Cellular Agriculture: The Magic Touch

The world of food science is quickly marching into new territories using post-animal biotechnology and bioeconomy models to provide sustainable and healthy food security and nourishment for a rapidly growing global population.

by Henk Hoogenkamp

The environmental challenges facing the global agricultural industry are increasing. Alternative and smarter ways to produce foods and include these into the daily diet will alleviate some of these pressures. The world's future may require a (r)evolution to create a society where animal products are animal-free. Right now, Silicon Valley investors are being attracted by synthetic biotechnology and the synthesis of whole genes or genomes are now becoming more like disruptive value propositions that will define technology-driven business models going forward. Agricultural civilization came before the technology-driven era by several millennia, but technology-driven inventions have since overpowered agricultural domination. Cellular agriculture has less ecological and environmental negative side effects when compared to traditional farming and animal healthcare. Cellular agriculture is a true groundbreaking entrepreneurial field, some of which is still in its early conceptual phases and in need of additional funding.

Biotechnology and bioprocessing focus on the wide range of systems that are used for transformations, including yeasts, enzymes, bacteria, and other fungi, plants and plant cell cultures. Food and agricultural products are described as "green biotechnology." In a broad sense, biotechnology is the interface between biology and engineering. And that is why Silicon Valley entrepreneurs are interested in dominating this rapidly emerging field of expertise. Many Silicon Valley investors see DNA modification as the next programmable venture with massive opportunities for the collective food industry, as well as medicine and biopharmaceuticals, including potent painkillers and cancer drugs. The speed of innovation is – at times – difficult to grasp, but it is evident that the accelerating transformation of the global food system is caused by truly innovative techniques in combination with improved marketing that will create a sustainable and nutritious food source.

Quite a few of these capital venture companies see biotechnology as a scalable innovation with a decent capital to growth ratio, not to mention that medicine and food security are highly dynamic environments to be operating in.

Creative Destruction

What the Silicon Valley high-flying food upstarts are doing right now is nothing less than creative destruction. Essentially, they are dismantling traditional thinking and rebuilding food science and technology implementations to lay the groundwork for a new sustainable future for affordable, healthy and accessible food security for the entire global population.

Outside the scope of cellular agriculture generated food and biopharma, an entirely new industry is emerging with products like the recently debuted yeast-derived spider's silk and vanilla extract which are not based on petrochemicals. The real driver of biosynthetic technology is the global market potential and the plummeting cost of DNA synthesis, which has become much more sustainable, precise and repeatable in a much shorter time frame. Yeast is the true champion here, because it can be seen as a eukaryotic cell – an organism whose cells contain a nucleus – just like the cells of livestock, companion pets and even ourselves. Modified yeast strains show how DNA can successfully be manipulated and subsequently be applied on a large scale. This is closing the gap between traditional technology and revolutionary disruptive technology.

Tissue Engineering

The science of tissue engineering – like growing functional organs for people – is similar to growing muscle tissue for food and meat. Perhaps the only difference is the scale and magnitude of production. It is certainly no coincidence that medical professors and doctors started working on entrepreneurial Silicon Valley cellular biotechnology food as their brainchild and some of them have become poster children for cellular agriculture.

Tissue engineering is a relatively new science, with most interest generated from the chronic shortage of donor organs or tissue for transplantation. This is creating a gap, which might be filled using re-engineered organs such as skin, cartilage and other soft tissues like muscle. These applications need to perform and maintain a biological function as they are used in a living person i.e. without being rejected.

The technology of regenerated biological material for medical applications is strikingly similar to that used for the creation of cultured meat, for example. The only actual difference is that synthesized cell cultured meat needs to duplicate or simulate traditional organoleptic quality such as color, taste and texture, as well as nutritional parameters like protein and bioavailable minerals.

Entrepreneurial Thinking

Science and technology are the source of innovation and entrepreneurial thinking with strong leadership while disciplinary and organizational structures with unique styles usually create the competitive edge. For many legacy food companies, experience and expertise have often become a barrier to success and hindered progress, they are usually driven by singular traditional thinking and void for disruptive creativity and aversion to risk taking. For example, cellular biotechnology has the potential ability to engineer and create hybrid protein versions using a specific yeast strain platform. As such, a non-plant potato protein isolate can be made, for exam-

ple. These developments are within reach and will contribute to a strategic readjustment by legacy protein manufacturers.

Protein Automation

The future of organism engineering is using software and hardware automation. In other words, biology by design will replace much of the legacy technology by self-replicating and self-repairing renewable molecular structures that build cultured ingredients or products via fermentation, with engineered or modulated yeasts. Designer enzymes are an integral part of these bioindustrial applications; uses range from cheesemaking to pharmaceuticals, or from textile fabrics to ecological friendly cleaning agents.

Biotechnology is a uniquely powerful technology that can reduce or eliminate the need to grow everything and manufacture everything. Instead, DNA modification is the new platform that can, for example, create cells that use amino acids (the building blocks of protein) to produce fragrances, instead of squeezing from flower petals. For the food industry, the biotechnology bottom-line is the potential for reduced demand for cows and meat-producing animals. This is even as the demand for dairy and meat rises and technologies that convert sugars into milk proteins and meat matures. Perhaps cultured milk protein and cultured meat can be seen as one of the biggest technological leaps for humanity, by using up to 90 percent less land, water and greenhouse gas emissions than conventional dairy and meat production.

Relatively speaking, cellular biotechnology today is still at its very early stage of success. There are clear signs that proteins are poised to become a sustainable next-generation ingredient or a product with huge potential for humanity.

Digital Genetic Coding

Recombinant DNA technology used to express genes in microorganisms (which are normally not expressed) to produce proteins can add to the portfolio to battle food security issues.

However, the very same technology can be used to creating new industrial materials, most of which are not even on the radar today. With help from artificial intelligence, including software directed robots, going forward, a few scientists can now equal or better the output of a great many traditional scientists and technologists working benchtop in a much shorter period of time. Biosynthetic technology is the next wave of manufacturing by using digital genetic coding giving it the ability to scale like a software company. To date, one of the biggest challenges facing the synthetic biotechnology upstarts is the issue of transparency. This has been the vocal center of debate around genetically modified organisms (GMOs). It is clear that cellular agriculture is ahead of government food regulatory guidelines with issues looming such as labeling and safety looming.

Using biotechnology and bioengineering as a manufacturing tool is the most sustainable option moving forward and a possible use of GMOs should not be hidden from the public.

To safeguard the future of the planet, synthetic biotechnology will be essential to sustain life and well-being for the human race. We should not try to run before we can walk and every measure should be taken to prevent the mixing of GM organisms with the natural world until the impact is fully understood.

Post-Animal Development

Major changes often upend people and societies. It is no surprise really that breakthrough technologies such as cellular agriculture are so overwhelming, especially since they will have a cataclysmic impact on the world. Many of the new technologies are all converging at the same time and interconnectedness and complexity might very well strangle corporate marketing communication with the core consumers.

As with all exponential technologies, most people don't see it coming. But it will happen at a faster speed than predicted. The creation of artificial intelligence is becoming exponentially better in understanding the world such as diagnosing diseas-

▼ Potential Platforms for Cellular Agriculture

Cellular agriculture is the "farming" of agricultural products from cell cultures. The cultivated animal cells are exactly the same as the traditional harvested products.

There is little doubt that these new technologies, also known as cellular agriculture, will ultimately emerge as the premier model to produce "meatless meat" or "kill-free meat" These products are exactly the same as the meat harvested from slaughtered animals.

- Hen-Borne Free Egg White: Another major disruptive technology is emerging in the arena of hen-borne free egg white. These egg whites are made using cellular biotechnology and cannot be distinguished from conventional egg white. These oval albumins deliver multiple applications for improved whip-ability, volume, texture, foaming, high overrun and strength to create and stabilize foods such as meringues, macarons and angel food cakes.
- Smart Bitterfree Coffee: Cellular biotechnology is setting up a platform to improve all kinds of food products. These improvements are eliminating allergens, boosting flavor, nutrition and protein content. For example, specially selected naturally occurring microbes can be used to create "cultured coffee" in which during a controlled 48-hour fermentation process the bitter notes have been eliminated. After roasting – a process that kills off all the microbes – the "coffee beans" are less astringent, less bitter and more aromatic.
- Leather and Silk Biofabrication: Biofabrication can be defined as growing nature's materials using living cells instead of animals. For example, collagen can be grown from which leather can be fabricated with the traditional structural and aesthetic properties including tanning and color fine-tuning.▼

es with much higher accuracy compared to when it is done by human doctors. Innovative software will disrupt most traditional industries in the next 5 to 10 years.

Cellular agriculture, including post-animal cell culturing, isemerging together with new technologies such as 3D printing, regeneration of human tissue, artificial intelligence, QR (quick response) codes, augmented reality, virtual reality and robotic interfaces. For now, the application of biotechnology to food production has only scratched the surface. Biotechnology, and in particular cellular agriculture, will eventually be able to utilize renewable energy sources and address consumer needs with wholesome food and other every day products, as well as provide the world's rapidly growing population with ecological sustainability. The technology, also termed "post-agriculture food production," has the potential to make cleaner, cheaper and more flexible food production, while leaving fewer "fingerprints" in the areas of food and energy waste, animal health support and chain management.

Creative Destruction

In general, the rather traditional food industry is bracing for rapid technological change that can radically alter the landscape.

The disruptive presence of the cellular biotechnology startups is being felt and shaking up conventional research structures by recalibrating human talent interactions toward the skills from digital to artificial intelligence.

Of course, these changes are fueling anxiety among legacy food companies, many of whom wonder how much disruption they can tolerate and how much they should embrace.

The answer is often a balancing act, because it is good to look in the future, as long as it does not disrupt the shareholder and stakeholder values of the present.

It is clear that for many legacy food companies change can be painful for the organizational structure, particularly when business is going well. Moreover, legacy food companies tend to have a culture of risk aversion and opt for models that have a zero-risk tolerance.

Smart technology will become increasingly mainstream in the food and health categories.

The digital revolution has created sophisticated ways to fast track, for example, screening for enzymes and its effect on matching the perfect protein modification properties.

Cellular agriculture companies create foods such as dairy and meat without using an actual animal.

It is the natural way forward for the new wave of animal-free proteins that delivers real milk or real meat. It is clear that agriculture biotech companies are working towards a disruptive advance in food and meat technology.

A new generation of young highly talented scientists and entrepreneurs recognize that the decade-old farming models cannot sustain the dietary needs of the rapidly growing global population.

Animal-free foods such as cowless milk or hen-borne free egg white use no animals, less land and water and no feed inputs, while matching nutritional value, performance properties, as well as superior culinary organoleptic characteristics.

The Only Constant is Change

The existing regulatory framework of biotech products dates back to 1986 and has largely remained untouched ever since. The huge innovations in biotechnology such as human tissue engineering and many forms of cellular agriculture urgently need an updated regulatory perspective, includeing joint input from government authorities such as the FDA, USDA, EPA, EFSA and biotech's greatest minds. The world of food science is quickly marching into new territories using post-animal biotechnology and bioeconomy models to provide sustainable and healthy food security and nourishment for a rapidly growing global population. Advancing the pioneering work, animal products such as – for example – egg white, dairy milk (including micelles casein) and meat are made by bioreactors instead of using farmed animals (see box). ▼

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