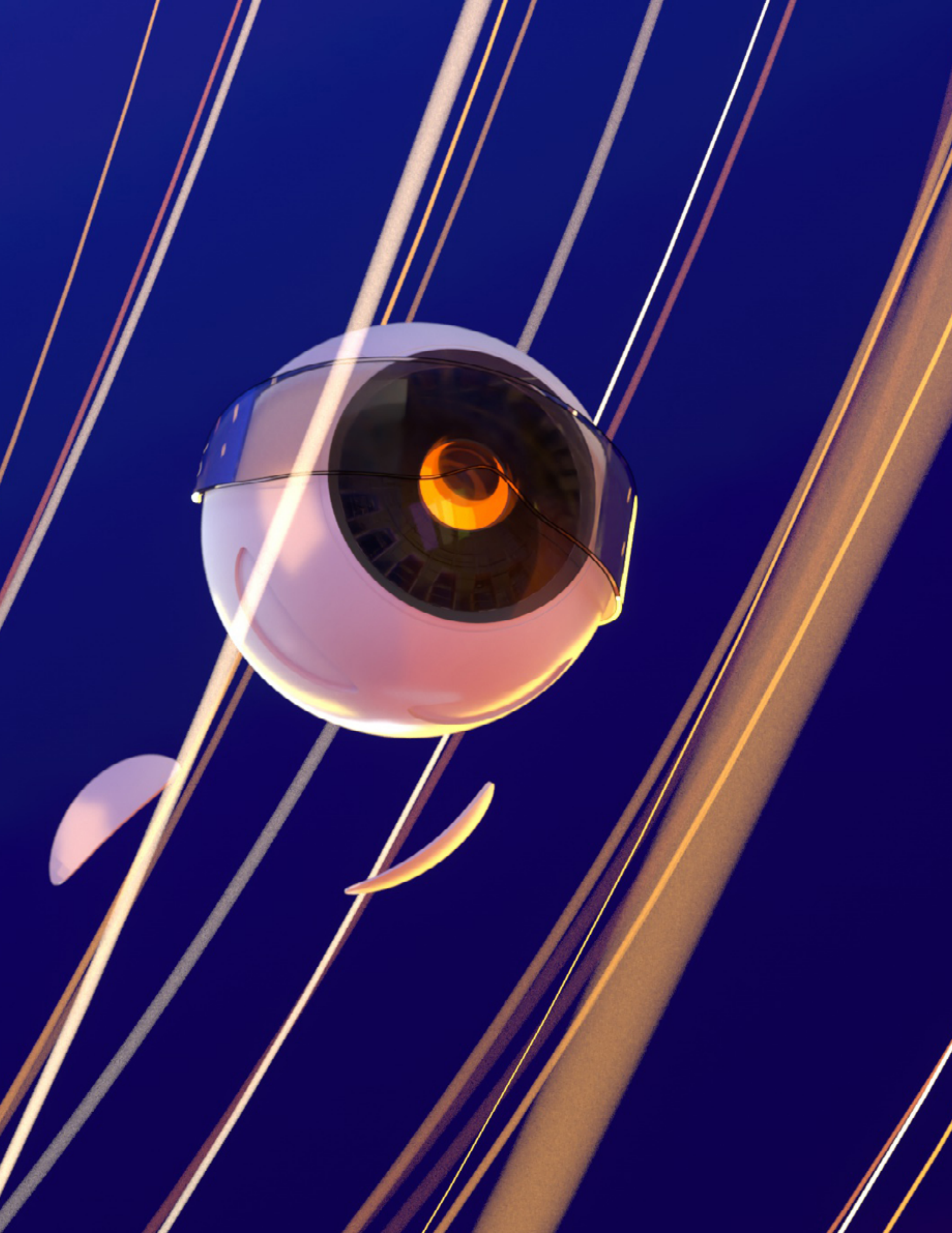
Investment Recipes

by AtonRā Partners



SPECIAL ISSUE

Sustainable Food: Technology To The Rescue

10 JUNE 2020

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On the Menu

Editorial

As some of our customers have been asking more and more about the emerging food technology space, we decided to prepare this special issue to provide a comprehensive view.

We looked at the whole value chain of the food sector, from agricultural production, through food transformation and preparation, to delivery and consumption, and identified the most promising technological developments. The underlying trends are, in our opinion, of secular nature, and their impact is likely to last for a very long time.

We have been following this sector within our sustainable future investment universe since inception, and we continue to monitor it attentively, as we believe it holds very interesting potential. Some positions providing exposure to this theme are already in our portfolios, although overall the sector development is still at the very early stages, and most of the investable names are either too small or not pure enough. Nevertheless, we are paying attention to the developments happening in this space and are following an opportunistic approach to add exposure within our portfolios.

The AtonRâ Team

SUSTAINABLE FOOD: TECHNOLOGY TO THE RESCUE

Feeding The World, A Medley Of Challenges (1/2)

Demographic the root cause

The need to feed a growing global population whose consumption habits are converging towards western standards, is increasing pressure on limited resources.

- By 2050, global population should grow by 26%, and food demand surge by 60%.
- Food production occupies 45% of the globe, contributes to >1/4 of global greenhouse gas (GHG) emissions, and consumes ~70% of available freshwater.

Changing climate

Rising temperatures and extreme weather events are making more difficult for farmers to obtain good crops and ensure the health of their livestock.

- Longer dry spells, irregular weather patterns, and floods, all appear to be related to global warming – farmers cannot rely anymore on known weather patterns.
- Warmer climates may also lead to more problems from pests and diseases, both for crops and for livestock, as climate leads to shifts in the geographical distribution of certain pests.

Ruined harvest and sick livestock

Loss of crop and livestock is becoming more common due to diseases that can be prevented, or cured if spotted early enough.

- Poor growth conditions also lead to poorer health for both crops and livestock, making them vulnerable to diseases.
- About 1.3bn tons of food, or ~33% of annual global food production is lost or wasted before it is actually consumed.

SOURCE:
Food and Agriculture Organization of the United Nations (FAO), World Population Prospects,
Mapping energy consumption in food manufacturing, Which Sectors & Industries Use The Most Energy & Electricity

Feeding The World, A Medley Of Challenges (2/2)

Carbon footprint

Intensive farming, and the general food value chain has a very significant environmental impact. With the global drive to a more sustainable lifestyle, the sector is under huge pressure to reduce waste and energy consumption.

- The food sector as a whole is directly responsible for about 25% of global greenhouse gases emissions.
- The food transformation industry is among the top-5 sectors in terms of industrial electricity consumption.

An issue spanning beyond simply producing more

The expected growth in food demand implies more than increasing production capacity across the value chain. There is a growing shift in public opinion demanding environmental and resources sustainability, ethical behavior and healthier products.

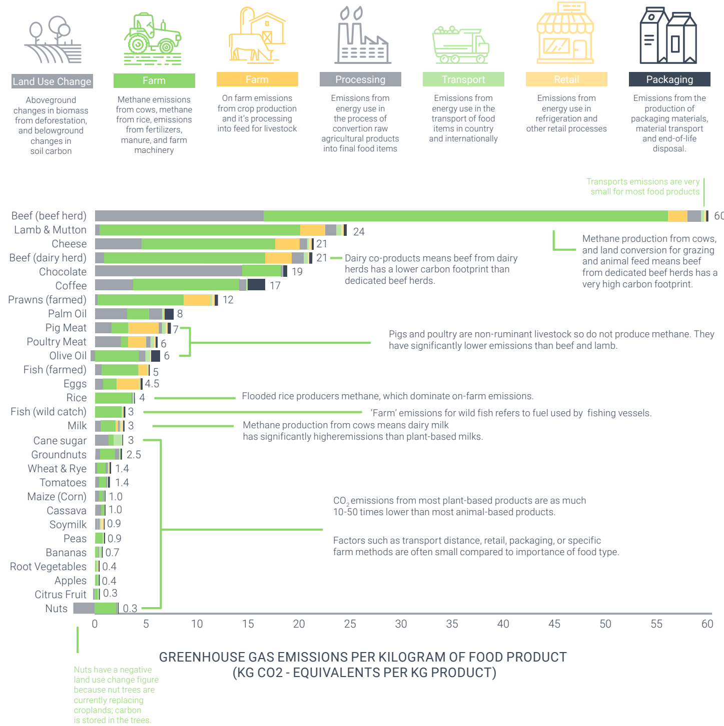
- Food products' health impact is now as important as taste or affordability.
- Unhealthy diets account for up to one in five premature deaths every year.
- Regulations include animal welfare, biodiversity and similar ethical issues.

The only viable solution is technology

To solve this issue the only viable option is to improve efficiency and develop alternatives – in both cases, technology is crucial. Reducing population, or radically changing consumption habits are either unethical or unpracticable.

- Food production is still one of the least digitalized industry, with 0.3% digital penetration vs. 2.5% for financials and 12% for retail.
- Technology-led innovation is reshaping the whole value chain, from agricultural production through transformation and preparation to consumer supply and consumption patterns.

FOOD: GREENHOUSE GAS EMISSIONS ACROSS THE SUPPLY CHAIN



Note: Greenhouse gas emissions are given as global average values based on data across 38.700 commercially viable farms in 119 cointries.
Data source: Poore and Nemecek (2018). Reducing food's enviormental impacts through producers and consumers. Science. Images sourced from the Noun Project.
OurWorldinData.org - Research and data to make progress against the world's largest problems.

SOURCE:
[World Population Prospects of 2019](), [Mapping energy consumption in food manufacturing]()
[Which Sectors & Industries Use The Most Energy & Electricity]()

Innovation Getting Traction

Producing food – the shift to agriculture 4.0

Technological innovation in agriculture focuses on optimizing scarce resources, and avoid waste by increasing available land surface, maximizing crop yields, and minimizing water usage. But it is the convergence of IoT, AI and edge computing that are finally enabling agriculture to turn digital, and farms to become smart.

- Satellite imagery, agricultural robots, drones, and sensors' data are supporting better decision-making and -implementation at the individual farm level.
- 5G will provide connectivity in rural areas, and cloud- and edge-based AI real-time analysis of ever growing datasets.

Transforming food – providing the next-gen food

Technological advancement coming from other sectors, like biotech, have made feasible from both a technical and economical standpoint to provide alternative foods with equivalent (if not better) nutritional qualities to the consumers.

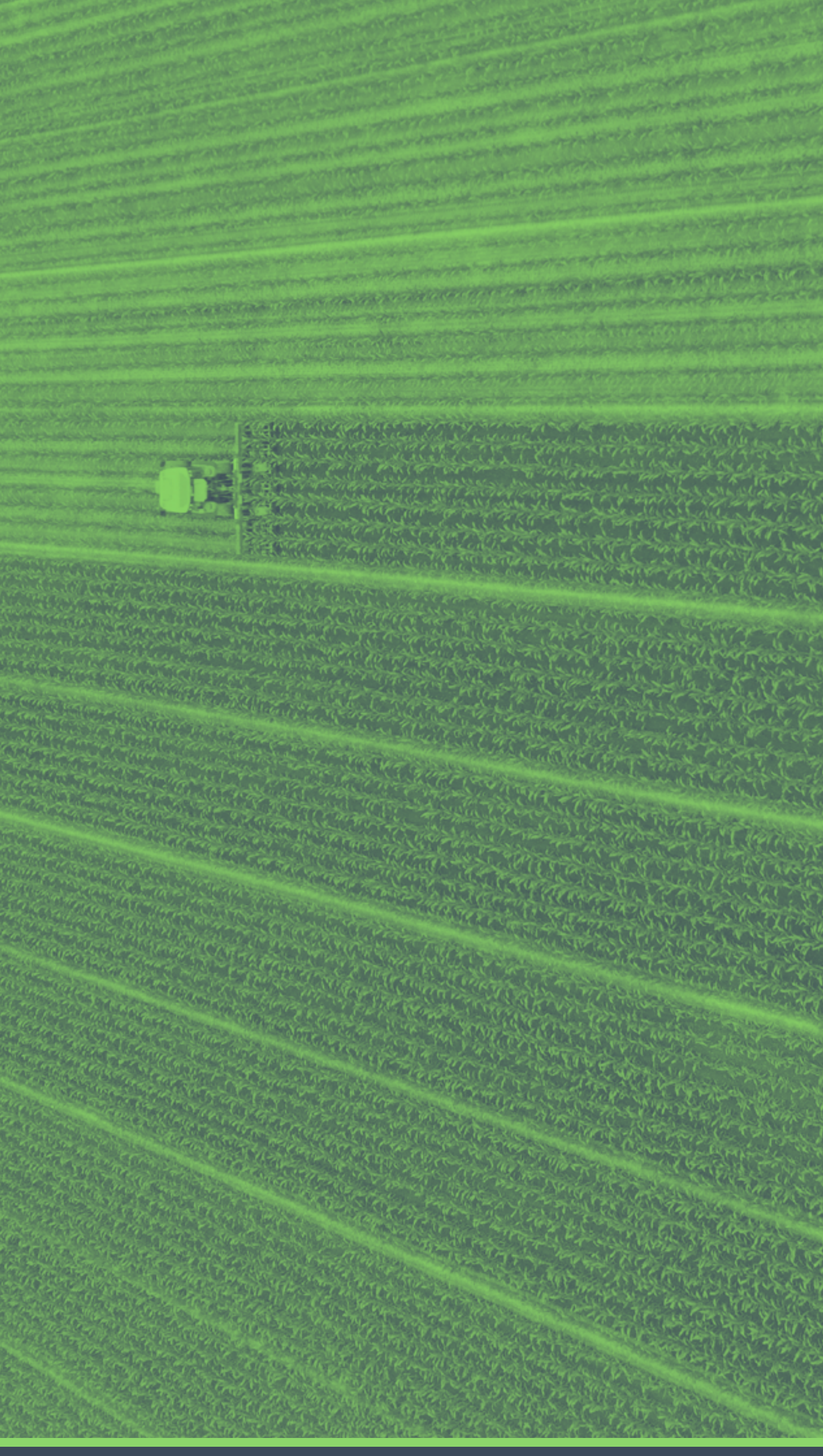
- Cellular agriculture and gene editing tools are being developed for food production.
- Plants-based proteins are already sustainable alternatives to meat.
- 3D food printing, nutrition apps and wearables help adjust habits.

Consuming food – connecting the dots

Technology is creating a seamless and connected digital chain for food that allows information to flow in both ways, from producer to consumer and viceversa. This results in optimized choices and greater adaptability, reducing waste and optimizing resource utilization.

- Digital tracking, smart packaging and food apps all contribute to integrate the consumer into the digital food ecosystem.

SOURCE:
Mapping energy consumption in food manufacturing
Which Sectors & Industries Use The Most Energy & Electricity



PRODUCING FOOD – THE SHIFT TO AGRICULTURE 4.0

Overview

Profitability

The key element to drive technology adoption is profitability for the farmer – but the channels to entice adoption are multiple. Accurate and reliable data, beyond helping to improve yields, has a direct impact on third parties, like banks providing working-capital financing or insurers covering crop damage.

- The dataset is the key – producing and owning accurate and reliable data is among the top priorities for the smart farms.
- Confirming this shift, big data players are starting to address this unexploited area, like Microsoft with its Azure-based FarmBeats offering.

Environmental impact

As technological improvements allow for a finer tuning of agricultural operations, scarce resources are better managed, waste levels and externalities reduced, and the overall sustainability increased.

- Water is the key element for both cost savings and environmental impact – vertical- and precision-farming as well as watertech, all cater to a significant reduction in water usage.
- Waste and externalities (like pollution or soil depletion) also see a clear improvement with more precisely targeted farming operations.

Health impact

Most of the technological improvements (notably in precision and vertical farming) result in better, healthier, crops and livestock while significantly reducing the need for pesticides, antibiotics and other chemicals.

- Consumers will benefit from products that contain less harmful chemicals.
- Also sector workers will be less exposed to the health hazards related to manipulating dangerous chemicals.

Precision Agriculture – The Tech (1/3)

Precision agriculture: a wide range of technologies applied to farming

Precision agriculture is about applying the right amount of input at the right location of a field and at the right time. Behind this concept hides a wide range of technologies used to gather, process and analyze data with the final goal of improving efficiency, productivity, and sustainability of agricultural activity.

- Technologies range from guidance systems (GPS, GIS), remote sensing, connectivity, telemetry, image recognition, AI & machine learning, variable rate technology (VRTT), etc.

Collecting and transmitting data at the cornerstone of smart farming

Precision agriculture cannot exist without data: its growth is closely linked to the development of new technology for data gathering and transmission. Sensors measure key weather parameters (sun radiation, wind speed, etc.), soil conditions (humidity, acidity, nitrogen levels, etc.). Satellites, fixed-wing aircrafts, drones provide field imagery with ever-higher spectral resolutions.

- The number of IoT devices used in agriculture is expected to reach 75mn this year, growing at a CAGR of 20%.
- Access to connectivity is key and the emergence of 5G & other low-powered networks for wireless data transmission will foster digitalization of the sector.

OEM shifting the battleground from tractors to data

Equipment makers are understanding how data generation is becoming increasingly relevant to customers, and consequently driving loyalty and renew rates. Data collection platforms need to be set-up and get connected to the various sensors, de facto tying a farmer to a main provider and driving equipment replacement choices.

- As an example, in 2017 John Deere acquired Blue River Technology, a provider of computer vision and robotics technologies to the farming sector, to strengthen its IoT-related offering.

Precision Agriculture – The Tech (2/3)

Processed data flows back into agricultural production

After data is collected & stored in real-time, it is analyzed with ML & AI techniques to optimize processes including seeding, ploughing, fertilizing and spraying.

- GPS sensors are installed on harvesting equipment to enable yield monitoring & mapping, allowing farmer to record crop yield by time & location.
- Advanced visual recognition systems enable accurate weed mapping, so variable spraying equipment can adjust the amount of product applied to the individual plant.
- The use of weeding robotics based on advanced computer vision is estimated to reduce pesticide usage by 90%.

A new generation of robots is coming

Agricultural robots, or agrobots are designed to help farmers performing difficult tasks such as planting seeds, crop harvesting, spraying, pruning, etc. While tractor guidance and auto-steer are already well utilized within farmers, progress in advanced vision systems and cheaper IoT devices are fostering the development of driverless & fully-automated robots.

- From a central location, an operator can operate multiple machines in the field, making suggestions and relaying additional information.

Overcoming workforce scarcity

The next step are unmanned autonomous tractors, which allow to address the big challenge of skilled labor scarcity. Indeed farming is not considered an attractive employment sector, and a decreasing number of young farmers are entering the industry.

- The average age of U.S. primary producers was 59.4 years in 2017 (from 58.3 in 2012).
- Global demand for driverless tractors should exceed 46k units by 2028 (from ~11k in 2018).
- Production through transformation and preparation to consumer supply and consumption patterns.

Precision Agriculture – The Tech (3/3)

A major market for drones

Agriculture is one of the biggest industrial applications for drones, which can be used to monitor field conditions, collect useful data, produce precise 3D maps, and even spray fertilizers and pesticides in precise spots of the field.

- Agriculture represented more than 25% of drone's total addressable market in 2015.
- Drone-based areal spraying can be up to five times faster than traditional machinery spraying, while improving efficiency and reducing the amount of chemicals sprayed.

Big Data, AI and ML bringing it to the next level

Today, the real value lies in the application of artificial intelligence & machine learning to the datasets collected with agricultural IoT. Computer vision models are able to distinguish between crop and weed, while predictive analytic models are used to interpret data, track trends, and provide farmers with recommendation and decision support tools.

- Climate variations, diseases, as well as pests and weeds infestations are all challenges that can be alleviated by AI solutions.
- The global agriculture analytics market is expected to double from $585mn in 2018 to $1.2bn by 2023.

Data impact extends through the farmer's business eco-system

Reliable and extensive datasets underpin real-time analysis and accurate predictions, which can be shared with third party stakeholders, like equipment makers, banks, insur-ances, and food producers, who also benefit from having access to such information.

- Banks and insurances can reduce administrative costs and better estimate risks, leading to improved pricing for their services.
- Food producers can anticipate crop yields and the ability to meet supply targets, and would be willing to pay a premium for reliable information like this.

SOURCE:
Research questions accuracy of drone data in agriculture

VALUE OF DRONE POWERED SOLUTIONS ADDRESSABLE INDUSTRIES

	2015
Infrastructure	45.2
Transport	13.0
Insurance	6.8
Media & Ent.	8.8
Telecommunication	6.3
Agriculture	32.4
Security	10.5
Mining	4.3
Total	**127.3**

Precision Agriculture – The Impact

Comparative benefits

Precision agriculture allows a farmer to better understand its field and produce in a more efficient way. Reduction of chemical use is beneficial both to the environment (less N2O emissions from soils) and farmers' economics. Continuous monitoring of soil health minimizes the risk of nutrient depletion, nitrate leaching and groundwater contamination.

- Fertilizers are estimated to represent 30% to 50% of total farming costs.
- All in all, precision agriculture seeks to reduce inputs while increasing production output.

Challenges

Initial capital costs for the acquisition of technologies remain high. While precision agriculture might be economically profitable for large farms, the business case becomes more challenging for smaller farms. Additionally, advanced features such as predictive analytics might take time before being fully efficient as they often require several months of track record.

- Small farms are estimated to produce up to 70% of world's total crops.
- Cooperative based models for dataset-sharing and farm data-networks are likely to develop and service small- and mid-sized farms.

Market potential

Driven by the advent of key enabling technologies such as IoT, wireless communication, advanced visions systems, and GPS positioning, the precision agriculture market is set to continue growing in the coming years, helping farmers to cope with labor shortage, productivity constraints and margin pressure.

- The precision agriculture market is expected to grow from $4.7bn in 2019 to $11.1bn by 2027 at a CAGR of 13%.

SOURCE:
Precision Farming Market Size, Share & Trends Report

Vertical Farming – The Tech

Grow food better and with less space

Vertical farming is an innovative way of growing crops in the absence of soil, in a closed and highly controlled environment. Layers of crops are stacked vertically one above another, allowing an optimal use of the available surface.

- One acre of vertical farm can lead to the same output of ten to twenty traditional soil-based acres (depending on crop species).
- Year-round production is guaranteed and the proximity of production & consumption locations lowers dramatically the use of fossil fuels for delivery.

Hydroponics, Aeroponics, or Aquaponics

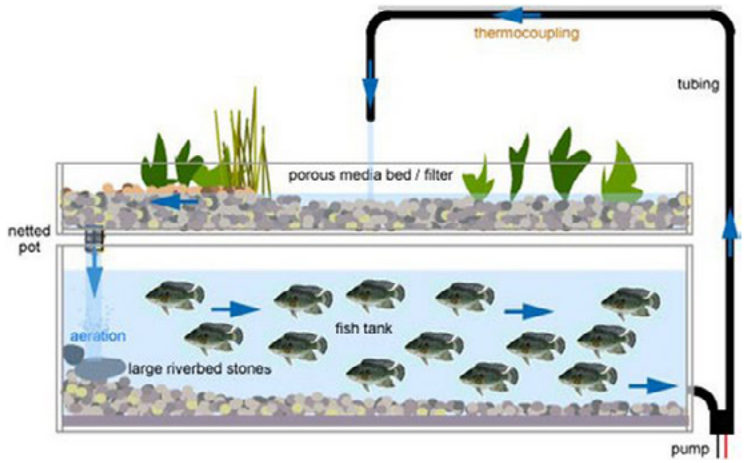
In a hydroponic system roots are submerged in an aqueous solution of macronutrients. In an aeroponic system plants are suspended in the air and nutrients transmitted through mist. Aquaponic solutions combine hydroponic techniques with aquaculture: in a closed-loop system, the water in which aquatic animals are raised is filtered and fed to the hydroponic system and then recycled back to the aquaculture.

- Hydroponic systems are today the most widely used, gathering more than half of global vertical farming revenues.

Controlling light, temperature, and water are key

In a controlled environment, temperature, humidity, water, and nutrients can all be controlled through customized software ensuring continuous optimal conditions. Lighting systems are essentials since they provide optimal photosynthetic wave-lengths to accelerate crop growth and maximize yield.

- The lighting component segment is estimated to represent 26% of vertical farming supplies' market share.



SOURCE:
Aquaponics and Vertical Farming
Raising crops: vertical farming in Japan

Vertical Farming – The Impact

Comparative benefits

Vertical farming can increase crop yield by a factor of ten to twenty. Additionally, it removes uncertainties related to climate conditions, making it possible to grow a wider variety of crops at once. This tailor-made management of environmental factors means that no herbicides, pesticides or fungicides are needed, and water usage is also reduced as it can be continuously recycled.

- It is estimated that vertical farming requires 95% to 99% less water compared to conventional field farming, and avoiding any agricultural run-off.

Challenges

High upfront investment cost as well as the intensive electricity needs for powering LEDs and maintaining constant control of the whole environment, take their toll on profitability. Also, vertical farms have to manually replicate processes freely performed in nature (such as photosynthesis or pollination). System's over-dependency on technology represent another risks, where any power outage could cause significant damage to a vertical farm.

- Studies estimate the building costs of vertical farms to be up to 48 times higher than that of conventional greenhouses.

Market potential

Vertical farms are still at their infancy, and current economic profitability suggest that the technology is not yet ready for mass adoption. But even if vertical farms won't yet replace large industrial farms they might find use cases in smaller installations to grow crops for local community (vs. importing from far) or for high value crops such as saffron or medical cannabis.

- The global vertical farming market is expected to grow at a CAGR of 24.6% from \$2.2bn in 2018 to \$12.8bn by 2026.

SOURCE:
Vertical Farming Market Expected to Garner $12.77 Billion by 2026

WaterTech – The Tech

Micro-irrigation: the way forward to save water

Micro-irrigation, also called low-flow irrigation, comprise a wide range of methods used to reduce water usage, the most common one being drip irrigation system, which slowly drip a controlled amount of water to the roots of plants through a network of pipes, valves, tubing and emitters.

- Expert estimates that smart and drip irrigation systems could reduce water usage from 20% to 70% compared to traditional sprinkler irrigation.

Smart irrigation to add automation and efficiency

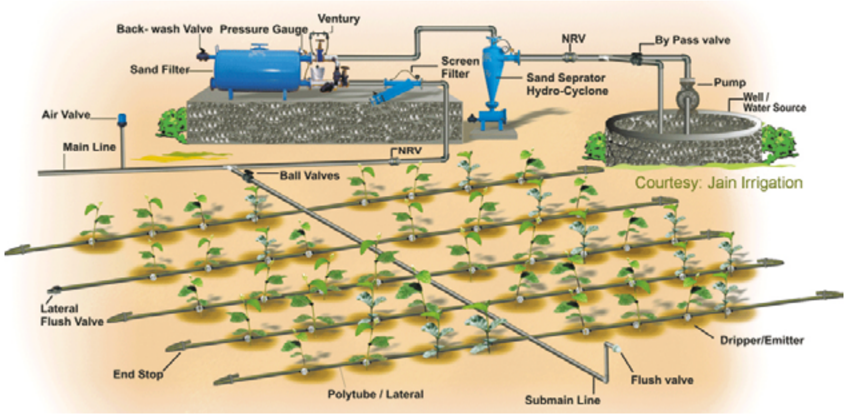
The use of precision agriculture technologies applied to irrigation enables producers to monitor soil tension and understand the water needs specific to each crop and adjust water schedules accordingly (irrigation scheduling).

- Weather-based systems with evapotranspiration (ET) controllers for temperature, wind, solar radiation and humidity calculate needs and adjust irrigation schedules.
- Soil moisture sensor-based systems use moisture sensors buried into the field to monitor soil moisture content and irrigate accordingly.

Finding alternative water sources will be key

Alternative water sources for irrigation can be found in rainwater harvesting (particularly popular in regions with heavy precipitation followed by long dry periods) and wastewater treatment (feasible when farms are located close to cities). Water desalination is also gaining interest as a promising solution for converting brackish water into low-salinity water for irrigation.

- Water desalination costs have dropped from ~$10/m3 to $0.5-$1.5/m3 today.
- Worldwide, it is estimated that 200mn farmers irrigate 20mn ha with raw or partially treated wastewater per year (approx. 8% of total), making it a significant market potential for water treatment technologies.



SOURCE:
Wiki Drip Irrigation

WaterTech – The Impact

Comparative benefits

Both smart & micro-irrigation technology have the potential to significantly reduce water usage by only supplying the right amount of water required. With water only provided to cultivated plants, negative side effects like weed growth (and the need for chemicals to treat them) or soil erosion are also reduced.

- Improper irrigation (over- or under-irrigation) is shown to create an environment favorable to disease, by over stressing crops.

Challenges

The relatively high initial investments required for deploying such technologies can be a challenge, especially in developing regions & for small farm owners. Further-more optimal water supply through advanced water management technologies requires specific skills that might not be easily available.

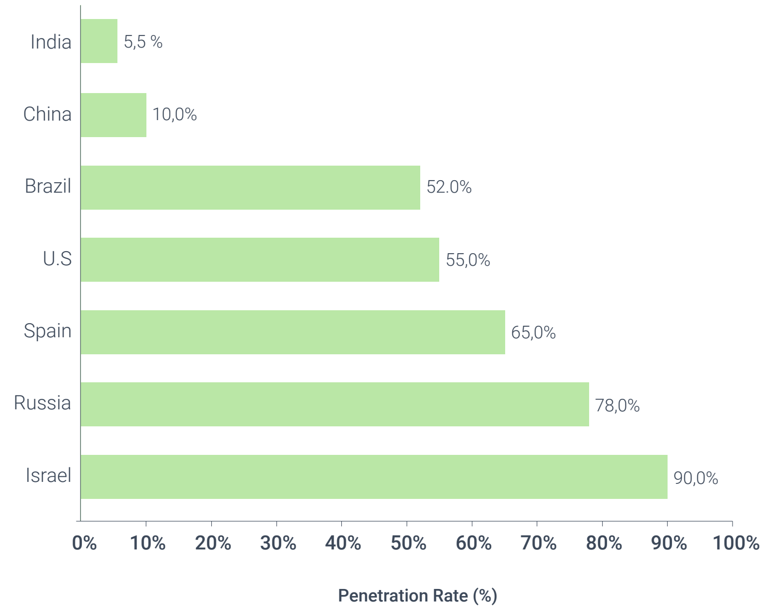
- Drip or smart irrigation are both reliant on specific devices/tools that are both relatively costly and require skilled set-up and maintenance.

Market potential

Fresh water scarcity being a major challenge in many dry-regions. While India and China (together representing up to 40% of global irrigated land) have not much adopted micro-irrigation technology, some countries (e.g. Israel) have emerged as technology leaders in innovative irrigation systems.

- The global micro-irrigation market is expected to grow from $4.0bn in 2018 to $14.8bn by 2027 at a CAGR of 15.7%..
- The global agricultural wastewater treatment market is expected to grow from $2.09bn in 2018 to 2.73bn by 2023 at a CAGR of 5.48%

MICRO IRRIGATION PENETRATION RATE



SOURCE:
ICFA: Market Update: Micro Irrigation (PDF)
Global Micro Irrigation System Market 2019-2027

Players – List Of Relevant Pure* Players In The Industries

VERTICAL FARMING

PRIVATE (4)

1. Aerofarms LLC
2. AMHYDRO (American Hydroponics)
3. Brightfarms Inc.
4. Illumitex Inc.

LISTED (1)

1. AeroGrow International Inc. ($0.1bn)

PRECISION FARMING

PRIVATE (5)

1. Dickey John
2. Farmers Edge Laboratories Inc
3. CropX
4. Ag Leader Technology
5. Granular Inc

LISTED (1)

1. Raven Industries ($0.9bn)
2. AgJunction ($0.2bn)
3. CropLogic ($0.1bn)

WATERTECH

PRIVATE (2)

1. Rain Bird Corporation
2. Netafim Limited

LISTED (2)

1. Lindsay Corp ($1.1bn)
2. Jain Irrigation ($0.1bn)

Market Size And Expected Growth

Vertical farming		24.6%	CAGR 2018 - 2026	$12.8bn
Precision farming		13%	CAGR 2019 - 2027	$11.1bn
Watertech	Micro-irrigation market	15.7%	CAGR 2018 - 2027	$14.8bn
Watertech	Agricultural wastewater treatment market	5.5%	CAGR 2018 - 2023	$2.7bn

For listed companies, market cap in US$bn is reported within brackets.

**: companies with >20% of revenues stemming from the sector.*

TRANSFORMING FOOD – PROVIDING THE NEXT-GEN FOOD

Overview

Profitability

Bio- and digital-technology developments are making it increasingly feasible from both a technical and economical standpoint to provide sustainable alternative foods. The key issue for large scale adoption remains cost – improvements aim for cost parity, or for justifiable premiums.

- The currently viable alternative foods already on the market are able to compete on price as well as taste, sustainability and healthiness.
- Dietary requirements and consumer habits remain strong drivers for food demand growth.

Environmental impact

Alternative foods require significantly lower amount of water to be produced, notably for alternative proteins (meat substitutes) and dairy products. Also, by reducing the need for livestock, they help reduce related externalities (animal waste, cruelty, etc.) and freeing up agricultural products currently used to feed animals.

- Globally, ~70% of soya, and about 50% of grains, are used to feed livestock.
- Livestock compete with human for carbohydrates and proteins sources.

Health impact

The use of advanced biotech tools in food prevents contracting meat-born illnesses and food allergies while increasing nutrient content as well as avoiding use of antibiotics and chemical substances. Nevertheless, as with most novel technologies, there is still not enough "history" and testing to provide widespread safety reassurance.

- Regulators are very restrictive on allowing technologies.
- Public remains skeptical on highly transformed foods despite its sustainability.

SOURCE:
Livestock - a driving force for food security and sustainable development

Genetics – The Tech (1/2)

Selective breeding: (un)natural selection

Humans have genetically modified plants and animals for thousands of years. Through "selective breeding", crops and animals were selected for reproduction according to their beneficial traits. Selective breeding is still used today.

- Modern corn originated as a wild grass called teosinte that had very small ears and few kernels.
- Selective breeding has generated bananas with smaller seeds and better taste.

Mutation breeding: accelerating selective breeding

In 1920, scientists began to expose seeds to chemicals and radiation (gamma rays, thermal neutrons, X-rays) to generate random genetic mutations at a faster rate to find new useful traits. The process is known as "mutagenesis" or "mutation breeding" and is still widely used.

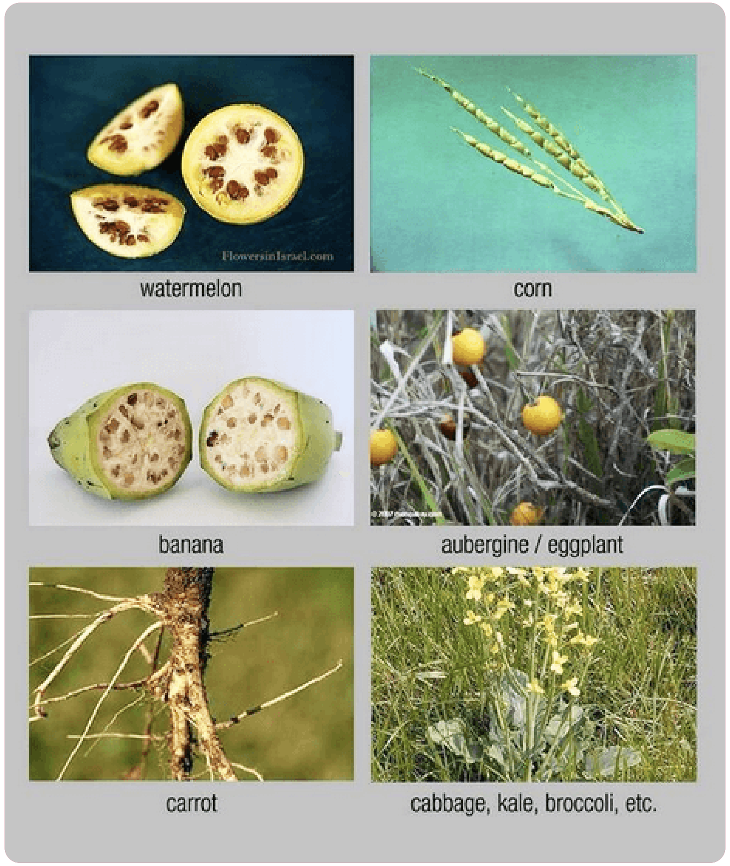
- In 1991, after 20 years of experiments, a new variety of Japanese's pear crop, resistant to black spot disease, was created.
- Red grapefruits and other 3,000 crop varieties, are the results of mutagenesis and have been sold for decades without any label.

Recombinant DNA technology: first-generation of GMOs

In 1987, scientists started to develop a method to cut a gene from one organism and paste it into another, called "recombinant DNA technology". Cisgenic refers to an inserted gene coming from the same species, else it is referred to as Transgenic. GMOs are organisms whose genetic material has been modified in a way that does not occur naturally and are strictly regulated.

- The first GMO vegetable was launched in 1994 (Flavr Savr Tomato) and the first GMO animal was approved in 2015 (AquAdvantage salmon).
- According to several published biotech studies, GMO technology adoption reduces chemical pesticide use by 37%, increases crop yields by 22%, and increased farmer profits by 68%.

HOW YOUR FOOD WOULD LOOK IF NOT GENETICALLY MODIFIED OVER MILLENNIA



Genetics – The Tech (2/2)

Gene editing tools: next generation of GMOs

Recently developed gene editing tools allow to place the genetic change in a precise spot inside the DNA without requiring foreign DNA. With previous methods genes were inserted at a random place in the genome.

- Gene editing reduces the time to research and develop a new seed variety to 3-5 years, (vs. 5-10 years fot conventional GMOs).
- In 2018, the U.S. distinguished GMOs from gene edited food, because the latter imitates the natural process. But the EU decided that gene-edited crops are considered GMOs.

Various technologies

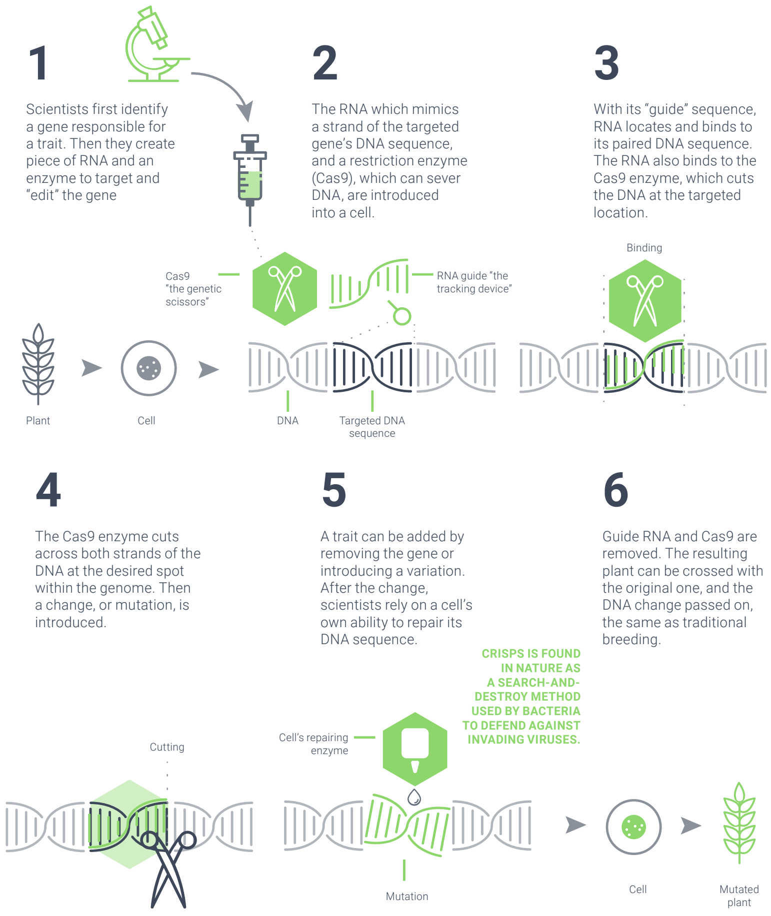
Three tools, Cluster Regularly Interspaced Short Palindromic Repeats (CRISPR) Cas-9 (2013), Transcription Activator-Like Effectors (TALENs) (2011), and Zinc Finger Nucleases (ZFNs) (2003), are currently used for the agricultural market.

- CRISPR is so far the cheapest, most efficient and easiest to use, as Cas9 does not need to be modified at the protein level to recognize a specific DNA sequence. TALEN and ZFNs are technically challenging and time consuming.
- However, CRISPR is less specific than TALEN and ZFNs and it may experience mismatches with unwanted target locations in the genome.

CRISPR Cas 9 and TALEN foods

Several gene edited foods are currently being developed, with some already approaching the market. These improve agricultural productivity, environmental resistance (thus reducing the use of chemicals) and eliminate some allergenic ingredients.

- Tomatoes designed via CRISPR with higher vitamin C levels and disease resistance are ready for market launch, while non-browning mushrooms are waiting for FDA approval.
- Calyxt's soybean oil has been the first gene edited food available. The soybean genome was designed using TALEN to improve the levels of oleic acids (contributing to good cholesterol).



GMOs vs. Gene Edited Food: A Quick Comparison

Genetically Modified Organisms (GMOs)	Gene edited (CRISPR)
Less accurate – the change is made in a random place in the DNA.	**Highly accurate** – target an exact spot where the change is needed in the genome.
DNA can be exotic – the genes inserted in the genome may be synthetic or from another species The modification would never naturally happened through evolution.	**DNA is native** – DNA that is already in the organism is cut and edited. You rewrite the genetic code to make it, for example, more resilient to diseases. The modification could naturally happened through evolution.
US regulation is rigorous due to the potential impact cross species altercation has.	**US regulation** does not regulate techniques that mimic a natural process
Timeline for research, product development and regulation: 5 to 10 years.	**Timeline for research, product development and regulation**: 3 to 5 years.
Highly expensive – only larger companies can benefit.	**Cost effective** – small companies could use this technology.

Crop	Purpose of CRISPR Alteration	Current Stage?
Cabbage	Improve growing patterns	Was produced and eaten prior to EU ruling
Coffee	Natural decaffeination to stop the expense of removing caffeine from coffee beans	Awaiting global regulatory approval
Corn	Non-transgenic improved crop yields	Awaiting regulatory approval for experiment
Wine (grapes)	Resist powdery mildew that affects sugar levels	Achieved proof of concept
Bananas	Fighting a deadly banana fungus, and extending shelf life	Achieved proof of concept
Soybeans	Drought tolerance, seed oil composition improvement, and herbicide tolerance	Achieved proof of concept
Potatoes	Non-browning when sliced, longer shelf life	Achieved proof of concept
Cotton	Reduce the length and risk of loss during the cultivation process	Achieved proof of concept
Canola	Improve shatter resistance and yield losses	Achieved proof of concept
Papaya	Gain resiliency to new tropical pests and abiotic stresses	Achieved proof of concept
Squash, Gourds, Melon, Watermelon	Resistance to Geminiviridae virus that significantly decreases yields	Achieved proof of concept
Alfalfa	Change squamosa promoter binding protein gene to improve future breeding	Achieved proof of concept
Casava	Resistance to Cassava Brown Streak Virus (CBSV), increase yield, and produce a waxy, starch-like substance	Achieved proof of concept
Sugarbeet	Increased tolerance to biotic and abiotic stresses, enhance tolerance to salt	Achieved proof of concept

Genetics – The Impact

Comparative benefits

The use of gene editing tools in food could prevent the risk of food allergies while increasing nutrient composition. Besides, they reduce the use of antibiotics, pesticides, and chemical substances. For GMOs, no negative health effect on humans has been demonstrated.

- Through CRISPR, the time and cost of breeding process as well as the risk of losses is reduced.

Challenges

Most gene editing food will be subject to strict regulation, and authorizations may be difficult to obtain, as similarly, most genetically modified foods are strictly regulated, and only a few have been approved. As the most advanced gene editing technologies do not contain foreign DNA and are more specific, they should not be regulated in the same way as GMOs.

- Regulatory risk adds to the cost of development, making gene edited food still expensive compared to more conventional alternatives.

Market potential

The agricultural biotechnology market (gene editing, GMOs, crop protections (including biopesticides/stimulants) is expected to grow from $33.8bn to $56.7bn by 2024, at a CAGR of 10.9% over this period.

- The plant breeding and gene editing segment is expected to grow the most at a CAGR of 20%, from $7.5bn in 2018 to $14.5bn in 2023.

SOURCE:
MarketsandMarkets; Globalnewswire, World Livestock 2011 (Food and Agriculture Organization of the United Nations (FAO)

Cellular Agriculture – The Tech (1/2)

Cellular agriculture: welcome the food of the future

Cellular agriculture focuses on the production of animal products, such as milk, eggs, and meat from cell cultures in laboratory. Using a combination of biotechnology, tissue engineering, and synthetic biology, the resulting food is exactly the same as produced from animals and plants.

- Acellular agriculture, also called "fermentation-based cellular agriculture" uses a microbe like yeast or bacteria to produce animal products like milk or eggs.
- Cellular agriculture refers to growing agriculture products that are based on living cells, such as meat.

Acellular agriculture: the new era of animal-free dairy products

Acellular animal products are made using microbes (such as yeasts or bacteria). Microbes are genetically modified to carry on the genetic instructions to produce the desired protein. The host organism is then grown in large quantities under controlled conditions in a bioreactor, a big steel tank filled with a nutrient medium.

- In 1990 the FDA approved a genetically modified bacteria that produced rennet, the enzyme used to make cheese. Cell-cultured rennet is purer and less expensive than animal-harvested rennet.
- On 2019, Perfect Day released its ice cream made from non-animal whey protein.

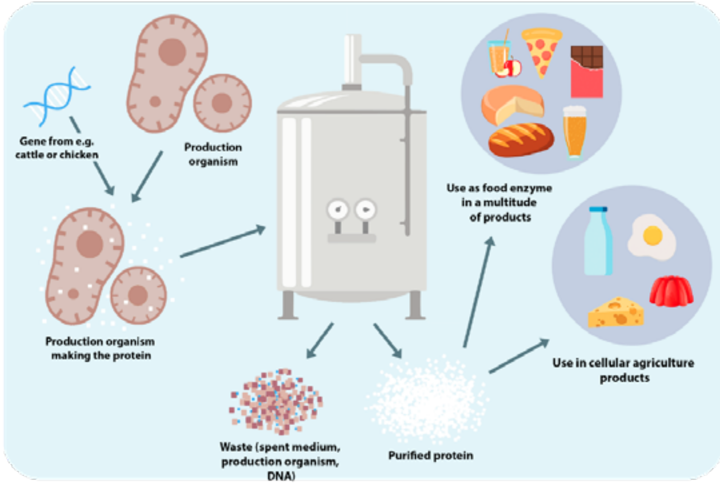
Acellular agriculture: how synthetic biology is impacting the food industry

With DNA synthesis the desired gene is identified from a sequence database and a piece of DNA is chemically synthetized to be introduced into the host's genome. With this technique foods are re-designed and enhanced by stripping unwanted compounds.

- For exemple, Ginko Bioworks designs custom microbes for customers across multiple industries, using synthetic DNA supplied by Twist Bioscience. Motif Ingredients leverages Ginko's technology to create novel solutions for food, like cow-free milk with no lactose.

SOURCE:
Cellular agriculture:An extension of common production methods for food

CELLULAR AGRICULTURE FOR ANIMAL PROTEIN



Cellular Agriculture – The Tech (2/2)

Tissue engineering applied to food

Lab-grown meat is the most well-known cellular agriculture product. Based on tissue engineering, an innovative field focused on growing functional organs for people in laboratory, it requires to take a small sample of animal tissue, isolate stem cells and put them in a bioreactor.

- The bioreactor is the chamber that houses the scaffold (a structural support to grow on) and the cell-culture serum (nutrient growth substances for cells).
- The first large-scale bioreactor for cellular agriculture could be ready during 2020.

Production challenges

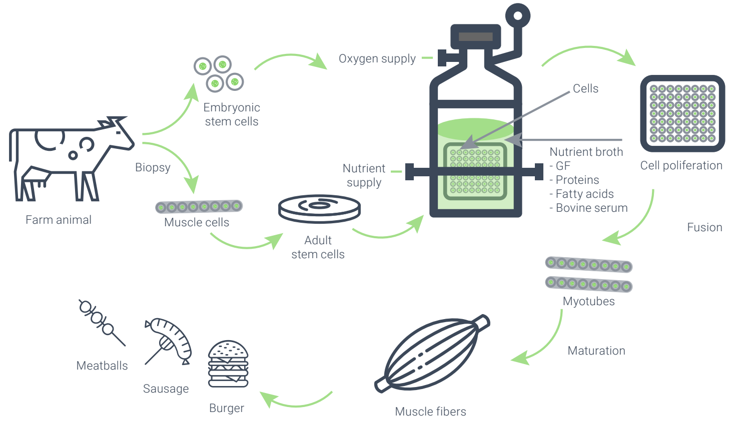
Stem cells have the special ability to replicate generating two cell types: one that is the exact copy of itself and the other that becomes a different cell type via differentiation. The main technological challenge is to find the right chemical cues in the serum and mechanical stimulation to differentiate stem cells into muscle cells.

- In 2017, Memphis Meat has been successfully produced muscle fibers from stem cells.
- The cell-culture serum, which is very expensive and obtained from animal blood, is a factor limiting large-scale production.

Lab-grown meat: the in-vitro hamburger soon on your plate

No cultured meat is commercially available yet. A number of projects are ongoing for fish and poultry, but so far, beef is the most advanced cell-cultured meat. Companies are working to create the best looking and tasting product while pulling down the production costs.

- The first prototype of a lab-grown burger was eaten in 2013, and it cost $325k.
- Mosa Meat expects to bring cultured meat to the market by 2022 at a price <10$/lb.



Cellular Agriculture : The Pricy In-Vitro Hamburger

Company	Foundation year	Geographical area	Focus	Price & commercial launch
Aleph Farms	2017	Israel	Beef	Recent costs: over $3,000/kg (November 2019 claim) Market entry: 2023 (November 2019 claim)
Finless Foods	2016	United States	Fish	Recent costs: $19,000/lb (December 2017 claim) Market entry: End of 2019 (July 2017 claim)
Just	2011	United States	Meat	Recent costs: circa €50 per chicken nugget (January 2020 claim) Prototype: December 2017 Market entry: unknown
Meatable	2017	Netherlands	Pork	Prototype: 2020 (January 2020 claim) Market entry: 2022 (January 2020 claim)
Memphis Meat	2015	United States	Poultry	Recent costs: $1,700/lb (February 2018 claim) Prototype: February 2016 Market entry: around 2020 (February 2017 claim)
Mosa Meats	2015	Netherlands	Beef	Intended costs by 2020: €60/kg (February 2017 claim) Prototype: August 2013 (Maastricht University) Market entry: 2022 (February 2020 claim)
Future Meat Technologies	2018	Israel	Meat	Intended costs by 2022: $10/lb (February 2020 claim) Market entry: 2022 (October 2019 claim)

Cellular Agriculture – The Impact

Comparative benefits

The use of advanced biotech tools in food could prevent the risk of contracting meat-born illnesses and food allergies while increasing nutrient composition. Besides, they reduce the use of antibiotics, and other chemical substances. Cultured meats could be produced in urban factories, reducing the environmental impact of global supply chains such as transport and cellular agriculture requires no animal cruelty.

- Growing meat in labs could reduce greenhouse gas emissions by 90%, lower land use by 99%, and decrease water and energy consumption as well.

Challenges

New advanced biotech technologies to make food are still expensive compared to more conventional alternatives. Even if costs are coming down fast, wider adoption is needed to ensure the economies of scale that would make the production process price competitive.

- A major challenge for the nascent cultured meat industry is the ability to scale-up, as some key components (like the serum to grow cells) are still expensive and difficult to obtain.

Market potential

The global cultured meat market is expected to show very attractive growth rates, with a CAGR of 15% between 2020 and 2025, going from $200mn to $570mn. But it still remains a tiny niche market, especially when compared to the overall global meat market.

- Today the animal meat represents a $1.2tn addressable market.
- By 2050, worldwide meat consumption is projected to increase by >70%.

SOURCE:
MarketsandMarkets; Globalnewswire, World Livestock 2011 (Food and Agriculture Organization of the United Nations (FAO)

Alternative Proteins – The Tech (1/2)

From simple to complex alternatives

Today, consumers have many options for sustainable alternatives to animal proteins, ranging from raw to more processed products based on type of source: plants, insects, algae or mycoproteins.

- Raw products give the consumer a feeling of natural. However, meat-analogues or "fake-meat" can more easily penetrate the existing meat market than conventional veggie products.
- Environmental impact, taste, safety, animal welfare, price and nutrition benefits offer opportunities but also challenges.

The secret: raw ingredients selection

Regardless of the way of consumption (natural or processed foods), the selection of alternative protein types have both a nutritional and taste impact.

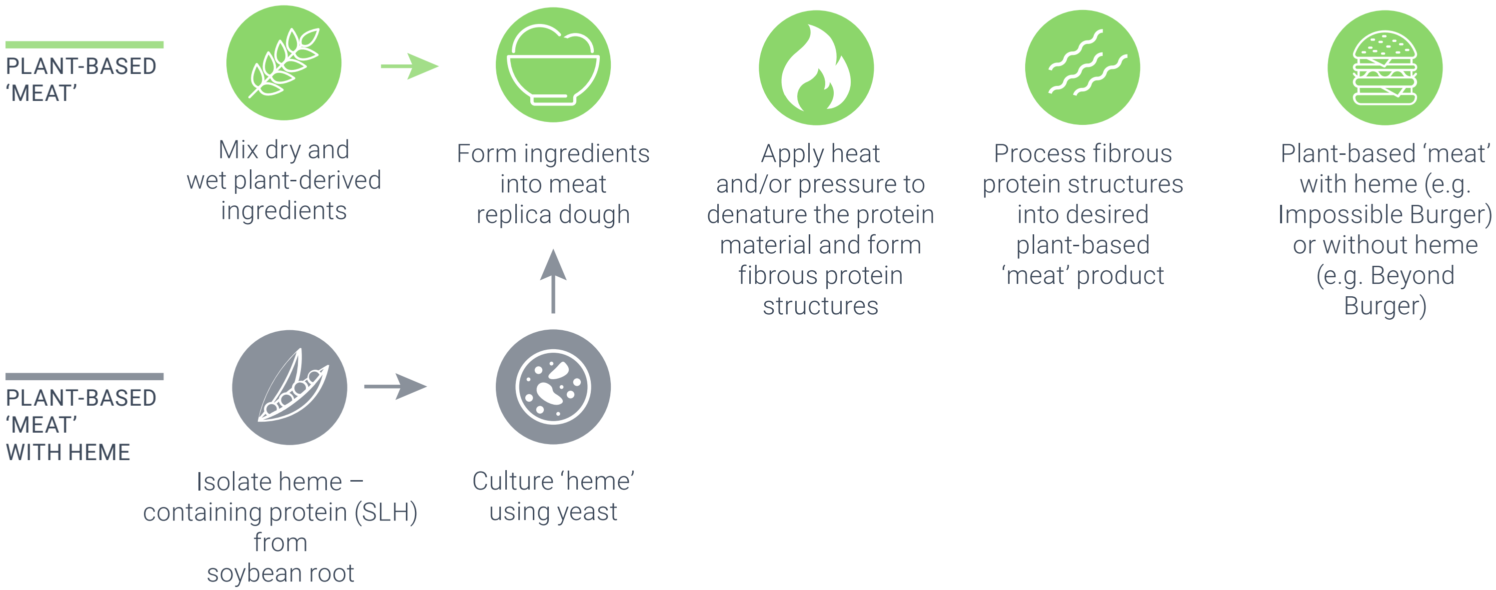
- Proteins are vital for all the functions of our body. They are made up of blocks of amino acids, 11 of which are created by us, but the 9 essential ones must come from the food.
- Not all sources are equal, as in addition to proteins we eat everything that comes with them, the good and the bad (fats, fibers, vitamins, sodium, etc.).

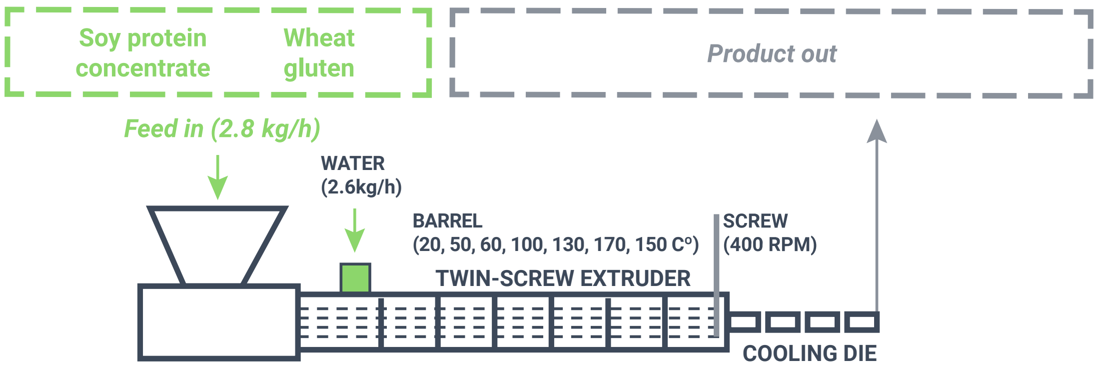
The best sources of vegetable proteins

Quinoa, wheat and soybeans are the only plant-based food that are "complete" proteins, meaning they contain the 9 essential amino acids. Plant-based proteins have the advantage of taste and are essential in the extrusion process to reproduce the fibrous texture.

- Beans are incomplete proteins but provide more fibers.
- Seaweeds absorb a significant amount of carbon from ocean water and supply a range of micro-nutrients and vitamins/ minerals. Its oil is rich of Omega-3 fatty acids, with a level of DHA equivalent to salmon-based oil.

Meat-Analogue – Transformation Process





Alternative Proteins – The Tech (2/2)

Next-generation of veggie burgers: meat-analogues

Meat-analogues try to replicate the texture, look and taste of real meat from plant-sourced proteins using a processing technology called twin-screw extrusion. At a molecular level, at least two sources of plant proteins (usually peas, soybeans) are extracted, isolated and transformed into a flour that is then mixed with a binding agent (methylcellulose), minerals/vitamins, liquids, and oil inside an extrude machine to create a dough. A final cooling die gives the fibrous texture.

- Time, pressure, temperature and design of cooling channels are the essential and secret parameters; the exact "recipe" and how ingredients interact remain opaque.

Fake bloody texture is the key

The extrusion process is used by almost every producers however the difference remains on the ability to reproduce the bloody appearance at the heart of the meat.

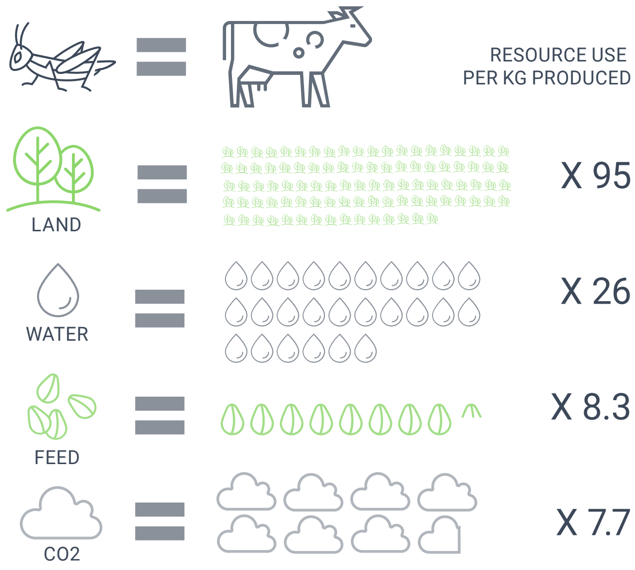
- The "bloody" aspect and taste of the Impossible Foods burger come from cultured heme. Soybean is used to produce the leghemoglobin.
- The process is expensive and with limited capacity. Despite the price they enjoy significant commercial success.

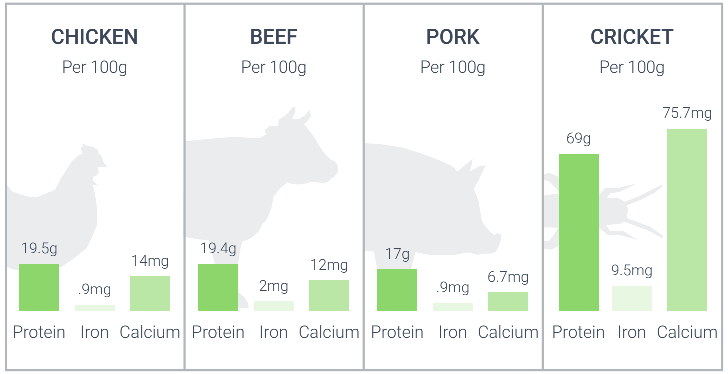
Insect is the new beef

In recent years, non-vegetal meat substitutes have emerged, notably insects. Besides being a great source of protein, these substitutes contain all essential amino acids, a high percentage of calcium, vitamins, omegas, and low level of fat. Nutritionally, insects are better than meat, and require low consumption of resources.

- Insects are the most diverse species, with more than one million types described and more than 1,400 species of edible insects currently eaten by humans.
- Insects could provide the calories needed for human nutrition and solve the problems of famine as their calorific value is 60% and 70% higher than beef and fish, respectively.
- Production process is relatively easy, as it consists of harvesting, inactivating the microbial on the insect, a heat treatment (to kill enterobacteria) and finally drying.

CRICKET VS. BEEF - SUSTAINABILITY

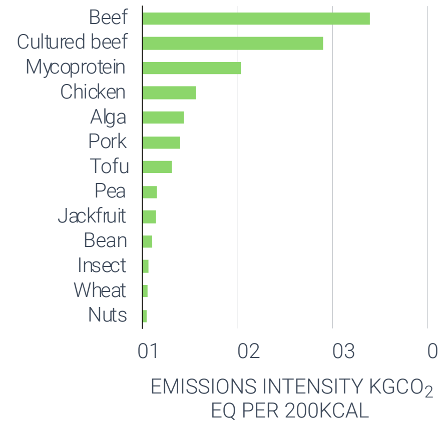




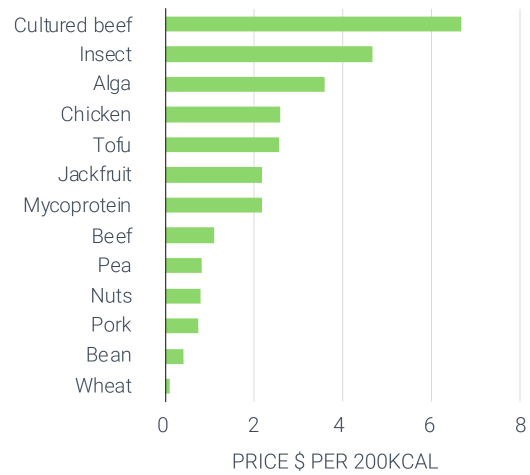
The Jungle Of Alternative Proteins: Which One To Choose?

Sustainable substi-tutes	Consumer perception	Taste	Novelty on the market	Nutrition Benefits (protein per 100g) vs. Beef (25/30%)	Examples of products
Soy-based (e.g., Tofu)	Concerns on oestrogene (but some recent studies on oestro-genics effects showed that the negative effects are very low), Gluten free, common allergen and usually GMO (only 6% in the US is non GMO)	Can be easily flavored as it has a neutral taste.	More than 10years	10-15% of proteins	Impossible Burger (soy + potato proteins, GMO but gluten free)
Gluten-based (e.g., seitan, wheat)	Could be allergenic	Neutral favor and meat-like texture	More than 10years	15-20%	.
Pea & niche types (e.g., chickpea, rapeseed, lupin)	Non allergenic , GMO free, gluten free and good safety	beany taste but can be masked	More than 10years	15-25%	Beyond Burger (rice and bean proteins, GMO & gluten free) , Awesome Burger (wheat and bean proteins Gmo free but not gluten free)
Fungi-derived (e.g., mycoprotein)	mold labeling required by the FDA (bad perception). Higher fiber and lower fat than meat	Mixed with eggs to mimic the texture but neutral taste	5 years	15-40%	Quorn Foods
Algae/Seaweeds	Could increase iodine levels and heavy metal toxicity		5 years	10-20%	New Wave Shrimp
Insects (e.g., crickets)	Could be allergenic	Limits because of unusual taste	5 years	20-60%	Jimini’s, Eat Grub

EMISSION INTENSITIES OF THE DIFFERENT FOOD TYPES



ESTIMATED CURRENT PRICES OF THE DIFFERENT FOOD TYPES



Alternative Proteins – The Impact

Comparative benefits

Fake meats are not always healthier: calories, percentages of fat and sodium are equivalent to a real meat burger. However, they contain more fiber, less saturated fat and zero cholesterol. Insects are more environmentally friendly because they produce less methane and consume less water. Improving the food supply for a more urban population will be crucial in the coming years.

- A meat-analogue burger uses almost 100% less water, 50% less energy, and is responsible for 89% less greenhouse gas emissions compared to a ¼ pound of beef.
- Insect farms have the capacity to produce on a large scale and at low cost.

Challenges

Consumers may prefer raw products, vegetables or meat, because they don't want to eat what they consider ultra-transformed products and as safety of some ingredients has not been proven. Also, some raw products, such as insects or algae, have still a "looks" and taste limits.

- Soy or "heme" protein which is an engineered soy protein are still looked at with suspicion from a safety point of view.
- Fungi-derived protein (mycoprotein) produced through fermentation has a mold labelling from the FDA leading to a bad perception of safety.

Market potential

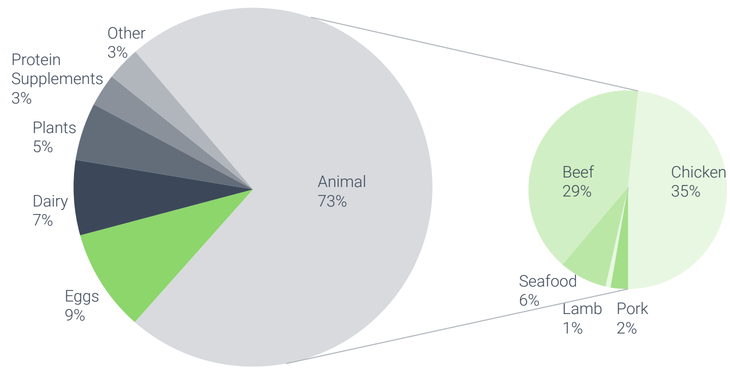
Plant based proteins (the main source of alternative protein) consumption increased by 17% in 2018. This market only represents $12bn over a global meat market of $1.2tr but it is expected to continue to grow to reach $28bn by 2025.

- Plant based proteins are expected to make one third of the global market by 2054.
- The edible insect market is expected to reach $522mn by 2023, at a CAGR of 42%.

BEYOND MEAT VS. IMPOSSIBLE FOODS

BEYOND MEAT		IMPOSSIBLE
250	Calories	240
20	Protein (grams)	19
18	Fat (grams)	14
6	Saturated fat (grams)	8
2	Fiber (grams)	3
390	Sodium (mg)	370
✔	Vegan	✔
✔	Non-GMO	✖
✔	Soy-free	✖
✔	Gluten-free	✔
Pea protein isolate	Ingriedients	Heme (GMO), soy, potato, protein

PROTEIN SOURCE CONSUMPTION IN THE U.S.



SOURCE:
MarketsandMarkets

3D Food Printers – The Tech

3D food printing: dinner is printed!

3D food printing is the manufacture of food using additive manufacturing techniques (layer by layer printing). Most common is extrusion-based printing, where ingredients with a pasty consistency (e.g. melted chocolate) and low viscosity are extruded and printed through a nozzle at constant pressure. The result is a raw paste that must then be baked.

- Binder jetting uses ingredients in powder form and a liquid binder is added to each layer of powder at a fixed temperature.
- Inkjet printing projects small edible droplets onto the surface bed, and is usually used only for final decoration.

Personalize what you eat

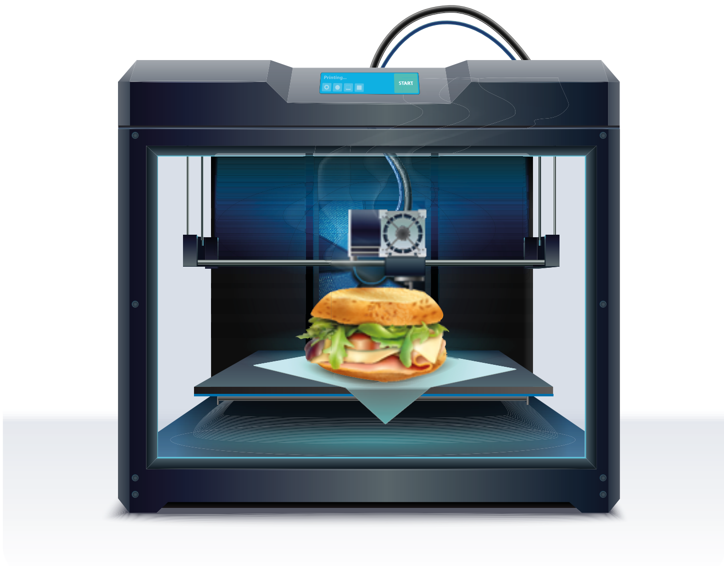
3D food printers allow consumers to personalize food with selected ingredients based on personal preferences and nutritional needs. But 3D printed food can be very useful in specific fields such as healthcare and space travel.

- Astronauts have specific dietary requirements and food must meet a certain number of constraints to be fit for space, notably in terms of volume. The NASA Advanced Food Program, together with BeeHex, developed the Chef3D, able to 3D-print pizzas.

Already printable

The most advanced 3D food printers allow users to remotely design their food on their computers or phones and have already been used to print pasta, chocolate, sugar and vegetable mixes, including alternative proteins.

- Choc Edge was the first commercially available 3D chocolate printer (2012).
- In 2013, an in-vitro meat was printed for the first time using a bioprinter.
- In 2018, Novameat printed the first meat-free steak made from vegetables that mimics meat texture.



3D Food Printers – Already On The Market

Name	Max Build Volume (mm)	Speed	Price
WiiBoox Sweetin	90 x 90 x 70	15-70 mm/s	$1,599
FoodBot S2	150 x 150 x 73	15-70 mm/s	$2,100
Zmorph VX	235 x 250 x 165	120 mm/s	$4,399
CreateBot Food 3D Printer	150 x 150 x 100	20-30 mm/s	$2,115
Mmuse Delta Food Printer	100 x 100 x 100	150-300 mm/s	$1,140
FoodBot D2	80 x 150 x 100	25-50 mm/s	$5,999
Mmuse Touchscreen	160 x 120 x 150	30-60 mm/s	$5,700

3D Food Printers – The Impact

Comparative benefits

Consumers and producers would be able to customize their food based on their diet (vegan, gluten-free), allergies or the nutrient content of the ingredients. This would ultimately save time and could be an effective technique for mass customization.

- Spinach can be made in the form of small dinosaurs, and children will it find way more attractive to eat. Insects, which are a great source of proteins at low cost, can be designed to have a more attractive shape.

Challenges

3D food printing is a relatively new technique and there still are constraints in terms of ingredients consistency and the need for separately cooking after printing. A powdery or pasty consistency is required, and the structure may undergo a change after deposition. Companies are working to make the 3D printer an everyday food processor, with the aim of including lasers to directly cook food during printing.

- Price ranges are still high, going from 1'500$ to 6'000$.

Market potential

Thanks to a rising demand for personalized food, the global 3D Food Printing Market is projected to grow at a CAGR of 32% between 2019 and 2025.

- The market was valued $91mn in 2019 and is expected to reach $484mn by 2025.

SOURCE:
Mordorintelligence.com, researchsandmarkets

Players – List Of Relevant Pure* Players In The Industries

GENETICS

PRIVATE(4)

1. Synthetic Genomics
2. Plant Edit
3. Caribou Bioscience
4. Syngenta

1. Yield10 Bioscience ($0.1bn)
2. Calyxt ($0.2bn)
3. Precision Biosciences ($0.4bn)

LISTED (3)

CELLULAR AGRI

PRIVATE (6)

1. Memphis Meats
2. SuperMeat
3. Mosa Meat
4. Just
5. Future Meat Technologies
6. Ginkgo Bioworks

1. Novozymes ($16.0bn)
2. Evolva ($0.2bn)

LISTED (2)

3D PRINTING

PRIVATE(2)

1. BeeHex
2. Foodini

LISTED (0)

ALTERNATIVE PROTEINS

PRIVATE (5)

1. Kite Hill
2. Impossible Foods
3. Novameat
4. Future Meat Technologies

1. Beyond Meat ($8.8bn)

LISTED (1)

Market Size And Expected Growth

Genetics: 20.0% $14.5bn
CAGR 2019 - 2023

Cellular Agri: 15.0% $0.6bn
CAGR 2020 - 2025

3D Printing: 32.0% $0.5bn
CAGR 2019 - 2025

Plant-based meat market
15.0% $27.9bn
CAGR 2019 - 2025

Edible insect market
42.0% $0.5bn
CAGR 2019 - 2023

For listed companies, market cap in US$bn is reported within brackets.
*: *companies with >20% of revenues stemming from the sector.*

CONSUMING FOOD – CONNECTING THE DOTS

Overview

Profitability

Integrating the consumer into the digital food chain is being driven by both the demand of consumers themselves, and the interest of other actors in the value chain.

- Consumers are becoming more wary of health and sustainability issues, demand better information about what they eat and are ready to pay the price when justified.
- Relevant data on consumers' demands and requirements allow producers, transformers and distributor to leverage their digital infrastructure to quickly adapt and maximize profits..

Environmental impact

The new technologies being deployed around the food consumer aim at reducing carbon footprint, avoid waste and optimize resource utilization. Digital tracking and innovative packaging contribute to reduce the intolerable amount of food wasted through the supply chain. Digital apps empower the consumer to take better informed decisions and directly influence the overall food supply chain.

- A third of the food produced is wasted through the food supply chain.

Health impact

Going digital has the most positive benefits for the end user – apps are fostering healthier lifestyle and dietary habits, while the digital innovations in the supply chain ensure fresher and properly sourced food lands on consumers' tables.

- Smartphone penetration rates are allowing a broader consumer base to connect to the digital food chain, contributing to a virtuous snowball effect.

Traceability – The Tech

Food-sensing technologies to improve safety, quality

Food safety & quality are a major concern for the industry across the value chain. The integration of non-invasive sensing technologies within the food supply-chain allows actors to closely track and monitor food, reduce waste and improve safety.

- Hyperspectral scanning identifies signs of food bruising or rotting, and near-infrared spectrometry measure moisture, protein or fat content to ensure integrity.
- Food recalls, happening when food is found to pose safety issues or defects that could endanger consumer, are estimated to cost on avg. $10mn (direct cost) per recall in the U.S.

IoT, Digital and Analytics technologies put at the service of supply chain

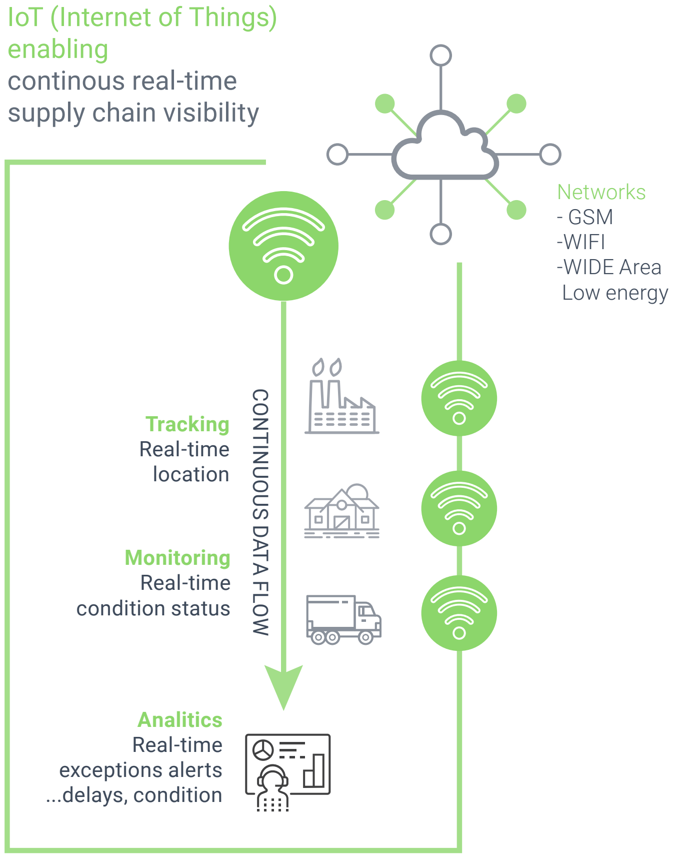
The use of IoT devices in the food industry is also benefiting supply chains. Food products are attributed unique identifiers (e.g. RFID tags or barcodes) gathering food-specific data such as origin, water usage, etc. and integrate a connected ecosystem.

- A third (approx.1.3bn tons) of all produced food is wasted or lost within the supply chain, notably during post-harvest, processing and distribution phases.
- Smart thermostats secure the cold chain during transport & delivery, inventory sensors help warehouse management & enable capacity planning, smart appliances (like connected fridges) assist consumers.

Blockchain applied to the food industry

Blockchain technology finds easy application in food traceability, where each actor of the supply chain securely shares labelled data points. Beyond improving traceability, blockchain technology could also help identify inefficiencies, track frauds, as well as revolutionize the pricing mechanism by providing more transparency.

- IBM's Food Trust network, a private & permissioned blockchain platform, enables trusted transactions throughout the entire food supply chain with a users list that includes Nestle, Unilever, Walmart, and Carrefour.



Traceability – The Impact

Comparative benefits

Transparency enables consumers to access info on food's origin, social equity, safety, and sustainability which are all elements impacting purchase decisions. Additionally, gathering data all along the supply chain journey allows stakeholders to better identify and address food losses, while it also improves visibility to governments who can more precisely identify and respond to food safety issues.

- Traceability helps to identify various issues, including unreliable transport network, inefficient cold-chain, poor harvesting practices.

Challenges

Lack of standardization and interoperability among solutions compound with difficult access to sufficient infrastructure especially for small farmers living in developing countries. For a truly interconnected traceability system to work properly, all value-chain players need to be involved, agree on the system used, the data collected, and how & where these are shared.

- Approximately 765mn people living in rural areas lack access to electricity.
- IoT devices are susceptible to hacking, which could threaten economics and health integrity.

Market potential

Food systems are to benefit from the deployment of new technologies seeking for end-to-end traceability through the value chain. Full traceability will only be achieved through technology deployment, standardization and stakeholder collaboration.

- IoT and Traceability for Food & Beverage Manufacturing market is expected to grow from $4.1bn in 2017 to $8.4bn by 2027 at a CAGR of 9.5%.

Next-Gen Packaging – The Tech

Bioplastics to clean up packaging

Plastic used in food packaging is a growing concern as people realize the impact of single-use plastic on the environment. Among new solutions is the use of so-called "bioplastics" which are generally made of either carbohydrate-rich plants (e.g. corn, sugar cane), sugar derivatives (e.g. cellulose, starch), non-edible by-products of food production (e.g. corn stover, straw, bagasse), or organic food waste.

- Today bioplastics represent less than 1% of the yearly 359mn tons of plastic.

Bio-based, biodegradable, or both

Bio-based plastics are not necessarily biodegradable. Bioplastics can be classified into 3 categories: bio-based & non-biodegradable usually made from bioethanol (e.g. bio-based PET, PE or PP), fossil-based biodegradable usually combined with starch (e.g. PBAT, PCL) or both bio-based & biodegradable (e.g. PLA, PHA. PBS).

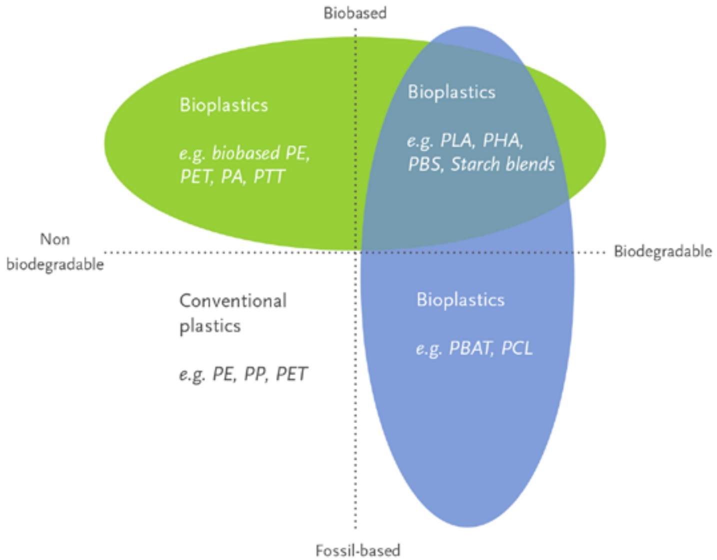
- Biodegradability of bioplastic happens when microorganisms present in the environment decompose the material into natural substances (e.g. water, compost, CO2).
- In 2019, 1.2mn (55.5% of total bioplastics produced) were biodegradable.

Active & intelligent packaging on the rise

Active packaging refers to packages that, in addition to contain and protect products, do also provide active functions such as sensing and monitoring food attributes and extending shelf-life. Active components include for instance: oxygen scavengers (preventing oxidation by absorbing oxygen), antimicrobials (prevent food deterioration by stopping the growth of microorganisms), antioxidants (slowing down oxidation), or advanced time-temperature monitors.

- Early adopters include U.K.'s supermarket chain Morrison who recently introduced an antibacterial trolley bag (reusable shopping bag).

SOURCE:
What are bioplastics?
Food Industry: Intelligent Packaging Paves the Way for Better Business



Next-Gen Packaging – The Impact

Comparative benefits

The use of bioplastics as a substitution to fossil-based plastic reduces significantly packages' carbon footprint while active packages reduce food waste. Active packaging does also feature higher quality and safety properties with longer high-quality preservation of food, while also providing information on food quality & integrity to consumers.

- Replacing the total annual European demand of fossil-based polyethylene (PE) by bio-based PE would save >42mn tones of CO2.

Challenges

Both bioplastics and active packaging are more expensive than traditional packaging solutions, therefore lacking direct economic incentives for packagers. The adoption of more sustainable packaging solutions is subject to regulatory-based incentives which are to be set & standardized on a global scale. Also biodegradable plastics still need to be disposed and composted in a proper manner to biodegrade.

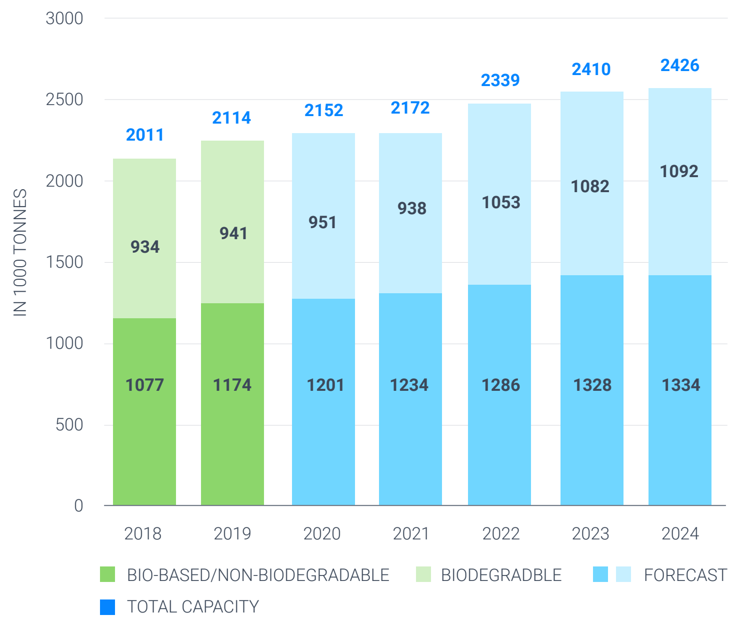
- Current low-oil prices is challenging the cost-competitiveness of bioplastics which are estimated to be 20% to 50% more expensive than conventional plastics.

Market potential

The use of next-generation packaging solutions is set to increase in the upcoming years, driven mainly by consumer pressure, as well as its health & environmental benefits.

- The global bioplastic market is expected to grow from \$8.3bn in 2019 o \$27.4bn by 2027 at a CAGR of 16.1%.
- The active and intelligence packaging market is expected to grow from \$17.5bn in 2019 to \$25.16bn by 2025 at a CAGR of 6.78%.

GLOBAL PRODUCTION CAPACITIES OF BIOPLASTICS



SOURCE:
Bioplastics Market Size, Share & Trends Analysis Report By Product
Active and Intelligent Packaging Market - Growth, Trends, and Forecast (2020 - 2025)

Food Apps – The Tech

The digital nutritionist: combine apps and wearables

Mobile platforms combine different types of biological variables (e.g., age, weight, food preferences, allergies, level of activity, body hydration, sleep, heart rate, etc.) to help consumers live better, healthier lives, including by tailoring their diet to specific needs.

- FoodMarble measures hydrogen levels to analyze a person's digestive health.
- Lumen has designed an inhaler-shaped product that measures carbon dioxide levels in the user's breath in order to monitor a person's metabolism.
- Livongo proposes remote access to nutrition and lifestyle coaches.

Raising food consciousness

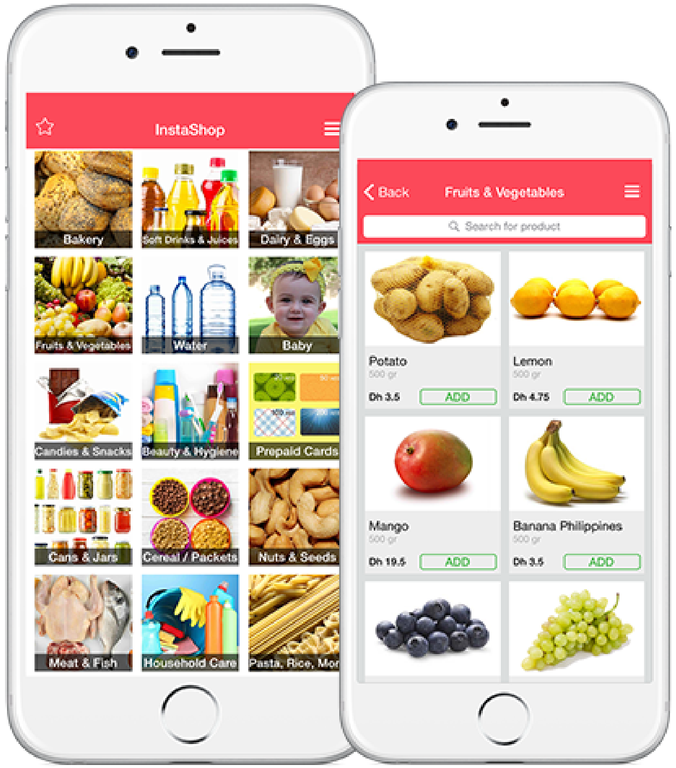
Consumers are more engaged, better informed and seeking greater transparency from food producers and distributors. Tools such as the Yuka smartphone app allow to scan products on the shelf to analyze their nutritional score and eventually offer alternatives to poorly rated foods promoting healthier consumption habits.

- Each app has its in-house algorithm that considers the nutritional value, the presence of bad additives and the organic origin.

Food delivery

The use of digital channels for food retail has caught fire during the COVID-19 out-break. New food delivery options are emerging, leveraging on new smartphone apps, ride-hailing services and new logistic platforms. This trend is expected to accelerate with notably the ongoing shift towards single-person households and the diversified & always-cheaper food delivery options.

- The emergence of new technologies such as autonomous delivery robots or drones would likely accelerate the industry shift towards digital retail.
- Some food delivery apps work directly with selected organic producers to deliver fresh seasonal foods or even meals.



Food Apps – The Impact

Comparative benefits

Healthy food and lifestyle is the first line of defense against most illnesses, such as hypertension, diabetes, obesity and heart diseases. Nutrition data integrates with other habits like exercise and sleep to ultimately help reach fitness goals and improve health.

- Mobile apps can provide personalized suggestions and nutrition tips.
- By proposing alternatives to unsustainable foods or working directly with organic producers, these apps are boosting the shift in consumers' habits.

Challenges

Users enter information about their diet, daily exercise routines, and medical and mental health conditions, so the utilization of nutrition apps and wearables raise significant questions regarding data protection. In addition, these apps are not always accurate. They put at the same level allergenic and toxicity, and do not consider the dosing.

- By applying the precautionary principle they tend to identify as dangerous ingredients whose toxicity has not been necessarily proven.

Market potential

Rising health awareness, the growing trend of digital solutions for healthcare and price (cheaper than group therapy or medication) are contributing to market growth.

- Personalized nutrition market is expected to reach $16.4bn by 2026, at a CAGR of 16%.
- The global market of food delivery represents $134bn in 2019 and is expected to reach $182bn by 2024, growing at a CAGR of 7.5%.

SOURCE:
Mordorintelligence.com, researchsandmarkets

Players – List Of Relevant Pure* Players In The Industries

APPS

PRIVATE (6)

1. Giki
2. Olio
3. Dietsensor
4. Nutrino
5. Oviva
6. Yuka

LISTED (0)

TRACEABILITY

PRIVATE(1)

1. FoodLogiQ LLC

LISTED (0)

PACKAGING

PRIVATE (2)

1. NatureWorks
2. Novamont

1. Corbion ($2.2bn)
2. Good Natured Products ($0.1bn)

LISTED (2)

Market Size And Expected Growth

Apps: 16.0% $16.4bn
CAGR 2020 - 2026

Traceability: 9.5% $8.4bn
CAGR 2017 - 2027

Active and intelligence packaging market

6.8% $25.1bn
CAGR 2019 - 2025

Bioplastic market

16.1% $27.4bn
CAGR 2019 - 2023

For listed companies, market cap in US$bn is reported within brackets.

**: companies with >20% of revenues stemming from the sector.*

Catalysts

- **Wider acceptance.** All advanced technologies have a steepening acceptance curve, as pioneers are followed by the masses. Early players able to establish brand recognition will reap the benefits.
- **Decreasing skilled workforce.** Skilled labor scarcity is affecting the agricultural industry in a way that accelerates the transition towards more automation & efficiency.
- **Product scalability.** Partnerships or M&A with major food and beverage diversified conglomerates will allow smaller, pioneering companies to increase their production, reduce costs and expand markets.

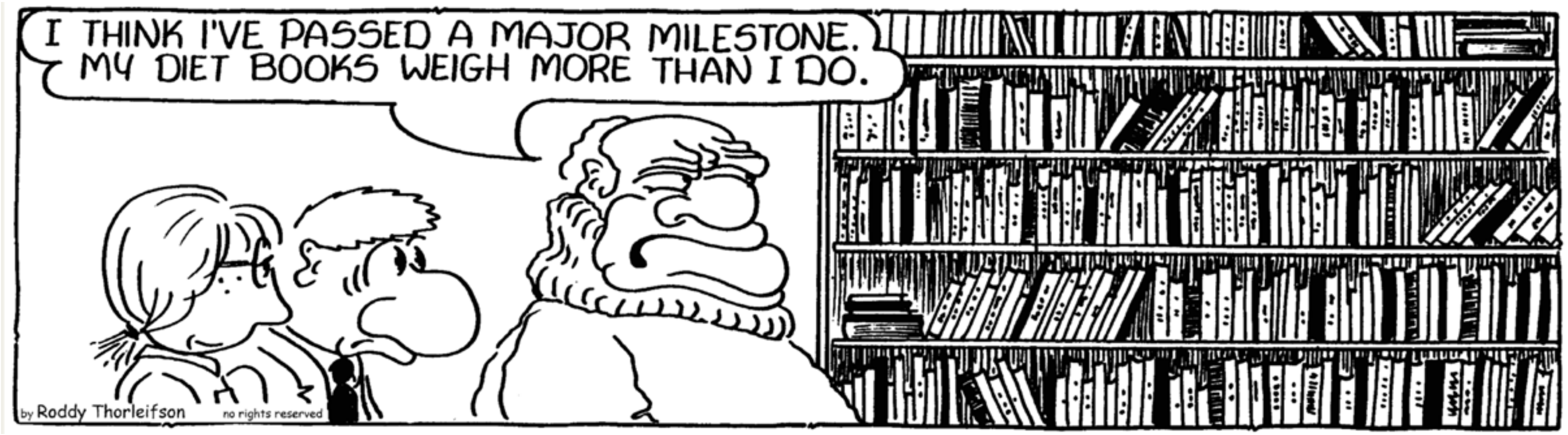
Risks

- **Health and safety.** The lack of long-term studies demonstrating the safety and health benefit balance can represent a limit for wide adoption of advanced technologies across the whole industry.
- **Standardization and interoperability.** The diversity of solutions and the lack of standardization might hamper the adoption of innovative farming technologies with traditional farmers being lost in all the new tech.
- **Regulation.** Regulators have to thread cautiously, and could limit the development of the markets for new technologies until they prove their safety for the consumer.

Bottom Line

- The constraints driving the digitization of the global food industry are ineluctable, and the tectonic shifts in consumer's demands and behaviours in both advanced and emerging economies are compounding the pressing need to act for the key players in the field.
- Nevertheless, we are still at the very early stages of this process and very few listed players offer proper and direct exposure to invest in this promising area. Since the beginning we have been closely following this segment our Sustainable Future universe and have already built some exposure. We are likely to selectively add some names to our portfolio as the opportunities arise.

CASUAL FRIDAY



SOURCE:
https://mooselakecartoons.com/

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About AtonRâ Partners

AtonRâ Partners is an asset management company, founded in 2004 with head office in Geneva, incorporated under Swiss law, duly approved by the Swiss Financial Market Supervisory Authority (FINMA) under the Swiss Collective Investment Schemes Act.

AtonRâ Partners is a conviction-driven asset manager combining industrial and scientific research with financial analysis. AtonRâ Partners focuses on long-term trends powerful enough to be turned into thematic equity portfolios.

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