Smart design of hydrogel-based biomaterials as extracellular matrices for tissue engineering applications

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Tissue engineering is an interdisciplinary area aimed at maintaining, rebuilding, and promoting the normal function of organs and tissues using biomaterials and live cells. To understand the interface between biomaterials and cells where cells respond to subtle changes of microenvironmental cues to eventually control cell phenotypes and fate decisions, cell adhesion onto the surface of biomaterials is critical. However, engineering cell culture microenvironments to recapitulate the 3D dynamic and complex nature of tissues at the biomaterial-cell interface is a major challenge. To tackle the engineering issues, hydrogel-based biomaterials could be smartly constructed as cell culture platforms to improve tissues' function, structure, and maturity comparable to native tissues in the body. Here I will present several hydrogel-based model systems where cells could be adhered and then guided through multiple biophysical, mechanical, and biochemical signals to program (e.g., stem cell differentiation) and reprogram (de-differentiation of cancer cells). These studies demonstrate the importance of the precise synchronization of microenvironment parameters existed in engineered biomaterials during cellular decision making for disease modelling and regenerative therapies.