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Commentary

The Potential of Stem Cell-Derived Controlling Native Cell Domains: A Novel Approach to Precise Tissue Engineering

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DESCRIPTION

Tissue engineering holds tremendous potential in regenerative medicine, offering solutions for various degenerative diseases and injuries. However, one of the major challenges in tissue engineering is replicating the complex microenvironments that regulate stem cell behavior within native tissues. Recent research has clarified the significance of native cell domains, also known as stem cell regulatory microterritories, in orchestrating cellular behavior and tissue regeneration. This article explores the concept of native cell domains and their potential application in precise tissue engineering.

Native cell domains

Native cell domains refer to the specialized microenvironments within tissues that regulate stem cell behavior, including proliferation, differentiation, and self-renewal. These microterritories are characterized by unique biochemical, biomechanical, and spatial cues that influence cellular responses. Within native cell domains, stem cells interact with neighboring cells, Extracellular Matrix (ECM) components, and signaling molecules to maintain tissue homeostasis and support regeneration.

Main components of native cell domains

Extracellular Matrix (ECM): The ECM provides structural support and biochemical cues essential for stem cell regulation. Native cell domains exhibit distinct ECM compositions and organization, influencing cell adhesion, migration, and differentiation. By representing the native ECM, tissue engineers can create biomimetic scaffolds that promote stem cell function and tissue regeneration.

Cell-cell interactions: Cell-cell interactions play an important role in maintaining stem cell niches within native tissues. Cell adhesion molecules, gap junctions, and paracrine signaling pathways facilitate communication between stem cells and their neighboring cells. Tissue engineering strategies aim to recreate these intercellular interactions to encourage stem cell-mediated tissue regeneration.

Soluble factors: Soluble factors, such as growth factors, cytokines, and chemokines, exert extreme effects on stem cell behavior within native cell domains. These signaling molecules regulate stem cell fate decisions, including proliferation, differentiation, and migration. Tissue engineers can incorporate bioactive factors into engineered scaffolds to modulate stem cell responses and enhance tissue regeneration.

Applications of native cell domains in tissue engineering

Precision medicine: By recapitulating native cell domains, tissue engineers can develop personalized therapies customized to individual patients. Patient-specific variations in native tissue microenvironments can be considered to design customized scaffolds and bioactive cues, optimizing treatment outcomes and minimizing adverse effects.

Organotypic models: Native cell domains serve as blueprints for constructing organotypic models that recapitulate the complexity of native tissues. These models facilitate drug discovery, disease modeling, and toxicological screening by providing physiologically relevant platforms for studying cellular behavior and tissue responses *in vitro*.

Regenerative therapies: Incorporating native cell domains into tissue engineering approaches enhances the efficacy of regenerative therapies for various diseases and injuries. By controlling the essential regenerative potential of stem cells within their native microenvironments, engineered tissues exhibit improved integration, functionality, and long-term viability upon transplantation.

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Challenges and future directions

Despite the potential of native cell domains in tissue engineering, several challenges remain to be addressed. Achieving precise control over the spatial and temporal presentation of biochemical and biomechanical cues within engineered constructs poses technical hurdles. Moreover, the translation of complex *in vitro* models incorporating native cell domains into clinical applications requires rigorous validation and standardization.

Future research efforts should focus on elucidating the molecular mechanisms underlying stem cell regulation within native cell domains. Advancements in biomaterials science, microfabrication techniques, and bioinformatics are poised to enable the development of next-generation tissue engineering strategies with enhanced biomimicry and functional integration.

Native cell domains represent complex microterritories within tissues that orchestrate stem cell behavior and tissue regeneration. By leveraging our understanding of these specialized environments, tissue engineers can design biomimetic scaffolds and culture systems that recapitulate the complexity of native tissues. The integration of native cell domains into tissue engineering approaches holds potential for advancing precision medicine, organotypic modeling, and regenerative therapies, ushering in a new era of personalized and effective treatments for a wide range of medical conditions.