

## **Transforming Meat for Environmental and Moral Improvement**

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In August 2013, at a cost of about \$350,000, the tissue engineer Mark Post unveiled the first synthetic hamburger. Here, we want to suggest that a grand challenge for synthetic biology of enormous potential environmental and moral value could be achieved through a strategic, long-term R&D program aimed at building the foundations for a synthetic meat industry that satisfied and ultimately displaced the nutritional, culinary, gustatory, and cultural values now provided by animal products.

The social science agenda here is rich and complex, and involves (1) effective science policies to guide syn bio R&D through appropriate institutional and innovation system models; (2) socio-technical system analysis, to understand the current meat production system in all its dimensions; (3) political, social and economic transition analysis, to elucidate the possible pathways for that system's transformation; (4) survey work and cultural analysis, to understand attitudes and beliefs about, opportunities for, and obstacles to a social transition from animal to synthetic meat; (4) anticipatory governance of the research enterprise (of course!) to help steer the necessary R&D reflexively and wisely.

The argument for bringing emerging syn bio capacities to bear on creating meat alternatives—either synthetically created meat products (factory or test-tube meat), or non-meat products that have all the qualities of meat—is rather obvious. As a matter of energy and environmental concerns, meat production is enormously costly and inefficient. FAO estimates, for example, that meat production accounts for about 14 percent of global greenhouse gas emissions. The effects of grazing on land quality is often highly deleterious, and growing demand for meat worldwide will continue to cause deforestation, ecological stress, and soil and water quality problems. Industrial meat production, in turn, creates enormous quantities of waste that are difficult to contain and are responsible for significant pollution costs such as widespread eutrophication. The energy inputs to creating animal protein are typically many times that required for equivalent vegetable-based nutritional value, and synthetic meats may also offer significant energy savings for a burgeoning global population. They may also offer health benefits through avoiding many of the contamination problems associated with animal meat.

Moreover, as two appreciative meat-eaters, we nonetheless would like to imagine a time when billions of animals do not need to be killed (often after living lives of great unpleasantness if not suffering) to satisfy our culinary whims. Indeed, for us the moral benefits of this grand challenge are as compelling as the environmental ones. We are well aware that we are hypocrites here, but that comes with the territory of being human. In a wonderful essay by E.B. White from the early 1950s, he describes the great sorrow of losing his pig to a painful disease, a sorrow of empathy and affection for an animal that, had it not so succumbed, would later that same year have been slaughtered for the culinary pleasure of his family. Can syn bio help make us be better people through a process of technological substitution?