3D Bio-printing of Tissues and Organs

Tissue/organ printing also known as 3D bio-printing is a major research area under healthcare where 3D printing has been used widely. This approach uses a layer-by-layer manufacturing process but uses cells, matrix materials, and bioactive molecules to develop artificial tissues and organs for transplantation purpose. The developed tissue or organ can also be used as an in vitro model for drug screening and discovery purpose as the printed tissue can recreate the complexity of tissue and recapitulate the major attributes of that tissue. There has been unprecedented progress of this technology over the last decade and many different types of tissues like skin, bone, cartilage, trachea, heart, and many more have been developed in the lab. This technology has huge prospects to address the tremendous need for artificial tissue/organ to save the end-stage patients suffering from major organ failure as the supply of transplants do not meet the requirement. We are working on several projects majorly based on 3D bio-printing concepts on developing artificial cornea, liver, esophagus, skin, trachea, and others. The primary step of this process to develop a bio-ink, which is printable formulation consists of cells, matrix materials, and other necessary supplements for cell survival and function. We develop a novel process to prepare bio-ink from human and animal tissues/organs by throwing out the cells from these tissues and dissolving the acellular matrix or extracellular matrix (ECM) by an in-house developed protocol. The ECM bio-ink is then mixed with the cells and used for printing a particular tissue construct by designing tissue-specific structure and architecture and employing a 3D bio-printer to reproduce that design. Depending upon the target tissue the most relevant cell types are chosen for printing the structure, like for printing corneal stroma, we use corneal keratocytes and for printing liver, we use primary hepatocytes. The printed tissue constructs are then cultured in a cell-culture incubator for their further maturation. Upon maturation, the tissues will be used for implantation purpose. Furthermore, the printed tissues are also being used as in vitro models for drug toxicity screening. We have developed an in vitro liver model using liver-matrix derived bio-ink and designing a sinusoid-mimicking structure to develop the “zonation” (a prominent feature of liver sinusoids). We could observe the zone-specific production of marker proteins, which further shows the usefulness of this model for zone-specific drug screening. The important feature of this in vitro model is that just by introducing a perfusion-based cell-culture model, we could develop the zonation. We are in the process of testing various known cytotoxic as well as safe drugs to evaluate the model further. Our primary interest is to develop this model as a reliable and reproducible liver model for drug discovery and screening and in future, we would like to collaborate with the pharmaceutical industry to validate this model further.

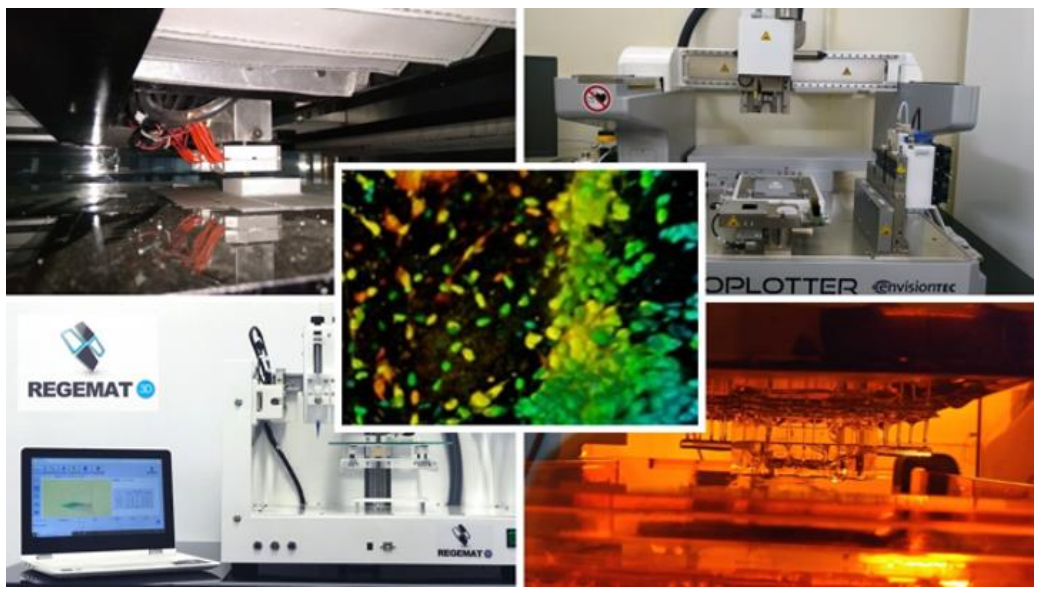

Figure 6: 3D Bioprinting facilities in BioFabTE Lab at IIT Hyderabad

Dr. Falguni Pati
Department of Biomedical Engineering