BIOPOLYMER-BASED HYDROGELS FOR THREE-DIMENSIONAL BIOPRINTING

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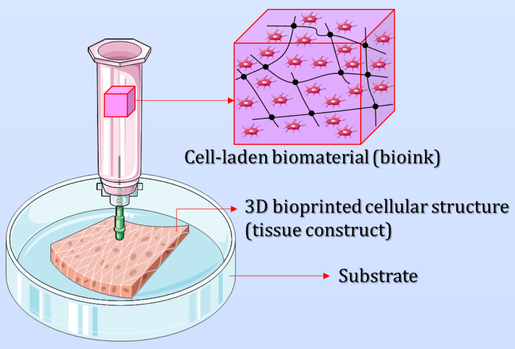
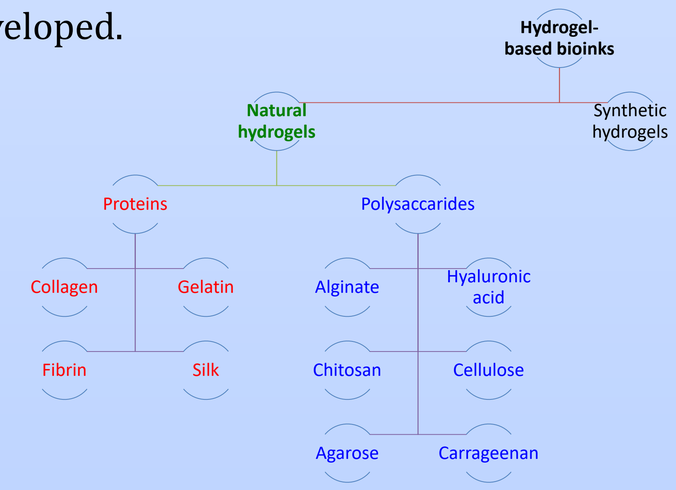
INTRODUCTION

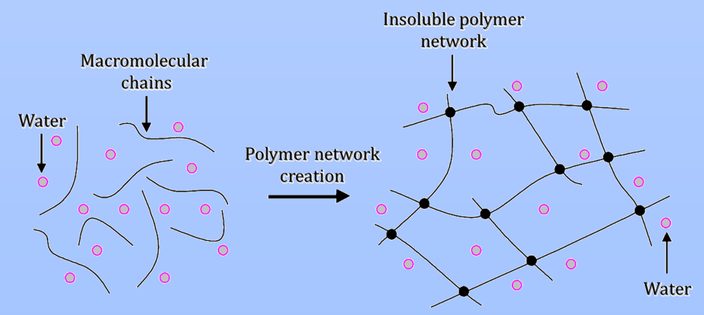
Three-dimensional (3D) bioprinting is an emerging technology that could be used in the generation of 3D cellular structures for tissue engineering applications. The interest in this technology is due to its capacity to enable the fabrication of precise 3D constructs composed of biomaterials laden with living cells, biomolecules and nutrients. The process involving the deposition of cell-laden biomaterials or bioinks on a substrate is referred to as bioprinting.



To promote the sufficiency of bioinks in 3D bioprinting, several researchers have investigated pathways to enhance ink properties to meet bioprinting requirements, with several synthetic and natural hydrogels developed.



These hydrogels are matrices made up of a network of hydrophilic polymers that absorb biological fluids. They can be created from a large number of water-soluble biopolymers including proteins and polysaccharides. The 3D structure of these hydrogels is due to the presence of structural crosslinks that are maintained the environmental fluid. The elasticity of these structures and the presence of a large amount of water enable the hydrogel to adequately mimic biological tissues.



TYPES OF BIOPOLYMER-BASED HYDROGELS FOR 3D BIOPRINTING

- Physical responsive hydrogels:
  - Temperature responsive hydrogels;
  - Photo/Light responsive hydrogels;
  - Electro and magnetic responsive hydrogels.
- Chemical responsive hydrogels:
  - pH responsive hydrogels;
  - Ionic responsive hydrogels.

METHODS OF PREPARATION OF BIOPOLYMER-BASED HYDROGELS

- Free radical polymerization;
- Physical crosslinking;
- Irradiation crosslinking;
- Chemical cross-linking.

FORMULATION AND USE OF BIOPOLYMER-BASED HYDROGELS FOR 3D BIOPRINTING

Tissues/Organs	Bio-inks
Cartilage tissue	▪ Human nasal chondrocytes with agarose hydrogel. ▪ Alginate-based hydrogel combined with human mesenchymal stem cells. ▪ Hyaluronic acid and alginate-based hydrogel with human articular chondrocytes loaded. ▪ Articular cartilage-resident chondroprogenitor cells-laden gelatin methacryloyl hydrogel. ▪ Human chondrocytes-laden nanocellulose hydrogel. ▪ Carrageenan hydrogel with chondrogenic cells. ▪ Silk-based hydrogel incorporated with platelet-rich plasma.
Skin tissue	▪ Fibroblasts with nanocellulose-alginate based hydrogel. ▪ Keratinocytes and fibroblasts seeded in collagen hydrogel. ▪ Human fibroblasts encapsulated in gelatin-methacryloyl hydrogel.
Neural tissue	▪ Human induced pluripotent stem cells with fibrin-based hydrogel. ▪ Schwann cells with methacrylated hyaluronic acid hydrogel combined with collagen. ▪ Neural progenitor cells with fibrin-based hydrogel. ▪ Fibrin-based hydrogel seeded with neural cell types for the modeling of brain tissue.
Chondral tissue	▪ Human mesenchymal stromal cells with a hydrogel comprised of collagen and supramolecular hyaluronic acid. ▪ Silk based hydrogel encapsulated stem cells. ▪ Human chondrocytes and osteogenic progenitors encapsulated in alginate hydrogel.
Bone tissue	▪ Osteoblast cells contained in chitosan hydrogel. ▪ Silk-gelatin hydrogel with mesenchymal stem cells.
Blood vessels	▪ Gelatin methacryloyl hydrogel with multiple cell types.
Cardiac tissue	▪ Human cardiac-derived cardiomyocyte progenitor cells with alginate hydrogel.
Periodontal tissue	▪ Human dental pulp stem cells with gelatin-alginate hydrogel.
Renal tissue	▪ Epithelial cells and endothelial cells with alginate, gelatin and pectin hydrogel.
Adipose tissue	▪ Human adipose-derived mesenchymal stem cells with gelatin-alginate hydrogel.
Tracheal graft	▪ Mesenchymal stem cells seeded in fibrin hydrogel.
Vascular constructs	▪ Primary neonatal human dermal fibroblasts with fibrinogen-gelatin hydrogel.
Meniscus tissue	▪ Fibrochondrocytes seeded on silk–gelatin hydrogel
Spinal cord	▪ Neural stem cells seeded on collagen-silk hydrogel.

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