Adhesion of eukaryotic cells and the influence of cytoskeletal contractility

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Abstract Almost all eukaryotic cells are capable of adhering to an extra-cellular matrix, to other cells, to hard and soft tissue and to artificial substrates, *e.g.* coated glass slides. Such adhesion occurs by specific and non-specific interactions between substrate ligands and cellular trans-membrane protein complexes. An additional phenomenon that is often coupled to cellular adhesion is cytoskeletal contractility driven by protein motors, with the commonest example being that due to myosin cross-bridging with actin filaments. Cases include smooth muscle cells, fibroblasts, endothelial cells and cardiac muscle cells. Observations indicate that the size of adhesive protein complexes, known as focal adhesions, is proportional to the degree of cell contractility, and the magnitude of the forces applied are also similarly controlled. Such phenomena have been incorporated into a chemo-mechanical model for cell adhesions interacting with ligands that are subject to contractile forces from the cytoskeleton. This model has been used successfully to simulate various cellular phenomena. These include the sensitivity of cell contractile forces to substrate stiffness, the orientation of cytoskeletal stress-fibres in smooth muscle cells that are cyclically stretched, and the location of focal adhesions and stress-fibers in cells adhering to patterned shapes of fibronectin, a ligand bearing protein. The model is also used to simulate the process of a spherical cell developing adhesion to a flat surface, and the shearing of an adhered cell on a flat surface where the cell body is forced sideways by a blunt tool.