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3D Printing of Human Tissue Mimics via Layer-by-Layer Assembly of Polymer/Hydrogel Biopapers

BRADLEY RINGEISEN, Naval Research Laboratory

The foundations of tissue engineering were built on two fundamental areas of research: cells and scaffolds. Multipotent cells and their derivatives are traditionally randomly seeded into sophisticated polymer or hydrogel scaffolds, ultimately with the goal of forming a tissue-like material through cell differentiation and cell-material interactions. One problem with this approach is that no matter how complex or biomimetic the scaffold is, the cells are still homogeneously distributed throughout this three dimensional (3D) material. Natural tissue is inherently heterogeneous on both a microscopic and macroscopic level. It also contains different types of cells in close proximity, extracellular matrix, voids, and a complex vascularized network. Recently developed 3D cell and organ printers may be able to enhance traditional tissue engineering experiments by building scaffolds layer-by-layer that are crafted to mimic the microscopic and macroscopic structure of natural tissue or organs. Over the past decade, my laboratory has developed a capillary-free, live cell printer termed biological laser printing, or BioLP. We find that printed cells do not express heat shock protein and retain >99% viability. Printed cells also incur no DNA strand fracture and preserve their ability to differentiate. Recent work has used a layer-by-layer approach, stacking sheets of hybrid polymer/hydrogel biopapers in conjunction with live cell printing to create 3D tissue structures. Our specific work is now focused on the blood-brain-barrier and air-lung interface and will be described during the presentation.