Advanced Biofabrication

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A central challenge in regenerating tissues and organs lies in directing interactions between (stem) cells and biomaterials so that new tissue acquires the structure and function of the original one. Current strategies attempt this through controlled delivery of biological factors, functionalizing scaffold surfaces, engineering topographical features, and tuning the chemical and mechanical properties of porous, cell-laden biomaterials. While these approaches have undeniably improved cell behavior on scaffolds, they still offer only limited spatial and temporal control, restricting their effectiveness in guiding the regeneration of complex, multi-tissue structures.

Here, we showcase several examples where advanced biofabrication technologies have enabled the creation of a new generation of biological constructs with precisely defined biological, physicochemical, and mechanical cues across macro-, micro-, and nanoscale dimensions. These engineered constructs exhibit finely tuned cell-material interactions that modulate stem cell activity and ultimately support the formation of complex tissues.

Together with contributions from the broader scientific community, these examples highlight how converging biofabrication technologies opens powerful avenues for designing instructive biomaterial systems capable of steering cell behavior. Further integration of these technologies will be essential to achieve even tighter control over stem cell fate through multiscale scaffold design. Such advances will allow the regeneration of highly intricate tissues -including vascular and neural components - and foster better integration with host environments. These advanced engineered tissues offer also the capacity to be used as human 3D in vitro models to study pathophysiological mechanisms and new therapeutical approaches with a higher sensitivity and reliability compared to conventional 2D culture systems and Organ-On-Chip models. By narrowing the gap between tissue and organ regeneration, these innovations will accelerate the translation of regenerative medicine strategies into clinical practice.