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Controlling Cell Function with Geometry

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This presentation will describe the use of patterned substrates to control cell shape with examples that illustrate the ways in which cell shape can regulate cell function. Most cells are adherent and must attach to and spread on a surface in order to survive, proliferate and function. In tissue, this surface is the extracellular matrix (ECM), an insoluble scaffold formed by the assembly of several large proteins—including fibronectin, the laminins and collagens and others—but in the laboratory, the surface is prepared by adsorbing protein to glass slides. To pattern cells, gold-coated slides are patterned with microcontact printing to create geometric features that promote cell attachment and that are surrounded by inert regions. Cells attach to these substrates and spread to adopt the shape defined by the underlying pattern and remain stable in culture for several days. Examples will be described that used a series of shapes to reveal the relationship between the shape of the cell and the structure of its cytoskeleton. These geometric cues were used to control cell polarity and the tension, or contractility, present in the cytoskeleton. These rules were further used to control the shapes of mesenchymal stem cells and in turn to control the differentiation of these cells into specialized cell types. For example, stem cells that were patterned into a “star” shape preferentially differentiated into bone cells whereas those that were patterned into a “flower” shape preferred a fat cell fate. These influences of shape on differentiation depend on the mechanical properties of the cytoskeleton. These examples, and others, reveal that shape is an important cue that informs cell function and that can be combined with the more common soluble cues to direct and study cell function.