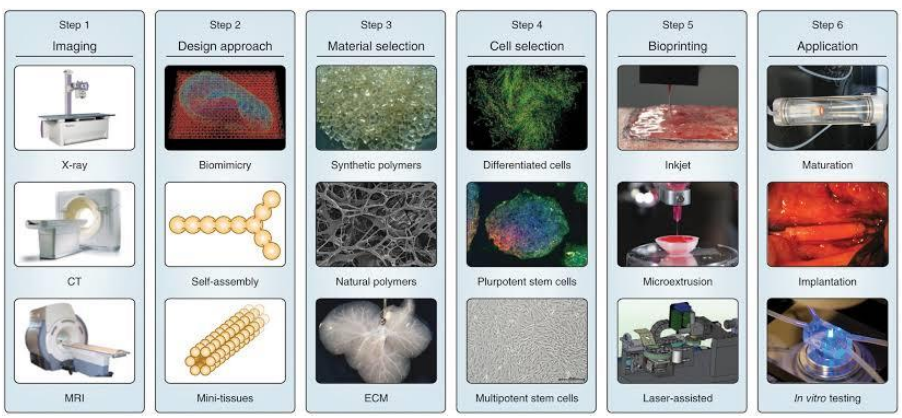
TRENDS IN BIOENGINEERING (QUALITATIVE)

Bioprinting :bioprinting is a technology where bioinks, mixed with living cells, are printed in 3D to construct natural tissue-like three-dimensional structures.

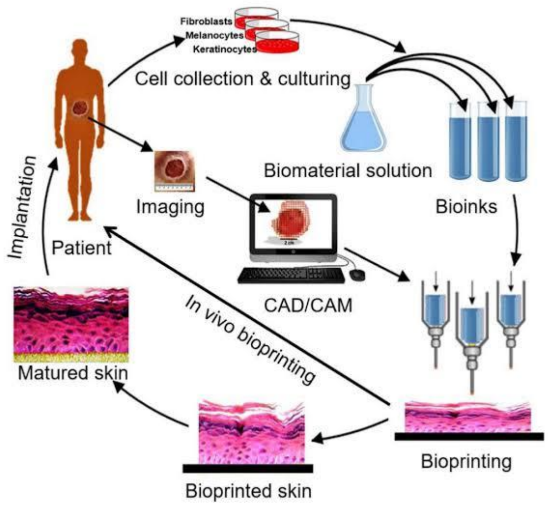
Bioprinting techniques and materials:



The concept of mini-tissues is relevant to both of the above strategies for 3D bioprinting. Organs and tissues comprise smaller, functional building blocks20,21 or mini-tissues. These can be defined as the smallest structural and functional component of a tissue, such as a kidney nephron. Mini-tissues can be fabricated and assembled into the larger construct by rational design, self-assembly or a combination of both. There are two major strategies: first, self-assembling cell spheres (similar to mini-tissues) are assembled into a macro-tissue using biologically inspired design and organization20,21; second, accurate, high-resolution reproductions of a tissue unit are designed and then allowed to self-assemble into a functional macro-tissue. Examples of these approaches include the self-assembly of vascular building blocks to form branched vascular networks22,23 and the use of 3D bioprinting to accurately reproduce functional tissue units to create ‘organs-on-a-chip’, which are maintained and connected by a microfluidic network for use in the screening of drugs and vaccines or as in in vitro models of disease24–26.

Combinations of the above strategies are likely to be required to print a complex 3D biological structure with multiple functional, structural and mechanical components and properties. The main steps in the bioprinting process are imaging and design, choice of materials and cells, and printing of the tissue construct (Fig. 1). The printed construct is then transplanted, in some cases after a period of in vitro maturation, or is reserved for in vitro analysis.Imaging and digital design An essential requirement for reproducing the complex, heterogeneous architecture of functional tissues and organs is a comprehensive understanding of the composition and organization of their components. Medical imaging technology is an indispensable tool used by tissue engineers to provide information on 3D structure and function at the cellular, tissue, organ and organism levels. These technologies include most noninvasive imaging modalities, the most common being computed tomography (CT) and magnetic resonance imaging (MRI). Computer-aided design and computer-aided manu-facturing (CAD-CAM) tools and mathematical modeling are also used to collect and digitize the complex tomographic and architectural information for tissues.CT imaging, used for both diagnostics and interventional procedures, is based on the variable absorption of X-rays by different tissues. The X-ray source rotates around the object, and as the X-ray beam penetrates the body, sensors measure the transmitted beam intensity and angle, and record the data as a compilation of pixels that represent a small volume (voxel) of tissue27. This imaging modality produces closely spaced axial slices of tissue architecture that, after surface rendering and stereolithographic editing, fully describe the volume of tissue.A second approach, MRI, also can provide high spatial resolution in soft tissue, with the advantage of increased contrast resolution, which is useful for imaging soft tissues in close proximity to each other, without exposure to ionizing radiation. MRI uses nuclear magnetic

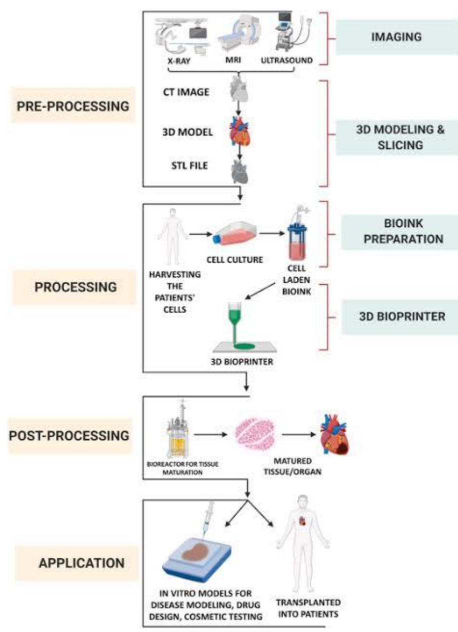
resonance: a strong magnetic field causes a small fraction of nuclei in the tissue being imaged to align themselves with the magnetic field28. Changes to energy states of nuclei produce radiofrequency signals, which can be measured with receiver coils. The contrast of biological structures can be greatly increased with the use of contrast agents such as barium29 or iodine30 for CT scans and iron oxide31, gadolinium32 or metalloproteins33 for MRI scans. These agents attenuate X-rays or enhance magnetic resonance signals that are commonly used to highlight structures, such as blood vessels, which otherwise would be difficult to delineate from their surroundings.



Once raw imaging data have been acquired from these imaging modalities, the data must be processed using tomographic recon-struction to produce 2D cross-sectional images. 3D anatomical representations can be produced for further analysis or modification. This process has been described as the transformation of 'analytical anatomy' into 'synthetic anatomy'34. One method to generate computer-based 3D models of organ or tissue architectures is to use CAD-CAM and mathematical modeling techniques35. The 3D anatomical representation produces views of organ anatomy while retaining the image-voxel information that can be used for volume rendering, volumetric representation and 3D image representation. Reconstructed images or models can be viewed in multiple ways, including as contour stacks, as wire-frame models, shaded models or solid models with variable lighting, transparency and reflectivity36.If the aim is to produce an accurate reproduction of the imaged organ or tissue, 2D cross-sections or 3D representation can be used directly for bioprinting applications. Alternatively, a direct copy of a patients' own organ may not be desirable (due to disease or injury)patinents. Medical imaging technology is an indispensable tool used Medicine and shelter. They also sequester carbon, fight pollution and bind the soil.The solution to catastrophic events like wildfires, floods and pandemics lies in restoring Green cover and restoring the balance in nature. Planting or adopting trees can help safeguard Jobs, human health and essential natural resources for millions of people.Or might not be economically feasible for large-scale production.

In this situations, computer-based models may entirely or partially Contribute to anatomical structural design, analysis and simulation37. Additionally, computer modeling can assist in predicting mechanical And biochemical properties of fabricated tissue constructs37–39. To Date, CT and MRI data have been used most often in regenerative Medicine to provide specific measurements of tissue dimensions to Aid the design of a bioprinted construct.The completed tissue or organ model is interfaced with numerically Controlled bioprinting systems for prototyping and manufacturing.

This is achieved by reversing the 2D to 3D reconstruction, such that the 3D-rendered model is divided into thin 2D horizontal slices (with cus-Tomizable size and orientation) that are imported into the bioprinter System. The anatomical and architectural information contained in the 2D horizontal slices provides the bioprinting device with layer-By-layer deposition instructions. Variations in the available bioprint-Ing technologies also affect tissue and organ design. Some bioprinting Systems deposit a continuous bead of material to form a 3D structure. Other systems deposit multiple materials in short interrupted or Defined spaces. Tissue design must take into account the capabilities And properties of the bioprinting systems, which we discuss next.

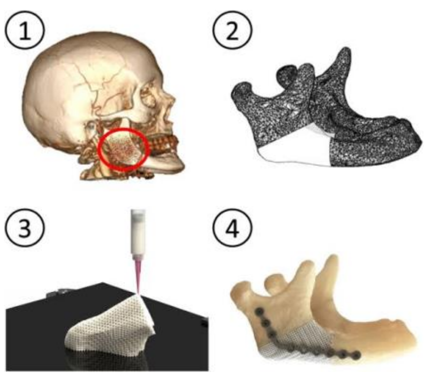


Tissue bioprinting strategies The main technologies used for deposition and patterning of Biological materials are inkjet40–43, microextrusion44–46 and laser-Assisted printing47–49 (Fig. 2). Different features of these technologies (Table 1) should be considered in light of the most important factors In 3D bioprinting, which are surface resolution, cell viability and the Biological materials used for printing.Inkjet bioprinting. Inkjet printers (also known as drop-on-demand Printers) are the most commonly used type of printer for both non-Biological and biological applications. Controlled volumes of liquid Are delivered to predefined locations. The first inkjet printers used for Bioprinting applications were modified versions of commercially avail-Able 2D ink-based printers50,51. The ink in the cartridge was replaced With a biological material, and the paper was replaced with an electronically controlled elevator stage to provide control of the z axis40,50(the third dimension in addition to the x and y axes). Now, inkjet-Based bioprinters are custom-designed to handle and print biological Materials at increasing resolution, precision and speed.

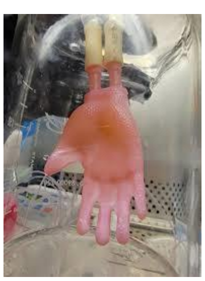
Inkjet printers Use thermal43 or acoustic50,52,53 forces to eject drops of liquid onto a Substrate, which can support or form part of the final construct.Thermal inkjet printers function by electrically heating the print Head to produce pulses of pressure that force droplets from the Nozzle. Several studies have demonstrated that this localized heating, Which can range from 200 °C to 300 °C, does not have a substan-Tial impact either on the stability of biological molecules, such as DNA52,53, or on the viability or post-printing function of mammalian

3D printing of ear, bone and skin

"Ears have been implanted by hand. It's now using a printer, which helps automate the process, which is important for the field." The milestone could open doors for investment and new excitement around 3D tissue printing, potentially paving the way for new therapies in regenerative medicine.

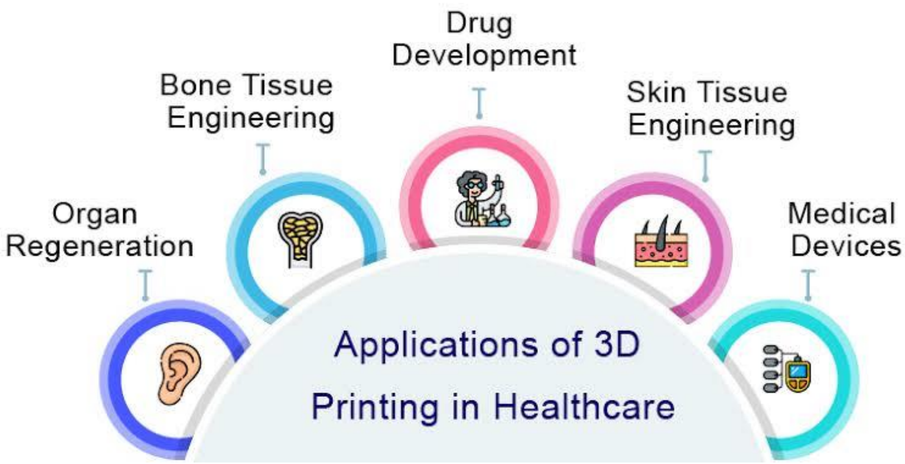


Bone tissue engineering can help to replace a critical defect bone. 3D printing is a useful technology for the fabrication of scaffolds critical in bone tissue engineering. There are different binders which can create bone scaffolds with requisite mechanical strength..



3D skin printing is a strategy used to provide an effective treatment for larger wounds due to strong shrinkage and scar reduction [145]. Porcine ECM has been used for a long time in wound repair due to its human-like structure.

Applications:



1. 3D bioprinting can be used for several biological applications in the fields of tissue engineering,
2. bioengineering
3. materials science.
4. The technology is also increasingly used for pharmaceutical development
5. drug validation.