3D Bioprinting and Tissue Engineering (SSB-914) Credit Hours 3 (3-0)

Systems biology is an inter-disciplinary science that studies the complex interactions and the collective behavior of a cell or an organism. Synthetic biology, as a technological subject, combines biological science and engineering, allowing the design and manipulation of a system for certain applications. It focuses on constructing artificial tools to achieve particular functions. Both systems and synthetic biology have played important roles in the recent development of microbial platforms for energy, materials, and environmental applications. 3D bioprinting and Tissue Engineering (TE) is a division of synthetic biology which deals with utilization of 3D printing techniques to fabricate tissues and organs via periodic arrangement of biological materials including biocells and biochemicals/bioinks in precisely controlled manner. Currently it is used to print tissues and organs for drug delivery researches. Technique has gained momentum in generation of 3D functional human constructs mimicking tissues/organs. 3D Printing & TE has been applied in versatile fields varying from integration of living cells to biosensing applications and from stem cells to artificial organ generation suggesting futuristic applications.

Learning Objectives:

This course is of interest for students with a bio sciences/medical, material chemistry or engineering background interested in the application of 3D bioprinting & Tissue Engineering in the field of Biological Sciences. It will provide insight in the opportunities of culturing living cells, tissue engineering, additive manufacturing technologies, micro/nano devices and 3D bioprinting in biomedical applications. In addition, it will also provide insight in the specific challenges encountered when translating 3D printing to biofabrication, such as the development of specific bioinks and the required control over processing conditions. Finally, it will provide state-of-the-art examples of how currently 3D Printing & TE is translated from bench towards the bedside.

Course Outline:

- Introduction:

Introduction to tissue engineering

Introduction to 3D Bioprinting

Anatomy and physiology of the human body

- Introduction to Biomaterials for TE & Bioprinting:

Introduction to Biomaterials Science

Materials in the living world today – Classes of Biomaterials

Structure and design of materials – Innovative Biomaterials for tissue engineering applications: Soft tissue replacement e.g. skin, connective tissues, heart, nerves, Hard tissue replacement e.g. bone, cartilage, tendon .

Development of bioinks (bioprintable materials, from metals and ceramics to hydrogels)

Tissue interactions/Tissue response to materials (cell-material interaction)

Nanomaterials for Tissue engineering e.g. nanotubes, nanoparticles and nanowires

- 3D Bioprinting

  Core Principles and Physical Foundations underlying 3D Bioprinting

  Basic process of 3D bioprinting

  Additive manufacturing and rapid prototyping

Biofabrication and 3D-Bioprinting Technologies and Tools

Blueprints (Digital models of tissues and organs)

Bioprinters

Technology platform and emerging trends in bioprinting

Validating assays applied to printed products

- Applications of 3D bioprinting & TE in Microbiology:

  Functional living materials.

  Microbial mono cultures by 3D Printing.

  Co culturing Techniques

  Fabrication of biofilms.

  Biomanufacturers

- Applications of 3D bioprinting and TE in Medicine:

Applications in Lab-on-chip

Organ-on-chip

Orthotics & prosthetics

Tissue & Bone implants

Regenerative medicine

- Applications of 3D bioprinting and TE in Research:

Drug Delivery

Importance of Tissue engineered products in Industry

Innovative bioactive research

- Challenges & Future Prospects in 3D Bioprinting & Biofabrication:

Opportunities & Challenges of 3D bioprinting & TE.

Risk involved in translation to industrial scale

Ethical and regulatory issues

Intellectual property and patent landscape

Personalized medicine and clinical needs

Future perspectives in terms of bench research and hospitals

Recommended Books:

Dasgupta N, Singh V et al. 3D Printing in Biotechnology: Current Technologies & Applications. Elsevier 2021.

Guvendiren M. 3D Bioprinting in Medicine, Technologies, Bioinks & Applications. Springer 2019.

Lanza R, Langer R, Vacanti J and Atala A. Principles of Tissue Engineering. Elsevier 2020.

Cho DW, Kim BS, Jang J, Gao G, Han W, Singh NK. 3D bioprinting: Modeling in vitro tissues and organs using tissue-specific bioinks. Springer 2019.

Zhang LG, Fisher JP, Leong KW. 3D Bioprinting and Nanotechnology in Tissue Engineering and Regenerative Medicine. Elsevier 2015.

Crook JM. 3D Bioprinting: Principles & Protocols. Springer 2021.