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A NOVEL APPROACH TO BIOMEDICAL APPLICATIONS USING 3D BIOPRINTING

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ABSTRACT

The sustainability of 3D printing for industrial usage is attributed to its characteristics, which include minimal material waste, ease of manufacture, low human participation, minimal post-processing, and energy efficiency. Various 3D printing techniques are covered in the study, along with their benefits and cons. All the materials that work with different kinds of 3D printing processes are explained in detail. Additionally, the document lists the several fields in which each kind of method finds application. Industry 4.0 has also been covered in detail in this section. According to the literature review, even though 3D printing has advanced significantly, there are still problems that need to be solved, like material incompatibility and material costs. Technologies used in Additive Manufacturing fall under the broad category of 3D printing. Each of them constructs objects in successive layers, with an average thickness of 0.1 mm. To put it simply, 3D printers fall into four categories. First, we have printers that extrude a material that is either molten or semi-liquid. Additionally, printers that firm photocurable resin exist. Thirdly, powder granules can be fused or bound together using printers. Last but not least, there are printers that fuse together sliced sheets of metal, plastic, or paper. It is now widely known that 3D printing has the potential to produce incredibly exciting and remarkable outcomes in the healthcare industry. The idea of using 3D printing in medicine is not new. In the late 1980s, work on the first commercial bioprinters and 3D printers got underway. But only because of increased funding and technological advancements over the past few years have the capabilities, applications, and demand increased.

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INTRODUCTION

Charles Hull created 3D printing, also known as stereo lithography, in the early 1980s while he was employed for Ultra Violet Products in California, a company that made plastic things out of photo polymers. Other researchers' discoveries in Charles' work have changed manufacturing and are set to do the same in a wide range of other sectors, including medicine. The basic design of the part we want to create is where we start with 3D printing, which is essentially an additive manufacturing process. Theafore mentioned design was produced using computer software that 3D printers may connect to. After then, this software creates a unique file type that is transmitted to the printer. After reading the file, the 3D printer applies one layer on top of the other to produce the object. Layers are used in almost all 3D printing processes to build parts. Rather than reading the pieces as a single unit, 3D printers read the parts as one single two-dimensional layer at a time. The ability of 3D printers to read files in the Standard Tessellation Language (STL) file format is the foundation for their operation.[1,2]

A revolutionary technology that allows us to print a wide range of materials, including simple muscle, neural, and cartilage tissue as well as entire organs, is three-dimensional (3D) printing of biological material. In this procedure, we first use patients cansfrom X-ray, CT, or MRI to create a 3D model of the structure we wish to print. This model is then printed layer by layer, accounting for every microscopic and macroscopic detail of the tissue. To replace a failing or damaged tissue or organ with a new one that will function structurally and functionally identical to the original organ is the primary objective of 3D bioprinting. When implanted inside the patient's body, this bioprinted tissue needs to be able to regenerate and differentiate on its own. Adequate tissue can be printed using the right technology and biomaterial, fulfilling all these necessary requirements. Consequently, sufficient biomaterials research is needed to identify the right material that can serve as native tissue. Commonly used bioprinting technologies, their uses, benefits, and drawbacks are covered in this review article along with the kinds of biomaterials (both natural and synthetic) used in 3D printing, their benefits and drawbacks, and their applications in various industries.[2,3].

Types of 3D Printing Technology:

Chart No.1. Types of 3D Printing Technology[4]

NAME	PROCESS	MATERIAL
SLS	Selective laser sintering process, it is similar as SLA method, though materials are solidified by infrared laser.	Ceramic, plastics, metal materials and wax.
FDM	Fused deposition modeling process, this printing technology is the most fundamental 3D printing technology and most commonly used.	PLA, ABS types polymer and some foods.
LOM	Laminated object manufacturing process. in this technology the materials are fused by hot roller.	Metallic materials and ceramic.
SLA	Stereo-lithography process, in this process the light responsive materials are solidified in to a lean layer.	Thermoplastics.
DLP	Digital light processing technique, it is also similar to SLA process, though it is more rapidly because the total layer manufacture after scanning the laser	Photopolymer.
3D Bioprinting	In this technique biomaterials are use as a printing ink, basically this technology is use in tissue engineering process.	Alginate, Hydrogel.

How does 3D bio printing work?

Viable cells, bio logical molecules, and bio materials are used in the process of 3D bio printing, which allows for the printing of biological structures.

3D bio printing, to put it simply, is the process of depositing bio logical material layer by layer to create three-dimensional structures such as organs and tissues.

Creating materials required for industrial applications is a component of additive manufacturing, which includes bio printing.

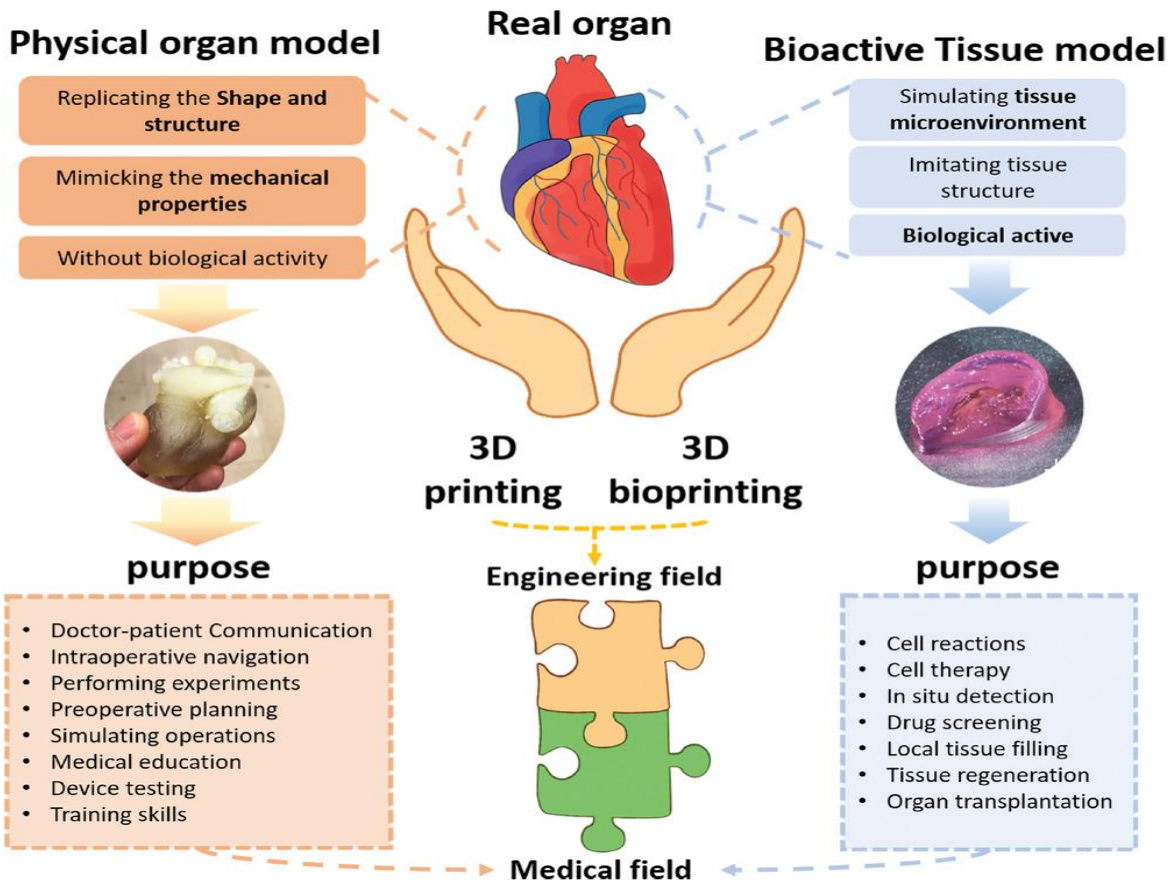

Fig No. 1 3D printing and Bio Printing.[4].

A proper micro architecture is the first step in 3D bio printing, and it is further stabilized by cell and tissue scaffolds while taking into account how manufacturing processes may affect the viability of the cells.

A primary driving force behind the creation of 3D bio printing has been the scarcity of bio logical structures needed for the restoration of missing organs and tissues.

The ultimate goal of the process is to offer a suitable substitute for animal testing and tissue implants in disease research and treatment development.

Though its application in estimating drug efficacy is currently restricted to the creation of organs and tissues, 3D bio printing holds great promise for replacing patients' failed or lost organs.

Compared to 3D printing, 3D bio printing is more difficult because the cells are more delicate and need extra care to allow them to proliferate and grow while also preventing the cyto toxic effects of the solvents used in the process.

In order to restore tissue and organ functions, 3D bio printing research is concentrated on developing methods that enable the creation of 3D living structures that are significant from a mechanical and bio logical stand point.[10,11]

The Fundamentals of 3D Bio printing-

The foundation of 3D printing lies in the layer-by-layer precise placement of biological elements, bio chemicals, and living cells, along with the spatial control of functional constituent placement onto the 3D structure that is being printed. Three separate methods are used in the 3D bio printing process:

Bio mimicry :

The process of creating exact replicas of the extra cellular and cellular components of tissues and organs through careful observation of nature itself is known as bio mimicry.

Self-governing assembly:

The process of replicating bio logical tissue by following the blueprint of embryonic tissue and organ development is known as autonomous self-assembly.

A developing tissue's cellular component generates its own extra cellular matrix and cell signals, enabling self-organization and patterning to create the required micro architecture.

Using this method necessitates a thorough understanding of organo genes is and the developmental mechanisms of developing embryonic tissues.

Building blocks of mini tissues:

The mini tissue building blocks approach makes use of the techniques from the two earlier tactics. Using this bio printing technique, tiny functional units of tissues and organs, referred to as.[7,8]

Process of 3D Bio printing:

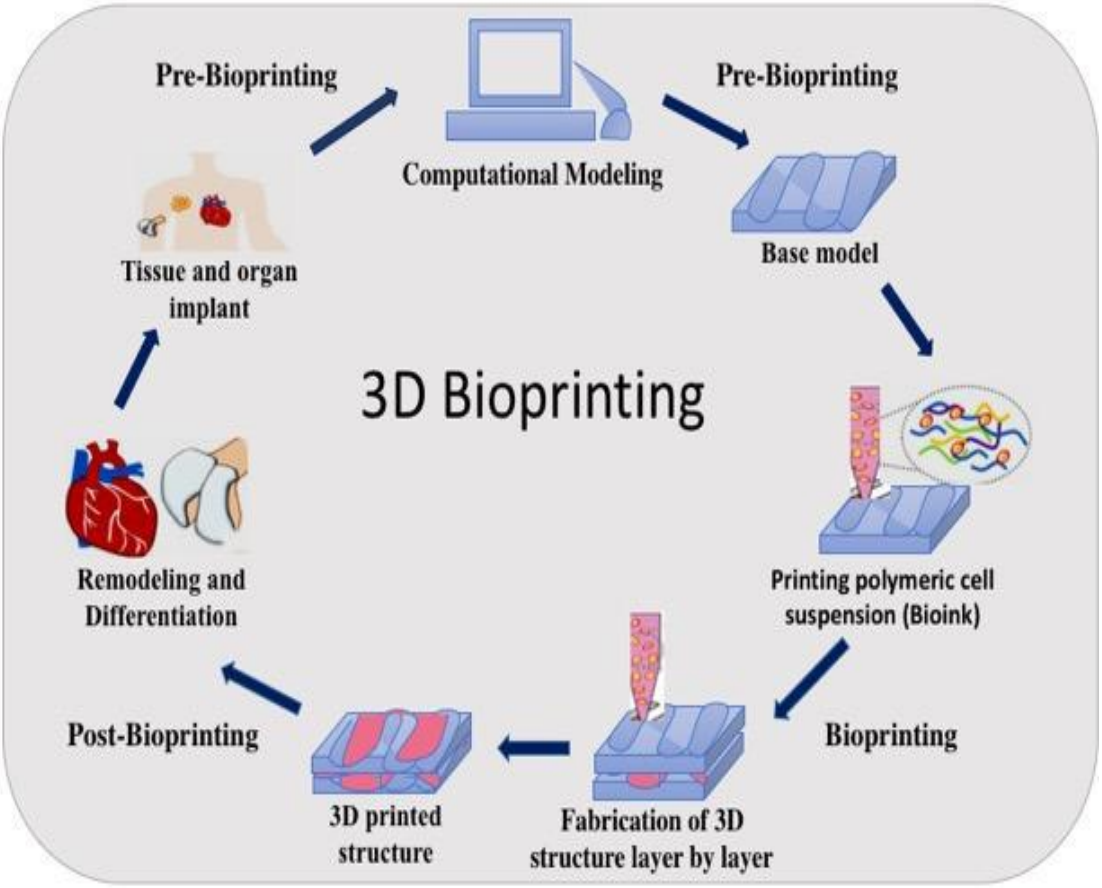

Fig. No. 2 Process of 3D Bio printing[9]

Bio printing before :

Creating a model that the printer will use and selecting the materials to be used are the first steps in the pre bio printing process.

Using bio prints:

Placing the bio ink in the printer to create a three-dimensional structure is the second step in the printing process.

After the cells, nutrients, and matrix are combined to form bio ink, the mixture is put on to the printer cartridge, which deposits the material according to the prepared digital model.

Reverse bio printing:

The final stage of the bio printing process, known as post bio printing, is crucial for giving the printed structure stability. Chemical and physical stimulations are needed to keep biological matter in its proper structure and functioning.[5]

Technologies used in 3D bio printing types-

1. Bio printing using extrusion–

Either fused deposition modeling (FDM) or semi-solid extrusion (SSE) is used in the extrusion-based 3D bio printing process. It has been extensively utilized in many different biomedical fields.

And makes it possible to create models that closely resemble the soft tissues and bone structures, which opens up the possibility of creating implants.

2. Inkjet-based bio printing:

This non-contact technique uses thermal, electrostatic, or piezoelectric forces to eject liquid droplets onto a substrate. This method has the advantage of producing droplet bio inks quickly and is relatively more acceptable in terms of cost and compatibility with living materials.

3. Pressure-assisted bio printing :

This method relies on the extrusion of biomaterials through the printer's nozzle to create a three-dimensional bio logical structure that enables direct integration of homogenous cells on to the substrate and room temperature processing. Pneumatic pressure, plunger pressure, or screw-based pressure in the form of a continuous filament work in unison to create the pressure.

4. Laser-assisted bio printing :

Employing a pulsed laser beam as an energy source, this technique prints bio materials on to a surface. By using a laser to cause liquid bio materials to evaporate and fall on to a solid surface in the form of droplets, the principle of laser-assisted bio printing is achieved. Cell adhesion and the maintenance of the biomaterial's growth are facilitated by the substrate, which can be either a cell culture medium or a biopolymer.[15,16]

Chart No.2. Advantages and Disadvantages. (22)

Technique	Advantage	Disadvantage
Stereolithography-based	High resolution. Easy to remove trapped materials .	Expensive equipment. Only photopolymer materials
Extrusion-based	Wide range of material choice low cost . Good mechanical properties .	Limited material to thermoplastics. Filament required. Viscosity and temperature of materials
Laser-based	Wide range of material choice High resolution .	Expensive equipment. Heat effect.
Inkjet-based	Low heat effect . High resolution .	Limited choice of materials. Limited hight. Difficulties in complex 3D geometries. Poor mechanical properties.

Objectives :

Chart No.2. Advantages and Disadvantages.[22]

- To comprehend how 3D printing works.
- To understand the3D printing process.
- To understand advantages disadvantages of 3D bio printing.
- To promote the knowledge & interests in about advance techniques in 3D printing.
- To study different types of 3D Printing technology.

Application of 3D bio printing:

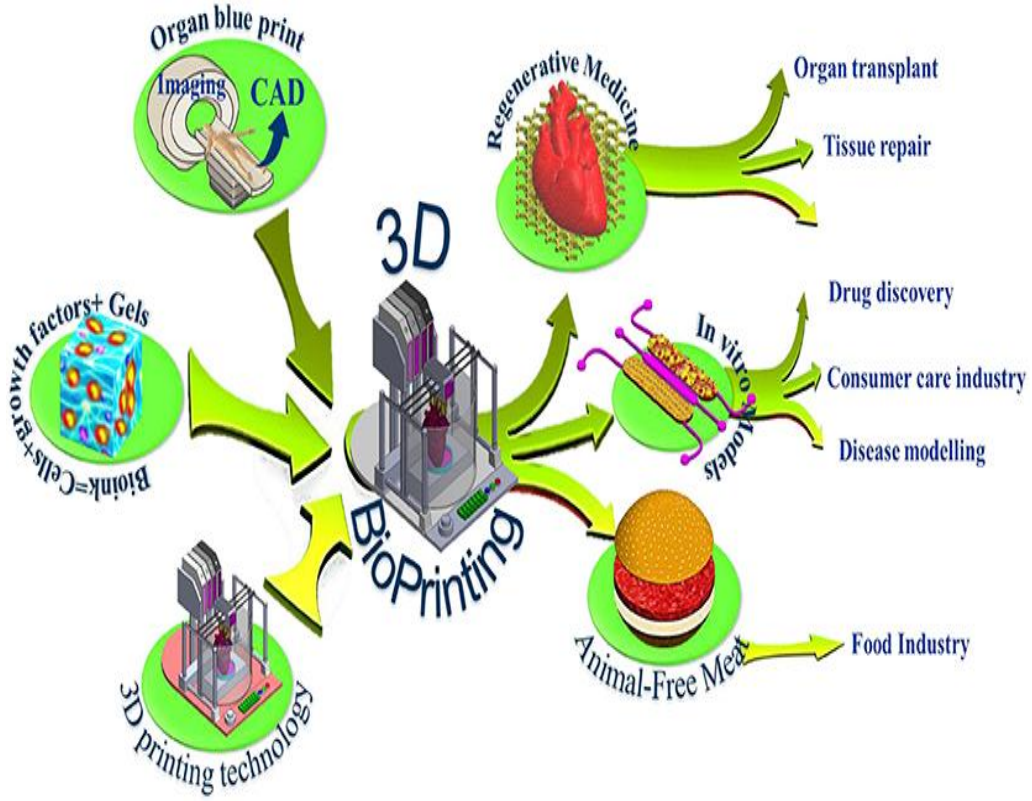

Fig No 3. Application Of 3D Bio printing.[21]

TEXTURE RECONSTRUCTION OF THE BODY:

This is the fundamental use case for 3D bio printing. It functioned as a building block for other applications. Rebuilding essential biological tissues is made easier by 3D bio printing.

RESEARCH ORGANS:

Since bio materials and organs have been successfully created through 3D bio printing. Launches a new phase in clinical research as a result. The organs are used to study interactions and responses between drugs and other organs.

TRANSPARENT ORGANS:

Given that various body tissues can be recreated via 3D bio printing. The environment created for these tissues allows them to proliferate and eventually form organs. Supplying synthetic organs with natural characteristics for surgical procedures and transplants.[20]

CONCLUSION

It is now widely known that 3D printing has the potential to produce incredibly exciting and remarkable outcomes in the health care industry. The idea of using 3D printing in medicine is not new. In the late 1980s, work on the first commercial bio printers and 3D printers got underway. But only because of increased funding and technological advancements over the past few years have the capabilities, applications, and demand increased.

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