



# When consumers go vegan, how much meat will be left on the table for agribusiness?

Meat alternatives could disrupt a multibillion-dollar global industry.

# Overview

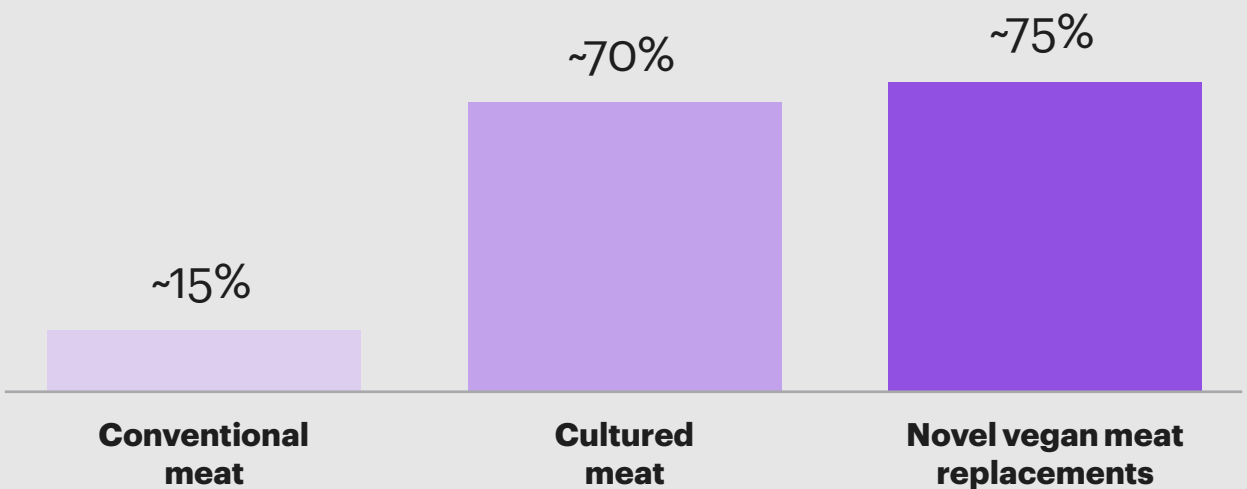
Global meat market  
(producing feed and meat):

\$1,000

billion in 2018

Cell- and fermentation-based technology companies will use their intellectual property **to cover as much animal products as possible.**

Conversion rate of plant calories to meat/meat alternative calories



The world's multibillion-dollar meat industry is facing disruption—possibly a massive one. So, what products have the most potential, what societal shifts are driving change, and who will benefit most? Drawing on our extensive research, we have pinpointed the main trends that are affecting the industry and identified several ways companies can prepare for the upcoming challenges.

## The meat business is huge, and it's growing

In 2018, the global population was around 7.6 billion. By 2050, it's projected to reach 10 billion. Sustaining all of these people will require a massive amount of food. And yet, nearly half of the world's harvest is used to feed livestock: about 1.4 billion cows, 1 billion pigs, 20 billion poultry, and 1.9 billion sheep, lamb, and goats, according to the Food and Agriculture Organization of the United Nations (FAO) (see figure 1). Only 37 percent of the remaining crops are grown purely for human consumption; biofuel and other industries account for the rest. So, most of the harvest is fed to animals to produce beef, pork, chicken, turkey, lamb, and goat meat. This does not include game, fish, or seafood.

It takes about 7 kg of grain in dry weight to produce 1 kg of live weight for cows in feedlots, around 4 kg of grain in dry weight per 1 kg of live weight for pigs, and just over 2 kg in dry weight for poultry, according to the American Oil Chemists' Society and our own field research. However, meat accounts for only about 40 percent of live weight. So poultry, for instance, actually requires 3 kg of grain to produce 1 kg of chicken.

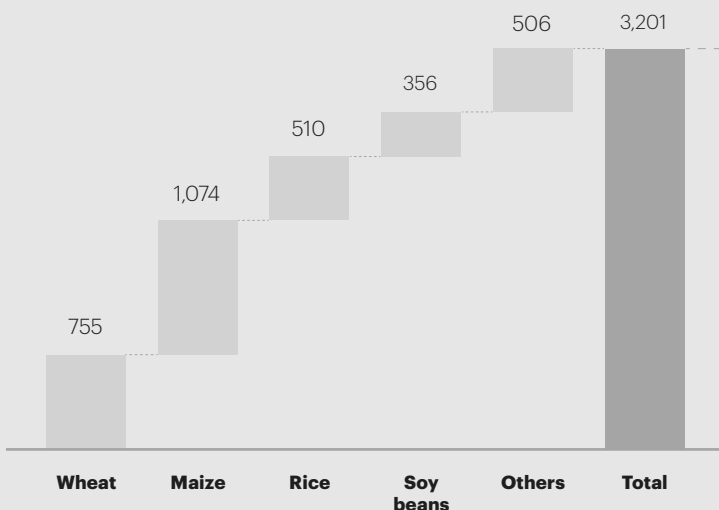
Bearing in mind that most meat has the same calories per kilogram as a mix of wheat, maize, rice, and soy beans, converting 46 percent of worldwide feed production into meat would add less than 7 percent to worldwide food calories—implying that 44 percent of today's global agricultural production would be enough to feed most people.

**Not feeding livestock but consuming the yield ourselves would provide enough food to nourish the global human population beyond 2050.**

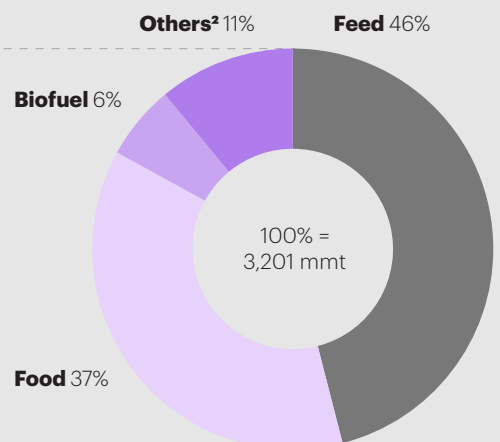
Figure 1  
**Livestock feed consumes a large fraction of the total harvest**

Worldwide production in 2018

mmt<sup>1</sup>



Worldwide consumption in 2018



<sup>1</sup> mmt = million metric tons

<sup>2</sup> Others = industry consumption and deterioration

Sources: Organisation for Economic Co-operation and Development, Food and Agriculture Organization of the United Nations; Kearney analysis

It is worthwhile to note that a purely plant-based diet would provide not only the same calories but also the same nutritional value if crops were planted that contained enough protein. So if we didn't feed livestock for slaughter, we could use today's global harvest to feed about twice as many people. Based on the world population today, we would have food for an additional 7 billion people—even more if less of the harvest ended up in industrial use and if waste was reduced.

Given the enormous global harvest needed to feed livestock, the size and influence of the global meat industry should be no surprise. Ultimately, meat is part of the global food chain—worth an estimated 10 percent of global GDP valued at \$8.8 trillion in 2018. Figure 2 shows the entire meat value chain from production and processing to retail along with its relationship to the agricultural industry.

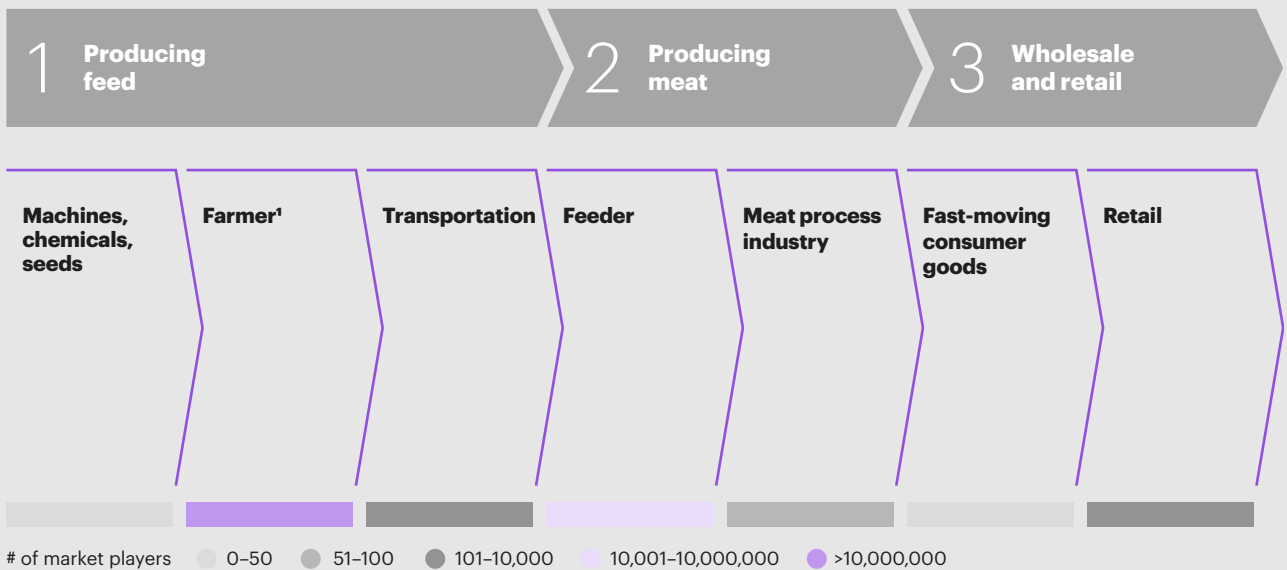
**Producing feed.** Growing plants requires a lot of equipment and machinery in addition to seeds, fertilizer, and agrochemicals. The monopolies on this are concentrated in the hands of a few major players. In 2018, throughout the agriculturally developed world, about 30 million professional farmers produced animal feed with a value of about \$600 billion. This only considers the yield consumed by livestock.

**Producing meat.** First, the feed is used to fatten live-stock. Then, the animals are slaughtered and made into meat products. The value added at this part of the chain was around \$400 billion in 2018. Five Rivers Cattle Feeding, LLC in Colorado and the “hog hotels” for pigs operated by Guangxi Yangxiang Co. Ltd stand out in terms of feed production. Meanwhile, the meat processing industry is highly consolidated; dominant enterprises include JBS, Tyson Foods, Cargill, BRF, Nippon Meat Packers, and Smithfield Foods.

**Wholesale and retail.** Meat and meat products are then processed by fast-moving consumer goods (FMCG) companies or sent directly to retailers. The value added during this step was around \$900 billion in 2018.

Even though the total meat value chain is worth about \$1,900 billion, meat replacements will disrupt the industry to the tune of about \$1,000 billion (see figure 3 on page 3). FMCG companies and retailers sell end products to consumers and are less affected—if at all—by new products and customers' changing behaviors. So, our focus here is on the potential disruption to the first two stages in the meat value chain: producing feed and producing meat.

Figure 2  
**The global meat value chain consists of seven steps in three areas**



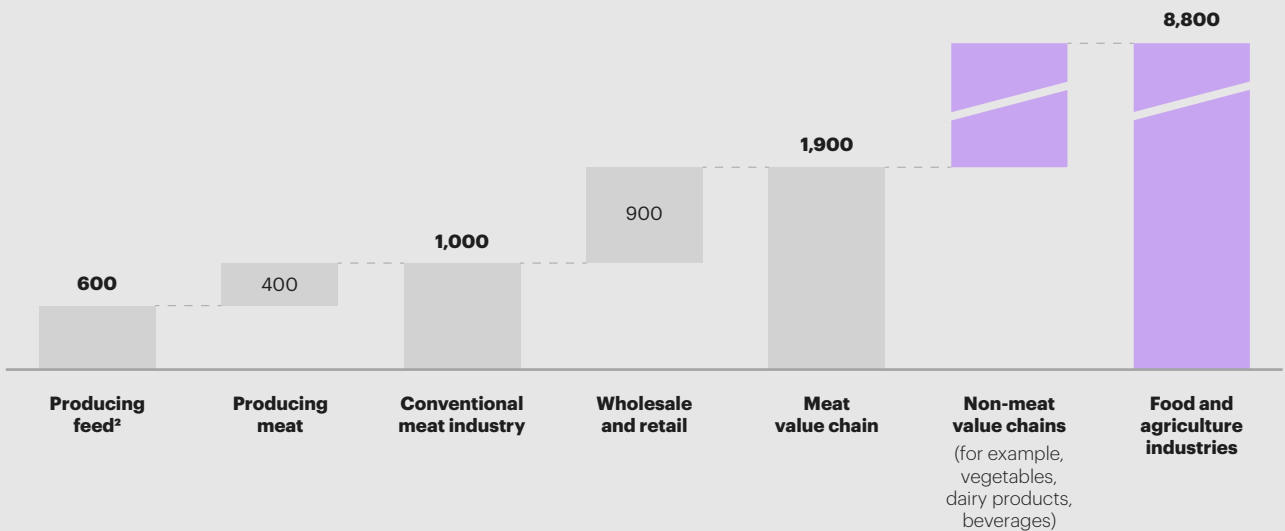
<sup>1</sup> Farmers cultivating at least five hectares

Sources: Organisation for Economic Co-operation and Development, Food and Agriculture Organization of the United Nations, Zion Market Research, Meat Atlas, Grand View Research; Kearney analysis

Figure 3

**The global meat value chain is worth around \$1,900 billion<sup>1</sup>**

\$ billion



<sup>1</sup> Numbers are rounded to hundred billions.

<sup>2</sup> Only the fraction relevant for meat production is taken into account.

Sources: Organisation for Economic Co-operation and Development, Food and Agriculture Organization of the United Nations, Zion Market Research, Meat Atlas, World Bank, Grand View Research; Kearney analysis

## Solutions for making conventional meat production more efficient are almost exhausted

The global agriculture and meat industry faces enormous challenges to meet the world’s growing demand for meat while transforming into a more sustainable structure.

**Land challenge.** In a world where arable land is shrinking as a result of global warming and urban development and the population is growing, acreage can only be increased by sacrificing natural habitats such as the rainforest, which is difficult to justify for producing feed. In 1970, the ratio of humans to arable land was around 0.38 hectares per head. By 2050, this is projected to decline to 0.15 hectares. The availability of fresh water, particularly in areas where there is less rainfall, makes maintaining fertile land a challenge. According to FAO and Aquastat, global agriculture already uses about 70 percent of blue water, which is hardly sustainable.

**Intensification challenge.** Agricultural production is already reaching its limits, and the downsides of industrialized farming practices can already be seen. For example, resistance to modern agrochemicals is on the rise, and soil compaction and erosion are posing problems. The reduction of biodiversity in intensively cropped areas is causing concern among stakeholders and decision-makers, and agrochemicals regulations are expected to become stricter worldwide.

**Livestock challenge.** Moving from field to feedlot, the use of antibiotics to avoid livestock epidemics will trigger antibiotic resistance among humans, opening the door to major health risks. Scandals involving feces—and the meat industry’s handling of those scandals—have contributed to consumers’ loss of appetite for factory-farmed meat. More people are against the industrialized slaughter of animals, and “non-slaughtered meat” is already appealing to many consumers. Industrialized meat production faces an image problem, viewed by many as an unnecessary evil.

So far, the meat industry has tried to address these challenges with more efficient production methods. The rise of digital farming means that crop regimes can be tailored to the needs of individual plots and fields, which has helped lift yields by 20 to 30 percent without more agricultural inputs. In meat production, optimizing conversion rates, such as by substituting fish with protein-rich insect meal, has also helped. Digital farming has improved the growth rate of animals by optimizing feeding regimes to reduce the amount of grain needed to reach slaughter weight by up to 10 percent. However, making conventional methods more efficient will not be enough.

None of the approaches discussed so far disrupts the production of meat but rather incrementally improves it. Next, we turn our attention to meat substitutes, which have the potential to transform the whole industry.

## New meat products and market players are evolving

Instead of concentrating on improving conventional meat production, several companies have focused on inventing products to replace meat. From plant- and insect-based meat alternatives to cultured meat, the list of new products and brands is long and growing.

New meat products can be grouped into five categories:

**Classic vegan meat replacements.** These products, which are free from animal-based ingredients such as egg, gelatin, and milk, have been around for years and are mainly based on tofu, seitan, mushrooms, or jackfruit. The main disadvantage is that they don’t taste like meat and therefore don’t attract most consumers. So far, this has been a niche market that caters to ethically minded vegans.

**Classic vegetarian meat replacements.** These products have been part of the portfolio of most large meat producers and retailers for several years. In addition to plant-based ingredients, these products contain some animal-based ingredients, such as eggs. So, livestock is still needed to produce them on a large scale. But most don’t taste like meat, which again makes them relatively unattractive to the average consumer.

**Insect-based meat replacements.** These products are made of insect protein, mainly mealworms and crickets. Some companies sell fried crickets, and others process insects into burger patties or meatballs. The main advantage is the superior conversion rate of energy and protein compared with conventional meat. However, while these products have enormous potential as food for livestock or for industrial food processing, they aren’t popular in most Western countries—not only because of the taste but also because most people don’t think of insects as food.

**Novel vegan meat replacements.** These products are made entirely from plants (see figure 4). The taste and consistency more closely resemble meat than classic vegan meat replacements, primarily because of a sophisticated production process that uses hemoglobin and binders extracted from fermented plants to mimic the sensory experience of eating meat right down to the blood. Founded around 2010, start-ups such as Impossible Foods, Just, and Beyond Meat have received substantial funds—up to \$900 million in 2018. Their products are already available in restaurants and supermarkets in several countries.

**Cultured meat.** This type of meat, also referred to as clean meat, cell-based meat, or slaughter-free meat, is created through exponential cell growth in bioreactors. The result is identical to conventionally produced meat. The first start-ups have offered public and private tastings of various prototypes, but no commercial products are available yet.

Figure 4

**The production processes for novel vegan meat replacement and cultured meat are quite different**

Process to create novel vegan meat replacement

1. Isolation and functionalization	2. Formulation	3. Processing
<ul style="list-style-type: none"> <li>Plant-protein concentrates are extracted from plants.</li> <li>Proteins are hydrolyzed (broken down) to improve their functional traits.</li> </ul>	<ul style="list-style-type: none"> <li>Binders, fats, and flavors are added to improve the sensory profile.</li> <li>Nutrients are added to at least meet the amount of nutrients in meat.</li> </ul>	<ul style="list-style-type: none"> <li>The mixture is shaped into final product via stretching, kneading, shear-cell processing, press forming, folding, layering, or extrusion.</li> </ul>

Process to create cultured meat

1. Cell isolation	2. Cell proliferation	3. Tissue perfusion
<ul style="list-style-type: none"> <li>An adult stem cell—called a satellite cell—is extracted from an animal.</li> <li>One cell is sufficient for the process and the animal can live on.</li> </ul>	<p>The cells are added to a bioreactor along with cell culture media, which causes the cells to proliferate.</p> <ul style="list-style-type: none"> <li>The result is exponential growth of the satellite cell.</li> <li>Cells are fed by a medium containing amino acids, salts, sugars, and signaling molecules.</li> </ul>	<p>A change in culture conditions pushes the cell to differentiate into muscle, fat, and connective tissue.</p> <ul style="list-style-type: none"> <li>Cells are structured via 3D scaffolding materials to muscle fibers.</li> <li>Muscle fibers are combined with fat to meat.</li> </ul>

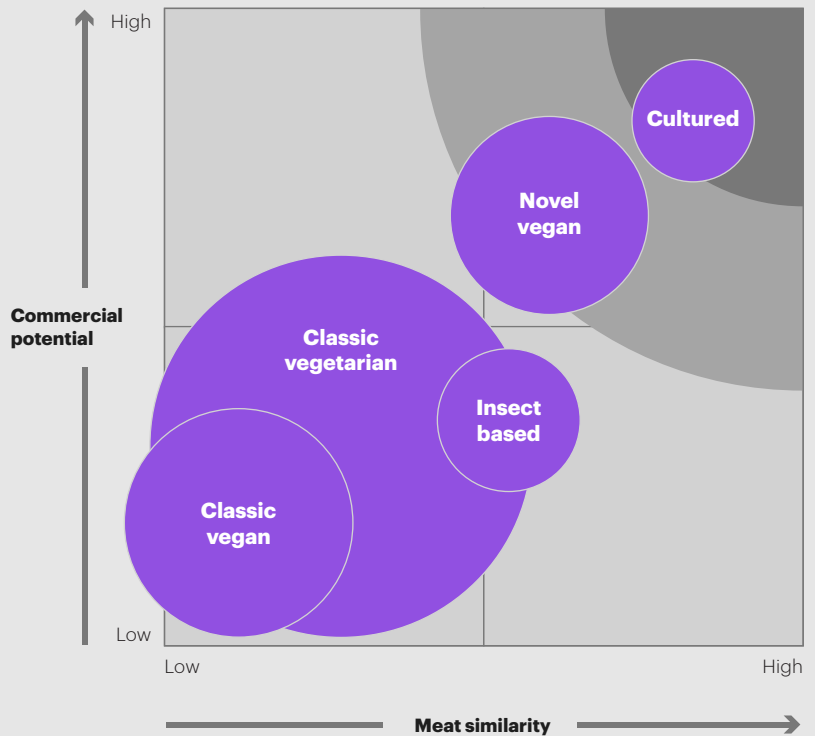
Sources: Good Food Institute, Impossible Foods; Kearney analysis

In 2018, the total market for plant-based meat alternative products was around \$4.6 billion. This is projected to grow by 20 to 30 percent per year in the next several years (depending on the region). This is a small fraction of the \$1,000 billion global meat market, so there is a great deal of untapped potential. In figure 5, all five product classes are plotted according to their similarity to meat, commercial potential, and total funding. Meat similarity is defined by the degree to which the sensory profile and mix of nutrients and vitamins match the meat. Commercial potential within the next decade is defined by possible market share, predicted growth, and competitiveness in terms of price, which is estimated based on expert interviews.

Because classic vegan, vegetarian meat replacements, and insect-based alternatives are less likely to tempt consumers who are not vegan or vegetarian, their commercial potential depends on the number of people who become vegan or vegetarian. However, novel vegan meat replacements and cultured meat could disrupt the conventional meat industry. This is why industry experts refer to novel vegan meat replacements as Generation 0 and cultured meat as Generation 1—terms that emphasize their relative novelty and potential as well as the pace of product development and market penetration. Novel vegan meat replacements are expected to be most relevant during the long-term transition toward cultured meat, but cultured meat is predicted to triumph thanks to its fusion of sustainability and tailor-made nutrition, which should satisfy a diverse range of consumers.

**Driven by advances in biotechnology, cultured meat and novel vegan meat replacements are becoming harbingers of much larger changes across the whole food value chain.**

Figure 5  
**Meat similarity drives the commercial potential**



- Bubble size = funding up to 2018
- = "Generation 1" corridor
- = "Generation 0" corridor

Source: Kearney analysis



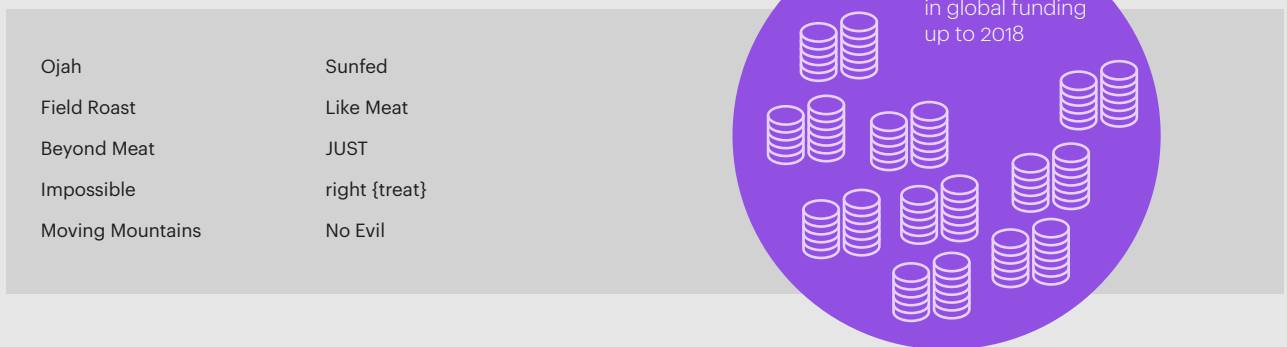
Figure 6

## The meat replacement industry is attractive for venture capital

### Selected cultured meat companies



### Established novel vegan meat replacement brands



Source: Kearney analysis

Major changes in the global meat market will be driven by the development and industrialization of biotechnological processes in the food industry. Within a few years, the emerging market and technology leaders in the business of novel vegan and cultured meat replacement will become an integral part of prestigious start-up spots such as California, Israel, and the Netherlands. Some ventures such as Google, Tesla, and Apple are already proving attractive to top university graduates. Figure 6 offers a snapshot of the most relevant and promising companies in both fields along with the corresponding global funding up to 2018. Venture capital firms, national funds such as China's, and large corporations such as Cargill, Tyson, Merck, Google, UBS, and PHW Group have already invested in start-ups, not only financially but also with their knowledge and experience in agriculture and biotechnology while also acting as suppliers or customers.

In addition to meat alternatives, several companies are hoping to come up with substitutes for seafood, leather, silk, egg whites, milk, gelatin, and even horn. Because their inherent structures are not as complex as meat, these products might hit the market even earlier than cultured meat. As a result, companies such as cultured leather producer Modern Meadow have attracted multimillion-dollar funding as they look to bring their products to market within the next few years. Leather has already attracted major investments thanks to its relevance to luxury goods designers.

# Which product will win in the future meat market?

To determine which new product has the most potential to disrupt the meat industry, we have considered eight criteria (see figure 7):

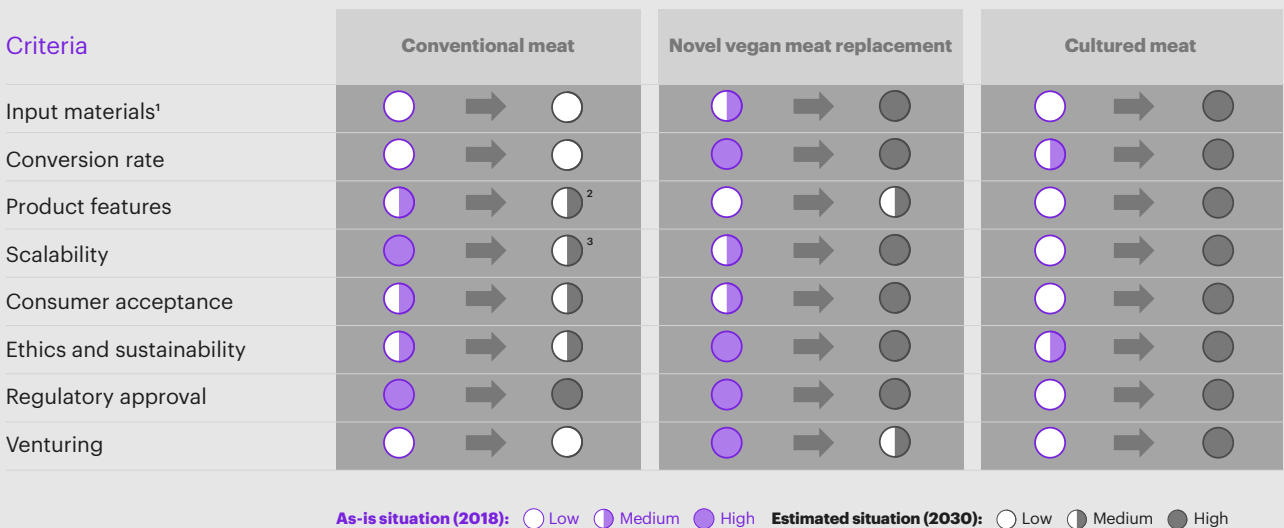
**Input materials.** The inputs for conventional and novel vegan meat are relatively similar: energy, water, and arable crops such as wheat, potatoes, soy, and coconut oil. In contrast, the inputs for cultured meat are amino acids and glucose to feed cells, as extracted via hydrolyzation from a large variety of biomass, including livestock by-products and several types of plants. According to industry experts, the best plants for this are soy, peas, corn, and red sugar beets. Although glucose and amino acids are relatively cheap, the signaling molecules that stimulate cells to differentiate are very expensive. Research and development initiatives are focusing on reducing this crucial cost block.

**Conversion rate.** Cultured meat needs much less input than conventional meat to create the same amount of meat. According to our field research, about 1.5 kg of soy, peas, maize, and red sugar beets is needed to produce 1 kg of cultured meat—a conversion rate of about 70 percent. As the technologies and production methods evolve, this should improve. In addition, cell-based technology can be used to produce livestock by-products such as gelatin, leather, and blood to meet the needs of industry customers. For novel vegan meat replacements, about 1.3 kg of arable crops are needed to produce 1 kg of plant-based meat—a conversion rate of about 75 percent. Plant-based meat has the same nutritional profile as meat. The conversion rate of conventional meat cannot be improved much and lags far behind meat replacement products.

**The conversion rates for cultured meat and novel vegan meat replacements are more than 4 times higher than for conventional meat.**

Figure 7

## Both novel vegan meat replacement and cultured meat have disruptive potential



<sup>1</sup> Input materials in terms of availability

<sup>2</sup> In addition to taste, shelf life and customization (for example, muscle-fat-nutrient ratio) have been taken into account.

<sup>3</sup> The scalability of meat will decrease due to stronger hygiene regulations and higher quality standards on the part of consumers.

Source: Kearney analysis

**Product features.** Cultured and novel vegan meat replacements have other advantages too, including the ability to customize the meat's muscle-fat-nutrient ratio (for example, by replacing fatty acids with omega and adding nutrients). The shelf life is longer, and less cooling is required for transportation since bacteria such as salmonella and E. coli do not incubate in the degradation process. Additionally, these new products cannot cause epidemics such as mad cow disease or bird flu because their production is subject to stringent controls that guarantee a high level of security in the supply chain.

**Scalability.** Novel vegan meat replacements can be mass produced and are already on the market—in contrast to cultured meat, which is not yet available to consumers. For now, production of cultured meat is minimal as the types of cell and bioreactors must be improved and streamlined. Nevertheless, the potential to scale up production is enormous, and industry experts predict the necessary technology will be ready by 2021. Based on scales in 2018, the US price for 100 g of conventional ground beef in retail stores is 80 cents—much cheaper than, for instance, a novel vegan 100 g burger patty that costs \$2.50 or cultured meat products at \$80 per 100 g. Cultured meat is expected to drop in cost by \$4 per 100 g within the next 12 years, and experts say production costs could decrease even more.

**Consumer acceptance.** With the trend toward semi-vegetarianism, novel vegan meat replacements are commercially viable. Interestingly, this also applies to cultured meat. In recent surveys, most respondents in Western countries say they would try cultured meat, and half say they would be willing to buy it. Similar studies show that people in India and China are particularly interested in cultured meat. Education about the benefits of cultured meat will be crucial to creating customers.

**Ethics and sustainability.** Both meat alternatives have the potential to overcome most ethical and ecological agricultural challenges. No animals are harmed during production, and much fewer livestock, land, and blue water are required. However, energy consumption in the form of heating and cooling is very high. Over the next decade, energy savings of more than 80 percent can be achieved when producing on a large scale with optimized bioreactors, according to industry experts.

**Regulatory approval.** Although novel vegan meat replacements don't face severe challenges with worldwide food authorities, cultured meat will need to be accepted by most worldwide food regulators. In November 2018, the US Department of Agriculture and the Food and Drug Administration agreed to jointly regulate cultured meat—the first step toward making cultured meat legally available worldwide.

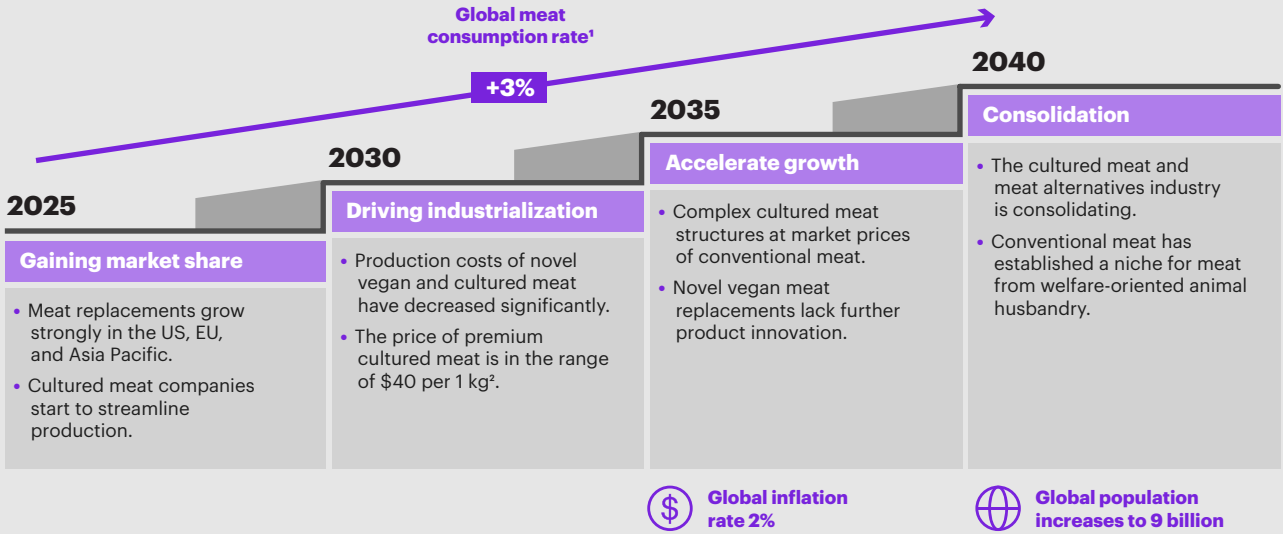
**Venturing.** In 2018, the worldwide funding of novel vegan meat replacement companies reached \$900 million, and the funding of cultured meat companies reached \$50 million. Since most cultured meat companies were founded around 2016 or 2017, this is the earliest stage of investment. Meat replacement start-ups also received significant financial and media support from large corporations, governments, and celebrities, including Richard Branson, Sergey Brin, and Bill Gates. More venture capital funds and corporate investors are expected to pour money into these companies within the next several years.

It's only a matter of time before meat replacements capture a substantial market share. The agriculture and conventional meat industry will feel the impact first, meaning about \$1,000 billion of the conventional meat market is at risk.

**Cell- and fermentation based approaches in food industries will pave the way for a tailor-made as well as animal mimetic nutrition culture.**

Figure 8

**Global meat consumption: Qualitative forecasting is required as historical patterns cannot be applied**



<sup>1</sup> The global meat consumption rate considers (1) changes in consumer behavior focusing on non-meat proteins and (2) centers of global population growth (low meat consumption countries due to cultural/religious affiliation).

<sup>2</sup> This price assessment applies only to the so-called muscle meat; the price of mechanically separated and mixed meat is of course even lower.

Sources: United Nations, World Bank, expert interviews; Kearney analysis

**The meat industry disruption is creating vast opportunities**

It's hard to predict how fast disruption will come, but wholesalers, retailers, and consumer goods companies are already trying to carve out a foothold by purchasing exclusive distribution rights or acquiring start-ups. (Tesco, for example, has bought distribution rights for the Beyond Meat Burger.)

Our qualitative forecasts of the meat market's development until 2040 are based on reliable economic data as well as on our own research. Figure 8 illustrates our methodology. The following three elements play a fundamental role:

- The meat market will grow slowly as global population growth takes place mostly in locations with low meat consumption, such as India and Africa. Considering an average inflation rate of 2 percent, the meat market will grow at around 3 percent per year in the coming decades.
- Novel vegan meat replacements will be most relevant in the transition to cultured meat, whereas cultured meat will win in the long run. This is because commercial competitiveness will gradually shift in favor of cultured meat over the next 15 years.
- The consumer and legal acceptance of cultured meat will be a global phenomenon. This hypothesis is backed by several surveys in India, China, and the United States as well as the global development toward non-slaughtered and resource-efficient products.

**Cultured meat will win in the long run. However, novel vegan meat replacements will be essential in the transition phase.**

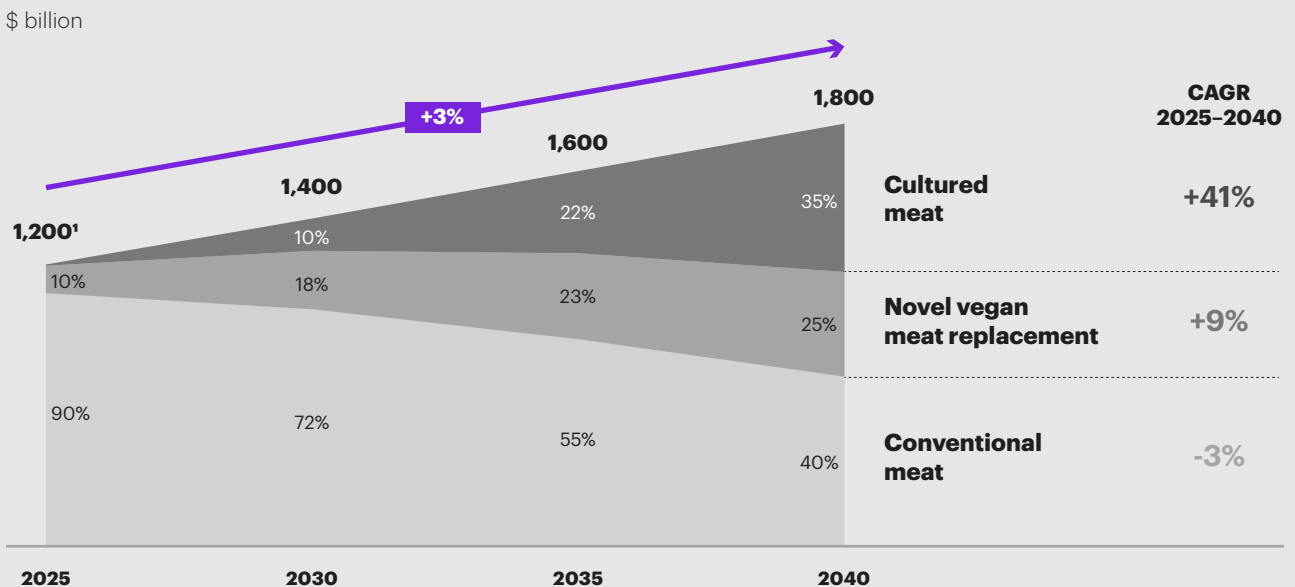
These new technologies will provide about a third of the global meat supply within the next 10 years (see figure 9). It is noteworthy that the demand for conventional meat declines by 3 percent despite a global increase in meat consumption of 3 percent per year. Novel vegan meat replacements will see strong growth during the transition (until 2030), whereas cultured meat—with an annual growth rate of 41 percent per year—will outgrow novel vegan meat replacements between 2025 and 2040 thanks to technological advancements and consumer preferences. The market share of conventional meat will shrink in favor of cultured meat and meat replacements. Biotechnology will also disrupt the food industry concerning milk, eggs, gelatin, and fish.

In addition to the advantages and opportunities, threats will also arise. For instance, the remaining livestock might not be able to produce enough manure to fertilize fields or by-products such as brain, skin, and horns. The use of manure and synthetic fertilizers will have to adapt to new market conditions, and efforts to replace animal by-products with synthetic substitutes will have to increase. In any event, structural transformations in conventional meat production are inevitable if the new products make up a significant proportion of the worldwide meat market.

Succeeding in the meat market in 2030 and beyond will require early investments as supply chains, production facilities, and distribution channels must be built up to respond to new requirements. Broad patent and brand portfolios must also be set up—and fast. Although patenting plays a crucial role in developing a product, strong brands are also vital for rapid and widespread distribution, especially when marketing is focused on ethical, health, and wellness concerns.

**In 20 years, only 40% of global meat consumption will still come from conventional meat sources.**

Figure 9  
**Global meat consumption: By 2040, conventional meat supply will drop by more than 33%**



<sup>1</sup> Numbers are rounded to hundred billions.

Sources: United Nations, World Bank, expert interviews; Kearney analysis

There is no doubt that cultured meat and new meat replacement products are going to disrupt the industry. We are already seeing a shift toward more consumption of non-meat proteins such as legumes and nuts because of lifestyle trends aimed at creating a more sustainable and healthier diet. But some passionate meat-eaters who watch their diets have no intention of becoming vegetarian or vegan.

In this context, the discussion about cultured meat and meat replacement products as well as how they can be produced in large-scale batches at attractive prices becomes technical rather than governed by emotion. And that raises the question: will we one day biologically engineer meat like we rise bread or brew beer?

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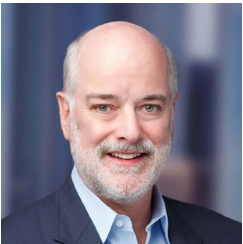
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As a global consulting partnership in more than 40 countries, our people make us who we are. We're individuals who take as much joy from those we work with as the work itself. Driven to be the difference between a big idea and making it happen, we help our clients break through.

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