Animal Product Alternatives

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This post is the result of a few hours' personal research on the current state of animal product alternatives. This is a shallow overview: I am not a scientist; I don't work directly on animal product alternatives; I'm just an enthusiast, someone obsessed with finding and evaluating ways of doing huge amounts of good in the world. The hope is to share publicly accessible information for other non-experts.

I welcome corrections or additions from anyone who knows more.

(Why focus on animal product alternatives? Because animal products are famously terrible for animals, the environment, and very often bad for our health.)

Animal product alternatives are only on the cusp of their growth. There may be amazing opportunities altruistic people to do massive amounts of good in this space with their money, time, or effort. (How this compares to other ways to do good for animals, the environment, or health is a larger discussion that I mostly can't tackle here.)

Current progress on animal product alternatives can be divided into three categories:

- plant-based alternatives
- fermentation-derived alternatives
- cell culture-derived alternatives

In what follows, I'll first discuss the fields and briefly (and incompletely) consider how these products measure up when compared to animal products. I'll comment on the environmental impact, reported taste, cost, nutrition, and impact on animal welfare.

After that (in the last section), I'll discuss of the opportunities to get involved in making the transition away from animal products happen faster. We can think about propelling both *technological/scientific breakthroughs* and *public behaviors* of reducing or

replacing animal products. I'll comment on opportunities to volunteer, to work as an employee, and to donate.

The major conclusions I have at this time are as follows.

- ***If you're looking to donate money*** in this space (less than $50,000 in a year), either the Good Food Institute or New Harvest are your best bets, as opposed to directly funding research.
- ***If you're looking to donate talent or a career*** in this space, the greatest needs seem to be in food science and biochemical engineering, and secondarily in marketing.
- ***If you're looking to donate volunteer hours*** in this space, there are several good options worth exploring, with one good one being to engage in 'evangelism marketing' for a leading food tech company, ideally with their guidance.

UPDATE 2016.11: The Open Philanthropy institute has given the Good Food Institute a $1 million grant, roughly doubling GFI's endowment. This surely lowers GFI's room for more funding. However, it's not presently clear to me how much it lowers it.

I. Plant-based animal alternatives

Plant-based protein products go back millennia. Ancient China gave us tofu and seitan, and falafel probably came from Ancient Egypt.

Only in the late 20th century did a wide variety of mass-produced, manufactured products become introduced. Perhaps the first of these new animal product analogs was the soy-based textured vegetable protein or TVP (introduced in the 1960s). Since the 1980s, the Western marketplace has accumulated more than a score of brands of plant- or fungus-based burgers, nuggets, and sausages, as well as soymilk and other alternative milk products. Some prominent brands include Morningstar Farms (1970s), Silk plant

milks (1978), Tofurky (1980), Quorn (1985), Gardein (1990s), and Daiya vegan cheese (2008) (all dates from the respective Wikipedia pages).

A second wave has emerged in the 2010s. The trend is not simply to create analogues that are moderately convincing. Two factors seem to distinguish them from their predecessors.

- The aim is to make *perfect replicas* at the level of taste, texture, or even chemistry.
- These products market themselves to the general public rather than to niche communities such as vegetarians and vegans. For example, Beyond Meat both insists that its products *are* meat (just not *animal* protein) and takes efforts to have them stocked in the meat section of grocery stores rather than the health-food section to which the previous wave of meat analogues had been confined.

Currently, the big three companies in this space are **Impossible Foods**, **Hampton Creek**, and **Beyond Meat**.

Currently, Impossible Foods is known for the Impossible Burger, which, although made entirely from plants, bleeds like a flesh-meat burger. Hampton Creek's main products include Just Mayo, and (the currently halted) Beyond Eggs which were reported to have been as good as chicken eggs. Beyond Meat's pea- and soy-based products include Beyond Chicken, Beyond Beef crumbles and meatballs, and the Beyond Burger, which apparently also 'bleeds' like a flesh-meat burger and sold out within an hour the first time it was stocked in Boulder, Colorado.

COMPARISON TO SENTIENT ANIMAL PRODUCTS

I can't find highly conclusive evidence or numbers regarding the metrics I'd like to judge these products on. And the numbers would be important for a final evaluation—especially for the purposes of comparing plant-based meats to cultured meats, which would be important to do.

But what I can do is relay some claims about the relevant factors, with links. Mostly about Beyond Meat, given my limited research time.

1. environmental impact

veganism in general. Overall, it's well known that eating vegan is much more environmentally sustainable. According to figures from the movie *Cowspiracy*–obtained from environmentalist John Robbins's book *Diet for a New America*–the typical American diet compared to a vegan diet uses 18 times as much land, 2 times as much CO_2, 11 times the amount of fossil fuels, and 13 times the amount of water. The new wave of animal product alternatives is typically vegan–as in the case of Beyond Meat, Hampton Creek, and Impossible Foods–so it is hopefully safe to assume advantages of several times, even if not as extreme as Robbins's figures suggest.

land, water, plant inputs: Ethan Brown says Beyond Chicken is about 35x more land efficient, 15x more water efficient, and 7x more feed input efficient than raising animal chicken.

time efficiency: Ethan Brown testifies that the process of producing Beyond Chicken takes 1-2 minutes, whereas feeding comparable ingredients to chickens takes 6-7 weeks. This will help with driving production costs below that of animal chicken.

2. taste

Beyond Meat is consistently cited as being barely distinguishable from animal chicken. One case in point is the New York Times's food critic Mark Bittman.

3. cost

Ethan Brown predicts that Beyond Meat can eventually drive the cost of Beyond Chicken 25% below that of animal chicken.

There is also a huge market, with American consumers alone spending around $188 billion USD on meat products.

4. nutrition

Ethan Brown plugs various perks of Beyond Meat products as compared to animal meats: they are free of cholesterol & saturated fats, were produced without the use of antibiotics or hormones, and being lower in sodium (Beyond Chicken) or calories (Beyond Beef Crumble) while having comparable amounts of protein.

Because the products in question are so new, so too will be any research on their health effects. For the time being, Ethan Brown often compares the pressure, heating, and cooling involved in the manufacturing process to that of making bread or beer. And it is noteworthy that the process does not involve genetic modification.

5. animal welfare

Virtually no animals would be harmed in the production of entirely plant-based foods, except for animals killed during crop harvesting. Since producing animal meat almost always involves industrially produced corn and soy anyway, we can expect a lower number of animals to be killed in the overall production than for plant-based products.

II. Fermented animal product alternatives

Clara Foods is a very new startup (founded in February of 2015) working to produce artificial egg whites by fermenting genetically modified yeast. This promises not only to replace some of the 12 billion or so eggs produced solely for their whites, but also to *improve* them insofar as they should be able to find new behaviors and protein

profiles not present in animal egg whites. For more information, I recommend the relevant section of the GiveWell writeup, and these 6-minute and 7-minute talks by CEO Arturo Elizondo.

Muufri is another very new startup working to synthesize the two key proteins in milk, casein and whey, via genetically modified yeast.

Other similar, smaller startups include the following (I learned about these by googling some of the names of organizations represented at New Harvest's July 2016 Experience Cellular Agriculture conference.)

- **Modern Meadow**: production of synthetic leather (and formerly 'steak chips')
- **Real Vegan Cheese**: yeast synthesis of milk proteins & cheeses
- **Gelzen**: making real gelatin without the animal
- **Spiber**: making spider silk without spiders
- **Sothic BioScience**: making blue horseshoe crab blood without the horseshoe crab (it's used in medicine and pharma)
- **Pembient**: bioengineered wildlife products such as rhino horn & elephant ivory
- **Forelight**: Naturally derived replacements for colors and dyes used the in food & beverage, animal feed, health and cosmetic industries

COMPARISON TO SENTIENT ANIMAL PRODUCTS

Here again, I can't find highly conclusive evidence or numbers regarding desirable metrics, but I can relay some claims about the relevant factors, with links. Mostly about Clara Foods' egg whites, given my limited research time.

1. environmental impact

According to Elizondo, it takes around 636 gallons to produce a dozen eggs, but five times less (roughly 100 gallons) to produce a Clara egg white.

2. taste

From the sound of it, Clara egg whites have the potential to mimic, or even subtly vary, the taste of traditional egg whites. But this is simply theoretical, since they have not yet entered production.

3. cost

Long term, Clara egg whites promise to be more cost-effective simply because it's more efficient to start from small ingredients and construct the final product. There's no need to wait for a chicken to grow up, lay eggs after several weeks, and separate out the yolks. Again, this is simply theoretical, since settled products have not yet entered production.

4. nutrition

Long term, Clara egg whites promise to be nutritionally superior because of the potential for customization. Again, this is simply theoretical, since settled products have not yet entered production.

5. animal welfare

To my knowledge, no animals are harmed in the making of these products.

III. Cultured Meat (i.e. engineered animal tissue)

To my knowledge, work on growing meat from cell cultures—AKA *in vitro* meat, cultured meat, or clean meat—includes a handful of prominent academic researchers, and a couple of fledgling companies, all of which are still 5 or so years from putting their

first products on the market (**SuperMeat**, **Memphis Meats**, **Mosa Meat**, and **Modern Meadow**–more on these later).

Cultured meat production thus far can basically be divided into the categories of 'ground meat' and 'cultured meat' categories. (I owe these terms to GiveWell's excellent writeup.)

Ground Meat

The greatest success thus far in producing cultured meat was the production of a cultured hamburger by Mark Post, a researcher in the Netherlands' Maastricht University. The basic idea, as GiveWell explains, (and see short video) is:

- to sample muscle stem cell tissue through a biopsy (i.e. removal of muscle tissue, using pain relief)
- encourage these cells to divide within a special scaffold
- allow them to mature and 'get exercise' through automatic contraction, and
- combine the muscle strands with each other along with "color, flavor and texture enhancers, such as separately grown fat tissue".

This was achieved successfully in August 2013, when the first artificial burger was officially tasted at a London news conference (see 1-hour video). Funded by Google founder Sergey Brin, the burger cost around €250,000 to produce (roughly $325,000). However, in 2015, Dr. Post optimistically estimated—via what metrics I'm rather unsure—that the cost could soon get down to a more reasonable $12 USD per burger (or $80 USD per kg). (Other estimates of eventual large-scale production price have been as different as $3.86 per kg and $430 per kg.)

Another breakthrough was that Memphis Meats created a lab-grown meatball in February 2016 that cost $18,000 to make.

Slab Meat

Most meat products consumed today are not ground-up bits of muscle tissue, such as a hamburger, but rather are large whole pieces of tissue with a characteristic fibrous structure. Givewell calls this 'slab meat'. To displace the current market for things like steaks, pork chops, and chicken breasts, cultured slab meat would need to be made. This is harder, and no one has accomplished this. Yet.

The most prominent academic research on slab meat is a $25,000 feasibility study by tissue engineering expert Amit Gefen of Tel Aviv University since January 2015 on slab chicken meat. It was funded by the Israeli nonprofit Modern Agriculture Foundation and as of July 2016 and appears to be ongoing.

Organizations

Somewhat promisingly, the leading scientific researchers in this area are all starting to gravitate toward new startup companies. This is promising because it indicates that experts most knowledgeable about the technologies are willing to put their names behind scaling up the technologies rather than redoubling research efforts. Pairing company with researcher:

- Memphis Meats (San Francisco) – Dr. Nicholas Genovese
- Mosa Meat (Netherlands) – Dr. Mark Post
- SuperMeat (Tel Aviv) – Dr. Yaakov Nahmias (with Dr. Amit Gefen apparently involved with related research funded by the Modern Agriculture Foundation)

Modern Meadow formerly produced a unique 'steak chips' product, but has since shifted its focus solely to producing artificial leather.

COMPARISON TO SENTIENT ANIMAL PRODUCTS

Here again, I can't find highly conclusive evidence or numbers regarding desirable metrics, but I can relay some claims about the relevant factors, with links. Mostly about SuperMeat, given my limited research time.

1. environmental impact

According to the BBC, an independent study (not clear which) lab-grown beef of the variety produced in Mark Post's 2013 experiment "uses 45% less energy than the average global representative figure for farming cattle. It also produces 96% fewer greenhouse gas emissions and requires 99% less land."

SuperMeat's promotional video claims that their style of cultured meat uses 99% less land, up to 96% less greenhouse gas emissions, and uses up to 96% less water. However, they do not provide support for this claim.

Uma Valeti, chief executive of Memphis Meats, has claimed that "her company's process [of making cultured meatballs] produces 90 percent fewer greenhouse gas emissions than traditional agriculture."

2. taste

The first in vitro burger was given decent but not overwhelming reviews. Same for the meatball.

Taste competitiveness should presumably be less of an obstacle if the objective is to grow a whole organ, since all factors contributing to taste should presumably be present.

3. cost

There are numerous obstacles to getting even cultivated ground meat off and running, as GiveWell aptly details. These obstacles include

- Finding cheap animal-free media for supporting muscle cell growth
- Establishing canonical cell lines to use for cell replication
- Designing efficient scaffolidng

- Developing efficient methods of harvesting and assembling a large number of muscle cells from the scaffold/bioreactor into the final meat product
- Finding methods to maintain sterility at lower cost
- Creating and maintaining industrial-scale bioreactors.

4. nutrition

Equivalent or potentially customizable. Remains to be seen.

5. animal welfare

My sources are inconsistent about the involvement of fetal bovine serum. Traditionally, this substance, extracted from fetal calves, has been used to replicate cells. New Harvest says Mark Post did not use fetal bovine serum to produce the in vitro burger in 2013; othersources seem to indicate that he did. What is clear is that finding an alternative—which Post indicates would probably come from algae—is one hurdle to clear on the way to industrial production.

SuperMeat indicates that their model does not require fetal bovine serum. What I'm unclear on is precisely what chemical medium their cultured chicken meat will grow in.

Although acquiring initial cells requires that an animal must be undergo a biopsy, I don't know why this would be especially painful or traumatic to a typical animal if done with anesthesia.

IV. Should people focus on plant-based or cultured meat?

Despite pessimism I've seen from GiveWell about cultured meat, and from Jesse Cliftonabout both plant-based and cultured meats, I think we should be rather optimistic about all three forms of potential animal products we've seen.

The reasons to be pessimistic about cultured meat I see being cited:

1. There are significant hurdles to cost- and taste-competitiveness (GiveWell)
2. There are inconsistencies in forecasts about time to market (Clifton & GiveWell)
3. Plant-based meats are far enough along to make much cultured meat research obsolete (Anonymous)
4. Public adoption of plant-based meats is likely to be low (Clifton)

To (1) I would quickly raise the following points.

- *Failure is still progress*: even if one of the companies like SuperMeat or Memphis Meats never becomes commercially viable, the world will learn a lot from their failure. This is
- *The leading researchers are putting their names behind for-profit companies*; this warrants an equivalent level of confidence in cultured meat technologies to scale and improve.
- *(Not one but) two soon-to-be commercialized* products have now been produced, by independent researchers (Post's burger and Genovese's meatball)
- *Customization* will eventually be sufficiently achievable—with plant-based and cultured products alike—that we should expect it to out-compete animal flesh-meats in the long run
- *The significant resource savings* suggest that, eventually, cultured meats will be more efficient to produce than sentient animal flesh-meats in the long run

To (2) I would simply point out that a lack of consensus is not itself a reason for pessimism about anything other than people's ability to predict the future—not about their abilities to innovate.

To (3) I would say that this point harbors a wildly overly optimistic view about plant-based products' ability to replace everything people want out of animal products. Thinking of both the huge variety of animal products, and of how some people demand very strict replicas, we need every tool available. For example, no one is making any plant-based alligator meat. But if in vitro technology improves enough, it could be used on any number of species, rather than necessitating use of yet a different plant and different manufacturing process.

To (4), I think the extent of public adoption simply remains to be seen; we need data about the public's opinions—over time, and after various interventions—before any skepticism or optimism can be warranted.

Perhaps the clearest conclusion we can draw about what is progress is that animal products that are easy to *perfectly* replicate are worth doing—and this is precisely what Clara Foods is doing with egg whites, for example.

For the purposes of promoting products, the products must exist before anyone can promote them. So volunteers will by default currently have to focus on plant-based products.

People giving money should focus on whatever is the least well-funded, which is currently cultured meat for the most part. But keep reading: really we should privilege funding boards or outreach organizations as a default.

V. Opportunities to Help

A. As a Donor

All three categories seem to have greater need for talent than for money. This is especially true of the plant-based field, where the big three new startups have budgets of eight or nine digits (in U.S. dollars). Similarly, the constraint in the fermentation and cultured meat fields is talent not money, although to a lesser extent: most firms here currently have budgets of only a couple million dollars.

The talent needs for employees mostly seem to be in science, and secondarily in marketing.

In my estimation, there is also enormous space for many people to help popularize products and ideas behind them as volunteers.

1. Room for More Funding

According to GiveWell's writeup, the three leading startups in this field seem to be enormously well-funded with seed capital. Bill Gates, along with many other venture capitalists, has funded all three companies to the tune of many millions: as of December 2015, the funding for Impossible Foods was $183 million, Hampton Creek $120 million, and it appears that Beyond Meat has raised around $17 million. Thus, opportunities for ordinary small and middle-level donors to become involved with well-off-the-ground plant-based animal product replacement companies are bound to be slim. This could be different, however, for other, less prominent companies I'm not covering here.

Clara's endowment is approximately $1.7 million.

Muufri's biggest grant was apparently $2 million.

SuperMeat thinks they need $2.5 million to get up and running, and as of July 21, 2016 have just exceeded a $100,000 crowdfunding goal for an initial phase (thanks to an impressive 2447+ backers).

About the other companies I've mentioned, I am not aware of their budget status. I'd love to be updated on this.

2. How to actually use money in this space: Funding Boards

The best interfaces for the public to get involved in the field seem be *indirectly*, by sending it through key funding/advisory boards—such as these nonprofits:

- **New Harvest** – San Francisco, USA
- **The Good Food Institute** (GFI) – USA

- **Modern Agriculture Foundation** – Israel
- **New Crop Capital** – USA

All these organizations seem to play some combination of the following major roles:

1. Funding aspiring companies and research projects
2. Promoting the projects and the products they produce

New Harvest seems focused more on the first goal, having played a major financial and advisory role in both Muufri and Clara Foods. They're focused almost entirely on innovations in the cellular agriculture space.

The Good Food Institute's work spans both to promoting plant-based and cultured meat alternatives. One of the more important aspects of their work is to create new interest in food science research and connect interested parties with opportunities to do good in the food science community. As importantly, it seems that an organization like this one will be reasonably heavily involved in facilitating public acceptance of meat alternatives—no easy task once we realize the powerful influence of disgust on people's reaction to new food ideas.

Modern Agricultural Foundation is a funding and advisory board for cultured meat research and entrepreneurship.

New Crop Capital functions mostly as a funding board for animal product alternatives of most any kind.

3. Well, Which One?

Which of these organizations should we support with marginal money or time? While I don't have sufficient knowledge or criteria for decide between them, they certainly *all*deserve our attention. At any point, they could present amazing opportunities to do good that eager, attentive altruists can snatch up.

One observation is that, for typical donors giving a few hundred to a few thousand dollars a year, helping funding boards is hard. This is because this requires a fair amount of coordination to provide significant seed money for a tech startup. Crowdfunding campaigns provide for this, but seldom do you find a crowdfunding campaign for someone to decide *between* projects (although that is an interesting idea!).

This makes GFI a rather interesting project. Suppose additional money would pay (for example) for some high-impact outreach by GFI. Even a low-level donor could fund one or two extra outreach efforts that could reach a few hundred more potential scientists who could change the next generation's food. This would be less conditional on others also donating.

On the other hand, GFI is merely an accessory to innovation, merely inspiring others to do the good work.

Really my final verdict for now about how to *donate* is that whether to prefer good food advocacy (à la GFI) or startup provision depends on the question of whether the existence of the product will fuel consumption, or whether consumption of the product will fuel innovation. Where I sit, I'm aware that the interest in all of the above products —especially Beyond Meat, Hampton Creek, Impossible Foods, and Memphis Meats—is rather intense.

So tentatively I suggest to the low- or middle-tier donor (again, I mean someone who will give a few hundred to a few thousand in a year) to look with a critical eye for solid crowdfunding campaigns, fund really promising ones if they exist, but otherwise to donate to GFI.

By contrast, someone looking to donate sums of 5 or more digits could pay for larger portions of a project's seed funding, and in that case they should explore options at the funding boards (possibly independent of any crowdfunding campaign and beyond what I've looked into here) before defaulting to GFI.

B. As An Employee or Entrepreneur

Looking at the jobs pages on the relevant startups' websites, they seem to be looking mostly for scientists and secondarily for marketers or product promoters. As of this writing, Impossible Foods advertises 4 jobs, all in product development; Beyond Meat advertises 4 jobs in scientific R&D and 1 in brand innovation; for Hampton Creek advertises 11 jobs in scientific R&D, 10 jobs in operations, and 5 jobs for product, plus a few other miscellaneous positions. Similarly, Clara Foods' job ads are mostly for scientists.

Someone deciding on a career who has the ability to go into food science should consider it—for more see 80000 Hours' writeup on high-impact science.

Another way to be employed in this sphere could be in non-profit advocacy, basically a role of communicating about the relevant science and technology and its importance. The Good Food Institute is currently advertising a job called Director of Corporate Engagement.

It's also notable that there are a lot of opportunities for totally new startup ideas in the short term. Just as an easy laundry list, I know of no one currently working on artificial versions of any of the following products:

- feathers / down
- suede
- fur
- wool
- honey
- beeswax
- blood
- bone (other than ivory/horns)
- isinglass
- lard
- etc.

- products that mix in vitro with plant-based solutions (cf. GiveWell point)
- products that genetically modify the meat to encourage cell growth (cf. GiveWell point)

C. As A Volunteer

There are plenty of ideas for how to volunteer, outside of giving money or working a job in the field.

Volunteers can be especially key to promoting specific products and the ideas behind them. Essentially, as a form of animal and environmental advocacy, people can engage in various forms of 'evangelism marketing' for the companies we've mentioned. And of course they should feel free to mix this with other forms of animal or environmental advocacy as they see fit. Presumably GFI (along with other parties who help sponsor or coordinate such grassroots outreach work, such as VegFund or The Humane League) can or will or should assist local individuals with projects of this sort.

Try any or all of the following, in approximately this order.

1. Gather 1-50 friends and write to a company–say, Beyond Meat. Ask them if you can be **brand evangelists** for them. Let them guide you about how precisely to do this.
    - Maybe you'll pass out coupons
    - Maybe they'll give you discounts; maybe not
    - Maybe they'll help you set up taste tests inside a store
    - Etc.
2. With or without the help of this company (or that of VegFund), set up as much of a **food tasting** (and/or Ask A Vegan) table as you reasonably can.

- Preferably inside a grocery store that sells the product if you can arrange this.
- Strongly consider making a **video** of this and publishing it on social media
  - Emphasize in the video that you were strictly a volunteer
  - Include statistics, if impressive, about
    - how many people thought the product was "real" meat from an animal who died.
    - how many people ended up buying the product (the company will almost surely track this if you're in a particular grocery store)
- Negotiate / coordinate with the company about precisely what sort of **literature** to bring along. Maybe they'll insist it all be company literature; or maybe you'll go with all Vegan Outreach type leaflets; or maybe some mixture thereof.

3. Get every friend you have to share the heck out of relevant stuff on **social media**. In a way that's appealing to the target audience, which is probably meat reducers.
4. Get every friend you have to **write** to some particular series of news outlets about the fascinating, important trend in meat alternatives (perhaps using the above taste test, if it happens, as a news piece).
   - *Forget the new iPhone, these days all the cool kids are lining up for the new Beyond Burger!*
   - Write to grocery stores or restaurants urging them to carry a certain product (perhaps using the above taste test, if it happens, as an indicator that they should try it).
   - Start a Change.org campaign along with any of these steps
   - Write op-eds and letters for newspapers about these things.
5. Get every friend you have to write to every **government official** they have about the need to put government dollars toward research on animal product alternatives.
6. See this page at Animal Charity Evaluators for other animal advocacy ideas such as reaching out to evildoing corporations and leafleting.