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OPPORTUNITIES FOR APPLYING BIOMEDICAL PRODUCTION AND MANUFACTURING METHODS TO THE DEVELOPMENT OF THE CLEAN MEAT INDUSTRY

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What is clean meat?



Figure 1: The first clean meatball, showcased in January 2016 in San Francisco. Photo courtesy of Memphis Meats.

Clean meat (meat grown using cell culture and tissue engineering methods, rather than obtained from animal slaughter) is an emergent biotechnology industry that will ameliorate the serious environmental, sustainability, global public health, and animal welfare concerns of conventional animal agriculture.

Animal agriculture poses massive threats to human health, the environment, and animal welfare. It is a leading cause of environmental destruction – including deforestation, ocean dead zones, and water and air pollution – and it contributes more greenhouse gas emissions than the entire global transportation sector. Furthermore, rearing animals poses significant public health threats from antibiotic resistance and zoonotic disease epidemics. Finally, consumers are increasingly concerned about the treatment of farmed animals, as evidenced by a growing number of legal reforms and governmental mandates to improve conditions and decrease the prevalence of animal protein in our diets.

Producing meat via large-scale cell culture alleviates all of these burdens by removing animal rearing and slaughter from the process.

Critical technologies

Critical Technology Elements (CTEs) for clean meat include immortalized cell lines for meat-relevant animal species (e.g. chicken, pig, fish, etc.), xeno-free media optimized for proliferation and differentiation of these cell lines, edible or biodegradable scaffolding to support vascularized tissue, and efficient bioreactors for cell proliferation and tissue maturation.

CLEAN MEAT INDUSTRY MIND MAP



Figure 2: Conceptual clean meat industry mind map illustrating CTEs and supporting areas of opportunity within this emerging sector.

Process development

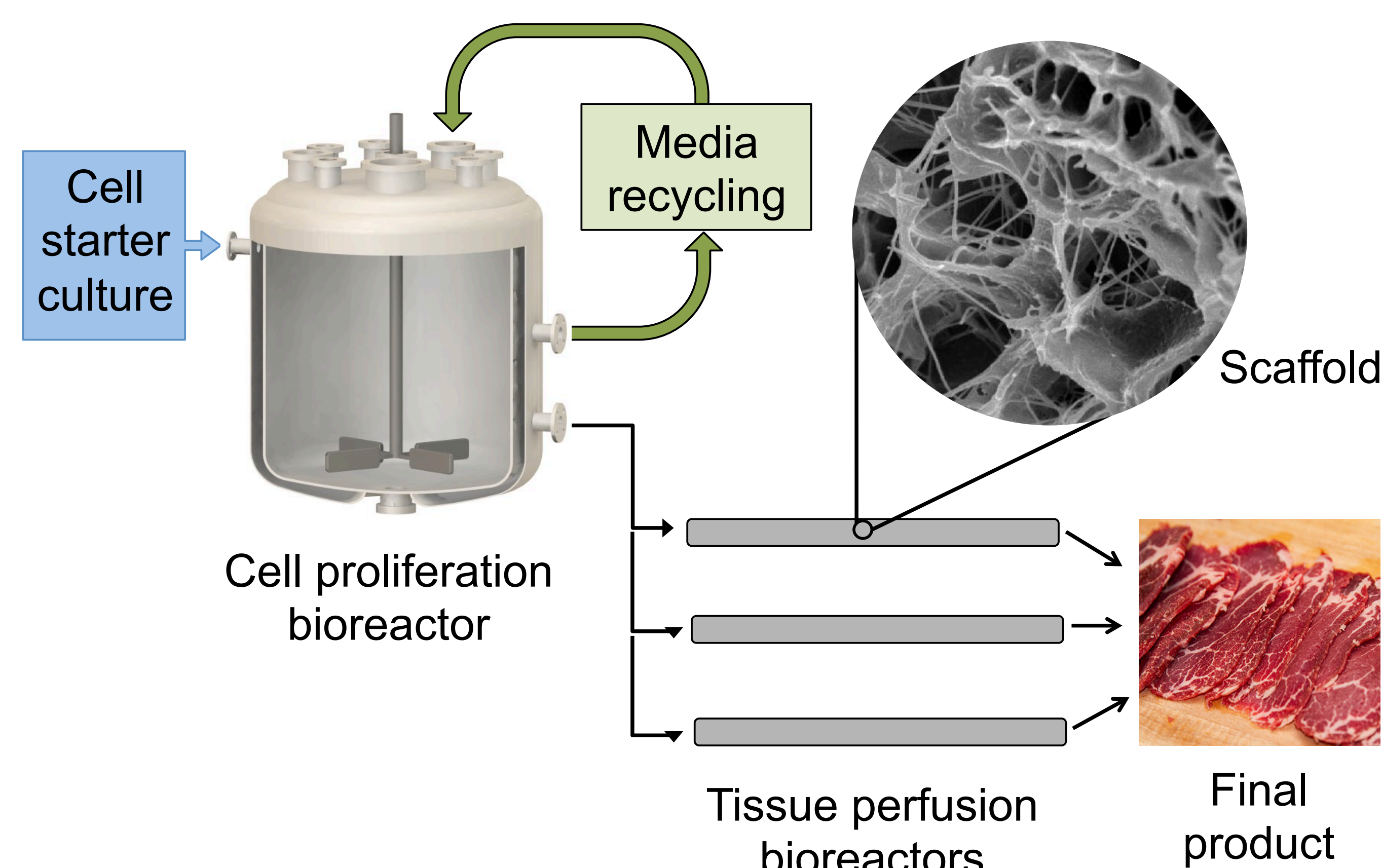


Figure 3: Schematic of a possible two-stage production process for large-scale clean meat production. The Good Food Institute, 2016.

Clean meat production begins with a cell line starter to initiate proliferation in a suspension bioreactor. Media in this bioreactor is a commodity item, and should be utilized efficiently via the media recycling system. The differentiation and tissue maturation stage occurs in a second reactor with a scaffold for tissue formation. The final product comprises complex tissues composed of multiple cell types.

Meat design requirements



Cell Lines

- Derived from agriculturally-relevant species
- Capable of differentiation into meat-relevant cell types (muscle, fat, fibroblast, endothelial, etc.)
- Genetically stable and immortalized
- Optimized for large-scale growth (tolerate suspension, controlled differentiation, etc.)



Cell culture media

- Xeno-free, antibiotic-free
- Chemically defined
- Optimized for clean meat-relevant cell lines
- Extremely low cost and high-scale production capacity
- Synthetic growth factors for fine-tuning cellular responses and differentiation



Scaffolds

- Edible and/or biodegradable and food grade materials
- Support cell adherence
- Support vascularization and media perfusion
- Biomechanical properties suitable for tissue maturation
- Scalable production capacity



Bioreactors

- Support cell line proliferation
- Support tissue maturation / perfusion (may require mechanical stimulus)
- Large volume
- Facilitate high-yield cell harvesting
- Real-time cell monitoring platform for QC
- Integrated media filtration and recycling

Opportunities for involvement

Roughly 93 billion pounds of meat are produced annually in North America. Hence, cell and tissue manufacturers and suppliers have massive growth opportunities in clean meat production.

Revenue generation may occur prior to developing clean meat as a final product – for example, cultured muscle and/or fat cells may serve as valuable ingredients to improve the taste profile or functionality of plant-based products. Furthermore, technologies developed with clean meat applications in mind will exhibit substantial cross-licensing opportunities within cellular therapeutics and regenerative medicine.

The Good Food Institute has produced a **Technology Readiness Assessment (TRA) for Clean Meat** to establish the design requirement relationships among the CTEs. This assessment has elucidated abundant opportunities to expand existing product lines tailored towards clean meat applications. For example:

- Bioreactor systems for whole-cell harvesting can be applied to cell proliferation for clean meat.
- Scaffolds for wound healing can be immediately used for tissue engineering of meat at small scales.
- Cell culture media suppliers can develop bulk, low-cost formulations and offer optimization services with clean meat applications in mind.

Developing new food technologies that facilitate a global shift away from animal products and towards more sustainable, healthy, and humane alternatives is arguably one of the single most impactful areas for commercialization because of the massive and far-reaching impacts of animal agriculture.



Figure 4: The first clean meat hamburger, unveiled in London in 2013.

Photo courtesy of Prof. Mark Post.

Learn more at: <https://culturedbeef.mumc.maastrichtuniversity.nl>

References

Brunner D, et al. Serum-free Cell Culture: The Serum-free Media Interactive Online Database. *ALTEX*, 2010.

Butler M. Serum and protein free media. In *Animal Cell Culture*, Springer International Publishing, 2015.

Hansmann J, et al. Bioreactors in tissue engineering – principles, applications and commercial constraints. *Biotechnology Journal*, 2013.

Kadim IT, et al. Cultured meat from muscle stem cells: A review of challenges and prospects. *Journal of Integrative Agriculture*, 2015.

Kolesky DB, et al. Three-dimensional bioprinting of thick vascularized tissues. *PNAS*, 2016.

Moritz MSM, et al. Alternatives for Large-Scale Production of Cultured Beef. *Journal of Integrative Agriculture*, 2014.

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