

Synthetic Food

By Ellio 1A207, Yifan 1A204, Ethan 1A208 and Jasperl 1A214
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Origins of Synthetic Food

Synthetic Flavour

Synthetic Food has appeared in history as early as 1851. Then, for the first time, pear, apple, grape or pineapple candies flavoured with compounds synthesized in laboratories instead of products of agriculture. I could not find a source that told me who exactly started this initiative.

(Nadia Berenstein, *The Inexorable Rise of Synthetic Flavor: A Pictorial History*, 2015)

Production

These flavours were simple combinations of esters diluted in alcohol, or single chemicals. They were not very advanced, compared to what would be produced later on in the century. By the end of the 19th century, flavours were getting more and more advanced, and cheaper as well. Synthesised flavours and the original fruit were almost indistinguishable.

Examples of such flavours are vanillin, butter etc. Through chemical synthesis and extractions, scientists were able to replicate genuine vanilla and actual dairy products to a T.

However, additives were also synthesized to mask "damage and inferiority", according to Nadia Berenstein of Popular Science. Action was taken, and from then on, synthetic food companies had to declare their products as "imitation" or "compound".

Synthetics were largely seen as impure ever since it started out; some still do today, but around 1906, reputable synthetic food manufacturers pushed back against such things. By chemical standards, synthetic food was purer than most organic foods, due to the absence of substances that make foods bad.

Compared to synthetic foods later in the review, these flavours were ancient. Process employed to create synthetic food evolved, as it will evolve in times to come. In 2026, there will be unimaginable new foods. For someone 100 years ago, meat made from plants was impossible, is it that unrealistic to look forward to even weirder things?

(Nadia Berenstein, *The Inexorable Rise of Synthetic Flavor: A Pictorial History*, 2015)

(C. Rose Kennedy, *The Flavor Rundown: Natural vs. Artificial Flavors*, 2015)

Distrusting Synthetics

Later, these additives were used to enhance processed foods, because production of such processed foods affected the food itself, rendering it smelly and tasteless. This was where synthetic additives come in. Such additives are still used today, unbeknownst to many people. According to the survey conducted by my group, many people refuse to eat synthetic foods, like plant-based meat, on the grounds that "It is synthetic! I cannot trust these kinds of stuff!" but would rather eat instant noodles. They are unaware of the synthetic preservatives in the instant noodles.

Over the following years, flavoured additives became increasingly popular, so much so that that era could be called the "golden age of processed foods". This time was also a time of chemical additives. Distrust grew, and soon, investigations proved that certain chemicals used in flavouring were harmful to humans in one way or another.

The need for natural, safe, pure, virtuous and "good" food was on the rise, and companies took advantage of that by making foods and declaring them "natural". People needed to hear that comforting word, and flocked to purchase these natural foods. But in reality, natural foods and artificial foods are actually very similar. In modern times, these synthetic foods have gone through heavy vetting and are generally harmless.

According to Nadia Berenstein of Popular Science, "The Food Additives Amendment, which became law in 1958, imposed a new set of requirements for food chemicals", "The permissibility of new chemicals is determined by an expert panel assembled by the Flavor and Extract Manufacturers Association, the industry's leading trade group", "The list of these permissible chemicals, known as GRAS, for "Generally Recognized As Safe," dictates the flavor chemicals that can be used in food flavors today", and "The 27th edition the list, published last year, contained nearly 3000 chemicals". We can rest assured that our health and wellbeing is a primary concern. (Nadia Berenstein, *The Inexorable Rise of Synthetic Flavor: A Pictorial History*, 2015)

In modern times, people are being cheated, or rather are cheating themselves. Instead of joining in on the fun of eating plant-based meat and helping to reduce climate change, they insist on their traditional barbecue and do not agree with new, modern ways of eating.

(Nadia Berenstein, *The Inexorable Rise of Synthetic Flavor: A Pictorial History*, 2015)

(C. Rose Kennedy, *The Flavor Rundown: Natural vs. Artificial Flavors*, 2015)

Changing Raw Materials into Different Forms

Before the science of chemistry was established, humans were able to exploit biochemical processes to create food and beverages. There are a few processes.

Pasteurisation: By mildly heating a food (less than 100°C, we can eliminate pathogens and extend shelf life. This is used on milk, fruit juices, wine, etc. This method was invented by Louis Pasteur, and from his name it is easy to see where they got the word "pasteurisation" from.

Fermentation: By fermenting a food, we are able to convert it into other forms, like how milk can be fermented to form cheese. It is a very common method of changing raw materials into different forms, and the earliest evidence for when it was first used dates back to 8000 years ago. It is narrowly defined as the extraction of carbohydrates in the absence of production.

Preservation: Adding salt is the simplest way to preserve food. Salt removes moisture and prevents decay. Now, we have advanced ways to preserve food, like the use of chemical preservatives.

Synthesis: Artificial flavours have been around since 1851. Such flavours are artificially made in chemical laboratories. There are also plant-based meats, engineered from ingredients of all sorts, like coconut oil, heme and yellow beans. The first truly artificial meat, however, was made in 2013, where meat was grown in a lab from stem cells with the help of enzymes.

These are a few ways food was made synthetic by exploiting reactions in a lab. New kinds of foods are being invented, like cultured meat or plant-based meat, which are actually "purer" than generic meat. With them will come newer ways to ensure the safety of the food we enjoy.

(Jessica Clifton, *A chemical history of food*-New Food Magazine, 2020)

(Wikimedia Foundation, *Pasteurization*, 2021)

(Wikimedia Foundation, *Fermentation*, 2021)

In Vitro Meat

The concept of in vitro is growing food from cells obtained from an animal. Nourishing stem cells taken from an animal like a cow with protein results in actual, edible beef. Such food takes away the need for animals to die, would have a positive impact on climate-change, and minimize health risks among other things.

However, such foods are ridiculously expensive at a price of 250,000 Euro. But there are many projects to change that, and scientists aim to have it on the market in the next 10-20 years.

In vitro meat is different from plant-based meat. Plant-based meat, as stated in the name, is made from plants and plants only. In vitro meat grows meat from cells taken from an animal. In plant-based meat, synthetic biology is exploited to create new foods.

Such foods are very expensive. Luckily for our wallets, the process to make this more affordable is in course. "Not only is the process in course, it is soaring ahead. At great speed."

(Lovers, B. Y. F. D. , *Synthetic Meat and Co: Is This the Food of the Future?*, 2015)

In vitro meat is different from plant-based meat though. Both are classified as "synthetic meat" or "fake meat", but the techniques employed to make them are different in many, many ways. Plant-based meat, like the name suggests, is made from plants.

If you do not have a net worth of at least a million dollars, this might not be the food for you... yet. As stated above, new projects are being realised with the purpose of allowing ordinary people like you and me to indulge in cultured meat without feeling guilty about killing an animal for the food on your table. Peace at last!

(Lovers, B. Y. F. D. , *Synthetic Meat and Co: Is This the Food of the Future?*, 2015)

Cultured Meat

The first cultured meat made with in vitro technology(above) was made in 2013 by Mark Post, who was a professor at Maastricht University. He was the first to showcase proof-of-concept for cultured meat by creating the first burger patty directly from cells. It was tested live on television in London on 5 August 2013. It was made with over 20000 thin strands of muscle tissue.

At that time, it cost \$300000 to make and took 2 years to produce. It was estimated to be \$10 by 2021, and the price still has to go down a little more to achieve that goal. Now, it sells for about \$50 per serving. The first time Singapore got to try such a food was in December 2020, which was when "chicken bites" produced by Eat Just were approved. There are many startups that revolve around this food, too many to name here.

Cultured meat came around because of people like Dutch scientist Van Eelen. He starved in the second world war and this led to his passion for food production and food security. There are other notable people who were important in this field. In 1991, Jon F. Vein of the United States secured the patent for the production of tissue-engineered meat for us to eat.

There are many incentives to create such synthetic, cultured meats. From ethics to practicality to efficiency, cultured meats are better in many ways. "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." Winston Churchill wrote in his 1931 essay *Fifty Years Hence*. And now, that dream is coming true.

However, many more people and companies recognise the benefits of such cultured meats. The project has received backing from NASA and PETA. NASA started a project to culture meat, and PETA offered a \$1 million prize to the first company to bring lab-grown chicken meat to consumers. Sadly, the deadline for PETA's competition expired with no winner, but that did not mean people were going to stop trying to make cultured meat.

This will change in the near future. Soon, with proper advertising, these kinds of foods will be on the rise. Fast food chain Burger King has already added a plant-based burger to their menu. If other fast food chains like McDonald's and KFC follow in Burger King's footsteps, the demand for plant-based meat will increase, which leads to supply increase, and because of the laws of supply and demand, the price for it will fall.

(Wikimedia Foundation, *Cultured meat*, 2021)

(Mark Post, *Journal of the Science of Food and Agriculture*, 2013)

(Fernando, J. , *Law of Supply and Demand*, 2021)

The Impact of COVID-19 on Synthetic Food

Synthetic Food Industry is doing better during the pandemic

COVID-19 has been causing a lot of economic losses for the majority of the industries, especially for the first half of 2020. For example, the cinema has not been doing well during the pandemic. However, some industries, including the synthetic food industry, managed to emerge during the pandemic and lead the world, surviving in 2020, and even earning almost double the amount of money earned in the year before COVID-19 broke out, which is 2019.

One of the examples is synbio, a synthetic food industry. This company earned \$1.9 billion by the end of 2019. At the end of 2020, it turns out that synbio earned \$3 billion. (LeMieux, 2020) The synthetic food industry is very hopeful that it will do better from 2020 to 2027. This clearly proves that synthetic biology is doing better during the pandemic, and it might be doing even better in the future, because synthetic food is able to replace the original food when less original food can be brought into the country from other countries. This could just be the start for the rise of the synthetic food industry, the future is unknown yet to us.

One possible trend is that now it is the second wave of the pandemic, the synthetic food market will be growing further and gaining powers to survive. The reason can be less food from other countries can be brought into the locals as there is risk of allowing the virus into the country. Thus, the country has to make synthetic food to make sure there is enough food to feed the people. Singapore is in a similar situation now. However, the price is estimated to remain elevated during the short term (businesswire, 2020), possibly due to the poor public awareness and acceptance of synthetic food. This also affects the business of the synthetic food industry.

(LeMieux, J., *With Synthetic Biology Nature is All Business*, 2020)

(Businesswire, *COVID-19 Impact and Recovery Analysis - Global Synthetic Biology Market 2020–2024* | *Evolving Opportunities with Amyris Inc. and Algenol* | Technavio., 2020)

Synthetic Biology is expected to gain market growth in the future

The global synthetic biology market size is estimated to reach USD 30.7 billion by 2026 from USD 9.5 billion in 2021, at a CAGR of 26.5% during the forecast period.

Factors such as a wide range of applications of synthetic biology, the rising R&D funding and zgrowing initiatives in synthetic biology, declining cost of DNA sequencing and synthesizing, and increasing investments in the market are propelling the growth of this market. The demand for fuel alternatives is currently increasing, while this can create chances for the market to grow.

Growing demand for protein therapeutics and personalized medicine and rising research in synthetic drugs and vaccines is expected to create new chances for the market as well. Other factors, like the increasing application of synthetic biology, increasing investment in synthetic biology, decreasing cost of DNA synthesizing and so on contributes to speed up the process of market growth from 2020 to 2027.

Synthetic products are popular due to transparency, sustainability and cost efficiency." says Areeb. (Markets and Markets, 2020). While the synthetic food market is growing, Singapore is also going to benefit from it, because Singapore has no natural resources, it has to rely on other countries heavily for food. The growth of the synthetic food market gives more opportunities for Singapore to get more synthetic food. In this way, Singapore will be less reliant on other countries for food.

However, biosafety, biosecurity, and ethical concerns related to synthetic biology would hamper the growth of this market. Synthetic biology still had a long way to go, they still need to work very hard in order to succeed in their business. There is no full guarantee that their market size would surely increase, their market is very dependent on the factors mentioned above.

(Markets and Markets,*Synthetic Biology Market*, 2020)

Synthetic Biology may have a good future and it will become even better

“Singapore has recently approved synthetic meat to be sold in the local market,” said Audrey Tan. (Tan, 2020) This definitely made synthetic biology to gain advantage in the future to compete with other industries.

With the first country approving the sale of the first synthetic product, while other countries are considering the approval of sale of synthetic food as the products have to be proven to be healthy and harmless to the human body.

It is an important step taken by the synthetic industry to continue with their business, any decision or factor may affect the future of synthetic food. They are emerging and very likely that these trends—the new levels of private and public financing, and investor interest in devices and life science tools—will continue into 2021. Maybe, one day in the future, everyone in the world will get to eat synthetic food like synthetic meat.

However, the majority of the people are anxious and unopened about eating synthetic meat. According to a survey my group did, more than half of the people responded “Unsure”, “Maybe no” and “Definitely no” when they were asked if they would want to replace farmed meat to synthetic meat. (Phillips, 2017)

The responses of people are not surprising and they are understandable. Those who said “Maybe No” and “Definitely No” in the survey could be thinking that the synthetic food is artificial and could have harmful chemicals contained which will negatively affect their body. They might also have worries about the hygiene of the synthetic food, because now the pandemic has been very serious and the people have been paying more attention to the hygiene of food.

They did not know much about the synthetic food and had bad impressions of it. The possible reason is that there are very few advertisements made for the synthetic food, causing poor public awareness. This eventually caused poor public acceptance of the synthetic food.

Poor public acceptance of synthetic food is a serious problem that made the synthetic food industry do less as well as they actually could. The problem can be solved by making more advertisements about synthetic food, and delivering speeches about the synthetic food. People thus understand better about the synthetic food and would want to accept and purchase synthetic food.

(Tan, A., *Singapore first in world to approve lab-grown meat for sale*, 2020)

(Phillips, C., *No animal required, but would people eat artificial meat?*, 2017)

Summary

In conclusion, the synthetic food industry actually has good potential to do better than now in a few years time, especially now it is the pandemic. Countries like Singapore, which depend heavily on other countries for food supply, especially need the help of synthetic food to prevent hunger. Synthetic food is a key to solve the food shortage problem and to slow down the rate of global warming. Now, the coronavirus is still existing. Synthetic food, especially synthetic meat, is a better choice as it is less likely to carry virus.

However, factors like public acceptance and awareness might affect the business of synthetic food. However, we might be able to reverse the situation by making more advertisements about synthetic food, so that people understand clearly about synthetic food. Then, they will be more willing to buy synthetic food. Synthetic food industry can thus achieve success.

Recently, Singapore has officially approved the sale of synthetic food, this is a vital step taken by the synthetic food industry. They can then expand their business slowly, causing success.

In the future, maybe synthetic food will be accepted by everyone in the world. Maybe synthetic food is available everywhere around the world. Maybe we will be eating more synthetic food than the original ones in the future. Maybe we will become inseparable from synthetic food. Well, nothing is impossible.

Synthetic Food Production

Beginning of synthetic meat production

The concept of producing these synthetic meat was by Jason Matheny in the early 2000s. Then, in 2013, a professor named Mark Post showcased a proof-of-concept for synthetic meat. Thus, synthetic meat across the world had been created and produced. Jason Matheny also created his own non-profitable organisation to help in the production of synthetic meat called, New Harvest.

In 2013, Mark Post, a professor at Maastricht University, showcased a proof-of-concept for cultured meat by creating the first burger with the patty made of cultured meat. Since then the idea of synthetic meat had been modified and been spread to the whole world.

(Wikimedia Foundation, *Cultured meat*, 2021)

Synthetic food production

Over the past several years, plant-based meat has been increasingly popular ever since it had been produced and introduced to the world due to reasons like environment, cost, and health benefits. Currently, the meat industry is worth \$1.4 trillion. However, experts believe that, within the next decade, meatless meat "could capture about 10 percent" of that amount. The meatless meat industry is expected to reach \$140 billion by 2029. My project group agrees with this and I think that the production of synthetic meat has given companies huge profits. Thus, the production rate of synthetic meat has been increasing around the world and the popularity of synthetic meat has increased over the years.

Synthetic food is created from substances that are chemically synthesized into edible products. Scientists in labs create food from proteins, carbohydrates, fats, vitamins, trace elements, cells and even air. You name it, they've probably found a way to make food from it. "While lab-based meat is still likely several years away from hitting supermarket shelves, plant-based protein continues to gain ground vs. its animal-based counterpart, and we expect this trend to continue for the foreseeable future," Scientists added. The stock remains more than 200% above its \$25 IPO price, trading up 5.6% at \$82 per share Thursday.

(CNBC, *Alternative meat to become \$140 billion industry in a decade, Barclays predicts*, 2019)
(C.O.nxt, *Food made from, quite literally, thin air*, 2021)

Initiatives taken by companies

More companies such as Shiok Meats, Nutrition Technologies and many more are still in the startup phase and may fail to gain traction but there are billions of dollars in funding behind these products, and plenty of desire for them to succeed. These companies have been increasing in popularity over the years ever since they started on this business while some have not as there are many companies that also produce synthetic products. Thus, there might be competition among them and some companies cannot earn profits through this business causing them to fail to succeed. Since the production of these synthetic products are highly demanded, more and more companies will want to start these businesses. This highlights that the world will soon be having more production of synthetic products than real meat that comes from animals.

The Impossible Meat contains an engineered heme, a protein originally derived from soy plant roots, that gives the burger its pseudo-meat flavor, color, and texture. Originally used to produce medicines, biofuels, and super bacteria designed to eat oil spills, synthetic biology is increasingly being applied to the production of food and fiber — from vegan burgers to “spider silk,” feed for farmed fish, synthetic flavors, and animal-free egg whites. The Beyond Meat on the other hand contains peas, mung beans, faba beans, brown rice for the proteins. Cocoa butter, coconut oil, expeller-pressed canola oil (uses pressure only, no chemicals) for the fats. Calcium, Iron, Salt, Potassium Chloride for the minerals. Beet Juice Extract, Apple Extract, Natural Flavors for the flavour and colour and much more.

A California accelerator, IndieBio, helps to churn out many of these new businesses.

Synthetic biology applications span from simple gene editing combined with fermentation processes, to cellular meats that culture food products from animal cells in the lab, to gene drive applications intended to change an organism’s genetics in the environment, such as a mosquito’s ability to spread malaria.

I think that this idea not only can be used for other purposes but also with this technology the synthetic products will be able to have the same taste as real meat making those who love eating meat be able to taste the taste of real meat bringing those who are vegans and meat-eaters together.

(FoodHack,  10 Singaporean FoodTech startups to watch in 2021, 2021)

(Impossible Foods: Meat made from plants, *Impossible Foods: Meat made from plants*, 2021)

(Beyond Meat - Go Beyond®, *Our Ingredients*, 2021)

(The Straits Times, *Singapore first in world to approve lab-grown meat for sale*, 2020)

Synthetic Food Studies

Companies in startup phase trying to create synthetic food

Most of the companies using synthetic biology are still in the startup phase, like Bolt Threads, Impossible Foods, Gingko Bioworks, and IndieBio and may fail to gain traction, just as the earlier applications of synthetic biology for biofuels failed to reach scale.

Still, there are billions of dollars in funding behind these products, and plenty of desire for them to succeed. With all that support, I can predict that they will most likely succeed, because they have many funds for them to continue on their project.

The reason is that the product created by the company has a lack of public information that leads to the unanswered questions about the safety and ultimate environmental, economic, and social sustainability of these products.

(Wilcox M. *Why Genetically Engineered Foods Have Some Scientists Nervous About the Future*, 2019)

Progress on creating Synthetic Food

Scientists are trying to identify the gene sequence in real meat so that they can make synthetic meat that not only tastes like real meat but also feels like real meat and they are already very close to eating. From all the synthetic food that I have eaten, most of their texture feels like real meat, just that the taste has to be stronger.

Thus, I think that scientists will succeed in identifying the gene sequence in real meat so that they can make synthetic meat that not only tastes like real meat but also feels like real meat soon.

(Wilcox M. *Why Genetically Engineered Foods Have Some Scientists Nervous About the Future*, 2019)

How is Singapore working on Synthetic food?

Singapore is also using science and technology to fully revolutionise the food production system.

Singapore overcame the lack of natural water resources by innovating and coming up with solutions like NEWater, reclaimed water and desalination of saline water. Now it is doing the same thing to meat! Whether it is high-tech farming for eggs, vegetables or fish food or cultivating meat in bioreactors, these methods can be used to feed other countries as well.

Singapore is the first country in the world to approve synthetic meat for sale. Navene Elangovan wrote “Regulators in Singapore on Wednesday (Dec 2) granted approval to American food manufacturer Eat Just to start selling nuggets and snacks made of lab-grown, or cultured, chicken.” (Navene E. *S’pore becomes first country to approve sale of lab-grown chicken*, 2020) The evaluation process includes ensuring the toxicity of the product is safe for eating before it is available in restaurants. Menus in Singapore could soon feature meat grown in facilities such as bioreactors rather than farms as authorities have already deemed one such product safe for eating.

The cultured chicken bites will be manufactured in Singapore by Californian start-up Eat Just, said its chief executive Josh Tetrick. He said that this paved the way for the product to be soon served in restaurants. There is no specific time for when it will be on the menu, but for a start the chicken bites will cost as much as premium chicken at a restaurant. Prices will fall as production increases.

(Tan A. *Turning to local production to ensure food security*, 2020)

How is synthetic food made?

Using fish food as an example. The process of making synthetic food is quite simple. It requires the fermentation of a type of microorganism and feeding them a type of liquid called methanol to stimulate and make them produce carotenoids. The fermented bacteria is then pasteurized and dried, which kills them and formulated into powder and milled into fish feed. This process is very similar to how synthetic meat is made for human consumption.

(Wilcox M. *Why Genetically Engineered Foods Have Some Scientists Nervous About the Future*, 2019)

Production of real meat

Research from the internet shows that the global meat production dropped from 2018 to 2020. The global consumption of animal proteins has been increasing since 1961. The source states that “The Food and Agriculture Organization of the United Nations estimates that meat production—a decent proxy for consumption—dropped in 2019, and it forecasts a decline again this year. Last year was only the second since 1961 in which production fell; two consecutive years of decline is unprecedented and could be the start of something durable. We’re already at peak pasture as far as demand is concerned, and it looks like we’re also approaching peak beef, even in places like steak-crazed Brazil.” (paragraph 2) This shows that beef production has been declining.

Beef production from 39% in 1961 declined to 20% in 2018. Pork production stayed exactly the same in 1961 and in 2018. While chicken production tripled from 1961 to 2018, and will soon surpass beef production.

As we can see that there is a huge decline in beef production, therefore, this will be a great disadvantage to restaurants serving beef steaks. There might not be enough beef to support the whole world. Therefore, restaurants should move towards synthetic meat to continue their business.

(Nathaniel B. *The World Is Finally Losing Its Taste For Meat*, 2020)

Negative effects of farming animals

Animal farming, which emits gases such as carbon dioxide, methane and nitrous oxide, has great negative impacts on climate change and contributes to greenhouse effect, global warming, land and water degradation, biodiversity loss, acid rain, coral reef degradation and deforestation.

Climate change poses multiple risks to human health and well-being. Natural disasters such as drought, flood and heatwaves have been described as the greatest threat to human health and well-being in the 21st century.

Beef production is an extremely high emitting sector of the meat production industry. Emissions from beef, such as carbon dioxide, methane and nitrous oxide, are ten times higher than the production of chicken or pork. Beef emissions are not just from the farm itself, it is also from deforestation to create space for farming. Beef farming uses a lot of land. Therefore beef production is an extremely high emitting sector of the meat production industry.

Companies like Burger King have created a lemongrass-infused bovine diet, which is basically a plant-based meat patty, to reduce emissions by a third.

Therefore, to save the environment and reduce emissions from farming, companies are moving towards synthetic food production as it has no negative impact on the environment and

plant-based meat production even has positive effects on the environment as plants produce oxygen and keep the air clean. So by farming plants, we help to save the environment too.

(Nathaniel B. *The World Is Finally Losing Its Taste For Meat*, 2020)

(True Animal Protein Price Coalition. *Global Meat Production Decline*, 2020)

(Francis V., Julian S. *Five Ways The Meat On Your Plate Is Killing The Planet*, 2017)

Popularity of synthetic food in restaurant

According to my research, synthetic food will be very common in restaurants in five years time. Stores like IKEA already feature synthetic food like synthetic burgers and meatballs in their restaurants. The making process is not complicated and this helps to save the environment.

Therefore, many restaurants would adopt it into their restaurant menu as meat production is declining. Soon, meat production will be so little that we do not have enough to supply the whole world and need to rely on synthetic food. Vegetable farming is a lot faster than animal farming. Vegetables take a shorter time to be old enough to be eaten, while animals take a longer time to be old enough to be eaten, sometimes years.

Why have synthetic food?

To save the world from global warming and greenhouse effect, many companies are also moving towards synthetic food and plant-based meat.

Thus, I predict that in five years time, synthetic food will be very common in restaurants.

Product Write-Up

In 5 years, things will be very different. From food trends to what food to eat, all sorts of new things will be introduced. Dining experience will greatly differ from present day eating. New dining norms will be established.

In the present day, we have burgers made out of real meat. Vegans are left out because they cannot eat the product. In the future, this will not be so. With the introduction of synthetic meat, vegans can enjoy the wonders of delicious meat. In the past, fast food companies like McDonalds, Mosburger and Burger King had original meat in their menus. However, there is a gradual shift in choices in the menu. For one, Burger King and Mosburger have included the Impossible Burger in their menus. With this, we are no longer restricted to basic burgers made with regular patties.

This results in many things. More people can become vegans with the knowledge that forfeiting meat is no longer a requirement. The environment is saved, because we farm less meat and instead grow crops to synthesise the synthetic meat. Synthetic food will have a positive impact on the environment and help governments achieve their new goal of being carbon neutral.

(Root, A. *Beyond Meat Stock Is Falling Because Plant-Based Burgers Might Not Be Vegan Enough*, 2019)

Real Meat	Synthetic Meat
<ul style="list-style-type: none">• Meat is inefficient to farm; takes 8 calories to farm 1 calorie of beef• Animals have poor living conditions before going to the abattoir• We're growing crops to feed to cows and pigs, instead of eating said crops. "Animals are an inefficient middle man," said Youtuber Mark Rober.	<ul style="list-style-type: none">• Made from ingredients such as apples, coconut oil, potatoes, heme and yellow beans• Ingredients obtained from plants, no harm to animals• Using plants to make more flavourful and varied foods. Not extremely efficient as we are still making changes to something already good enough but still more efficient than farming animals

COVID-19 Impact

The synthetic food industry, managed to emerge during the pandemic and lead the world, surviving in 2020, and even earning almost double the amount of money earned in the year before COVID-19 broke out, which is 2019. From \$1.9 billion in 2019, it shot up to \$3 billion. As one man's meat is another man's poison, COVID-19 ruined many restaurants and food businesses, but the synthetic industry was able to benefit in these trying times.



COVID-19 has enhanced the development of synthetic food, because synthetic food can help to fulfill the demand for food in some countries and reduce hunger during the pandemic. As for now, synthetic food is not very well-known as it is still at the starting stage. In the future, synthetic food would be very well-known, and eventually become a part of people's life. In the future, synthetic meat will eventually replace real meat. As synthetic meat is modified to be more healthy, people would be more willing to purchase synthetic meat, synthetic would thus become increasingly popular. However, the synthetic food industry needs to convince people that synthetic food is safe and healthier than traditional food. Only then can they do well.

In the years to come, the numbers will increase. With more vegans, the demand is high and supply will rise to meet it. With more supply, the price will drop, attracting more customers and more profits can be made.

(Southey, F. *Are consumers on the Mediterranean keen to try and buy cultured meat?*, 2021)

(LeMieux, J., *With Synthetic Biology Nature is All Business*, 2020)

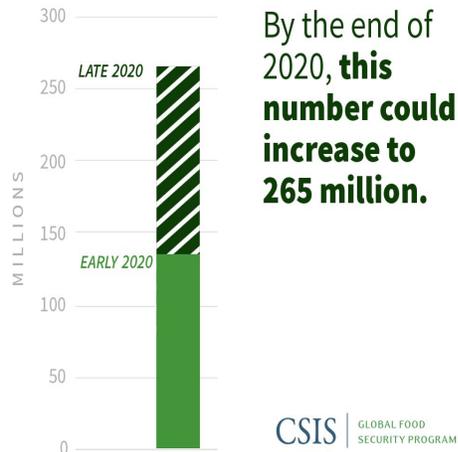
(Businesswire, *COVID-19 Impact and Recovery Analysis - Global Synthetic Biology Market 2020–2024 | Evolving Opportunities with Amyris Inc. and Algenol | Technavio.*, 2020)

(Fernando, J. , *Law of Supply and Demand*, 2021)

Increased Demand During COVID-19

COVID-19 will accelerate the demand of synthetic food globally because the outbreak caused people to be very concerned about the safety of the food they consume, and synthetic food is a better alternative. Being manufactured in factories, it is much safer. As such, more trust will be placed in it in comparison to regular meat.

At the beginning of 2020, **135 million people** faced acute food insecurity.



People thought real meat is more dangerous because the origin of the coronavirus is from real fishes, and synthetic food is made of ingredients like plants, which is less likely to have traces of the virus remaining on it. People have paid more attention to synthetic food during the pandemic as people hoped to depend on synthetic meat instead of real meat, thinking that synthetic meat is safer.

(Shibata, N., Phoonphongphiphat, A., & Watanabe, S., *Coronavirus*

accelerates demand in Asia for plant-based meat, 2020)

(Ahuja K., & Rawat A., *Industry trends*, 2018)

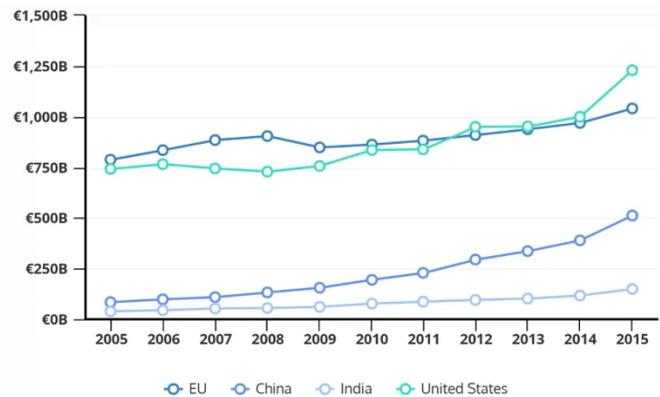
(CSIS, *Covid-19 and Food Security: What You Need to Know.*, 2020)

Popularity of Synthetic Food in Five Years

In Singapore in five years time, synthetic food will be very common in restaurant menus. Stores like IKEA already have synthetic burgers featured on its menu, and many other restaurants feature that too.

Since there is already synthetic food in restaurants now, in five years time there will be even more synthetic food featured on restaurant menus, and it will be so common that it will overtake food made from animal meat. I also predict that the price of synthetic meat will be as cheap as the price of regular animal meat that we are eating now in five years time.

Even though it is very expensive now because the production of it is small, it costs about \$50 per serving and \$300,000 in August 2013. As time goes by, production increases so the price will decrease. In five years time, synthetic food will be very common in restaurant menus and will cost the same as regular animal meat that we are consuming now.



Synthetic food production will be modified and it will be highly demanded by society. The synthetic food will also take on many different shapes and forms. More and more companies will also thrive in society as the world goes into a world with new technology.

The IT service output has grown massively; technology is on the rise. With new technology, new products come and more businesses will prosper.

(Wilcox M. *Why Genetically Engineered Foods Have Some Scientists Nervous About the Future*, 2019.)

(Tan A., *Turning to local production to ensure food security*, 2020.)

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Synthetic Food Production

The concept of producing these synthetic meat was by Jason Matheny in the early 2000s. Then in 2013, a professor named Mark Post showcased a proof-of-concept for synthetic meat. Thus, synthetic meat across the world had been created and produced. Mark Post also created his own non-profitable organisation to help in the production of synthetic meat called, New Harvest.

In 2013, Mark Post, a professor at Maastricht University, showed a proof-of-concept for cultured meat by creating the first burger with the patty made of cultured meat. Since then the idea of synthetic meat had been modified and been spread to the whole world.



(CNBC, *Alternative meat to become \$140 billion industry in a decade, Barclays predicts*, 2019)
(C.O.next, *Food made from, quite literally, thin air*, 2021)

Product Slides Presentation

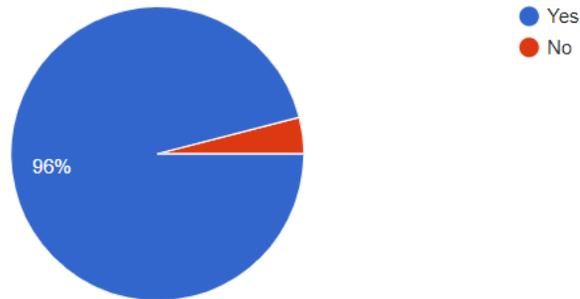
https://docs.google.com/presentation/d/1OQi-FDVfYQaLCa7kG3YIMEK8Zm3IZ3CrwUYBrNlxD6w/edit#slide=id.ge3c6ef4ead_0_45

Google Form/Survey

Do you know what synthetic food is (plant-based meats, artificial cheese etc.)?



25 responses



If yes, have you eaten it and did you like it?

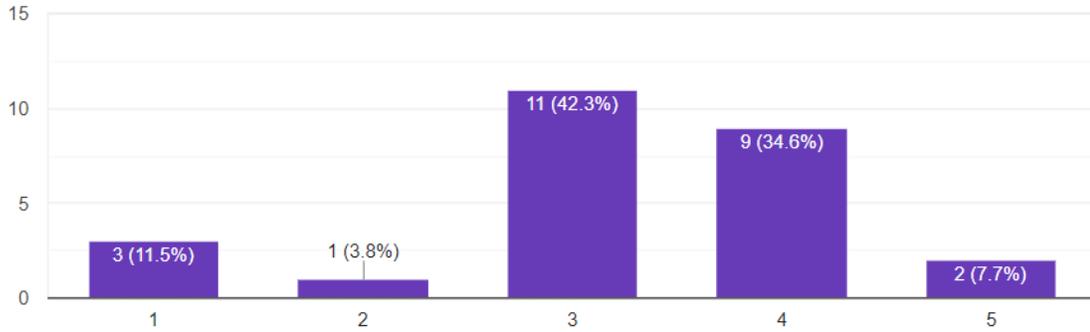
25 responses



How much did you like the food?

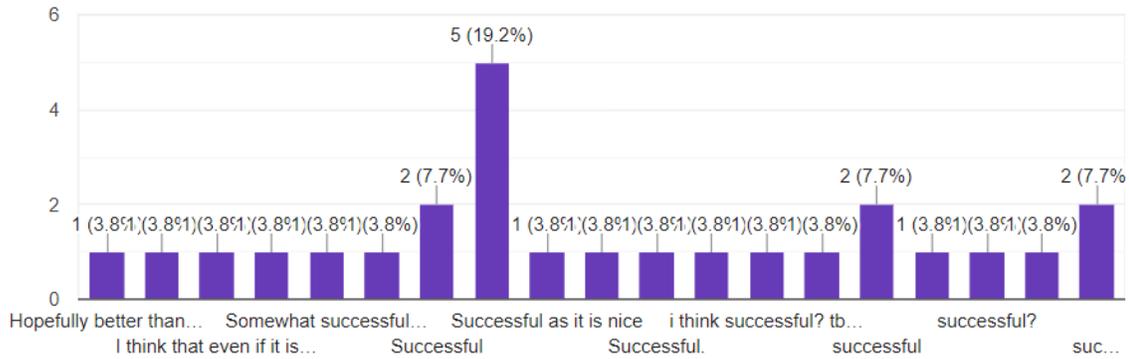


26 responses



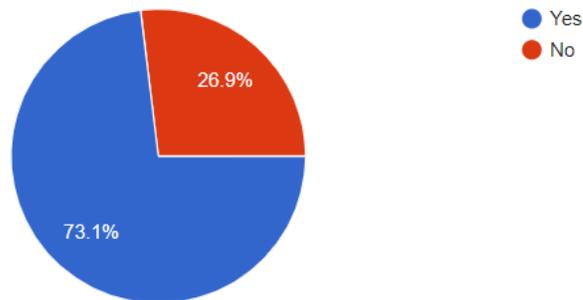
Where do you see synthetic food in 5 years time? (successful/unsuccessful?)

26 responses



Would you patronise a restaurant that only serves synthetic food?

26 responses



In Singapore

We use animal cells to make synthetic meat instead of plants. This also helps the environment as instead of slaughtering animals to make meat, we use their cells to make synthetic meat so that the animals can live and we can get our meat. Thus, the synthetic meat production in Singapore is different from other countries that produce synthetic meat made of plants and not only do we save the environment but Singapore still preserved the real taste of the real meat in the synthetic meat. Not only that, Singapore was also the first country to approve synthetic meat to be sold here. The company, Eat Just Inc., was approved by Singapore to sell synthetic meat here as Singapore felt that synthetic meat was a good idea. Afterwards, more companies were approved to have the sale of synthetic meat in other countries. Singapore also has our own factory that can produce synthetic meat.

Most people know what synthetic food is, and have eaten it before. They ate it at places like Swensens, IKEA, P.S. Cafe, 7-11, etc.. They think synthetic food will be popular in the future, depending on whether it is capitalized on by large fast food chains. They also think it is a great alternative for vegans. It helps save the environment and most agree eating it is worth it. Almost three quarters of people would be willing to patronise a restaurant that only serves synthetic food.

Individual Reflections

Elliot

This project work was the first big one. In primary school, project work was not worth much and counted very little towards our final grade. This changed in secondary school. I carried my previous mindset over and it did not serve me well. Through the hard way, I learnt the new expectations we had to meet for project work. We had to be ambitious with our project, and effort needed to be put in. It took a while to adapt to this new environment.

However, we managed to "buck up" and made progress in our project. In the end, despite many issues with meeting up, we were able to do much research and conduct surveys with the community. Various obstacles were overcome, like conflicting schedules, lack of ideas and motivation, and in the end, we managed to create something we were proud of.

Ethan

During this project work, I learnt that everyone has to do a part in the project in order for us to get a good grade and also to help one another through the tough times of the project work, for example when we are about to go for the final evaluation. We had to help one another when one is having difficulties doing his part. When we first started off with this project, we were behind time as we could not find a mentor. However, now we are currently on task and are almost ready to present our project to the judges during the final evaluation.

Yifan

I have learnt a lot from Project Work. I have a very deep sense of teamwork now, as each of us had to do our parts properly, so that we can get a good final product at the end of year. I had also learnt to prioritise better as I had to spend time on Project Work every weekend. Finally, I have learnt to write academic essays and the skills to cite contents from sources and not plagiarize. There are a lot of things I have learnt throughout the process of the Project Work, especially this is my first exposure to Project Work.

Jasperl

I have learnt how to retrieve information and make product write-ups, and many more skills in presentation through project work.

It is not an easy task when retrieving information for our project as I did not know where to search for them at first, but after that we learnt how to easily retrieve information we need, instead of putting irrelevant information inside our document.

I believe that project work will benefit us now and in future, because when we grow up, we need to find a job and might also be required to do a presentation. Therefore, I feel that project work will benefit us now and in the future.

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