# Chapter 6
# Additive Manufacturing Developments in the Medical Engineering Field

**Sampath Boopathi**
https://orcid.org/0000-0002-2065-6539
*Muthayammal Engineering College, India*

**Richa Khare**
*Amity University, India*

**Jaya Christiyan K. G.**
*M.S. Ramaiah Institute of Technology, India*

**T. Vijay Muni**
https://orcid.org/0000-0003-1363-7249
*Koneru Lakshmaiah Education Foundation, India*

**Smriti Khare**
https://orcid.org/0000-0002-0278-5302
*Amity University, India*

## ABSTRACT

*The additive manufacturing technology has been applied in various sectors: the manufacturing of industrial components, toys, medicine, medical-surgical instruments, and tissue engineering sectors. In the tissue engineering field, it has been intensively applied to make biomaterials, organs, and drugs. The fundamental procedures of the additive manufacturing process, the various additive manufacturing techniques, and advanced methods that have been applied in the making and synthesis of organs in the tissue engineering fields have been described. In this chapter, the computer-aided tissue modelling process, different fundamental and advanced biomaterials, and advanced scaffold manufacturing applications in emerging tissue engineering fields have been illustrated.*

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## INTRODUCTION

The additive manufacturing method is an emerging technique in various commercial, industrial, and medical applications due to their technical flexibility, use of various materials, ability to make complex profiles, and low manufacturing cost. In contrast, the materials were separated using conventional and unconventional manufacturing methods such as milling, lathe, drilling, and grinding operations, as well as electrical discharge and electrochemical machining processes (Boopathi, 2022b). The pollutants and harmful contaminants have also been emitted during the material removal process as opposed to material addition processes (Boopathi, 2021). In additive manufacturing techniques, the product is made by adding materials layer by layer based on the model developed by the users. The four basic and important procedures of additive manufacturing techniques are: (1) developing three-dimensional (3D) models using computer-aided design (CAD) software packages according to user requirements, (2) slicing the objects; (3), selection of the materials based on the applications; and (4) model printing using a 3D printing machine. The basic components of 3D printing methods are (1) hardware, (2) software, and (3) materials. Materials selection is a very important process for selecting suitable components, slicing methods, 3D printing machines, and location of usage. Recently, additive manufacturing (AM) or three-dimensional printing (3DP) techniques are now used in many biomedical applications, such as the printing of patient-specific parts, devices, specific models, and implantations or organs. The 3D functional tissues and organs are made using biocompatible materials by 3DP techniques, which is called the bioprinting technique. The successful methods of bioprinting organs have been useful to human society in organ transplantation and cancer tissues. Some terminology is needed to understand this chapter by the readers. The materials that have been utilised in biological systems are called biomaterials. Any materials that are fully or partially inserted into the body to replace the existing or to support the organs are called implantation materials. Any material used to replace a limb, organ, or tissue of the body is called a prosthesis. The functional organs of the human body have been replaced by a medical device called an artificial organ (Roopavath & Kalaskar, 2017).

In this chapter, the additive manufacturing/3D printing techniques in the Tissue Engineering field, various materials for making different tissues, possible and advanced additive manufacturing methods in various medical fields, and a variety of medical applications have been elaborated.

## 3D PRINTING PROCESSES IN TISSUE ENGINEERING

In the tissue engineering process, the live cells, biomolecules, and polymers are properly mixed and form the engineering structure of the tissue in vivo (Figure 1). (Badekila et al., 2021).

Live cells are used to make the ‘bio-ink’ in which all cells are living in vivo. The bio-molecular building blocks are built by adding bio-ink with polymers for easy flow. It has been used to make tissues and organs. Then organs are built by tissue engineering polymers with the reference of computer-added tissue or organ models. Various additive manufacturing techniques have been used to fabricate bio-molecules in vivo format (Bongiovanni Abel et al., 2020). The computer-aided tissue engineering principles are also illustrated below.