Innovative Solutions for Future Cell Culture Development

The world is still confronting complex and urgent challenges. Populations continue to grow, while many societies are ageing, placing heavy burdens of chronic and degenerative diseases on people's lives and healthcare systems. At the same time, pressure on the planet is intensifying, raising serious concerns about sustainability, equity and whether humanity can safely coexist on Earth. Yet, there is also hope. Breakthroughs in science, medicine and technology are already emerging, carrying the potential to transform our future.

Cell Therapy: Clinical Reality and Expanding Approvals

Cell therapy (CT) has progressed from experimental trials to a growing portfolio of clinically approved treatments. By expanding healthy cells in culture and delivering them into the body, CTs can replace or support diseased or damaged cells, modulate cellular functions through signalling molecules or direct interactions, or, in the case of engineered immune cells such as CAR-T, eliminate malignant or dysfunctional cells. CTs have already transformed oncology, particularly haematological cancers, and hold promise for conditions including diabetes, chronic kidney disease and liver failure.

The global cell therapy market is valued at approximately USD 17 billion in 2025 and is projected to approach USD 30 billion by 2029.[1] The stem cell therapy segment alone is worth nearly USD 19 billion this year, with expectations that it will exceed USD 78 billion by 2032.[2] Regulatory momentum is accelerating; as of 2025, the FDA has authorised 44 distinct cell therapies in the United States and seven CAR-T products, while globally more than 100 cell and gene therapy products are now commercially available.[3,4] The accelerated approval of lifileucel (Amtagvi) in 2024, the first tumour-infiltrating lymphocyte (TIL) therapy for advanced melanoma, further demonstrates how CTs are expanding beyond blood cancers into solid tumour indications.

Regenerative Medicine: Beyond Repair Toward Organ Restoration

Regenerative medicine (RM) represents a broader paradigm: it aims not only to treat, but to restore or replace organs and tissues lost to injury or disease. RM encompasses tissue engineering, biomaterials and gene-based approaches that stimulate endogenous repair. Unlike CT, which primarily uses cellular products as direct therapeutic agents, RM strategies often combine cells with scaffolds, growth factors, or gene editing tools to regenerate functional tissue.

The regenerative medicine market reflects its breadth and ambition. Valued at over USD 32 billion in 2025, it is projected to exceed USD 200 billion by 2035,[5] with some estimates suggesting USD 144 billion by 2030 at an annual growth rate above 24%.[6] Advances in 3D bioprinting, organoids and CRISPR-based genome engineering are driving this growth, alongside increasing demand for solutions to chronic organ shortages and degenerative diseases. RM is being applied to regenerate cartilage, myocardium, liver tissue and even complex organ structures, marking a shift from replacement medicine, such as transplants, dialysis and prosthetics, toward true biological restoration.

Future Directions

While CT and RM are distinct, their trajectories increasingly converge in practice. For example, stem cell-based constructs are used in regenerative scaffolds and engineered immune cells may one day be applied to regenerate damaged tissue in addition to fighting disease. At the same time, next-generation CT modalities, such as CAR-NK cells and *in vivo* CAR-T therapies, are redefining the boundaries of cellular medicine.[7] In parallel, RM is moving toward large-scale clinical translation, with bioengineered tissues and organs gradually progressing into human trials.

Together, these two fields represent complementary but independent frontiers; CT offering near-term breakthroughs in oncology and immune disorders and RM driving long-term transformation in how we repair, replace and ultimately regenerate the human body.

Cellular Agriculture in 2025: Growing Meat Without Animals

Cellular agriculture uses many of the same culture techniques as cell therapy, but applies them to a radically different purpose, producing animal products directly from cell cultures rather than raising livestock. By expanding muscle and fat cells harvested painlessly from animals, scientists can cultivate steaks, sausages and other meat products.

Market Growth and Commercialisation

Although still in its infancy, the cellular agriculture sector is expanding rapidly. The cultured meat market is valued at around USD 0.28 billion in 2025 and could reach USD 0.54 billion by 2029.[8] More optimistic forecasts project growth from USD 568.8 million in 2024 to USD 36.6 billion by 2034, reflecting a remarkable CAGR of over 50%.[9] Broader cellular agriculture, including dairy, leather and biomaterials, may surpass USD 6 billion by 2033.

Regulatory approvals are beginning to open doors. Singapore was the first to allow commercial sales of cultivated meat in 2020, and in 2023,[10] the U.S. Department of Agriculture approved cultured chicken products from Good Meat and Upside Foods, enabling limited restaurant sales.[11] Despite this progress, production costs and scale-up remain major obstacles to widespread adoption.[12]

Environmental and Social Impacts

The potential impact on sustainability is profound. According to the United Nations, conventional animal agriculture is one of the largest contributors to land degradation, biodiversity loss,

greenhouse gas emissions and water pollution. By contrast, cellular agriculture requires far less land and water, eliminates the need for antibiotics and avoids manure-related pollution.[13] In addition, lab-grown meat could play a role in addressing food insecurity, particularly in resource-limited regions, since production is faster and less dependent on traditional supply chains.

Looking Ahead

The coming decade will determine whether cultivated products move from novelty to mainstream. While high production costs and regulatory fragmentation present real challenges, the promise of cellular agriculture, reducing environmental impact while providing ethical and scalable protein sources, makes it one of the most closely watched innovations in food and biotechnology today.

The Culture Medium at a Crossroads

When considering the future of regenerative medicine, cell therapy and even cellular agriculture, one common foundation emerges: the culture medium. For decades, fetal bovine serum (FBS) has been the "gold standard" supplement for cell culture, providing a complex mix of growth factors, proteins, hormones and nutrients essential for cell proliferation and differentiation. Yet, its use is increasingly problematic. Aside from ethical concerns surrounding the harvesting of bovine fetuses, FBS carries risks of contamination with prions, viruses and endotoxins, and is plagued by high costs and lot-to-lot variability.

The search for alternatives has fueled growth in the serum-free media market, which was valued at USD 1.9 billion in 2024 and is projected to nearly double to USD 4.05 billion by 2030 at a CAGR of 13.7%.[14] Recombinant protein growth factors have served as one solution, but they remain expensive, unstable and limited in scalability.[15] Regulatory agencies are also encouraging a shift toward animal-free and chemically defined systems, which are considered safer and more reproducible for clinical applications.

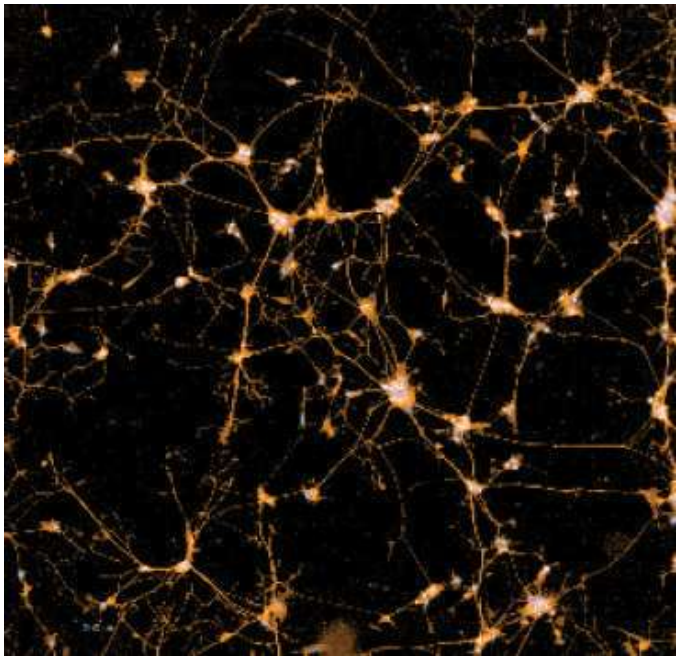

Figure 1. Neurite development induced by PG-003 (BDNF alternative peptides) Note: SH-SY5Y cells were treated with PG-003 and neurite formation was confirmed.

Shaping the Future of Cell Culture: Beyond Fetal Bovine Serum

Beyond recombinant proteins, a variety of animal-origin–free strategies are being pursued to replace fetal bovine serum, including plant-expressed growth factors, chemically defined media and peptide-based receptor agonists. Synthetic peptides in particular have drawn attention, as they can mimic natural growth-factor activity while being chemically defined, stable and scalable. Several research groups and companies are advancing this approach; for example, in Japan it has reported that peptide analogues engage FGFR2b, HGF, BDNF, and VEGF pathways (Figure 1). Rather than positioning one solution as dominant, these developments illustrate the broader trend toward reproducible, animal-free systems for regenerative medicine, cell therapy and cellular agriculture.

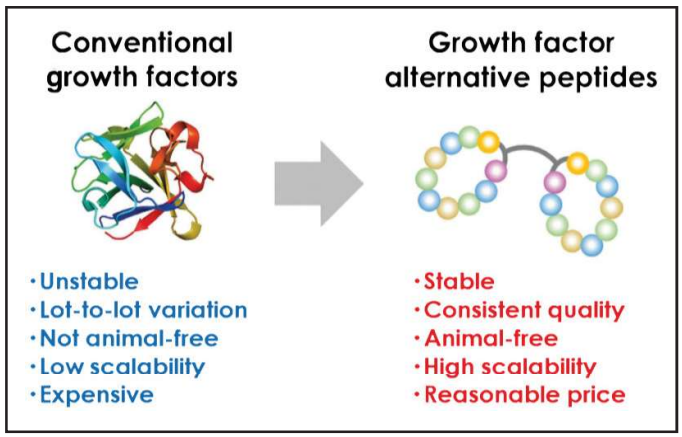

Figure 2. Comparison of growth factor alternative peptides with conventional growth factors.

Beyond the Lab:
Applications in Regenerative Medicine and Cultivated Meat

The implications extend far beyond academic research. In regenerative medicine and cell therapy, stable and reproducible culture systems are essential for clinical translation, where regulatory scrutiny is particularly high. Meanwhile, in cellular agriculture, cultivated meat producers require vast amounts of growth factors. Traditional recombinant proteins drive costs prohibitively high, but synthetic peptides could enable more affordable, scalable and ethically sound production. If successful, this innovation could transform not only laboratories but also the food supply chain, offering sustainable protein sources that align with environmental and animal welfare goals. Industry observers suggest that within the next decade, widespread adoption of synthetic peptides could reduce culture media costs by more than half, accelerating commercialisation and making animal-free systems the new norm across biotech and food industries.

Conclusion

As demand for serum-free and defined media grows across biotechnology, regenerative medicine and cellular agriculture, synthetic peptides are emerging as a credible successor to FBS. Their progress highlights how replacing a single component, long taken for granted, can open the door to safer therapies, sustainable food production, and a new era of biotechnology.

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