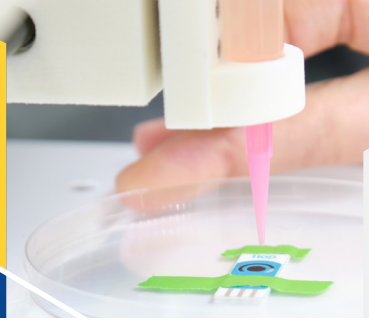
CAS INSIGHTS™

R&D TRENDS: 3D PRINTING AND BIOMEDICINE — A POWERFUL ALLIANCE



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Overview

The 1980s represent the birth of 3D printing technologies, which have continued to develop at a rapid pace. Innovation in biomedical 3D printing applications holds significant potential.

Background: Every major industry, from aerospace to construction, leverages 3D printing technology for rapid and cost-effective manufacturing.

Market potential: The global biomedical 3D printing market was estimated at $1.45 billion in 2021 and is expected to reach $6.21 billion by 2030.

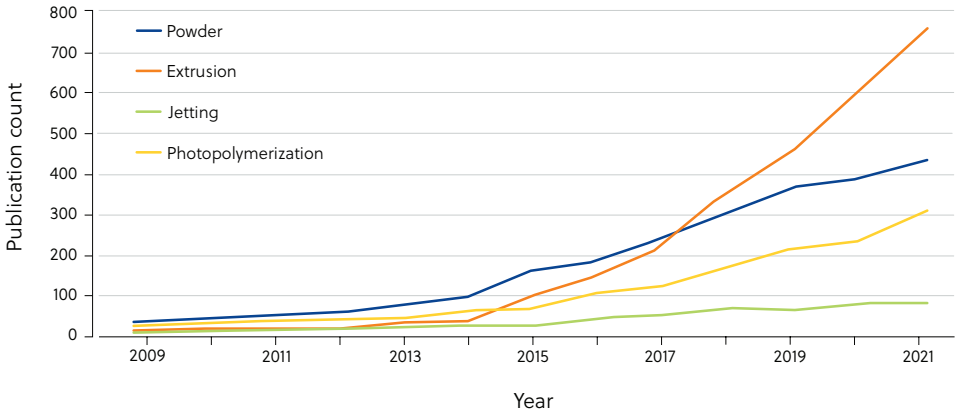
Opportunities: The orthopedics and prosthetics sectors show ample growth potential.

Key benefits: The provision of personalized medicines, devices, tissues, and organs by 3D printing technologies will likely transform healthcare systems and present significant cost and efficiency savings.

Key challenges: The technology is still in its infancy. Human biomechanics are yet to be fully replicated by 3D printing technologies. Other challenges include donor site morbidity and graft failure.

Publication trends in 3D printing techniques

Innovation is growing, owing to a steady increase in patient generation. The four primary categories of 3D printing are powder bed fusion, jetting, extrusion, and photopolymerization. Extrusion-based technologies remain the most popular types of biomedical 3D printing.



Popular substances employed in biomedical 3D printing

Synthetic polymers, natural hydrogels, and inorganic materials all contribute unique properties to a wide variety of 3D printing applications.

Material	Applications
Synthetic polymers	
Polycaprolactone	Liver-on-a-chip, bone generation, cartilage reconstruction
Polyethylene	Medical implants, facial, and cranial reconstruction
Synthetic hydrogels	
Polyvinyl alcohol, Polyethylene glycol	3D scaffolds, vascular construction, cartilage tissue engineering
Natural hydrogels	
Gelatin, hyaluronic acid	Organs-on-a-chip, scaffolds, vascular networks, skin tissue, and muscle constructs
Inorganic substances	
Hydroxylapatite, HAp ($Ca_5(PO_4)_3(OH)$)	Filler in dental material and bone repair
Alumina	Dental crown model, artificial teeth, and denture base materials
Gold	Used to form hydrogels for tissue engineering or medical implants

How biomedicine is harnessing 3D printing

Tissue, organ, and cartilage fabrication

Biofabrication, the creation of tissue and organs using cells, biomaterials, and 3D printing technology, has gained attention for its ability to create viable constructs. Bioprinted scaffolds loaded with stem cells can create articular cartilage and menisci, preventing complications such as immune response rejection.

Muscle tissue engineering

Skeletal muscle tissue constructs can replace or restore diseased or injured skeletal muscle tissue. 3D bioprinting is an excellent tool for this purpose, capable of mimicking the hierarchical structure of native muscle tissues.

Skin tissue fabrication

Tissue-engineered skin substitutes have widespread applications, from replacing animal models in research to the regeneration of human tissue.

Pharmaceuticals

Personalized medicine has been regarded as an unattainable goal in pharmaceuticals, yet 3D printing may help to make this a reality, allowing modifications to medicine dosage, shape, size, and delivery characteristics.

Anatomic modeling

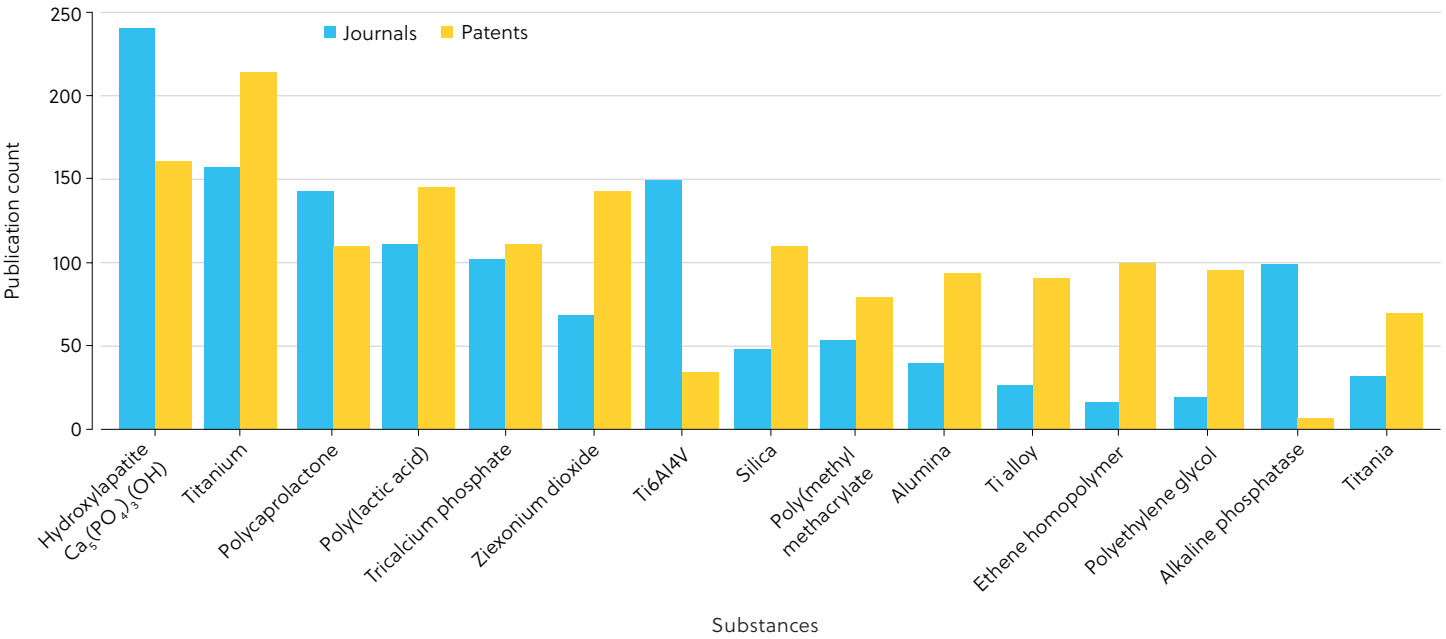
Used before surgery, accurate anatomic models can aid in precise sizing and placement for future implants, account for unexpected anatomy, and create models for surgical resection and reconstruction.

Implants and prosthetics

3D printing allows for images from X-ray, magnetic resonance imaging, or computerized tomography to be translated into 3D print files to rapidly fabricate customized prosthetic limbs and surgical implants within 24 hours.

Significant market potential in the orthopedics and prosthetics sector

Inorganic substances are favored in orthopedics and prosthetics, with hydroxylapatite and titanium featuring prominently. Interestingly, the number of filed patents in this area remains high, suggesting that many opportunities are yet to be commercialized.



Looking ahead

The use of 3D printing technology in biomedicine is garnering significant interest. The long-term benefits of economic and efficiency savings will likely outweigh the initial investment. Standardizing processes and the implementation of regulatory frameworks will help to maximize the quality and safety of 3D printed outputs in biomedicine.

Learn more at cas.org/insights

More comprehensive information and references can be found at cas.org/3d-report

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