A conversation with Isha Datar, March 10, 2015 and July 24, 2015

Participants

- Isha Datar – CEO, New Harvest
- Lily Kim – Science Advisor, Open Philanthropy Project

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

Summary

The Open Philanthropy Project spoke with Ms. Datar of New Harvest as part of its investigation into the development of animal products made without animals such as cultured meat, milk, and eggs. Conversation topics included New Harvest's history and mission, cultured animal product research and entrepreneurship, and remaining technical challenges.

New Harvest

New Harvest's history

Dr. Jason Matheny, now Director of the United States Intelligence Advanced Research Projects Activity (IARPA), founded New Harvest in 2004. Dr. Matheny is an animal activist who sees cultured meat as a way to reduce animal suffering. In 2004, Dr. Matheny founded New Harvest because he thought that cultured meat was a scientific possibility and the remaining challenges associated with its development were more a matter of engineering than scientific discovery.

Between 2004 and 2013, Mr. Matheny ran New Harvest as a part-time project. He was instrumental in convincing the Dutch government to fund research on cultured meat from 2005-2009.

Ms. Datar was hired as the full-time executive director of New Harvest in January 2013. This was good timing, as there was momentum building around cultured meat research, associated with the announcement of the first cultured hamburger being tasted in late 2013. Having a full-time employee has increased New Harvest's capacity to build a community around cultured meat and connect researchers, entrepreneurs, and funders. New Harvest recently hired a full-time development director (Gilonne D'Origny) as a second employee. Because New Harvest remains a very small organization, it can continue to be flexible, take risks, and make decisions quickly.

New Harvest's mission

New Harvest is a strategic grant-making organization devoted to kickstarting an industry of of animal products made without animals. These technologies use cell cultures to replace substances conventionally obtained from animals. In the past year New Harvest has broadened its work beyond cultured meat to include cultured milk, eggs, and more. New Harvest would like to kick start a new industry around

these new technologies to make animal agriculture obsolete. To further these goals and populate the new industry with more players, New Harvest supports academic research and entrepreneurship by issuing seed research grants of up to $50k. New Harvest seeks projects that are inspiring (raise awareness and quantify impact), involve groundbreaking technology (address a neglected goal), or are commercially promising. Such grants would:

1. Create an academic discipline around cellular agriculture, including cultured meat.
2. Support entrepreneurial pursuits for cultured animal products that are ready for business investment

For New Harvest, fueling a new industry involves not only commercial investments but investments in the academic research pipeline feeding into the commercial endeavors.

There is a lot of "untapped talent" in academia, because many researchers are interested in work on cultured meat, but there are not structures to support them. For example, Ms. Datar is aware of anonymous tissue engineers in academia working on food applications using grant money that was actually awarded for medical research. The researchers are resorting to these measures because of their desire to work on the problem combined with the lack of dedicated funding for the food applications of tissue engineering.

In addition, this work is underfunded because it lies at the boundary of two established academic disciplines, with neither discipline taking ownership and funding this research: academic synthetic biologists and tissue engineering researchers are focused on medical applications rather than food, as determined by their grant funding, and food science academic departments do not have experience with cell culture technology. There is no way for tissue engineering researchers to use their medical grant funding toward food products.

New Harvest would like to develop teams of talent by building academic centers around the world that are focused on cellular agriculture research. As an initial step, New Harvest is linking interested researchers with projects that would be relevant to cultured meat development. For example, it is working with a PhD student in the United Kingdom who is researching edible cellular scaffolds. New Harvest is not funding that work directly, but the project is framed in such a way that it will be very relevant to cultured meat research. This is a way to use existing funding mechanisms to support cultured meat research.

New Harvest is also interested in helping academic researchers get large grants (e.g., from the National Science Foundation (NSF)) for cellular agriculture, by helping researchers write the grants. New Harvest sees this as a grassroots approach to getting more research funding from government funders like the NSF or the U.S. Department of Agriculture (USDA).

New Harvest also encourages entrepreneurial pursuits and helps new businesses attract startup funding.

New Harvest is actively populating the field of cellular agriculture. For example, in the past year, New Harvest helped start two companies in the space, Clara Foods and Muufri. While New Harvest did not directly invest dollars into the companies, Isha Datar assembled the founding teams, as the New Harvest Egg Project and the New Harvest Dairy Project, respectively, and found them seed funding and lab space at an incubator. Within a year, both companies raised significant follow-on funding (see below). New Harvest retains founding equity in the companies they co-founded as a means to raise funds to further the field.

New Harvest wants to populate the field of cellular agriculture with several players. In order to avoid the monopolization issues that plague animal agriculture, New Harvest plans to support and invest in a wide range of research and companies. New Harvest believes that a viable, self-sufficient ecosystem – academic discipline and industry – is a more resilient long-term goal than funding a single or small set of researchers.

New Harvest is not opposed to plant-based meat alternatives, but supports the cellular agriculture products more because there is sufficient attention and funding in the advancement of plant-based foods. New Harvest believes that the more definitions of what protein can be, cultured or plant-based, the less likely the reliance on animal-based protein.

New Harvest's funding

New Harvest is funded entirely by hundreds of individual donors whose gifts range from very modest amounts to tens of thousands of dollars. Several executives of prominent animal welfare organizations are donors.

In the recent past New Harvest has begun more actively fundraising with the hire of Gilonne d'Origny, Development Director. New Harvest is in engaging with large foundations and high net worth donors.

New Harvest is transitioning from an organization that connected researchers to existing opportunities to a direct granting organization. This will allow New Harvest to expand the field more quickly.

Animal products without animals

Ideally, work on animal products made without animals will be balanced between academic, business, and non-profit sectors:

- **Academia –** explores high-risk research questions
- **Non-profit advocacy –** funds a lot of the academic research
- **Business –** donates to non-profit groups and benefits when academics produce business-opportunity-ready technologies

Maintaining a balance across the three sectors will help to ensure that research is properly evaluated and that projects are safe, efficient, and transparent. New

Harvest plans to work across all three areas and help make connections between them.

There is very little non-profit involvement in cultured meat. The only other organization focused in this area is The Modern Agricultural Foundation, an Israeli non-profit which recently raised $30,000 to fund a detailed plan on how to create cultured chicken.

Most cultured meat research is focused on beef because it makes the best environmental and cost argument. Chicken is relatively inexpensive and energy efficient, although animal welfare remains a big issue. New Harvest is hoping to explore options for all animal products. There are two types of animal products – those that are tissues (meat, leather) and those that are collections of proteins and other molecules (milk, eggs). Tissue-based products are more novel and therefore further from market viability than non-tissue products. Non-tissue animal proteins have been made in culture for decades (insulin has been made in culture instead of from pig pancreases since the 70s, rennet for cheese has been made in culture instead of the fourth stomach of calves since the late 80s)

Academic research on cultured meat

History of academic work

Cultured meat has been a topic of interest for over a century:

- 1912: Dr. Alexis Carrel cultured chicken heart tissue.
- 1931: Winston Churchill predicted cultured meat in his essay "Fifty Years Hence"
- 1997: A NASA funded experiment, run by Dr. Morris Benjaminson, looked at growing fish muscle in culture. This was the first modern cultured meat experiment.

The Dutch government, influenced by New Harvest, funded about €2 million of cultured meat research from 2005-2009. This research eventually led to Dr. Mark Post developing the milestone cultured hamburger and helped to establish the field.

Research needs

There needs to be more academic research on cultured meat development. Ms. Datar encourages any researchers interested in cultured meat to get involved. Considering how many academics are interested in cultured meat, there aren't that many actively conducting research in the field.

There is a lot of expertise in academia that is relevant to cultured meat, but it is divided across the medical community and the food science community. A lot of medical research is focused on tissue engineering (e.g., human organ regeneration), but this work is not concerned with mass production, food quality, sustainability, or affordability. There are experts on meat production and taste in the food science community, but they are not familiar with aseptic cell culturing. It is difficult to get

governmental funding for cultured meat research because it doesn't fit into any single existing academic discipline.

Traditional academic processes are generally slow and focus on solving one small problem at a time. New Harvest hopes to foster and support laboratories that will apply an entrepreneurial spirit to academic research. For instance, if Ms. Datar had unlimited funds, she would create an institute focused on all aspects of cultured meat production, with a focus on prototyping. This iteration is important for scientific advancement.

Cultured meat has gotten a lot of media attention over the last ten years. This coverage explains the potential environmental, public health, and animal welfare benefits of cultured meat, but it also gives readers a sense that there is more of a scientific community dedicated to this work than there really is. Media coverage has not increased the amount of academic attention. There is little reliable funding available.

Dr. Mark Post's research

Dr. Mark Post, Professor of Vascular Physiology at Maastricht University, developed a cultured meat hamburger, which was completed (and tasted) in August 2013. Sergey Brin, a co-founder of Google, funded his research. Dr. Brin likely contributed around €1 million to the project, but the actual amount is not known. He is continuing to fund Dr. Post's research, but at a lower level due to organizational changes at Sergey Brin's foundation. Mark Post's prototype burger was important because it showed that no new science was needed to make cultured meat, and that it was only an engineering problem from now on to bring it to a marketable product.

Dr. Post is currently working on developing animal-free growth media and on growing cultured meat from myosatellite cells, which are more mature than stem cells. New Harvest recently granted Dr. Post $50,000 for his research on animal-free growth media.

Dr. Nicholas Genovese's research

Dr. Nicholas Genovese, a visiting scholar at the University of Missouri, has recently joined the first academic lab in the United States dedicated to cultured meat. The lab can accommodate four scientists and Dr. Genovese is the first hire. Dr. Valeti helped to secure this commitment and is funding some of the research personally.

Dr. Genovese's research has been focused on isolating agricultural animal stem cells. Prior to this appointment, People for the Ethical Treatment of Animals (PETA) funded his research for two years.

In vitro consortium

In 2011, Dr. Matheny and Dr. Stig Omholt, Division Director of the Faculty of Medicine at the Norwegian University of Science and Technology, organized a consortium to bring together cultured meat researchers from around the world. However, their plans required them to raise lots of money and they didn't create a

structure for fundraising. A lot of attendees were peripherally interested in the field, but didn't continue working in cultured meat. New Harvest may organize another consortium in the future.

Cellular Agriculture entrepreneurship

There are several cultured food companies currently working on bringing products to the market:

- **Clara Foods** – Clara Foods is producing animal-free egg whites. It recently received $50,000 from IndieBio, a synthetic biology accelerator. Clara Foods started its work in March 2015. Within months they had raised an additional $1.7 million.
- **Muufri** – Muufri is producing animal-free milk. New Harvest helped Muufri receive its first round of funding ($30,000) from a biology accelerator program in April 2014. In September 2014, it received $2 million more from Horizon Ventures, a venture capital firm run by Li Ka Shing, who is an ethical vegan. Muufri is already ready to move into a second laboratory space.

Milk and egg whites have no cellular materials, which makes them easier to reproduce without the animal. Muufri and Clara Foods are working on producing the necessary proteins and fats contained in milk and eggs, respectively, via yeast brewing. New Harvest started both these companies – they began as the New Harvest Dairy Project and the New Harvest Egg Project. New Harvest assembled the teams helped both these companies find and secure their start up funds.

- **Modern Meadow** – Modern Meadow is valued at over $12 million. It has a long-term goal of producing cultured meat. In the shorter term, it is producing animal-free leather. People are willing to pay more for a small piece of leather than they are for a small piece of meat. Modern Meadow has received investments from a variety of sources and recently raised $11 million.

In total, over $12 million has been invested in various cultured meat businesses. Any investor interested in this topic should invest in these ventures and other early-stage research. Investors should also see contributions to New Harvest as an investment in further investments given New Harvest's track record of creating investable opportunities.

Remaining technical challenges

There are several technical challenges that currently limit cultured meat production:

Developing cell lines

- **Stem cells –** Most work on stem cells has focused on human and model organism cell lines, which have very few agricultural applications. Cell lines from different species behave in different ways. Once agricultural animal stem cells lines are established and their behavior is better understood, it will be possible

to reproduce them on a mass scale. Stem cells must be directed to become muscle cells. Dr. Genovese is working on this. When stable cell lines are established, it would be possible to produce cultured meat without ever collecting cells from animals again.

- **Myosatellite cells** – Myosatellite cells are more mature than stem cells – they are already destined to become muscle cells. Research on myosatellite cells is still in its early stages. Dr. Post and Modern Meadow are collecting tissue from recently slaughtered animals to explore ways to create myosatellite cell lines. It is possible to collect myosatellite cells from live animals via a biopsy (with applied anesthetic).

Note that cell lines are useful not only as a source for the cultured meat cells, but as a research tool. Using well-understood and well-established cell lines would allow researchers to conduct more reproducible research, furthering our understanding of how to optimize conditions for cell growth, differentiation, and formation into fibers and tissues.

Developing scaffolds

Scaffolds are the structures on which muscle cells would be grown; they are important because muscle cells need to be attached to something in order to grow. In addition, cell cultures that lack veins and arteries can only grow about 0.5 millimeters before the bottom cells begin to die because they aren't exposed to the growth media. Mark Post developed scaffolding approaches to make his burger, but these scaffold designs are inefficient and labor-intensive to use at scale because they were intended only for academic prototype use. At this stage, developing successful scaffolds would have broad applications for cell culturing beyond cultured meat development.

There are currently two approaches:

- **Creating scaffolds with large surface areas** – Modern Meadow is working on growing cells on thin sheets over a large surface area. Mark Post is working on scaffolds that involve beads and noodle-like strings. This is the "ground beef" approach.
- **Creating vasculature** – This could either be a scaffold made that resembles a vascular system, or growing a vascular system within the tissue. This approach has the potential to yield thick tissues. It is the "steak" approach.

When designing a scaffold, researchers need to determine if the scaffold will stay with the final product, or if it will be removed and reusable.

Developing animal-free cell media

Media is the substance that feeds cultured cells. Standard media in all mammalian cell culture contains fetal bovine serum and is harvested from cow fetuses. Standard media is basically a by-product of other processes and works very well in cell culture. However, because it comes from cow fetuses it isn't standardized across batches. Animal-free media is more consistent and allows more standardized

experiments. Dr. Post used animal-free media towards the end of his hamburger production. However, producing this animal-free media is very expensive and time intensive. Also, currently available animal-free media may not be the most efficient for promoting high cell growth.

The challenge is to make animal-free media affordable, scalable, and high performing (optimized for cell growth). It is possible there may be one media needed for promoting high cell growth that would be switched to a second media for differentiating the earlier stage cells into muscle fibers. This would be attractive to all kinds of research that uses cellular culture (e.g., organ regeneration). Marketing and selling animal-free media could help finance other cultured meat research.

Designing bioreactors

Bioreactors are vessels that the muscle cells would be grown and cultured in. At the university research level, they may be small a few litres), but for commercial production they would need to be much larger (tens of thousands of liters) to grow the quantity of cells needed to make meat. Bioreactors are generally aseptic environments with controlled temperatures. Dr. Marianne Ellis, a New Harvest board member, is a chemical engineer who researches hollow fiber bioreactors. This model is very scalable and could be useful for cultured meat production. A lot of wastewater treatment facilities, for example, rely on hollow fiber bioreactors. Because this research is relevant to cultured meat development, New Harvest is connecting interested PhD students with research projects examining hollow fiber bioreactors. However, much research is still needed on scaling up production, because the technical parameters and conditions for successfully culturing cells at large scales are different from that at the small scale, and still need to be developed.

While bioreactors would be needed for cultured meat manufacturing, they are a lower priority for cultured-meat-specific funding because bioreactor research and development is already funded in the tissue engineering field (both academic and commercial). Affordable animal-free media and cell lines are more important to fund in the near term, because they are specifically needed for cultured meat and are not funded by other sources. They are also a necessary first step to understand before they are grown in scale in bioreactors.

Other Concerns

Cost

Producing cultured meat is very expensive at the moment. This is largely because it is still in the research stage and there is no well-engineered manufacturing process yet. There haven't been serious explorations into scaling-up production processes.

New Harvest's website has the most recent preliminary cost estimate, which eXmoor pharma produced in 2008. However, it is now seven years old and doesn't factor in the more recent developments. Dr. Post and Modern Meadow have both done their own cost estimates, but these figures are not public.

Dr. Post's hamburger cost around £300,000 to produce, which includes the cost of paying laboratory technicians' salaries. Presumably, when cultured meat production is scaled up and commercial, several costs will come down.

There are also significant costs involved in purchasing cell media and maintaining bioreactor temperatures. However, if these sorts of expenses were subsidized in the same way that meat production is subsidized in the United States, the price differential would be reduced. It is difficult to compare prices with traditional meat, because it is priced artificially low.

In the long term, costs will inevitably come down. There is the potential to take advantage of the high costs and exclusivity around cultured meat at the moment. For example, the tasting of Dr. Mark Post's hamburger was a very exclusive event. Modern Meadow is producing steak chips that also have very exclusive tastings. Investors and other public figures are trying them. While prices are high and availability is low, this sort of attention can help to brand eating cultured meat as an intelligent and responsible choice.

Regulatory concerns

Because there is no precedent for cultured meat, there will definitely be regulatory concerns when product development reaches that stage. Modern Meadow and lawyers from the New Harvest community are interested in starting a conversation with regulators now. It's impossible to predict the final product with complete accuracy, but early conversations will help developers know what sort of data to collect and other potential requirements.

Flavor

Ms. Datar is not concerned about reproducing flavor in cultured meat. It is already possible to produce good flavors from vegan yeast extracts and other animal-free sources. Ms. Datar sampled meat-flavors at a food technology conference and was very impressed. Judges from Mark Post's hamburger tasting remarked that it definitely didn't taste like a meat substitute.

Nutrition

It will be a challenge to create cultured meat that has identical iron content to animal products. This needs more research.

Cultured meat products may not be nutritionally identical to their animal counterparts. Cultured meat could be made nutritionally superior by substituting better types of fatty acids for saturated fat. Flavor may also be more important than nutrition. Most people don't eat meat for nutritional reasons.

Use of antibiotics

Currently, cell culturing relies on the use of antibiotics. Cells are exposed to bacteria when plates are opened and closed and with other human handling.

It is a challenge to minimize antibiotic use, but a well-designed bioreactor could help. Culturing cells in an aseptic environment would reduce contamination. In that setting, individual contaminated batches are still possible, but less overall antibiotic protection would be necessary.

Other consumer concerns

A lot of consumer questions, such as the extent to which people will actually eat cultured meat, may be more easily answered once the science is more developed. Currently, there are more people working on the consumer aspect and related social science questions than there are people working on developing cultured meat itself.

However, educating people about cultured meat will be important. This is one of New Harvest's goals. Once people learn more about the current status of meat production and the positive impact of cultured meat, they will be more likely to try it and pursue this area of research. It is also important to begin to inform consumers about cultured meat now, so that when it does reach the market they are well informed. Ms. Datar does not want to reproduce the controversy around genetically modified food, which was first approved in 1994, but didn't have a consumer education campaign until 2004. Transparency regarding scientific research and production will be important.

A few media sources have run polls asking about people's willingness to try cultured meat. *The Guardian* ran a poll after Dr. Post's burger in August 2013. This is probably the most unbiased poll.

Timing

It is hard to predict when cultured meat may be ready to go to the market. As more people get involved in research and entrepreneurship, the pace of progress will increase. Dr. Post predicts that a cultured meat product will be ready in seven years. Ms. Datar believes that it could be ready earlier if more momentum builds behind the project and several more researchers are focused on this work.

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