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MSCI Thematic Insight

Subject Area: **Food Revolution**

The Future of Proteins?

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Introduction

Food trade shows continue to be almost overwhelmed with innovations around plant-based products following the surge of interest in animal-product alternatives that accompanied the IPOs of companies such as Beyond Meat (2019) and Oatly (2021)[1]. However, in today's very different economic environment, plant-based sales are stalling in many countries[2] and some players are even moving away from this market[3]. In this thematic insight, we review some of the structural reasons that drove those investments into alternative protein companies, the types of products currently being developed, as well as the challenges the companies face right now and that may have to overcome in the future.

1 For example, the biennial "The Global Food Marketplace" trade fair (in French, Salon International de l'alimentation, or SIAL) held in October 2022, which specializes in the food processing industry, as reviewed in Le Monde.

2 https://www.ft.com/content/9cb81801-eb42-455c-ad3e-805fb9bd46c7

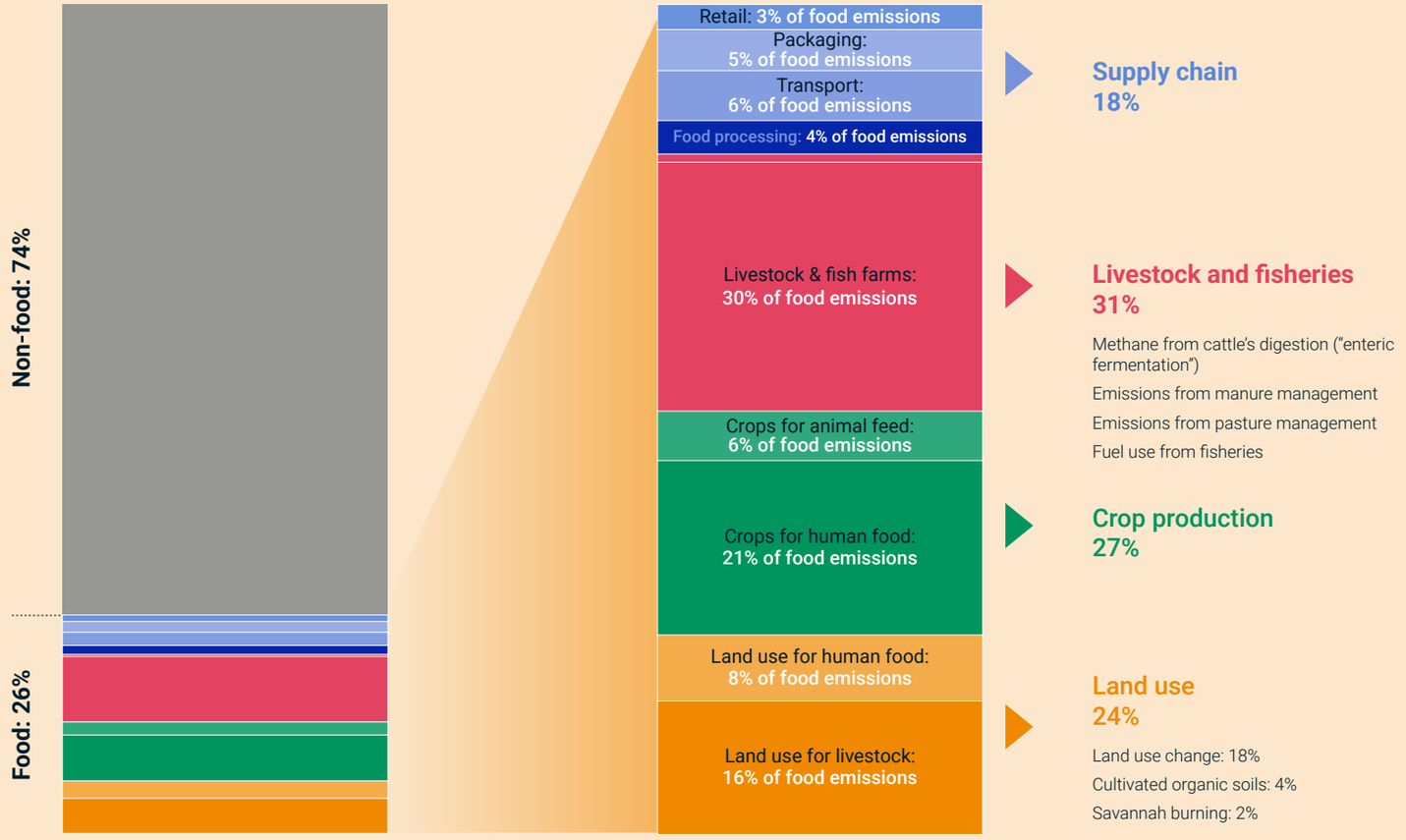
3 JBS closed its US plant-based food business (https://www.reuters.com/business/retail-consumer/meatpacker-jbs-close-us-plant-based-foods-business-planterra-2022-10-03/) and McDonald's ended its plant-based McPlant burger in the US (https://www.restaurantbusinessonline.com/food/mcdonalds-ends-its-plant-based-test-us-now-what)

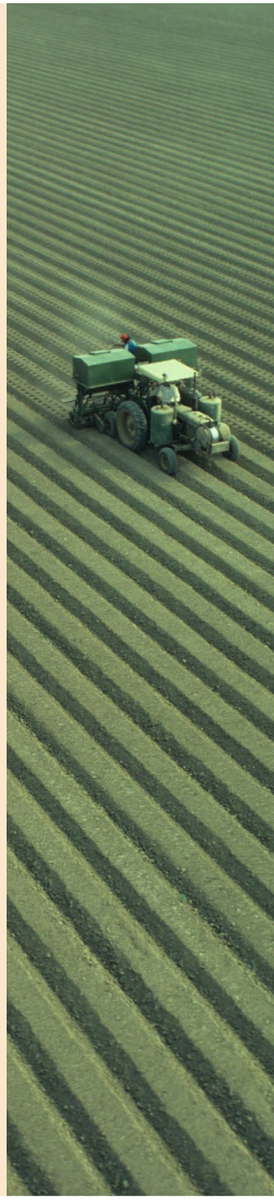
Why have proteins been **placed at the core of the Food Revolution?**

Our current food system is a very significant contributor to climate change risk: it has been estimated that it is responsible for more than 26% of global emissions[4]. Digging down, we see that the main contributors are livestock and fish farms. When combined with their associated land use and animal feed requirements, they alone account for 14% of all emissions. There is, of course, much country variation. Crops to feed animals are proportionally more extensive in places like the US and Brazil, while livestock practices vary widely.

Exhibit 1:
Global greenhouse gas emissions from food production

Source: FAO: Our World in Data. Original Chart by Hannah Ritchie reproduced under CC-BY with data drawn from Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.





4 Based upon the meta-analysis of 570 studies as contained in Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.

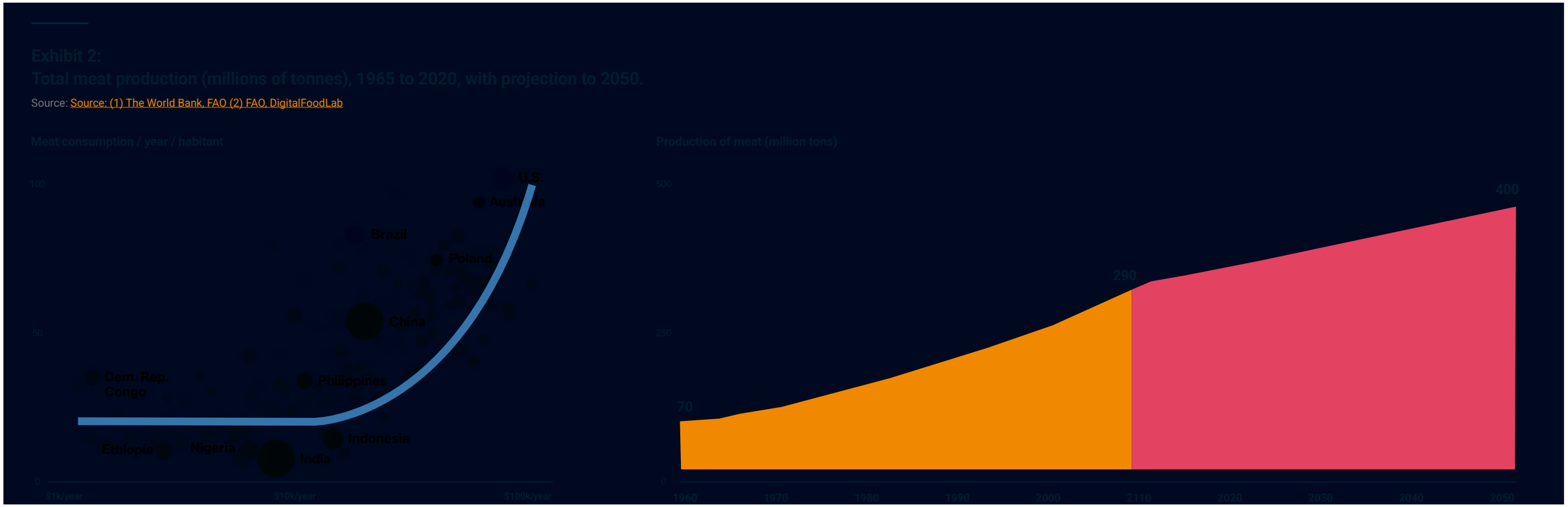
As shown in Exhibit 2, this climate crisis imperative is fighting against the recent trends in population and income growth. Meat consumption in any given country has been strongly associated with the per-capita income level. Consumers have increased steadily their meat intakes as soon as annual income per capita has reach global "middle-income status" (around USD10k/year). Somewhat surprisingly, there is no obvious cultural bias to this trend: meat consumption has increased even in countries with a high vegetarian population like India (where poultry production has quadrupled since 1960).

Aside from fighting climate change, health is also central to arguments or lower meat consumption. The link between meat consumption (especially highly processed meats) and health[5] issues such as cardiovascular diseases and certain types of cancers has become more and more established. Consequently, public policy has been becoming more aligned with trying to discourage the excessive consumption.[6]

While environmental, health and animal welfare concerns have been the main drivers behind the desire for alternatives to animal proteins, even in the richest Western countries, overall meat consumption has not declined in the past decades. Consumers may be moving away from beef towards poultry and fish but are not sustainable either. This tension between a growing demand for proteins and the fight against climate change is the catalyst for investigating the potential of alternative proteins.

Exhibit 2:
Total meat production (millions of tonnes), 1965 to 2020, with projection to 2050.

Source: Source: (1) The World Bank, FAO (2) FAO, DigitalFoodLab



5 https://eatforum.org/lancet-commission/eatinghealthyandsustainable

6 Such policy moves have been seen not just in US and Europe but also, for example, in China. The Netherlands has seen city-level action with Haarlem, for example, banning advertising of some meat.

What are the **Alternatives?**

The space of alternative proteins is much wider than often thought. There are multiple different potential technologies, and more than a few of them are already available. This space can be split between "alternatives" and "substitutes". Alternatives include, for example, many traditional products such as tofu or tempeh that don't try to replicate the look or taste of animal proteins. Conversely, substitute proteins seek to mimic the texture, taste and functionalities of their animal equivalents.

Exhibit 3:
Alternative and Substitute Proteins – present and future
Source: Digital FoodLab

There is intense commercial and academic research seeking ways to create alternatives to the proteins we consume today[7]. Most solutions under development remain far from the supermarket shelf, and even those available today have great scope for improvement. We can distinguish at least four types of alternative protein:

- **Plant-based products:** these are perhaps the most well-known with many products already available to consumers. Leaders include large food conglomerates like Nestlé and Kellogg's along with high profile disrupters such as Oatly, Beyond Meat and Impossible Foods. This category is now facing multiple challenges as sales have gone stale, after the initial boom.
- **Biomass fermentation:**[8] the aim is to identify bacteria or fungi that can produce a large quantity of protein (biomass) through fermentation. Quorn (owned by Monde Nissin) is the probably the most well-known and long-standing example while new entrants include companies like Nature's Fynd (which is itself backed by a food major in Danone).
- **Precision fermentation** involves the genetic modification of a strain of yeast to produce through fermentation a target protein. To date, this has been mostly used to create dairy and egg proteins[9]. This is a field with many startups but one current leader (Perfect Day). Large companies are also now entering the field through partnerships (for example, Nestlé[10] and General Mills[11] with Perfect Day), in-house R&D and by creating dedicated ventures (Fonterra, the world's largest dairy coop, did so with DSM[12]).
- **Cellular agriculture** involves the use of animal cell cultures to re-create, for example, proteins and fats. This can support many applications: not just meat, seafood and dairy products but also ingredients[13]. Again, this is currently dominated by private company startups with just a few listed[14]. For most, their ability to scale their production remains in doubt.

Singapore was the first country to authorize the sale of some cellular agriculture products[15]. Each company has to ask for a regulatory approval for each new product, and even then distribution is extremely limited by low supply. Aside from regulation and scaling production, creating products with the appearance and texture of meat may take many years. The US joined Singapore at the end of 2022 with an FDA approval for Upside Foods[16].

7 The Good Food Institute reported USD 5 billion invested in alt proteins in 2021, up some 60% from the prior year and well spread across the categories. In Europe, there has been research from both national governments (e.g. the Netherlands) as well as the EU as a whole.
8 See, for example, https://gfi.org/fermentation/ for an overview.
9 https://theeverycompany.com/do
10 https://www.foodnavigator-usa.com/Article/2022/09/12/Nestle-teams-with-Perfect-Day-to-pilot-animal-free-milk-elevating-the-concept-with-its-clout-scale
11 https://www.fooddive.com/news/general-mills-launches-animal-free-dairy-cheese-brand-bold-cultr/610159/
12 https://www.foodingredientsfirst.com/news/fonterra-and-dsm-introduce-precision-fermentation-start-up-for-dairy-like-proteins.html
13 To date, these are mostly alternatives to animal fats from companies like Hoxton Farms in the UK, cultimate in Germany or nourish ingredients in Australia.
14 There are a few listed funding vehicles like CultFoodScience (cellular agriculture and Agronomics (broader biotech and proteins) as well directly listed entities such as SteakHolder Foods.
15 https://www.cell.ag/blog/singapore-gives-regulatory-approval-for-eat-just-cell-based-chicken
16 https://www.fda.gov/food/cfsan-constituent-updates/fda-completes-first-pre-market-consultation-human-food-made-using-animal-cell-culture-technology

Beyond **Animals**

When considering alternative proteins, we have focused on alternatives to animal products such as meat, seafood and dairy. However, other food products have notable environmental impacts and alternatives are being developed for them. Examples include coffee and chocolate (whose climate impact has exceeded pig meat), honey (for biodiversity reasons) and even vegetable oils (for example, C16 Biosciences has promoted its alternative to palm oil[17] while Zero Acre has focused on vegetable oils that are better for plant-based food.[18])

Additionally, we have yet to discuss the importance of insects and algae as potential sources of proteins. Both are examples of innovations that have failed to reach mass market. Today, they are used for animal feed and pet food (insect-based)[19] or as a source of functional ingredients (as substitutes to additives, based on algae).[20]

Precision fermentation and other technologies can be used for many other applications, notably key components of honey, coffee and cacao. It can also be used to create healthier alternatives to ingredients and additives such as fats, sugar or preservatives. Synthetic biology has the potential to transform the current food system and supply chains.

17 https://www.foodnavigator-usa.com/Article/2022/11/28/c16-biosciences-gears-up-to-launch-fermentation-based-palm-oil-replacement-for-personal-care-in-2023-food-in-2024

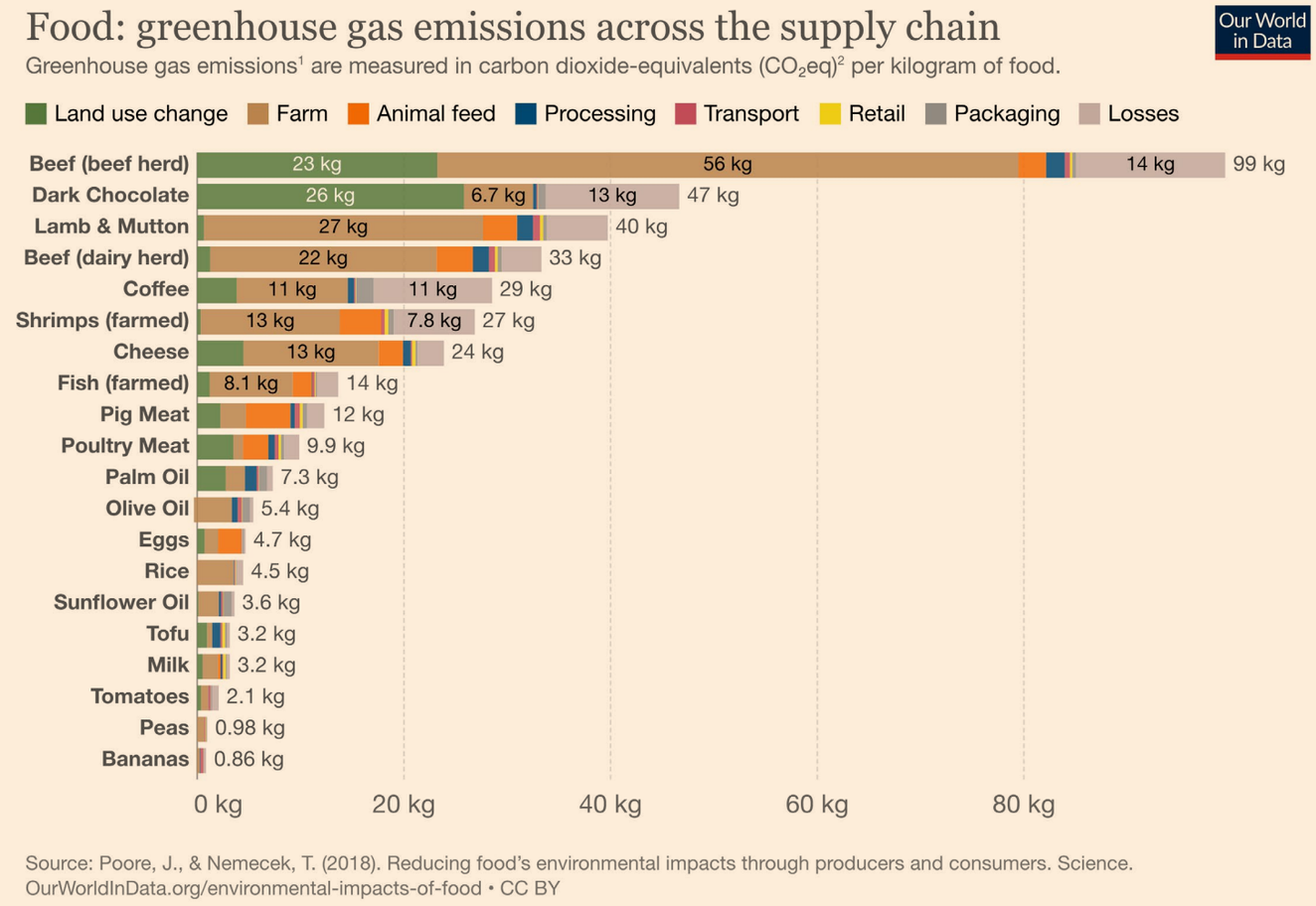
18 https://techcrunch.com/2022/02/02/zero-acre-biotech-fermentation-alternative-to-wasteful-unhealthy-vegetable-oils/

19 https://www.digitalfoodlab.com/%F0%9F%90%B6-future-petfood/

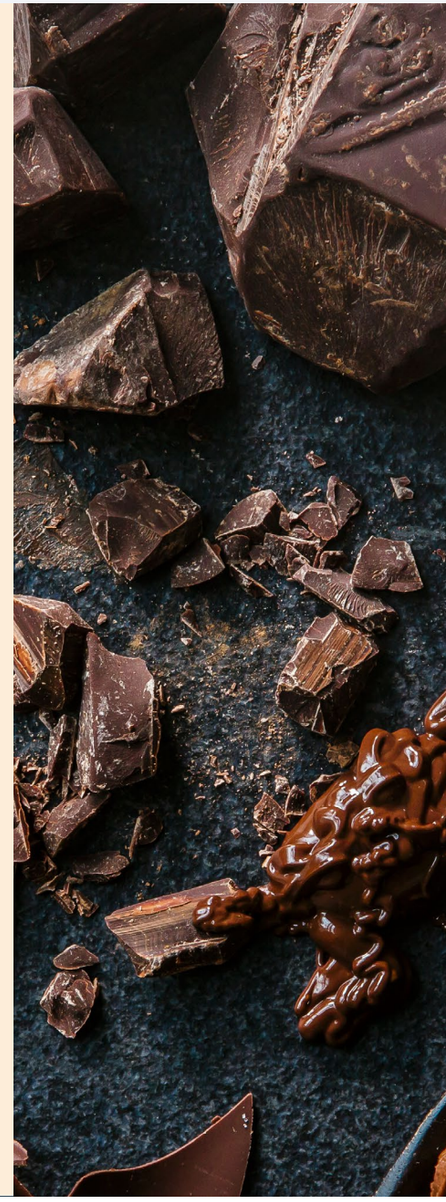
20 https://microphyt.eu/

Exhibit 4:
Greenhouse gas emissions across the supply chain (CO2 equivalents)

Source: FAO, Our World in Data



Source: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science.
OurWorldInData.org/environmental-impacts-of-food • CC BY



What are the Challenges for **Alternatives?**

After a cycle of rapid growth, sales of plant-based meat have been stagnating for more than a year in the US amidst higher inflation and the cost-of-living crisis. Plant-based meat currently represents only 1.4% of the sales (by value) in the US, although plant-based milk has reached 16%[21]. In the table we outline some of the key current and structural challenges for this emerging alternative protein sector.

	Circumstantial		Structural		
Challenges	**Capabilities**	**Price**	**Taste & Texture**	**Nutrition & health**	**Acceptance**
Current state	Downstream capabilities (factories) too limited to sustain the demand. Upstream there is a limited supply of suitable crops.	Plant-based meat prices too high (plant-based milk is near-parity in some countries)[22]. Reaching price parity could increase significantly sales. For other alternatives, price is higher still vs. animal proteins (2x to 10x multiplier).	Many alternatives are not considered convincing enough by consumers both in terms of taste and texture.	Health is a key reason for consumers to buy plant-based products. However, the high level of processing in available products is a growing concern.	Many industry players expected plant-based alternatives to be strongly welcomed by consumers. However, they are facing strong social debate. This is even truer for more "technical" alternatives.
Short term developments	Many facilities would need to be built globally for plant-based meat and milk	Increasing production capabilities.	In 2023, "whole cuts" of meat or seafood should be released by food majors. Taste remains a key focus of R&D.	New, cleaner recipes are being developed.	Alternative protein players (big and small) are creating their own lobbies.[23]
Longer term industry objectives	New crops with higher yields and better functionalities are being developed.	New alternatives have a price curve that is similar to wind or solar energy with a steep decrease year over year. They could reach parity by 2030. A carbon taxes on meat may play role in reaching parity.	Hybrid products (mixing plants with precision fermentation or cellular agriculture ingredients) could help to improve dramatically the taste of the products.	The use of ingredients from precision fermentation and cellular agriculture should help simplify the recipes. New crops could also help.	Some governments have become supportive of alternatives as an element of their green policy. How to make alternatives more socially "acceptable" and desirable remains an open question.

To date, governments have been somewhat ambivalent when considering alternative proteins. Some have been historically supportive including Israel, Singapore and the Netherlands[24]. Other major governments have more recently displayed some interest:

- in the US, a recent executive order signed by the president is aiming at maintaining the country's advance in biotechnology[25]
- in China, the last edition of the five-year plan (released in 2022) mentions cellular agriculture.[26]
- the EU is financing research projects around alternative proteins.[27]

Beyond the discussion of social normalisation, many countries are debating the way alternative proteins (mainly plant-based products) should be named. In the US, recent legal battles have ended in favor of the use of "meaty" and dairy names being used by their plant-based equivalents.[28] Conversely in the EU, many dairy names are banned for milk substitutes following an ECJ ruling[29] while South Africa banned the use of "meaty" names for plant-based alternatives was banned in the summer of 2022.[30]

Precision fermentation and cellular agriculture products are not yet authorized in any major market. For the former, it may be more straightforward as many ingredients based on this technology are already widely used in the pharma and food industries. However, for the later, the process will likely be long and complex, especially in the EU.

21 https://www.plantbasedfoods.org/2021-u-s-retail-sales-data-for-the-plant-based-foods-industry/
22 For example, recently in Canada or the UK.
23 For example, in the US https://www.plantbasedfoods.org/ and in the EU https://ensa-eu.org/ and https://plantbasedfoodalliance.eu/
24 https://www.foodnavigator.com/Article/2022/03/17/a-sign-of-strong-political-support-for-cellular-agriculture-dutch-house-of-representatives-votes-in-favour-of-cultivated-meat-tastings
25 https://www.whitehouse.gov/briefing-room/presidential-actions/2022/09/12/executive-order-on-advancing-biotechnology-and-biomanufacturing-innovation-for-a-sustainable-safe-and-secure-american-bioeconomy/
26 https://vegconomist.com/politics-law/five-year-agricultural-plan/
27 EU Horizon initiatives are outlined in https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl6-2022-farm2fork-01-07 and https://gfieurope.org/blog/horizon-europe-announces-e32-million-for-sustainable-proteins/
28 Courts cases include those in Mississippi and Arkansas.
29 https://www.dairyreporter.com/Article/2017/06/14/Plant-based-products-can-t-use-dairy-names-European-Court-of-Justice
30 https://www.iol.co.za/news/environment/look-no-more-meaty-names-for-plant-based-foods-in-sa-b8873d58-3604-4d8d-8703-bab4e27fcb70

Next Step: **Infrastructure**

All technologies mentioned, except plant-based, the process happens in a bioreactor, in which pressure, temperature and other environmental variables can be controlled. Advances in such devices seem likely to be the key to the future of alternative proteins. Those existing today are not well suited to the most advanced technologies and remain in short supply. Moreover, as a company advances a new product, it has to scale production from small tanks to larger ones. The large number of startups in the space would seem to imply they have to buy bioreactors of small and medium sizes that become useless rapidly as progress achieved.

This is creating an opportunity for large companies and consortiums, such as that created by Givaudan, Bülher and Migros, to establish labs where other smaller companies can experiment with a set of bioreactors. Meanwhile, other players are looking to create a cloud computing infrastructure around the bioreactors so that rental period could be shrunk to the time of active use. This could accelerate the time to market for technologies such as precision fermentation while also creating a new element of the alternative protein ecosystem.

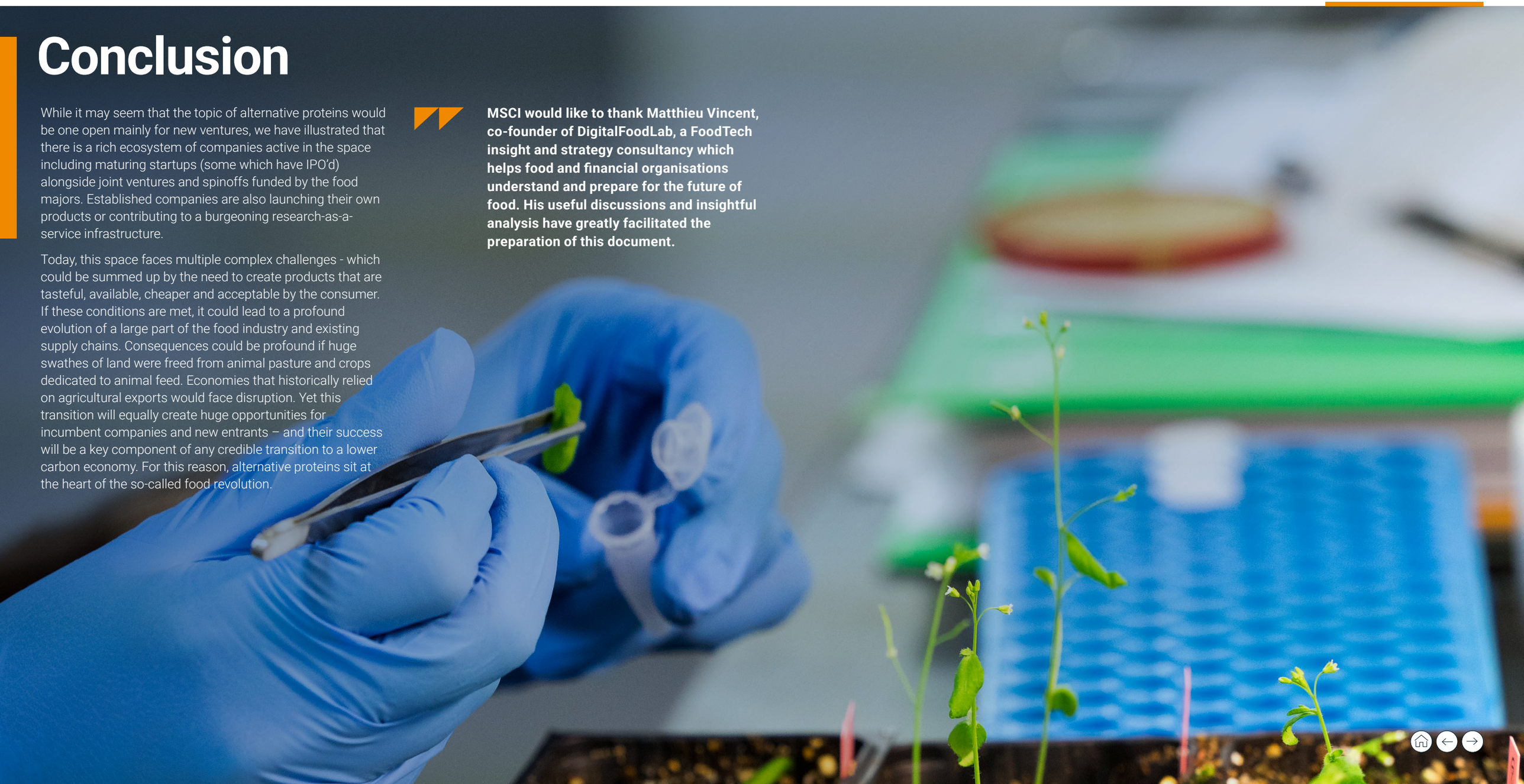
See, for example, https://www.thecultivatedb.com/ , https://www.planetarygroup.ch/ or https://www.adm.com/en-us/news/news-releases/2022/adm-and-temaseks-asia-sustainable-foods-platform-inaugurate-scaleup-bio-joint-venture/

Conclusion

While it may seem that the topic of alternative proteins would be one open mainly for new ventures, we have illustrated that there is a rich ecosystem of companies active in the space including maturing startups (some which have IPO'd) alongside joint ventures and spinoffs funded by the food majors. Established companies are also launching their own products or contributing to a burgeoning research-as-a-service infrastructure.

Today, this space faces multiple complex challenges - which could be summed up by the need to create products that are tasteful, available, cheaper and acceptable by the consumer. If these conditions are met, it could lead to a profound evolution of a large part of the food industry and existing supply chains. Consequences could be profound if huge swathes of land were freed from animal pasture and crops dedicated to animal feed. Economies that historically relied on agricultural exports would face disruption. Yet this transition will equally create huge opportunities for incumbent companies and new entrants – and their success will be a key component of any credible transition to a lower carbon economy. For this reason, alternative proteins sit at the heart of the so-called food revolution.

MSCI would like to thank Matthieu Vincent, co-founder of DigitalFoodLab, a FoodTech insight and strategy consultancy which helps food and financial organisations understand and prepare for the future of food. His useful discussions and insightful analysis have greatly facilitated the preparation of this document.



Contact us

AMERICAS	
US	+1 888 588 4567 (toll free)
Canada	+1 416 628 1007
Brazil	+55 11 4040 7830
Mexico	+52 81 1253 4020

ASIA PACIFIC	
China	North: 10800 852 1032 (toll free) South: 10800 152 1032 (toll free)
Hong Kong	+852 2844 9333
India	+91 22 6784 9160
Malaysia	1800818185 (toll free)
South Korea	00798 8521 3392 (toll free)
Singapore	800 852 3749 (toll free)
Australia	+612 9033 9333
Taiwan	008 0112 7513 (toll free)
Thailand	0018 0015 6207 7181 (toll free)
Japan	+81 3 4579 0333

EUROPE, MIDDLE EAST & AFRICA	
South Africa	+27 21 673 0103
Germany	+49 69 133 859 00
Switzerland	+41 22 817 9400
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