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Cellular agriculture and food systems priorities

Foods created by tissue engineering have captured imaginations within the food systems community. In this issue, we explore how cellular agriculture aligns with food systems priorities of sustainability, health, equity and economy.

Food systems have social, economic, health and environmental domains and, as *Nature Food* readers will attest to, our broad community often struggles to reach consensus on how specific practices can fulfil the multiple priorities of these domains. Cellular agriculture speaks to game-changing innovation for environmental sustainability, a world with less animal agriculture — and it speaks to investment. Now that the technology is deployable, our community must take stock of cellular agriculture to ensure its trajectory aligns well with the objectives of sustainable food systems and public policy.

Cellular agriculture draws on research and techniques from tissue engineering, regenerative medicine, synthetic biology and fermentation. Mosa Meat, headed by Professor Mark Post of Maastricht University, presented the first cultured beef burger in 2013 and while the field is best known for the hamburger, seafood, milk, eggs and egg-derived products (such as ovalbumin) can also now be produced by this technology. Creating realistic cellular food products that arise from complex developmental processes presents many technological hurdles — and over *Nature Food*'s three years in publishing to date, we have witnessed researchers in the field rise to the challenges. Cell culture media for cellular agriculture can now be utilized without fetal bovine serum[1], plant-based scaffolds have been developed to facilitate 3D cell culture[2], muscle tissue fat marbling can be replicated[3], and seafood waste can be repurposed as a cell source for cultured fish production[4], to name but a few.

Investment in cellular agriculture is high risk, but has high potential for long-term growth, making it attractive to private investors. In December 2021, Samir Kaul of Khosla Ventures wrote that "start-ups are now the first source of innovation in all categories of food technology, while incumbents have taken a wait-and-see approach"[5]. In 2013, backed by Google co-founder Sergey Brin, Mosa Meat produced their first burger patty at a cost of €250,000. When cultured meat was first approved for sale in Singapore in late 2020, Eat Just's lab-grown chicken nuggets were available in one members club for S$23 per serving[6] — now they are now available at selected markets for as little as S$4. Upside Foods Series A supporters included Bill Gates, Cargill and Richard Branson at its inception; now funding additionally comes from the likes of Tyson Foods, Whole Foods and Indiebio, and this year the company has obtained US$400 million in Series C funding. In 2021, venture capital investors poured US$1.9 billion into cellular agriculture markets[7].

And it is not just venture capitalists who are enthusiastic about investment in cellular agriculture. Last year, the US Department of Agriculture awarded a five-year, US$10-million grant to Tufts University to establish the National Institute for Cellular Agriculture[8], and earlier this year, the Dutch government announced it would invest €60 million in the field[9] — the largest ever public investment in cellular agriculture.

In 2020, Herrero and colleagues wrote that "the transformational power of a technology depends on the economic and political context, the needs of the society and its socio-economic conditions" and that the deployment of technologies must be accompanied by broader support to safeguard desired food systems outcomes[10]. In this focus issue, we present insights from the field of cellular agriculture that address technological innovation alongside environmental and social concerns. Our aim with this focus issue and the accompanying webinar is to kick-start a broad dialogue around the potential and pitfalls of deploying cellular agriculture for sustainable food systems.

The sustainability credentials of cellular agriculture are presented widely in terms of impacts averted from the livestock sector, yet life cycle assessment approaches must address uncertainties in scaling up production and the consequences of scaling down livestock production. From the One Health perspective, aseptic processes could substantially reduce antimicrobial use in meat production, supporting the global race against antimicrobial resistance. As the technology and investment are consolidated, issues of people, planet, profit, power and justice are critical to get to grips with in order for the technology to become transformative. It is argued that the field must focus on mission more than market, and on the value systems of individual consumers.

Principles of equity, ethics, safety and security must underpin technological developments in food systems, and a shared vision and sense of purpose can make innovation truly transformative. These are big asks, not of technology, but of people. This focus on cellular agriculture presents diverging values, visions and paths forward for the field. From imagination to now the intersection of academia, industry and policy, the technology of cellular agriculture has progressed rapidly. Now, the discussion must look towards consensus and collaborative action.

Join our webinar to continue the conversation.

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