

Thematic Research The Great Protein Shake-up?

17 September 2019

Key Takeaway

Alternative meat is seen as a disruptor of the global meat industry. This is a formidable proposition. The meat industry stands at over \$1.4tn and is set to reach \$2.7tn by 2040. Alternative meat is still in an embryonic stage (our best case is \$470bn of total meat market by 2040, worst case a mere \$90bn). But such disruption is not without precedent (GMO, dairy) - could a potential Meat Tax and the ongoing crisis in China's pork industry be the catalysts?

Global meat consumption projected to grow at 3% CAGR to 2040. The world's food economy is increasingly being driven by a shift of diets and food consumption patterns towards livestock products with global meat consumption growing at 4% CAGR in volume terms over 1990-2018. Poultry and pork continue to undergo a significant increase in production and consumption. Per capita meat consumption increased 93% over 1990-2018. As a result of all this, we forecast meat consumption in US dollar terms to grow globally at 3% CAGR over the next two decades.

An emerging alternative meat industry is gaining a foothold. There have long been alternatives to meat in the form of vegan and vegetarian alternatives, but these have typically been on the fringe of the market. However, new technologies in the form of plant-based alternative and a cellular-based (lab created) meat have been making significant breakthroughs. Currently, plant-based alternatives are ahead in the commercialization process, with one company, Beyond Meats (BYND), recently listing, and others seeking to grab market share. The cellular-based alternative meat industry does not yet have a commercially available product and is currently very expensive. We forecast the alternative meat industry could win 9% market share by 2040, which equates to \$240bn in revenue.

A Meat Tax or China's pork crisis could become catalysts. There are emerging calls for a Meat Tax, given the impact on the climate and increasing focus on the possible negative health consequences of a meat heavy diet. The recent introduction of increased sugar taxes around the world is one example of how the meat industry could be subject to a similar tax. Our bull case factors in a globally introduced Meat Tax of 10% in 2025 that sees alternative meat gaining 17% market share by 2040, equating to revenue of \$470bn.

Plant-based alternatives are first-movers, but cellular meat could overtake. A three-way battle for market share is taking place between the plant-based alternatives for which there are already commercial products, the cellular-based lab meat developers who are still trying to bring a product to consumers, and players in the traditional space who will try to protect their existing market while hedging their bets with investments and forays into the alternative meats space. The cellular meat players need to deliver a 10-40x cut to production costs to compete with traditional meat. We believe this would come through cuts in the cost of growth medium and larger bioreactors.

Watch out for Jefferies Alternative Meats Day in New York in early December 2019



Selected Plant-based Meat Companies

Country	Company	Ticker
USA	Beyond Meat	BYND US
USA	Good Catch	Private
USA	Impossible Foods	Private
UK	Moving Mountains	Private
China	Ningbo Sulian Foods	Private
USA	Prime Roots	Private
China	Qishan Foods	Private
China	Right Treat	Private
China	Shuangta Food	002481 CH
China	Suzhou Hongchang Foods	Private
China	Starfield	Private

Source: Jefferies

Selected Cell-based Meat Companies

Country	Company	Ticker
Israel	Aleph Farms	Private
USA	Arzeda	Private
China	Avant Meats	Private
USA	Balletic Foods	Private
USA	Blue Nalu	Private
USA	Bond Pet Foods	Private
USA	Clara Foods	Private
USA	Finless Foods	Private
Israel	Future Meat Technologies	Private
USA	Glycosyn	Private
Japan	Integriculture	Private
USA	Just	Private
Netherlands	Meatable	Private
USA	Memphis Meats	Private
USA	Mission Barns	Private
Netherlands	Mosa Meats	Private
USA	New Age Meats	Private
Singapore	Shiok Meats	Private
Israel	Super Meat	Private

Source: Cellbasedtech.com

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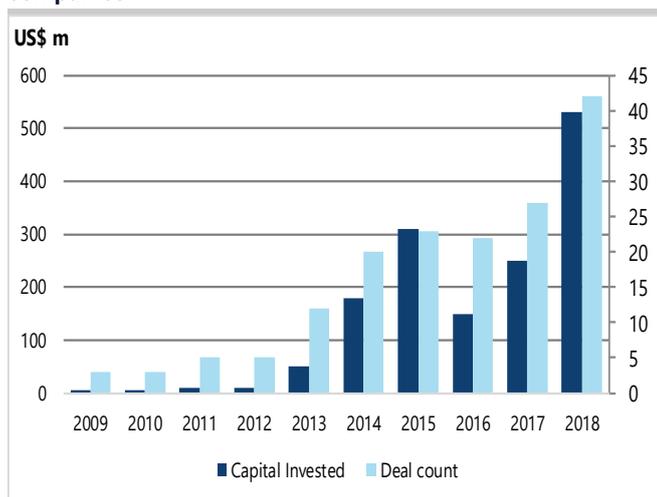
Executive Summary

The global meat industry already stands at over US\$1.4tn in sales and is growing at 3% CAGR based on our estimates, driven by rising wealth and population growth, such that by 2040 we estimate that it could reach US\$2.7tn. But this large industry may be about to be disrupted with an emerging alternative meat industry beginning to gain a foothold. The drivers of this disruption include climate change with claims that the traditional meat industry is a significant contributor to greenhouse emissions, shifts in global diets, and technology that is enabling these new products. We highlight 6 key findings:

1) Plant-based alternative first to scale, however, cellular could overtake once it gets going

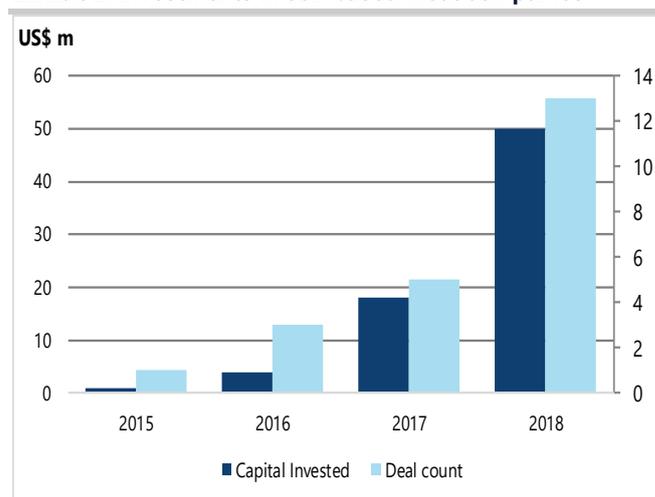
There are two competing alternatives – Plant-based alternative meat and Cellular-based alternative meats. Both emerging industries are attracting significant start-up investment. The plant-based alternative meat sector is already producing commercial qualities of product, and more IPOs look set to launch in the next 2-3 years along the lines of Beyond Meat. The cellular-based alternative industry has the potential to grow fast off a small base and could quickly start mass producing real meat if it can reduce costs and industrialize the current lab-based approach.

Exhibit 1: Investments in pre-exit plant-based food companies



Source: Good Food Institute

Exhibit 2: Investments in cell-based meat companies



Source: Good Food Institute

2) Cellular-based alternative meats need a breakthrough in cost reduction

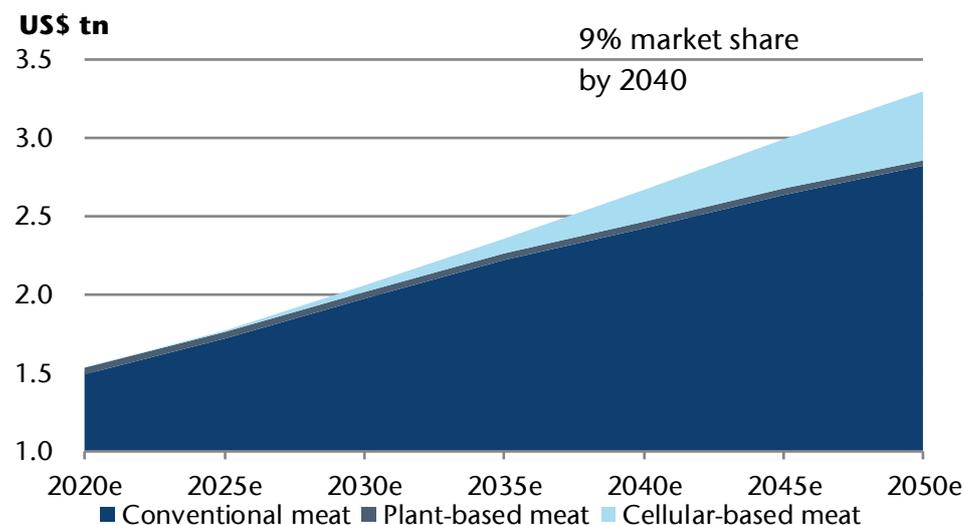
We believe that the bottlenecks currently exist in 'growth medium' and 'tissue perfusion'. Large bioreactors up to 50,000 L will be needed, as well as a batch process. Current costs of growth medium prohibit scale and need to be significantly reduced.

3) The alternative meat industry could reach US\$240bn by 2040

In our base case, meat alternatives take 9% market share by 2040. We envisage a bull case where a tax on traditional meat driven by health and climate change concerns helps alternative meats reach 18% market share by 2040. In a bear case, we see lower overall growth in meat consumption and, due to lower customer adoption rates and a harsher policy environment, alternative meats only reach 4% market share by 2040, but under this scenario this would still be a US\$90bn industry by 2040.

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Exhibit 3: Base Case estimate: Global market size for alternative meat products - US\$240bn by 2040

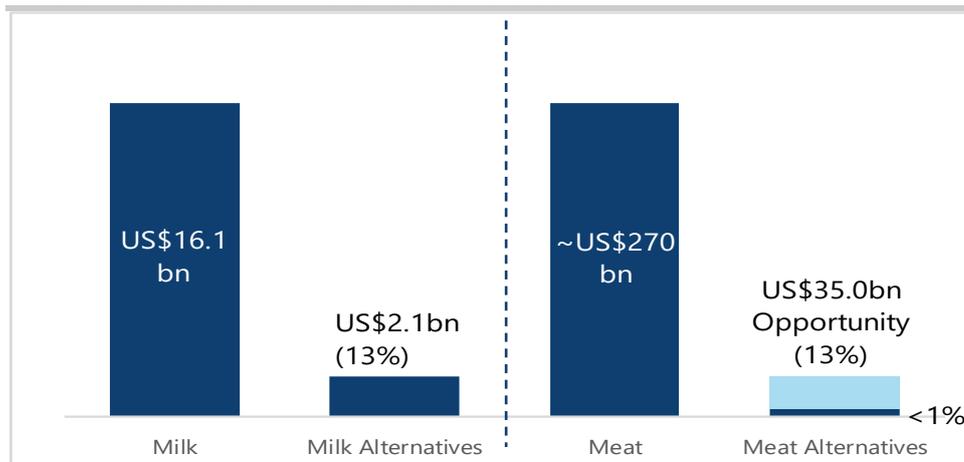


Plant-based and cellular meat consumption grows at **12% CAGR** over 2018-40e

Source: Jefferies estimates

- 4) **This degree of disruption has been seen before in agriculture**
The dairy industry has already experienced a similar degree of disruption. In the US today, almost 13% of milk now comes from plant-based alternatives such as soya and almonds.

Exhibit 4: Penetration of milk alternatives in the US



Source: Beyond Meat, Jefferies

- 5) **A Meat Tax is just starting to be discussed and could act as a catalyst**
There are very early discussions in only a few countries around a tax on meat. These discussions are being driven by concerns about climate and health. While our view is that such a tax is unlikely, especially in the US, investors should consider it as a potential catalyst in the future.
- 6) **The crisis in the Chinese pork industry could act as a catalyst for the Asian names**
China's pork industry is in crisis as a result of an outbreak of African Swine Fever, and experts report that in some areas more than 30% of the breeding sow population may have already died or been culled. This is placing significant pressure on the supply chain and, while the current government response is to provide subsidies to encourage supply, we believe that longer term the government could look to grow and support an alternative meat industry.

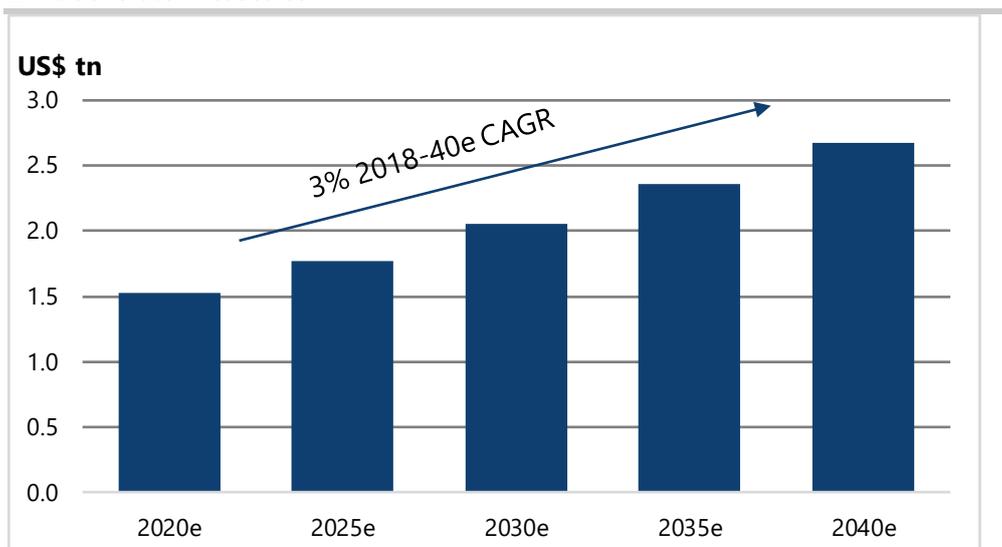
Global Meat Industry Could Reach US\$2.7tn by 2040

While meat consumption has been relatively static in the developed world, annual per capita consumption of meat has doubled since 1980 in developing countries. Growing population and incomes, along with changing food preferences, are increasing the demand for livestock products.

World meat production is projected to double by 2050

We project global meat sales to grow at 3% CAGR over 2018-40e to reach US\$2.7tn, most of which is expected in developing countries. The growing meat market provides a significant opportunity for livestock farmers and meat processors in these countries. Nevertheless, increasing livestock production and the safe processing and marketing of hygienic meat and meat products present big challenges.

Exhibit 5: Global meat sales



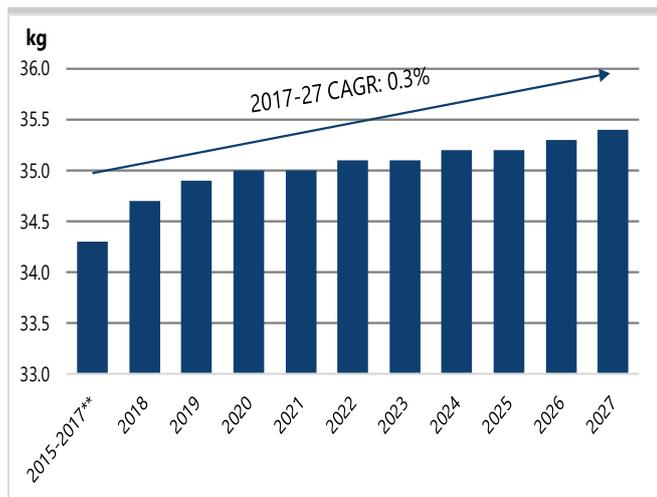
Source: Beyond Meat and Jefferies estimates

A well-established empirical relationship known as Bennett's Law shows that as people become wealthier, their diets change from being largely based on starchy staples to diets that incorporate increasing amounts of refined grains, fruit, vegetables, meat and dairy. The degree to which these food types become incorporated in diets depends on their relative costs.

According to the Food and Agriculture Organization of the UN, livestock production currently accounts for one-third of global crop land that is used to produce feed for animals, and competes for land, water, energy and labor, and is being challenged by the vagaries of climate change and socio-economic pressures. Increasing productivity throughout the whole livestock sector will be fundamental if the sector is to meet the growing demand for quality livestock products while minimizing its impact on the environment and the world's natural resources.

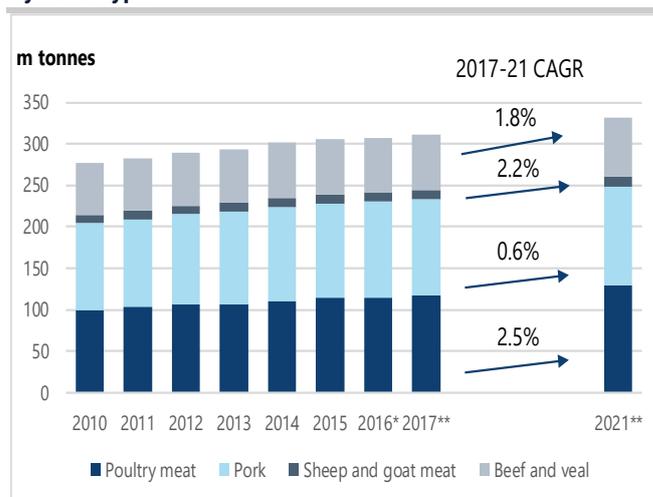
Livestock production currently accounts for one-third of global crop land

Exhibit 6: Projected per capita meat consumption worldwide from 2015 to 2027



Source: OECD and FAO

Exhibit 7: Meat consumption worldwide from 2010 to 2021 by meat type



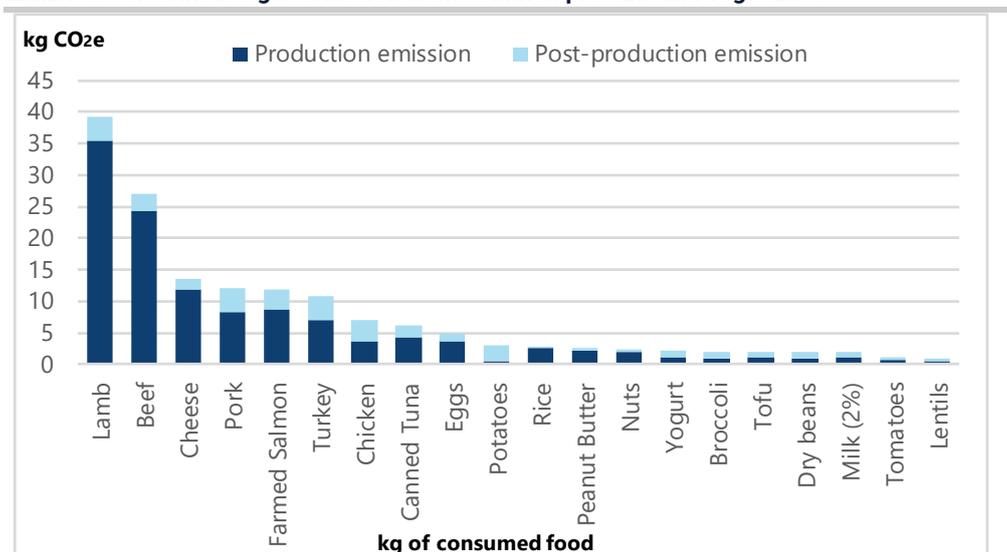
Source: Gira, Bord Bia

But is growing all this meat bad for the planet?

Increasingly, research is pointing to animal agriculture as a significant contributor to global warming. A recent study by the University of Oxford indicated that raising livestock for meat, eggs and milk generates up to 15% of global greenhouse gas emissions, the second highest source of emissions and greater than all transportation combined. It also uses about 70% of agricultural land, and is one of the leading causes of deforestation, biodiversity loss and water pollution.

A study by the Environmental Working Group (EWG) and CleanMetrics Corp set out to calculate the CO₂ footprint per kg of protein rich food consumed on an end-to-end life cycle assessment.

Exhibit 8: Greenhouse gas emission from common proteins and vegetables



Source: Environmental Working Group, Jefferies

Interestingly, lamb appears to be the biggest offender – both lamb and beef are responsible for generating methane, or CH₄, via enteric fermentation. CH₄ is the supposedly bad greenhouse gas, as its impact is 23x higher than that of CO₂ (if one buys into the science of climate change). The methane emissions from enteric fermentation are comparable between lamb and beef,

Raising livestock for meat, eggs and milk generates up to 15% of global greenhouse gas emissions

Lamb and beef are the most carbon-intensive

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however, lamb tends to have higher net greenhouse gas (GHG) emissions because lambs produce less meat in relation to live weight than cows.

There is some evidence that eating too much meat is bad for us

An overly meaty diet has been linked to heart disease, diabetes and certain cancers—things our distant ancestors never had to worry about, because they didn't live long enough to die as a result of such chronic diseases.

However, the only clear way to ascertain the long-term health impact of meat in people's diets is through epidemiological cohort studies in which tens of thousands of participants report their dietary intakes, and their health is followed over many years in order to identify the association between meat consumption and risk of disease. The results of these studies have to be interpreted so as to allow for potential confounding factors. Randomized controlled trials in humans are extremely difficult to conduct, especially over more than a few weeks or months, so it is difficult to measure the long-term effects on health.

Meat is a good source of energy and a range of essential nutrients, including protein and micronutrients such as iron, zinc and vitamin B12. In high-income countries, large prospective studies and meta-analyses generally show that total mortality rates are modestly higher in participants who have high intakes of both red and processed meat than in those with low meat intakes. However, part of this may be due to the linkage of high meat intakes with other major risk factors such as smoking, alcohol consumption and obesity, because the information needed to remove statistically the influence of these confounding factors may not be available.

The strongest evidence for an adverse effect of high meat intake on health is colorectal cancer. The World Health Organization's International Agency for Research on Cancer has classified processed meat as carcinogenic to humans because of an association with colorectal cancer, and red meat is classified as probably carcinogenic to humans, again based mainly on evidence of links to colorectal cancer.

Other issues facing traditional meat include the use of antibiotics and proximity of production facilities to residential areas

Modern animal husbandry is increasingly reliant on antibiotics, yet resistance appears to be increasing. If unaddressed, the growth of antibiotic resistance is projected to become a significant public health issue. Although there is no clear evidence that antibiotics in foods harm people directly, many commentators agree that the over-use of antibiotics in food-producing animals is a problem. It can contribute to the development and spread of drug-resistant bacteria, which is a potential risk to public health.

Another key impact of the rise of intensive meat production is the impact on local communities. A 2016 report by the European Environmental Agency found that 94% of ammonia emissions in Europe are now generated by agricultural activities, such as manure storage and slurry spreading. Another study found that in the Netherlands, the lung function of people living close to pig farms was on average 5% worse than that of people living further away from such farms. In the US, meat processor Tyson Foods has faced several community issues, including disbursing a US\$500,000 community service payment for an accidental discharge from a Tyson Foods facility in Missouri in 2014 and local protests that have derailed plans to build a new poultry plant in Kansas in 2017.

Meat in moderation is a good source of energy and nutrients

Manure from animal feedlots is a significant environmental issue

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A number of corporates are starting to take meat off their menus

Exhibit 9: Snapshot of corporates that are taking meat off their menu

Type	Company	Details
removing meat	Virgin Atlantic	Airline Virgin Atlantic has been removing ingredients deemed unsustainable such as beef, unsustainable palm oil, and soy from in-flight menus. The initiative is part of the company's ongoing partnership with the non-profit organization the Sustainable Restaurant Association (SRA). Founder Richard Branson is quoted as saying that animal agriculture will soon be a thing of the past. He is also reported to be an investor in clean meat start-up, Memphis Meats.
	WeWork	Company policy changed in 2018, specifically removing red meat, poultry and pork from company menus and expenses policy.
replacing meat	Ikea	According to a press release, Ikea is working on the development of a new meatball that looks and tastes like meat but is made from plant-based proteins. The plan is to begin customer-facing tests early 2020.
	Del Taco	In April 2019, Del Taco announced a partnership with Beyond Meat to sell plant-based beef in its tacos. According to a spokesperson for the company, the Beyond taco was one of the most successful product launches in the company's history, with two million sold by end of June 2019.
	Burger King	Rolled out sales of the soy based Impossible Whoppers across all 7000 US locations.

Source: Jefferies

There are emerging discussions about a "Meat Tax"

Given the climate impact and increasing focus on possible negative health impacts of a meat heavy diet there is some evidence of growing calls for a Meat Tax. The global increase in sugar taxes being introduced around the world suggests that one potential future for the meat industry includes a similar tax.

Like sugar, red meat has been linked to an increased risk of cancer, heart disease diabetes, which is what also laid the groundwork for similar taxes.

Early talk of a "sin" tax for meat

Exhibit 10: Countries with discussions on "Meat Tax"

Country	Details
Germany	August 2019: lawmakers from across the political spectrum proposed raising VAT on meat from 7% to 19%. They say that would decrease the nation's consumption of meat, a win for animal welfare and for the environment.
Denmark	The Danish Council of Ethics recommended an initial tax on beef, with a view to extending the regulation to all red meats in future. It said that in the long term the tax should apply to all foods at varying levels depending on climate impact.
Sweden	Plans to introduce a meat tax in Sweden were initially discussed by Sweden's Agricultural Board in 2013, but with no successful outcome. Interest in the concept has now been reignited as a petition launched by the environmental campaign group Swedish Food and Environment Information (SMMI).

Source: Jefferies

A meat tax in the US? – Will likely be a big battle

The traditional meat industry in the US is a formidable lobbying force, and as such the likelihood of a quick and easy implementation of a Meat Tax are extremely low. Our North American Food analyst *Kevin Grundy* believes a meat tax is very unlikely at the federal level, and indicates that a read-through from the soft drink industry, which has fought the sugar tax state by state, county by county, for many years, suggests that traditional meat producers could behave in a similar

fashion. It is important to note that the US accounts for approximately 12% of current global meat consumption.

Sugar taxes have had mixed results

Despite once being considered a fringe policy issue, sugar taxes have spread around the world. A recent review of sugar taxes globally carried out by the University of Otago and published by *Science Daily* in June 2019, said on average the purchase of sugary drinks dropped by 10% when laws were introduced. The study looked at the impact in four US cities, Spain, Chile, France and Mexico. The World Health Organization recommends governments impose a 20% tax on sugary drinks, saying the evidence for reduced consumption and meaningful health effects is strongest for this food category. Most notably, the US has not introduced a sugar tax at the federal level, however, some states have done so on their own (see our Jefferies note from 2016: [Food & Beverages: Election '16: Public Opposes "Sugar Tax"...](#)).

Exhibit 11: Countries implemented / proposed sugar tax

Country	Existing tax (Y/N)	Details
Australia	N	The Australian Beverages Council announced in June 2018 that the industry would cut sugar content by 10% by 2020, and by another 10% by 2025. The Australian Medical Association continues to press for a sugar tax
Chile	Y	The tax rate was increased from 13% to 18%, for drinks containing 6.25g added sugar per 100ml. In contrast, the tax rate on drinks with less added sugar was decreased to 10%. This has led to a 21% decrease in the consumption of sugary drinks
Colombia	N	A 2016 proposal for a 20% sugary drink tax was turned down by the Colombian legislature despite popular support for it
Denmark	N	A sugar and fat tax that previously existed were repealed in 2013 and 2014
France	Y	First introduced a targeted tax on sugary drinks at a national level in 2012
Hungary	Y	First introduced in 2011
Mexico	Y	Tax approved in Oct 2013, a 2017 study showed consumption was down by more than 6%
Norway	Y	Jan 2018 the government increased the tax
Portugal	Y	Introduced in 2017
Philippines	Y	Law passed in late 2017 included a tax on sugar sweetened drinks
Ireland	Y	Tax introduced in May 2018
South Africa	Y	Introduced in 2018, first African country to do so. Set at 20% or 2.29 cents per gram of sugar
Singapore	N	In late 2018 the Ministry of Health began consultation on measures which include a sugar tax
UK	Y	Introduced in 2016 called the "soft drinks levy"
US	N	Some cities (Philadelphia, Berkeley) have introduced their own tax

Source: Jefferies

Swine Fever Presents an Opportunity for China's Alternative Meat Industry

The African swine fever epidemic currently sweeping through China has thrown a light on the sustainability issues facing its meat industry, and in particular highlights the pork industry's vulnerability to epidemics. After suffering a devastating blue ear disease outbreak in 2006/7, the Chinese pork industry is battling to contain an outbreak of African swine fever that has now reached the main pork producing area in SW China, sending pork prices in the country to an all-time high. The current epidemic started in 2018 and has resulted in the culling of millions of animals. The virus is transmitted by ticks and direct contact between animals, as well as contaminated food, animal feed and people travelling between places. But there is currently no vaccine available for African swine fever and the mortality rate can be as high as 100%. It has not yet been known to infect humans.

Pork prices have already risen 40% in 2019 on shortages. The epidemic has brought into question the sustainability of the pork industry in China, and consumers in China are looking for alternatives to pork or pork that is imported from countries free from swine fever. This could act as a strong catalyst for an emerging alternative meat industry in China.

Chinese Wholesale Pork Price Rising on Shortages Due to African Swine Flu



Source: Bloomberg, Jefferies estimates

Alternative Meats Could Significantly Disrupt the Industry

A three-way battle is emerging over the future of meat. Initially, this battle is being fought over red meat such as lamb and beef, but there are already signs that poultry, veal, pork, fish and shellfish meat could be disrupted.

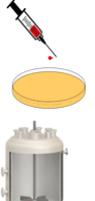
Plant-based – This already established and commercialized process uses hemoglobin and binders, extracted via fermentation from plants, which imitates the sensory profile of meat and even blood to complete the meat-like experience. Using vegetable oils can help to provide fat for the cooking process. Some plant-based producers use pea protein as a base while others are using wheat and potatoes proteins. Scientists have been able to mimic an iron rich molecule called heme, that is abundant in muscle. They have engineered yeast to help through fermentation mimic a plant-based heme source.

Cellular-based – also sometimes called Lab Meat or clean meat. This process of cell-based production uses a live animal’s adult muscle stem cells, raising them in a nutrient-rich environment until they take on the look and shape of the desired meat. The process leverages the natural propensity for the cell to divide and keep on dividing. One of the many challenges is to force cells to develop into different types of meat – muscle, fat, tendon etc. In order to form the meat substitute into something that resembles conventional meat, scaffolding structures are needed. The first lab-grown burger was presented at a news conference in London in 2013, its tissue grown in a lab at Maastricht University in the Netherlands at an estimated cost of over US\$500,000 per pound. Now, the US has at least 9 cell-culturing companies, more than 20 worldwide and with potentially more companies gearing up in China. The Bill and Melinda Gates Foundation that has also invested in this space has flagged cellular agriculture as one of the five food technologies that could bring about real change in developing world.

Winston Churchill appears to have gone some way towards predicting this disruption. In 1932 he wrote a predictive essay that was published in the March 1932 edition of *Popular Mechanics*

“New strains of microbes will be developed and made to do a great deal of our chemistry for us. With a greater knowledge of what are called hormones, i.e., the chemical messengers in our blood, it will be possible to control growth. We shall escape the absurdity of growing a whole chicken in order to eat the breast or wing by growing these parts separately under a suitable medium. Synthetic food will, of course, also be used in the future.”

Exhibit 12: Comparison of production process and cost of traditional vs alternative meat

Methodology	Process	Current cost of final product (est.)- Burger meat	Time to create (aprox.)
Traditional meat production 	<p>Breeding</p> <ul style="list-style-type: none"> Animals selected for optimal meat production and disease resistance Mate or artificial insemination <p>Raising</p> <ul style="list-style-type: none"> Acquire land Grow feed for animal Feed – grass/ grain/ other Protect from disease Monitor weight gain <p>Slaughtering</p> <ul style="list-style-type: none"> Transport to slaughter house Kill Butcher and segment key cuts Process hide 	USD 4- 8/ lb 	18 months
Plant based substitutes 	<p>Isolation</p> <ul style="list-style-type: none"> Plant protein concentrates are extracted from plants Proteins are broken down to improve their functional traits <p>Formulation</p> <ul style="list-style-type: none"> Binder fats, flavors added Nutrients and vitamins added <p>Processing</p> <ul style="list-style-type: none"> Mixture is shaped into final product via stretching, press forming 	USD 10- 12/ lb 	1 week
Cellular meat substitutes 	<p>Cell isolation</p> <ul style="list-style-type: none"> Stem cell extracted from an Animal A single seed cell is sufficient to start the process <p>Cell proliferation</p> <ul style="list-style-type: none"> Cell is added to a bioreactor containing a cell culture medium Cell proliferates Exponential growth in cells <p>Tissue perfusion</p> <ul style="list-style-type: none"> Changing culture conditions causes the cells to differentiate into muscle, fat tissue etc. Cells are structured via scaffolding materials Muscle fiber is combined with fat to produce meat 	USD 500- 2,000/ lb 	9 weeks

Source: Jefferies

Cellular meat alternatives currently costly, but will get cheaper fast

Cultured meat is currently produced using many of the same tissue engineering techniques traditionally used in regenerative medicine and as a result the costs are extremely high. So high in fact that currently no commercial products are yet available. In 2013, the emerging biotech field of lab-grown meat products held a tasting of a lab-grown burger that cost US\$330,000 dollars. While many people are skeptical that industries pursuing the development of cell-cultured meat would create an affordable product anytime soon, many biotech companies say that they are approaching an affordable product.

Memphis Meats claim that it can currently produce a pound of lab-grown meat for approximately US\$2,400 dollars, a big decline from the cost 5 years ago. Memphis Meats hope to have the cost of a lab-grown burger down to around US\$5 within a few years. Another start-up called Future Meat Technologies currently produces around a pound of meat for US\$360 and believes it can reduce the cost down to somewhere between US\$2.30-4.50 by 2020/21.

One of the biggest expenses in growing cells is the culture medium. The mixture in the bioreactor that encourages cell proliferation is a liquid made up of amino acids, sugars and salts, vital foods to help cells divide and grow. Future Meat Technologies has indicated that it is deploying a process that can clean and recycle the medium. Its process also avoids using serums, which are made from animal blood, and which have been used by some other companies working in the field and are both expensive and unappealing to consumers who want to avoid animal products entirely.

Some industry experts believe that cellular grown meat will eventually be cheaper than traditional meat from animals. Along with other advantages, such as avoiding the risk of contaminants like salmonella, and eliminating the need for antibiotics, which are heavily used in animal husbandry today, many think that this clean meat could eventually be in a position to replace the traditional version, subject to consumer and regulatory acceptance.

Cellular meat needs to move from lab to commercial scale

Currently, the culture medium costs in excess of US\$400 per litre and we estimate that to grow 1 kg of meat in the lab could require 500-1000 L, hence the high cost of meat that has been grown so far. To scale up to a batch process that can produce 2,000 to 5,000 kg of meat at a time will require bioreactors as large as 20,000 L.

Future Meat Technologies currently produces around a pound of meat for approximately US\$360 and believes that it can reduce the cost down to somewhere between US\$2.30 to US\$4.50 by 2020/21

Can cellular meat begin to compete on price?

The move to commercial scale meat production requires a more than 10x fall in the cost of culture medium

Exhibit 13: Example of possible cost reductions in commercializing cellular meat

	Current bench-based prototype production	Fully commercial industrial production	
		Highest	Lowest
Starting cells	2.5 ml	2.5 ml	2.5 ml
Growth medium cost (US\$/L)	400	40	0.5
Bioreactor size	50L - 100 L	20,000 L	20,000 L
Maximum cell density in medium	4x10 ⁷ /ml	4x10 ⁷ /ml	4x10 ⁷ /ml
Medium needed	1000L	140,000/L	20,000L
Time needed for cells to double	28 hours	28 hours	28 hours
Days to maturity	20 days	40 days	50 days
Number of doublings needed	18	24	24
Meat harvest per batch	1kg	3,500kg	3,500kg
Yield per L of medium (kg/L)	0.001	0.025	0.175
Material cost of meat (US\$/kg)	2,000 – 3,000	200	1.5

Source: GFI, Jefferies note assume 1Kg of meat contains 8 x10¹² cells

In order to deliver the step reduction in the cost of production the industry will need to significantly cut the cost of the substrate culture that the cells grow in. A typical substrate used by this emerging industry might have similar properties to Essential 8™ – produced by Thermo Fisher Scientific. This is a product that helps cells to grow and divide. It contains the essential nutrients, amino acids and compounds that stem cell cultures need. Its currently sold in 0.5 L bottles and is not produced on the 140,000 L scale described above.

Traditional meat producers will lobby hard for status quo

Livestock constitutes more than 40% of agricultural output by price, and meat production, processing and retailing is a significant economic sector in many countries. The sector has considerable political influence and allocates large amounts of money to advertising, lobbying and marketing. Lobbying from the meat industry was intensive during the formulation of US Dietary Guidelines, and some NGOs claimed that this influenced eventual recommendations. Non-state bodies seek to influence policy on meat and other food types, often by developing alternative narratives that resonate with sections of the public. Issues raised include animal welfare, the idea of what is “natural,” and how production systems accord with worldviews on economic equity and globalization versus localization.

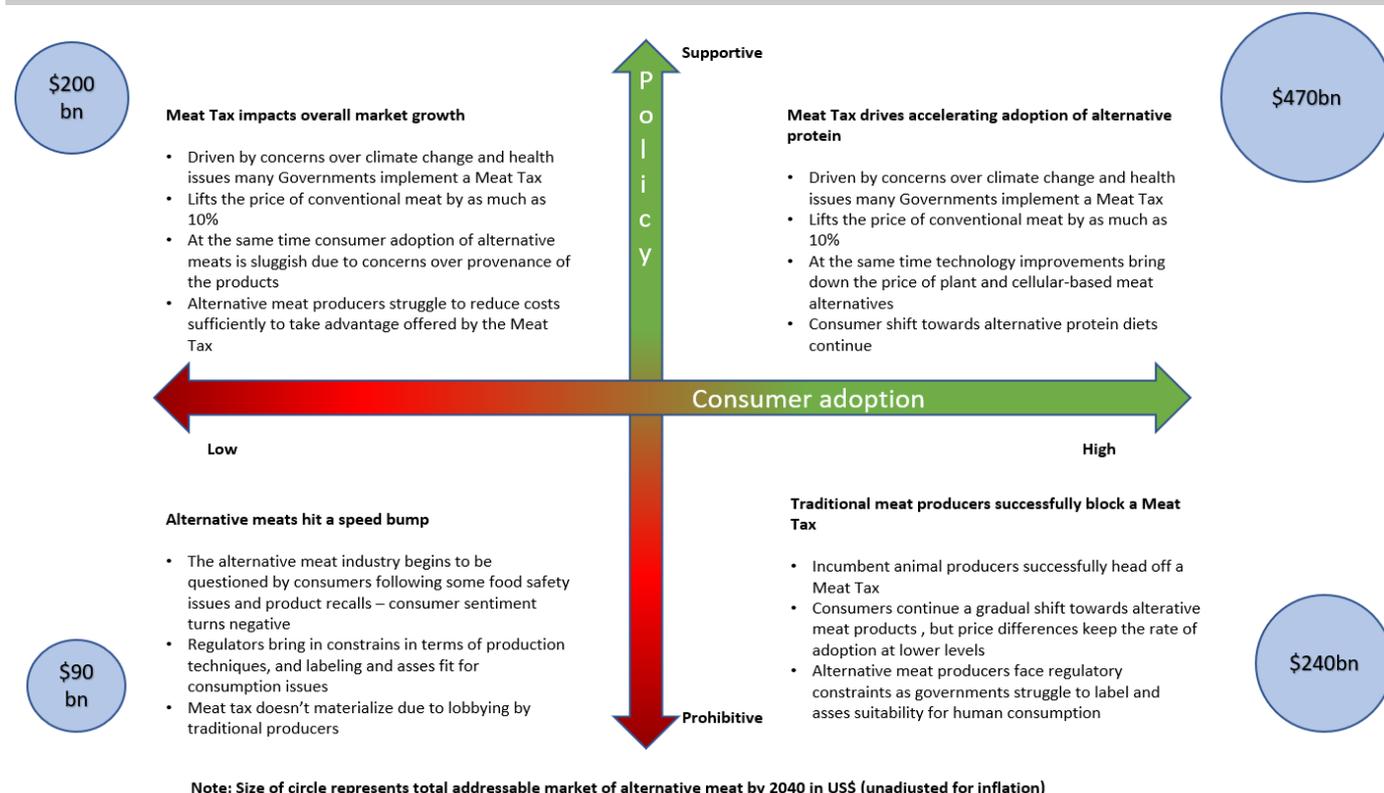
The sector has considerable political influence

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Jefferies Envisages a Number of Possible Futures for the Alternative Meat Industry

Looking forward, there a number of factors that can influence how fast and how large the alternative meat industry can grow. Technology is clearly a key factor, but it is increasingly useful to simply assume that technology will find solutions to help lift productivity and reduce costs. It is just a timing issue. This leaves us two drivers that we consider to be critical: government policy and regulation and consumer tastes and adoption. In the matrix below we have tried to envisage a number of possible futures, some of which might include a tax on traditional meat that could lift the cost of that product, making alternative meats more competitive. Some alternative futures could be negative for the alternative meat industry, specifically ones that involve some kinds of product failure that results in significant recalls of product for health or safety reasons.

Exhibit 14: Axis of Uncertainty for the Alternative Meat Industry



Source: Jefferies

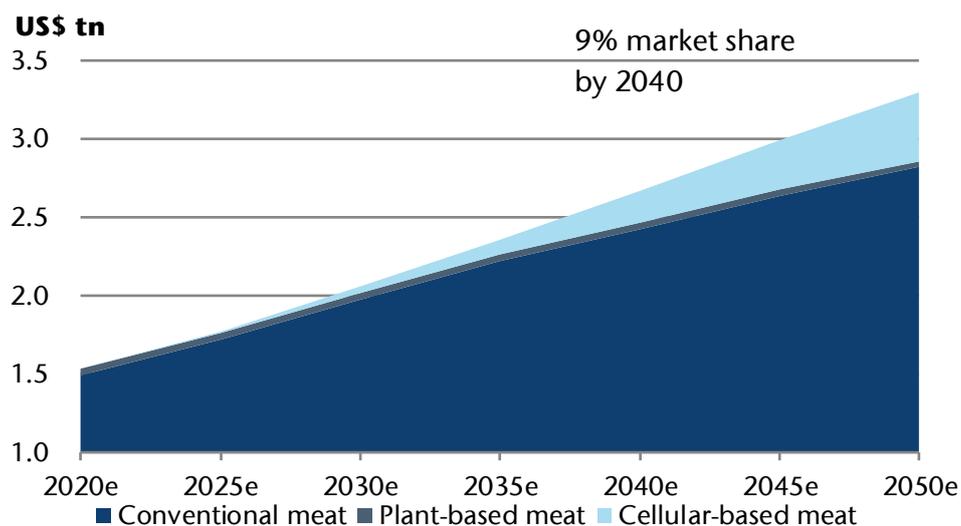
We estimate the size of global alternative meat market could grow to US\$240bn by 2040

In our base case, we assume a 3% CAGR for global meat sales over 2018-40e to US\$2.7tn and we assume the market share of cellular meat and plant-based meat to amount to 7%/2% in 2040 from 0%/1% in 2018, amounting to US\$240bn sales in total.

In our bull case, we keep our 3% CAGR assumption for global meat sales over 2018-40e unchanged. However, the introduction of a global Meat Tax in 2030 should lift the price of conventional meat by 10%, and we expect an acceleration in alternative meat adoption with the cellular meat/plant-based meat market share growing to 14%/4% in 2040, representing US\$470bn sales in total.

In our bear case, we lower our growth assumption for global meat sales to 2% CAGR over 2018-40e, assuming a slowdown in global meat consumption on the back of increased level of health concerns. More than that, we expect several headwinds facing the alternative meat industry, including 1) weaker consumer confidence on regulations and product recalls in 2022 and 2) no Meat Tax. Hence, we expect the adoption of alternative meat will be much slower with cellular meat/plant-based meat market share only reaching 3%/1% in 2040, translating into US\$90bn sales in total.

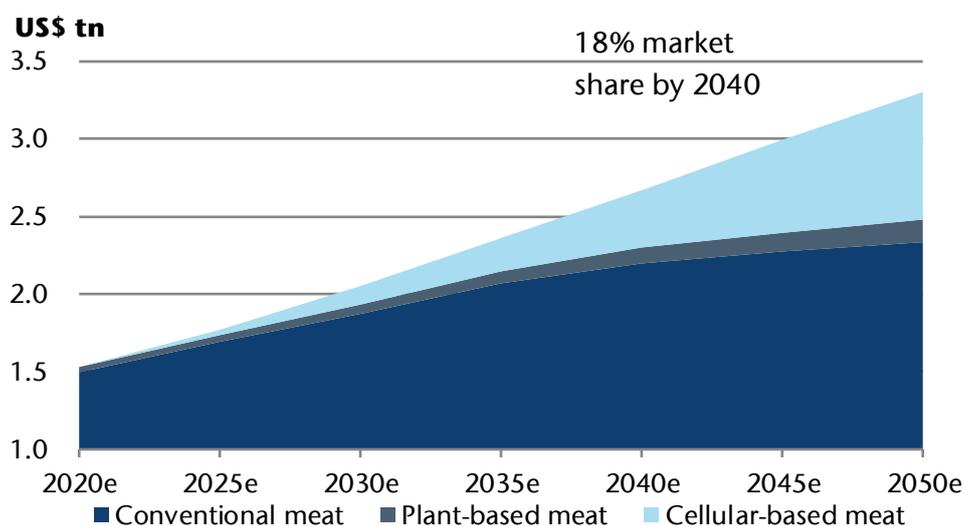
Exhibit 15: Base Case: Estimate of global market size for alternative meat products - US\$240bn by 2040



Plant-based and cellular meat consumption grows at **12% CAGR** over 2018-40e

Source: Jefferies estimates

Exhibit 16: Bull Case: Estimate of global market size alternative meat products - US\$470bn by 2040

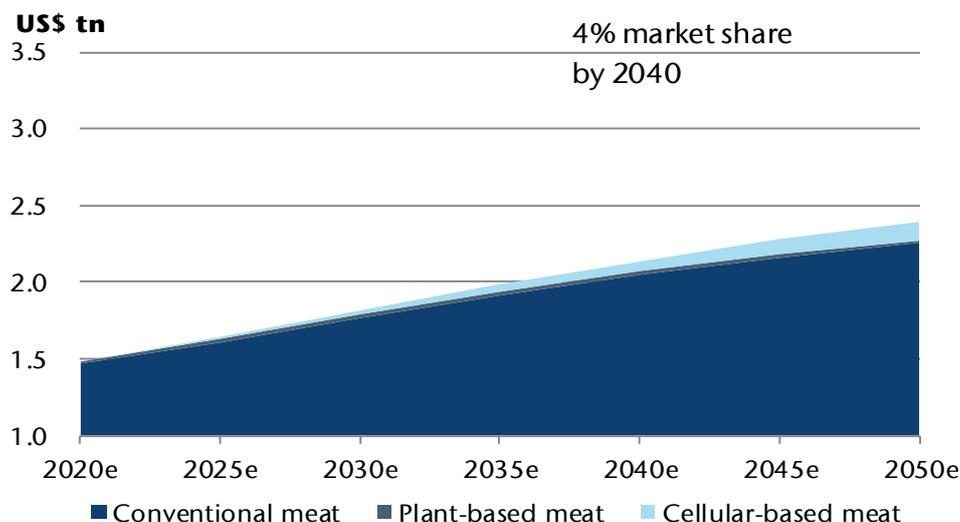


Plant-based and cellular meat consumption grows at **15% CAGR** over 2018-40e

Source: Jefferies estimates

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Exhibit 17: Bear Case: Estimate of global market size for alternative meat products - US\$90bn by 2040



Plant-based and cellular meat consumption grows at **7% CAGR** over 2018-40e with total meat consumption only growing at 2% CAGR vs 3% CAGR in our bull and base case

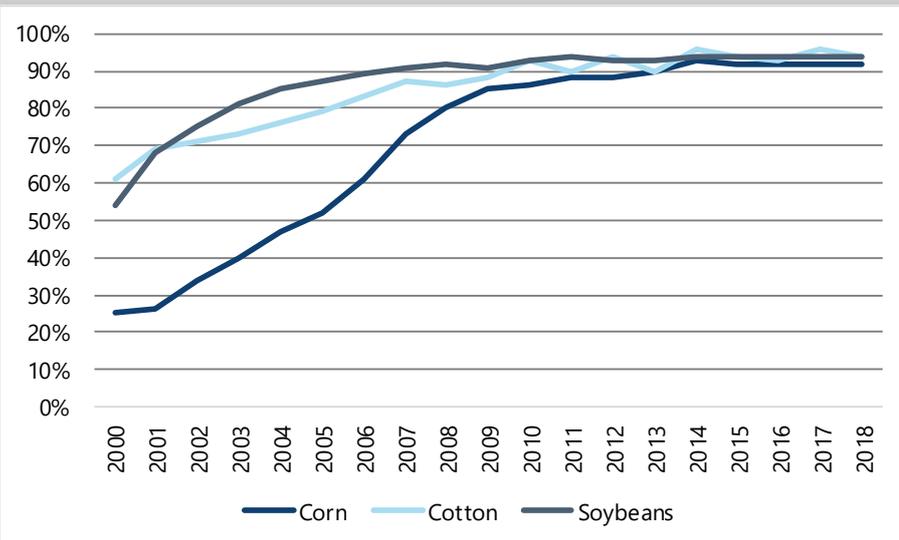
Source: Jefferies estimates

Have we ever witnessed this kind of disruption before?

In the scenarios above we are projecting varying degrees of displacement / disruption. In our bull case above, plant-based alternative meat and cellular-based alternative meat combined reach 18% market share by 2040, and 30% by 2050. This level of penetration into a significant and established traditional meat industry may at first glance appear fanciful. However, there are examples of this kind of displacement taking place over similar time frames. Take genetically modified (GMO) corn, cotton and soybean, as the graph below demonstrates - in the US they moved from almost no market share to 90%+ in almost 2 decades. It is important to note that more than 90% of GMO corn is currently fed to animals.

The shift on GMO corn, cotton, and soybeans is significant in the US

Exhibit 18: Percent of GMO crops planted in the US

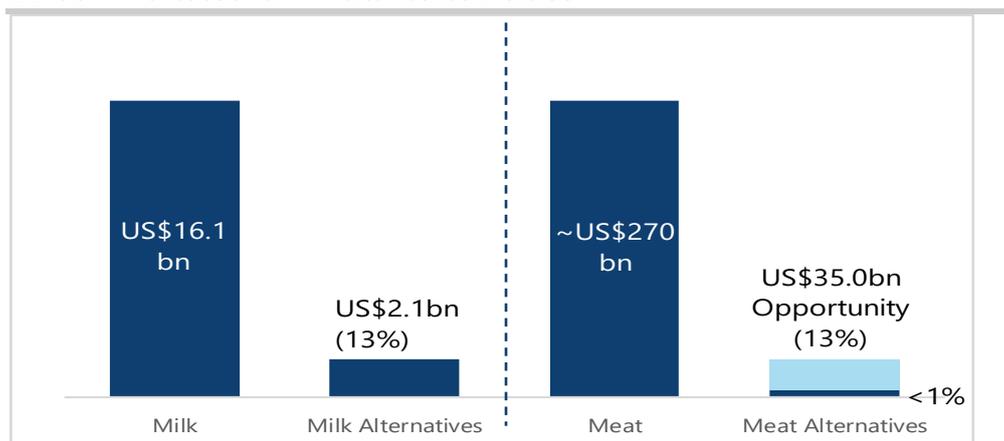


Source: USDA, Jefferies

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Another example is the ongoing disruption of the milk category in the US by the plant-based milk alternatives such as soybean milk, according to our US Food Analyst Kevin Grundy (see our Jefferies note - [Growth Appeal: Lifting Estimates and PT Post Strong 2Q Results, Hold July 30, 2019](#)). Plant-based milk alternative market size now amounts to US\$2.1bn in the US, representing 13% of the total market size of the milk category in the US. And unlike the example of GMO food, there is an actual taste difference between dairy milk and plant-based milk alternatives. At 13% market share, meat alternatives would represent a US\$35bn opportunity in the US given the existing size of the US meat market. Assuming alternative meat achieves 13% world meat market share by 2040, this would translate to US\$350bn sales (based on our global meat market size of US\$2.7tn), compared to US\$240bn in our base case.

Exhibit 19: Penetration of milk alternatives in the US



Source: Beyond Meat, Jefferies

Regulation of alternative meats still at an early stage

For policymakers, civil society and industry incumbents, meat analogues raise a number of challenging questions:

- Do meat analogues belong in their own realm of meat alternatives or that of conventional meat?
- How should they be defined and regulated by lawmakers?
- And what position do they hold in a sustainable, healthy and equitable food system?

With innovation fast taking place, policymakers are being forced to respond quickly to new production methods and products. However, regulation is also being used as the new battleground by the traditional (and powerful) animal protein lobbies to slow the growth of the alternative protein sector. In the US, 24 states have passed legislation barring the use of words such as “steak”, “burger” and “milk” for plant-based foods.

Exhibit 20: Regulation on alternative meats in the EU and US

Region	Details
EU	<ul style="list-style-type: none"> • Newly-developed foods are regulated under the Novel Food Regulation • In the EU, cultured meat will be regulated under the Novel Food Regulation unless GMOs are used during production • Plant-based alternative meat may not require authorization under the Novel Food Regulation if the component ingredients and processing techniques already have a history of use in the EU. - In the case of the Impossible Burger, which contains plant ‘heme’ produced using GM yeast, authorization under either the Novel Food Regulation or the GMO Regulation is likely to be required
US	<ul style="list-style-type: none"> • USDA and FDA have jointly announced a framework for regulating cell-based meat and poultry • Initial details are scant, but the USDA will oversee food processing, labeling, and distribution, and the FDA conducting inspections and safety checks

Source: Jefferies

Product labeling likely to be an issue for the time being

Labelling is one of the main regulatory bottlenecks for plant-based meat options already on the market and will likely be an issue for cell-cultured meats when they make it to market in the near future. Difficulties relate to the legal or customary name under which they may be marketed. In the absence of specific regulations on plant-based meat or cultured meat, it's likely that the basic principles of product information provided to consumers will apply in that it be clear, precise, easy to understand and not misleading.

In the US, there is a debate taking place as to how to label these products. Options include "cell-based meat," "slaughter-free meat," or "clean meat". Some states have tried to move to prevent the product being called meat, however, we believe that the USDA labeling authority is very likely to override the states.

An Emerging Set of Mainly Private Companies in the Space

There is a fast-growing list of companies that are trying to commercialize both plant-based alternative meats and cellular-based meats. It appears that start-ups tend to specialize in either one technology or the other with little or no overlap.

Exhibit 21: Selected Plant-based Meat Companies

Country	Ticker	Company	Details
US	BYND US	Beyond Meat	Listed in 2019 with strong post IPO price performance
US	NA	Good Catch	Offers plant-based alternatives to shredded tuna, crab cakes, and fish patties that are made from lentils, chickpeas, and fava beans
US	NA	Impossible Foods	Impossible Foods, the company behind the Impossible Whopper, is a privately-held company Utilize a synthetic "heme" in their products Closed a US\$300m funding round in May 2019
UK	NA	Moving Mountains	Introducing its B12 burger (named after its vitamin B12-rich wheat, soy and pea protein patty) to 23 Hard Rock Café locations across Europe, including London, Rome, Paris and Prague
China	NA	Ningbo Sulian Foods	A local Chinese manufacturer with plant-based products ranging from beef ball, dried beef to steak, fish fillet and ham
Spain	NA	NovaMeat	3D printed plant-based steaks and chicken Syringes containing the food paste placed in a 3D printer print out the mixture in the shape of a small steak that can then be cooked
US	NA	Prime Roots (aka Terramino Foods)	Uses fungi, algae, other plant-based ingredients to create a "salmon" burger
China	NA	Qishan Foods (aka Whole Perfect Foods)	Signed a partnership agreement with Wal-Mart to develop and distribute plant-based meat products for the Chinese market
UK	NA	Quorn	Uses natural fungi for fermentation to create "mycoprotein" to substitute animal protein to make products from ham and sausage to burger and pizza.
China	NA	Right Treat	Launched Omnipork, a product made from soy pea and mushroom protein - aimed at the Asian market Production outsourced to Thailand with R&D team in North America
China	002481 CH	Shuangta Food	Shuangta is a glass noodle producer based in China. The company maintains to supply pea protein to Beyond Meat as raw material. In June 2018, Shuangta announced its plan to enter the space of alternative meats
China	NA	Suzhou Hongchang Foods	A Taiwan-headquartered company which began producing plant-based meat in 1995. They have over 300 SKUs selling across more than 30 countries now
China	NA	Starfield	Starfield plans to roll out its first plant-based burger in September in Shenzhen, a burger similar to Impossible Whopper

Source: Jefferies

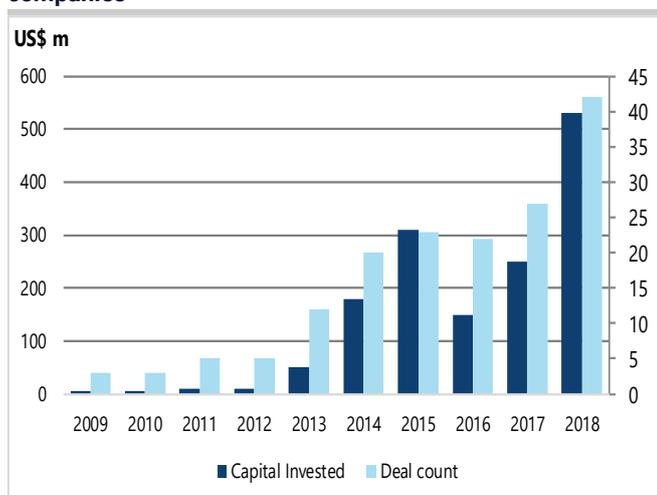
Exhibit 22: Selected Cell-based Meat Companies and Capital Raised So Far

Country	Company	Capital raised to date (US\$)	Details
Israel	Aleph Farms	NA	Cell cultured meats
US	Arzeda	15.2 mil	Acellular cultured proteins.
China	Avant Meats	NA	Cell cultured fish
US	Balletic Foods	NA	Cell cultured meats
US	Blue Nalu	4.5 mil	Cell cultured fish and seafood
US	Bond Pet Foods	NA	Cell cultured Pet food
US	Clara Foods	3.5 mil	Acellular cultured egg whites
India	ClearMeat	NA	Cell cultured chicken
US	Finless Foods	3.8 mil	Cell cultured fish - Bluefin tuna
Israel	Future Meat Technologies	NA	Cell cultured chicken
US	Glycosyn	14 mil	Acellular cultured human milk oligosaccharides (hMOS)
Japan	Integriculture	2.7 mil	Cell cultured meats
US	Just	220 mil	Cellular cultured beef (wagyu)
Netherlands	Meatable	3.5 mil	Cell cultured beef
US	Memphis Meats	20.1 mil	Cell cultured meats
US	Mission Barns	3.5 mil	Cell cultured meats
Netherlands	Mosa Meats	8.8 mil	Cell cultured beef
US	New Age Meats	0.25 mil	Cell cultured pork
Belgium	Peace of Meat	NA	Cell cultured foie gras
Singapore	Shiok Meats	4.8 mil	Cell cultured crustaceans
Israel	Super Meat	4.2 mil	Cell cultured chicken

Source: Cellbasedtech.com

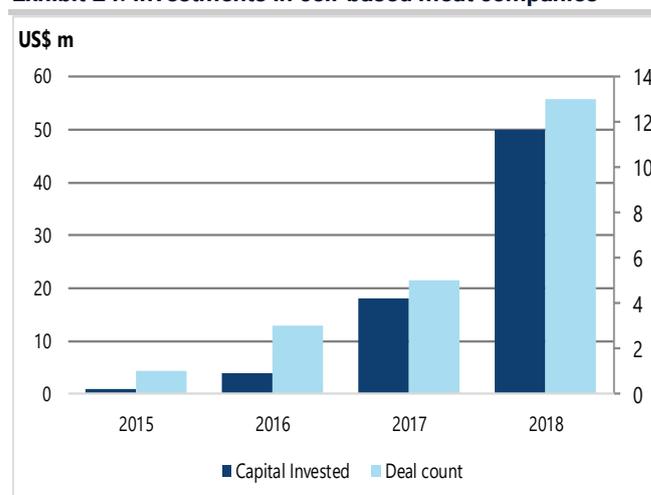
In addition to the newer companies, traditional global food companies are rapidly expanding their alternative protein offerings. On the manufacturing side, companies are expanding their exposure to alternative proteins primarily through acquisitions, venture investments and new product launches.

Exhibit 23: Investments in pre-exit plant-based food companies



Source: Good Food Institute

Exhibit 24: Investments in cell-based meat companies



Source: Good Food Institute

Exhibit 25: Snapshot of traditional meat companies entering alternative meat space

Company	Ticker	Market Cap (US\$ bn)	Details
Nestle	NESN SW	330	Owns vegetarian brand Garden Gourmet, Launched the incredible burger and acquired Sweet Earth
Tyson Foods	TSN US	33	One of the biggest in the sector formed Tyson Ventures to back alt meat companies Taken a significant stake in Memphis Meats Launched its own plant-based products under brand raised and rooted
Conagra Brands	CAG US	14	Has a brand of vegan-meat products called Gardein that includes plant-based turkey cutlets, chicken strips, chicken wings, burgers, sausage and meatless meatballs currently available at most grocery stores in the US
Maple Leaf Foods	MFI CN	3	In 2018 acquired Lightlife Foods from PE firm Brynwood Partners
Marfrig	MRF3 BZ	1	Plans to enter the plant-based category in an exclusive tie-up with Archer Daniels Midland
JBS	NA	NA	In early 2019 one of the largest beef processors globally unveiled a plant-based version of a burger
Cargill	NA	NA	Invested in Memphis Meats and Aleph Farms
Smithfield Foods	NA	NA	Aug 2019 launched its own meat free range under Pure Farmland brand
Bell Foods	NA	NA	Invested in Mosa Meats start-up
Hilton Foods	NA	NA	bought 50% of Dacló Food, a Dutch vegetarian food company
Nortura	NA	NA	Launched a line of vegetarian alternatives to meat, called MEATish
Perdue Foods	NA	NA	It is planning to sell frozen chicken nuggets mixed with cauliflower, plant protein, and chickpeas
COFCO	NA	NA	Partnered with China-based food tech venture capital fund Bits and Bites, which has to date funded Chinese and international companies advancing technology from gene editing to cellular agriculture to clean-protein pet food

Source: Jefferies

Should we consider the picks and shovels?

In any new technology rollout, investors need to consider investing in the technology companies or alternatively looking at those who supply the industry.

Bioreactors. Our research indicates that one key component in the race to develop cellular based meats is the bioreactor. To put into context the scale of cultured meat production, in the region of 8×10^{12} cells are required to acquire 1 kg of protein from muscle cells, which would need a 'traditional' stirred tank bioreactor in the order of 5,000 liters. The scale-up (in a few large bioreactors) or the scale-out (in many smaller bioreactors) are key challenges here. A number of companies are currently manufacturing and installing these types of bioreactors, including US headquartered **ABEC Inc**, which claims to have the largest biopharma equipment manufacturing capacity globally.

Plant protein powders source companies. Examples include **Axiom Foods**, whose current plant-based product portfolio includes rice and pea proteins, rice and oat dairy alternatives. **AMCO Proteins** is a competitor that manufactures powder-based dairy proteins, protein blends and hydrolyzed proteins. **Carbery Group** from Ireland focuses on dairy ingredients. We understand that a significant part of the pea protein used in Beyond Meats burger and sausage products – is sourced from just a private company **Roquette** that is headquartered in France and ships the pea protein to a storage facility in Chicago, Illinois.

Investment into pea protein manufacturing is expected to push up production from next year onwards. Roquette is building a processing plant in Manitoba, Canada, while **Verdient Foods** of Saskatchewan is also planning new capacity.

Cellular based meat is going to require significant quantities of substrate mixture. This is the liquid that the cells will grow in. Currently, companies such as **ThermoScientific** (TMO) produce culture medium, but on a small scale. We are not aware of any company producing substrate in the quantities that the industry will need.

Food additives and enzymes

In addition to the key raw ingredients, there are a range of nutritional additives, texture enhancers and coloring producers who stand to benefit from this growth in alternatives meats.

Some examples are:

- **Calyxt** (CLXT): produces High Oleic Soybean Oil
- **Corteva Inc** (CTVA): produces seed products for soy, sorghum, corn and wheat
- **Koninklijke DSM N.V** (DSM.AS) is a producer of taste modulators used in plant-based proteins
- **Novozymes A/S** (NZYM.B.DC) produces enzymes used in plant-based protein production
- **International Flavors & Fragrances Inc** (IFF) produces a range of taste and nutrition enhancements for the industry
- **Givaudan** (GIVN.SW) is helping to bridge the taste gap between animal and plant protein with flavor solutions that provide a more authentic meaty taste
- **Chr Hansen** (CHR.DC) develops and produce cultures, enzymes, probiotics and natural colors

Appendix I: Details of Some Plant-based Meat Companies

Beyond Meat: One of the fastest growing plant-based material product companies in the US, founded in 2008. The company started selling plant-based chicken products in supermarket chains in 2013 in the US and began selling plant-based beef products in 2014. The company undertook an IPO in 2019 and now offers diversified plant-based beef, pork, and poultry products.

Good Catch: A US-based plant-based seafood company founded in 2016. The company offers plant-based seafood that are gluten, dairy and GMO free. Its signature products are fresh fish-free tuna. On top of this, Good Catch also offers frozen seafood alternatives.

Impossible Foods: One of the largest US-based plant-based meat companies founded in 2011. In 2016, Impossible Foods launched its first product, the Impossible Burger. While Impossible Foods also produces other plant-based meat products such as chicken, fish, and pork, their focus is on plant-based beef. In April 2019, the company started partnering with the fast-food chain Burger King to roll out plant-based burgers across the US.

Moving Mountains: A plant-based meat company founded in the UK in 2016. Its first product B12 burger (named after its vitamin B12-rich wheat, soy and pea protein patty), which is made of coconut oil to create a fatty consistency, was launched in 2018 at Mildreds, a vegetarian chain in the UK. After that, the company further launched the B12 burger at Marstons, a national pub chain with over 400 outlets in the UK.

Ningbo Sulian Foods: A plant-based meat company founded in China in 2011. Sulian Foods has a wide assortment of preservative-free plant-based meat products, ranging from beef ribs and beef jerky to fish fillets and ham. Other than through distributor channels, Sulian also generated some sales through catering channels.

NovaMeat: Started by Italian bioengineer Giuseppe Scionti, this Spanish start-up claims to be producing the "world's first" 3D-printed meat-free steak made from vegetable proteins. The company's first prototype mixed a limited amount of protein content with a paella colourant. The company says that it can print a 100g steak in 30 mins.

Prime Roots (aka Terramino Foods): A plant-based meat companies founded in the US in 2017. Prime Roots uses fungi as an alternative protein to produce plant-based products, ranging from bacon and lobster chunks, to chicken tenders and shrimps.

Qishan Foods (aka Whole Perfect Foods): A pioneer plant-based meat company founded in China in 1993. In the early days, most of Qishan's products were exported. However, domestic demand from vegetarians spiked and hence Qishan now also generates the majority of its sales from its domestic market. Currently, the company produces 50 new products every year.

Quorn: A pioneer plant-based meat company founded in the UK in 1985. Quorn uses natural fungi in a fermentation process to create "mycoprotein" to substitute animal protein to make products ranging from ham and sausage to burger and pizza. "Mycoprotein" is protein-rich, high in fibre, and low in saturated fat. Quorn now has more than c.100 SKUs.

Right Treat: A plant-based meat company founded in HK in 2018. The company launched its first product, Omnipork, a plant-based pork product, in 2018 using soybeans, peas, mushroom and rice proteins. While the company's western counterparts are mainly focusing on beef, seafood, and poultry, Right Treat is aiming at the large pork-consuming population in China with its unique plant-based pork products.

Shuangta Food: A plant-based meat company in China that originally was a glass-noodle manufacturer. The company maintains to supply pea protein to Beyond Meat as raw materials for the latter's plant-based meat products. In June 2018, Shuangta also announced its plan to enter the space of alternative meats.

Suzhou Hongchang Foods: A plant-based meat company founded in China in 2010 with a Taiwanese parent. Currently, Hongchang has more than c.300 SKUs across, beef, pork, poultry and fish, selling in more than 30 countries.

Starfield: A plant-based meat company in China. Compared to its western competitors, the company admitted that its product is less meat-like on the texture front due to the fact that the output protein of Starfield is strip-shaped as opposed to ball-shaped. Starfield set the retail price of its first plant-based burger at RMB28 (US\$4), compared to US\$5.99 for Impossible Whopper, the plant-based burger sold at Burger King in the US.

Appendix II: Details of Some Cell-Based Meat Companies

Aleph Farms: An Israeli company that first created a cell-based beef steak in 2018. The company expects to build bio-farms that resemble dairy farms. The company expects to launch its products on a commercial scale by 2023.

Arzeda: US-based protein engineering company founded in 2008. The company specializes in designing enzymes for both agricultural and manufacturing uses. Basically, it develops the blueprint for the DNA sequences, which act as the backbone for the new proteins. Currently, Arzeda is designing new enzymes that catalyze the formation of new food products such as cultured proteins.

Avant Meats: Hong Kong's first cell-based seafood company focusing on fish products such as fish maw and sea cucumber. Given the relative simplicity of fish maw with its singular cell type, the company is able to multiply the fish maw product within 6 weeks, much faster than traditional meat. Conventional fish maw sells at very high prices in Asia, so focusing on this product in Asia looks like an interesting strategy.

Balletic Foods: Specialized cell-based meat producer in the US founded in 2017. The company's target is to trim greenhouse gas emissions with the production of cell-derived meat through the isolation of muscle stem cells.

Blue Nalu: A cellular seafood specialist founded in 2018 in the US. It aims to roll out lab-grown seafood products without any genetic manipulation with a target to bring healthy seafood to people in a sustainable way for the environment. In terms of marketing, rather than using its own brands, the company will partner with the existing retail and foodservice players to market its products.

Bond Pet Foods: A cell-based US pet food manufacturer founded in 2015. It aims to make animal-free high protein pet foods products through a mix of clean and antibiotic-free animal protein via fermentation with natural ingredients to produce healthy pet foods.

Clara Foods: A cellular meat company founded in the US in 2015 and the producer of the world's first chickenless egg proteins. For now, Clara Foods has developed an agreement with its investor Ingredion, a global ingredient solutions provider, to expedite the commercialization capability in different proteins.

ClearMeat: Claims to be India's first cellular based meat company. This Delhi-based company started in 2018. Currently working on using chicken cells to create a texture-like edible chicken keema.

Finless Foods: A cultured fish meat provider founded in the US in 2017. Finless Foods is now trying to bring down the production cost through cutting the amount of nutrient media used. It now expects the first product to be out in around 2021.

Future Meat Technologies: An Israeli company founded in 2017. Unlike many cultured meat companies that aim at producing cell-based meat on a large scale, the company plans to enable small businesses and individuals to produce their own cell-based meat through the distribution of bioreactors and capsules containing the starter tissue.

Glycosyn: A hMOS (human milk oligosaccharides) producer founded in the US in 2002. As of now, Glycosyn has developed proprietary technology to manufacture hMOS through processes like biosynthesis, which includes the hMOS commonly found in mother's milk.

IntegriCulture: A Japanese cultured meat company. Now developing cell-based foie gras, which is expected to be launched in the mass market by 2021. It also plans to roll out its first products in the supplements and cosmetics space by early 2020.

Just: A cultured meat company founded in the US in 2011. Just targets to roll out its first cultured meat products in 2019 (already pushed back from 2018) and is now in the process of a taste test, which is reported to be going well.

Meatable: A Dutch cell-based meat start-up founded in 2018. For now, Meatable primarily focuses on beef but it will expand to other areas like chicken and pigs later on.

Memphis Meats: A cultured meat company founded in 2015 in the US. It claims to have created the world's first cell-based meatball in 2016 and the world's first cell-based poultry in 2017. In 2018, Memphis Meats received investment from Tyson Foods, the processed meat giant in the US.

Mission Barns: A cell-based meat company founded in 2018 in the US, whose founder was a former employee of Just. The company focuses on creating animal fat, since this is where much of the distinctive flavor of meat resides. It has created products like duck sausages and plans to create more structured products like duck breast and steak in the future, which will take more time.

Mosa Meat: A Dutch cultured meat company with its chief scientist creating the first cell-based hamburger back in 2013. The company now expects make its cultured meat products commercially feasible in 3 to 4 years.

New Age Meats: A cultured meat company founded in the US in 2018. The company has created its first prototype sausage product, which tasters find difficult to distinguish from regular sausages.

Peace of Meat: A cultured meat company founded in Belgium in 2019. The company is working on its new product of cultured foie gras now with its head of Food Design joining from Super Meat, an Israeli cultured meat company.

Shiok Meats: A cultured meat company founded in Singapore, it claims to be the first one in SE Asia. The company focuses on crustacean meats and plans to launch the world's first cell-based shrimp. In 2019, it created cell-based shrimp dumpling.

Super Meat: An Israeli cultured meat start-up founded in 2015 focusing on cell-based chicken meat. The company expects its first cultured chicken products to be available to the mass market by 2021.

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(Article 3(1)e and Article 7 of MAR)

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Underperform - Describes securities that we expect to provide a total return (price appreciation plus yield) of minus 10% or less within a 12-month period.

The expected total return (price appreciation plus yield) for Buy rated securities with an average security price consistently below \$10 is 20% or more within a 12-month period as these companies are typically more volatile than the overall stock market. For Hold rated securities with an average security price consistently below \$10, the expected total return (price appreciation plus yield) is plus or minus 20% within a 12-month period. For Underperform rated securities with an average security price consistently below \$10, the expected total return (price appreciation plus yield) is minus 20% or less within a 12-month period.

NR - The investment rating and price target have been temporarily suspended. Such suspensions are in compliance with applicable regulations and/or Jefferies policies.

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NC - Not covered. Jefferies does not cover this company.

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Other Companies Mentioned in This Report

- Beyond Meat, Inc. (BYND: \$158.97, HOLD)
- Calyxt, Inc. (CLXT: \$7.74, BUY)
- Corteva, Inc. (CTVA: \$29.40, BUY)
- DuPont de Nemours, Inc. (DD: \$72.14, BUY)
- Royal DSM N.V. (DSM NA: €108.35, BUY)

Rating and Price Target History for: Beyond Meat, Inc. (BYND) as of 09-16-2019



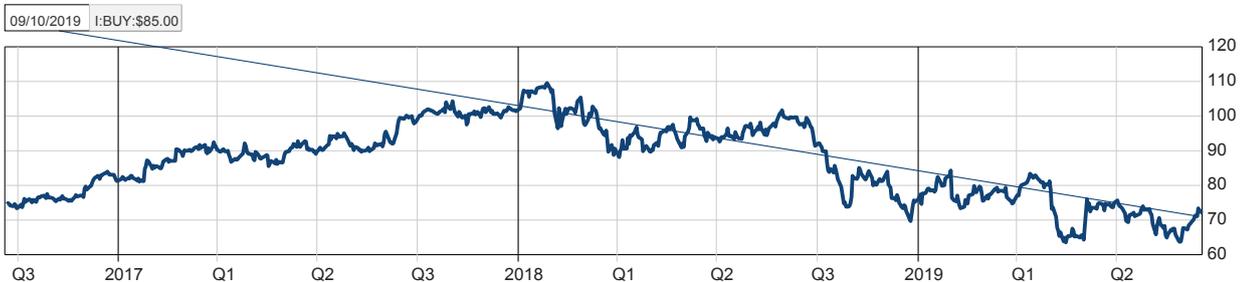
Rating and Price Target History for: Calyxt, Inc. (CLXT) as of 09-16-2019



Rating and Price Target History for: Corteva, Inc. (CTVA) as of 09-16-2019



Rating and Price Target History for: DuPont de Nemours, Inc. (DD) as of 09-16-2019



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Notes: Each box in the Rating and Price Target History chart above represents actions over the past three years in which an analyst initiated on a company, made a change to a rating or price target of a company or discontinued coverage of a company.

Legend:

I: Initiating Coverage

D: Dropped Coverage

B: Buy

H: Hold

UP: Underperform

Distribution of Ratings

Distribution of Ratings						
			IB Serv./Past12 Mos.		JIL Mkt Serv./Past12 Mos.	
	Count	Percent	Count	Percent	Count	Percent
BUY	1163	53.42%	85	7.31%	14	1.20%
HOLD	869	39.92%	18	2.07%	3	0.35%
UNDERPERFORM	145	6.66%	1	0.69%	0	0.00%

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