A conversation with an anonymous source about cultured meat development, April 23, 2015

Participants

- A scientist with 18 years experience in the tissue engineering industry
- Lily Kim, PhD – Science Advisor, Open Philanthropy Project

Note: The person whom we had this conversation with wanted to remain anonymous, so we have posted the content of the conversation with any information that would identify the person removed.

These notes were compiled by the Open Philanthropy Project and give an overview of the major points made.

Summary

The Open Philanthropy Project spoke with a scientist with experience in the tissue engineering industry as part of its investigation into cultured meat development. Conversation topics included the obstacles to the development of cost-competitive cultured meat and potential future directions.

Cultured meat challenges

Cost

Cultured meat is likely to be a very expensive product. An analogy is the cost to manufacture a six-pack of beer. The actual beer is the cheapest component. The price is significantly increased by the cost of the bottles, packaging, distribution, manufacturing and overhead costs. The same holds true for tissue engineering. The necessary infrastructure is much more expensive than the cells themselves. More significant costs include:

- Employing the necessary skilled technicians, quality, regulatory and manufacturing staff
- Maintaining sterile environments and lab spaces, especially cleanrooms, which use expensive fans and filters to maintain very low levels of air contamination
- Sterile disposable plastic ware
- Necessary supplements and cell media

Most clinical applications of tissue engineering remain very expensive. For example:

- Apligraf, developed by Organogenesis, is an allogeneic living cell based product used to heal chronic leg ulcers. It has been on the market for 17 years and has been produced at a significant scale (i.e., over a thousand units per week). A hockey-puck sized piece of Apligraf takes three weeks to manufacture and costs hundreds of dollars.
- Provenge, developed by Dendreon, is a personalized immunotherapy for prostate cancer. A patient's immune cells are removed, re-programmed to

seek out and destroy cancer cells, and injected back into the body. A course of treatment costs $93,000 and at one point had a margin of ~50%.

Time to manufacture

The amount of time that it will take to culture a batch of meat in the laboratory is likely also significant, if grown de novo. If it was possible to take cells from a vial, plate them (or combine with an existing scaffold), and grow meat overnight, manufacturing could be done reasonably cheaply.

However, it normally takes at least two-to-three weeks for cells to elaborate a matrix, grow and secrete proteins, and become a tissue. This significantly increases costs. Three weeks of manufacturing requires more media, more incubators, and more laboratory space.

Cell therapy companies are currently trying to reduce or remove manufacturing time, and the technology gains and cost reductions made here are something that cultured meat may be able to piggyback off of. For example, cell therapy companies are pursuing point of care treatment, where a technician would remove cells from a patient's body with a blood draw, manipulate them at the beside, and re-inject them. Restricting the therapy to the bedside (or implanting a biomaterial "vaccine") significantly reduces manufacturing time (vs. sending the cells to a lab for manipulation and programming, then sending them back to the patient for re-injection).

Regulation

Getting cultured meat approved by regulatory agencies may also be a significant obstacle. It's very expensive to get cell-based therapeutics approved due to the many (~10+) years in clinical development and are tested in three to four clinical trials. Regulation requirements for cultured meat will be different, as it is not meant to cure a disease; presumably it is less stringent than for clinical enterprises, though it may still be a challenge.

Consumer opinions

It's not clear how the general population will react to cultured meat. Some portion of the population will likely never want to eat meat grown in the lab, even if it's cheaper and healthier because of the "ick" factor. Consumers can be very fickle about food products, as evidenced by the backlash against genetically modified organisms (GMOs).

The consumer market is much different than the pharmaceutical market, where products come with a doctor's approval.

Funding

It is unlikely the venture capitalists will make any big investments in cultured meat in the near future. Venture capitalists generally want 3-5X returns on their investments in three to five years. Making cultured meat profitable still depends on

major manufacturing hurdles and a big shift in consumer mindsets. A typical venture capitalist won't be interested in taking on those risks.

Antibiotic usage

Antibiotics, such as gentamicin, are widely used in cell culturing. When a product takes three weeks to grow, losing it to contamination is a significant financial loss. Antibiotics are typically used at relatively low doses, and as such, the systemic exposure may only equivalent to regular use of Purell or Lysol wipes (acknowledging this is a guess and better confirmed through someone who knows the details better).

Future directions

Timeline

Without a major technological breakthrough, it seems very unlikely that cost-competitive cultured meat will be available in the next 10-15 years.

It is already possible to make a football field size of 2mm thick meat. That technological hurdle is done, which means the product is maybe 70% of the way there in terms of technical risk. However, in order to have a viable business, it needs to be 95% of the way there. The additional 20-30% comes from making gains in manufacturing, which is doable in the long term. The target product profile will also matter. It is likely more difficult to manufacture thick pieces of cultured meat because of the mass transport challenges.

Reducing manufacturing costs

Many large companies are getting involved and/or (re)investing in tissue engineering manufacturing or supplying manufacturing tools, including GE Healthcare, Invetech, Lonza, Sony, and Panasonic. It's likely that they will make real progress in reducing manufacturing costs, which the tissue engineering community needs to survive. The cultured meat industry will also benefit from this work.

It's much cheaper to work in lower classification cleanrooms, which allow slightly higher levels of particulates per cubic meter. Maintaining only subsections of larger rooms as class 100 cleanrooms could also cut costs substantially.

New ideas

It would be much cheaper to produce synthetic meat that doesn't rely on live cell cultures. Many tissue engineering products have stopped using live cells and now rely on collagen biomaterial, such as bovine dermis. It's possible to electrospin collagen and produce tissue-like substances. The final products are not quite as good as those that use live cells, but they're 90% of the way there and are significantly cheaper to produce.

This sort of technological pivot could reduce development time and unit cost by 90%. For example, it might be possible to electrospin collagen to produce a large

mat, seed that with live cells, let them grow for ~days, and produce a synthetic hamburger.

It's also possible that there will new technological breakthrough that no one has considered yet. There are lots of new things happening in genetic engineering. For example, CollPlant, a company focused on revolutionizing tissue repair, is starting to express human collagen protein in tobacco plants.

All Open Philanthropy Project conversations are available at
http://www.givewell.org/conversations