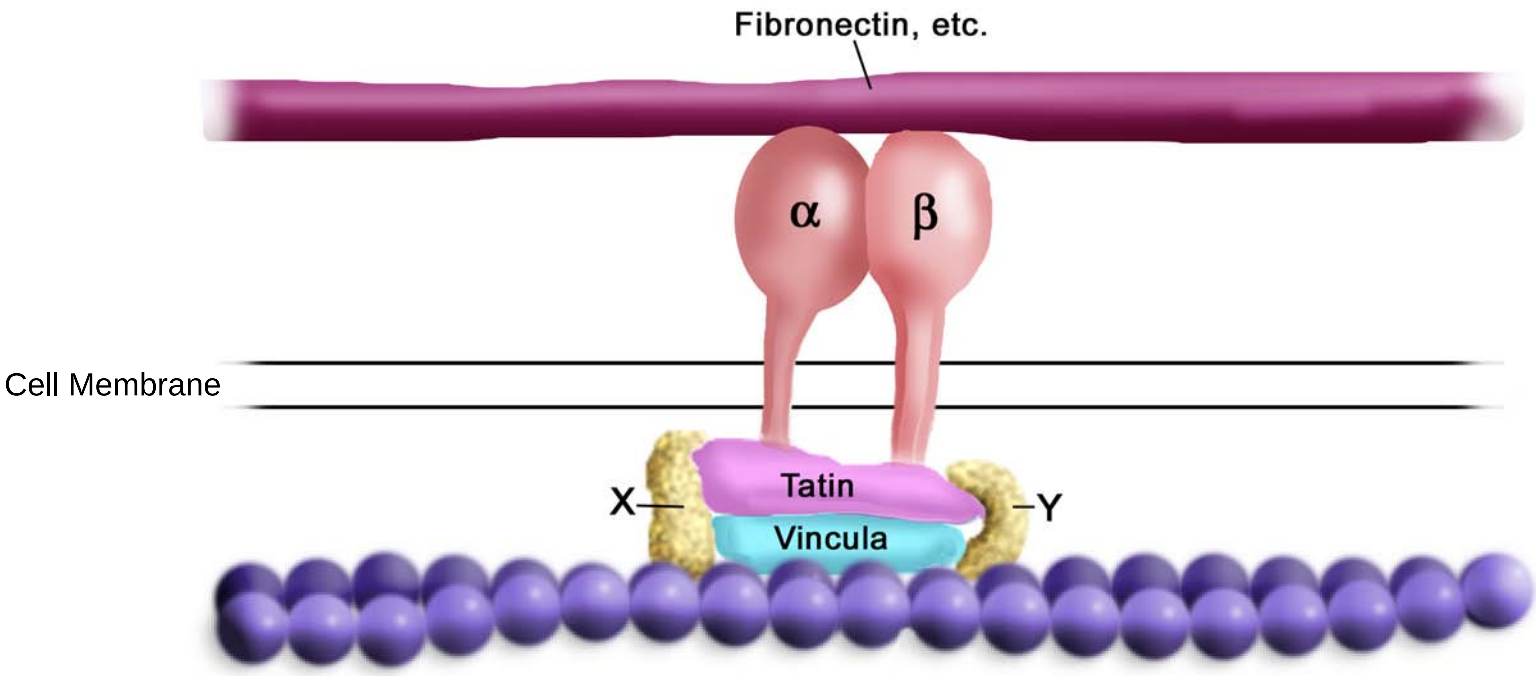
Image removed due to copyright considerations.

Cell membrane sketch showing transmem-brane proteins





Specific cell-matrix interaction through integrins



After Hynes, 1990

Another model of a specific cell-matrix interaction

Image removed due to copyright considerations.

Fibronectin molecule shown attaching a cell to the surface of a collagen fiber.

FIRST ARTICLE

See Freyman, T.M., I.V. Yannas, R. Yokoo, and L.J. Gibson.
"Fibroblast contraction of a collagen-GAG matrix."
Biomaterials 22 (2001) 2883-2891.

Conclusions on Linearity vs. Cooperativity of Fibroblast Contraction of Matrix

- The contractile force increases linearly with cell density.
- The average contractile force is calculated at 1 nN per cell.
- The kinetics for development of force are also independent of cell density.
- In this model cells must develop contractile forces individually, not cooperatively.

SECOND ARTICLE

See Freyman, T.M., I.V. Yannas, Y-S. Pek, R. Yokoo, and L.J. Gibson. "Micromechanics of Fibroblast Contraction of a Collagen-GAG Matrix." Experimental Cell Research 269 (2001) 140-153.

Conclusions on Micromechanics of Fibroblast Contraction

- The aspect ratio of cells increases with time and eventually saturates, just as the force does.
- Initiation of cell elongation occurs stochastically.
- The force plateau most simply results from buckling or bending of individual struts in the matrix by cells.
- Matrix deformation (contraction) occurs as a result of cell elongation, not cell contraction.

THIRD ARTICLE

See Freyman, T.M., I.V. Yannas, R. Yokoo, and L.J. Gibson.
"Fibroblast Contractile Force Is Independent of the Stiffness Which Resists the Contraction."
Experimental Cell Research 272 (2002) 153-162.

Conclusions on the Effect of Matrix Stiffness on Cell Contraction

- The contractile force generated by fibroblasts was independent of matrix stiffness in the range 0.7 – 10.7 N/m.
- Contractile forces generated by cells are force-limited, not displacement-limited.
- As cells elongate, cell-matrix adhesion sites hypothetically form at the cell periphery, increasing length of matrix strut under compressive load and decreasing load required to buckle the strut.