Organ engineering: Possibilities and challenges ahead

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Cartilage, bone, and skin can already be regenerated in vitro, and these tissues are currently available for clinical applications. However, regeneration of more complex tissues such as the liver and pancreas has yet to be fully realized.

In a recent paper published in *Science and Technology of Advanced Materials* (STAM), Tetsushi Taguchi of the International Center for Materials Nanoarchitectonics (MANA) in Japan gives a comprehensive overview of the key technologies and materials required for the regeneration of organs. This review emphasizes the importance of the development of methods for the assembly and adhesion between individual cells and/or vesicles for in vitro regeneration of organs.

Aspects of organ engineering covered in this paper include:

Technological considerations for cell/vesicle assembly

Gravity affects growth and functions of cells - in reduced gravity conditions, cell samples retain their functions for extended periods and can be used for regeneration of tissues. For example, liver cells cultured in microgravity exhibit functions of the intact liver for at least 30 days owing to enhanced cell to cell interactions under low-shear conditions. The 3D structure of cartilage tissue can be reconstructed in microgravity from the bone marrow cells without a need for supporting scaffolds

Culturing cells on patterned surfaces is important for organ regeneration. With this aim, researchers have exploited the tendency of cells to adhere preferentially to hydrophobic (water repelling) surfaces as opposed to hydrophilic (water loving) ones. They produced liver cells on patterned polyethylene glycol brush surfaces by culturing liver cells underlaid with cells that line the interior surface of blood vessels (known as endothelial cells). Notably, the new cells functioned normally for extended periods of time. In this case for example, the liver cells secreted water-soluble proteins (albumins) for at least one month.

Cell printing is another technology for creating organ-like 3D structures. Computer-aided printing of viable mammalian cells has been demonstrated on paper made from soy agar and collagen, another group of proteins prominent in the flesh and connective tissues of mammals. Furthermore, there have been reports on injection molding of arbitrarily shaped cells found in cartilage known as chondrocyte-alginate structures. In another innovative approach, artificially prepared vesicles known as liposomes were assembled on a quartz crystal microbalance via layer-by-layer growth using the membrane protein bacteriorhodopsin as a binding reagent.

Taguchi concludes the technology section by describing the recellularization of the liver matrix and the potential of this method for lung regeneration.

The STAM paper describes potential materials for the in vitro assembly of cells and vesicles. Examples include the use of thermoresponsive polymer-grafted surfaces—such as poly(N-isopropylacrylamide)—for the generation of cell sheets made of cardiac myocytes, hepatocytes, or periodontal ligament cells.

More information: Tetsushi Taguchi, "Assembly of cells and vesicles for organ engineering", *Science and Technology of Advanced Materials* 12 (2011) 064703. dx.doi.org/10.1088/1468-6996/12/6/064703, Published 10 October 2011

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