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13D RESEARCH & STRATEGY
Thematic and Innovation Research

WHAT I LEARNED THIS WEEK®
Excerpt from August 5, 2021

A bio-based disruption is underway driven by precision fermentation. What are the implications?

Precision fermentation is akin to the semiconductor in the 1970s: a fundamental technology with the potential to disrupt a wide range of sectors including food and agriculture, pharmaceuticals, cosmetics, materials and more.

Precision fermentation, along with solar, wind and batteries, and autonomous electric vehicles are disrupting the food, energy and transport sectors with the potential to cut greenhouse gas emissions more than 90% by 2035. The technologies powering this disruption are commercially available today, or will be by 2025, according to a new report from independent think-tank RethinkX. **Market forces are key to driving these disruptions**, cutting more carbon faster than "band aid" approaches like subsidies, carbon taxes and biofuels. Societies must also choose to support and **accelerate these disruptions in order keep global warming below 2 degrees Celsius**, the report concludes. (We will bring you **our analysis of this intriguing report** in the next issue of *WILTW*.)

The costs of precision fermentation have plummeted from $1,000,000 a kilogram 20 years ago to less than $100 kilogram today. Precision fermentation is scalable, decentralized, low-carbon and has a minimal environmental impact. Driven by climate change, resource constraints, sustainability concerns and ESG, **rapid growth in precision fermentation is inevitable, offering a range of investment opportunities.**

Food and agriculture is a $5 to $10 trillion sector depending on the dataset and is very vulnerable to disruption. In 2020, the Covid-19 pandemic caused considerable disruption in meat production. **Another major vulnerability was exposed this year with climate-driven extreme weather** producing frost

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in Brazil, record floods in China and Europe, record heat and droughts in the U.S and Canada that have devastated crops. **Food prices have reached their highest level in a decade,** reports the Food and Agriculture Organization.

Extreme weather has become more frequent and will only increase as the climate continues to heat up. **Crop-disease risk will also grow with the USA, Europe and China hardest hit,** according to new research in *Nature Climate Change*. So how can everyone be fed sustainably including the additional one billion people expected by 2040?

Meeting future food needs amid resource constraints and climate change has been a 13D theme since 2001. In 2018 we said alternative protein sources were inevitable (See *WILTW* November 29 2018). **Today plant-based meats are a fixture at fast-food restaurants and plant-based milk is a household staple**.

By 2035 some 11% ($290 billion) of all meat, eggs, and dairy eaten around the globe will not come from animals, according to an analysis by the Boston Consulting Group and the Blue Horizon Corporation. That could save as much carbon dioxide equivalent (CO2-e) as Japan emits in a year, conserve enough water to supply the city of London for 40 years, and promote biodiversity and food security. **The alternative-protein market could reach 22% in 2035** with sufficient investment and regulatory assistance, their research concludes.

There are three ways of producing alternative proteins: plant-based, cultivated and fermented. Some plant-based and cell-cultured products also use precision fermentation (PF). The successful **Impossible Burger uses PF** to make a key ingredient called 'heme', a protein that gives it a meaty taste. **The ability of PF to deliver specific ingredients, be they for food, pharma or commodity chemical, combined with its scalability, makes it a keystone technology in the bio-based disruption that's underway.**

Precision fermentation combines modern biotechnology, metabolic engineering, artificial intelligence, machine learning with fermentation, a centuries-old process to preserve foods and create alcoholic beverages. **This synthesis of new and old creates "microbial cell factories" that can produce specific proteins needed for alternative meat, milk, eggs and much more.**

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In a pioneering use of precision fermentation (PF), biotech company Genentech received approval for a **genetically-modified yeast that made human insulin—Humulin—**in 1982. Previously insulin was extracted from the pancreas of tens of millions of animals.

PF has the potential to be up to 100 times more land-efficient, 10-25 times more feedstock-efficient and use far less water compared to animal agriculture. Consider the dairy cow's four-chambered stomach where feed is converted to milk via microbial fermentation. Only about 4% of the feed becomes milk. With PF, **feed conversion can be 40 to 80%**. Life-cycle analysis shows animal-free dairy products **emit 84% less greenhouse gases**.

And there will be far less waste. **Indeed some PF processes use waste as a feedstock for the microbes.**

We quote **George Monbiot, a British environmental activist and columnist at The Guardian**: "Before long most of our food will come neither from animals nor plants….but from brewing microbes through precision fermentation."

Costs have fallen to $100 per kilogram of protein. **By 2025 meat, eggs, dairy grown in fermentation tanks will reach cost parity with those from animals, and be up to five times cheaper by 2030,** according to modeling by RethinkX. While they advise this cost-reduction curve is based on limited data, the **disruption of industrial animal production will be "irreversible" by 2030**.

We quote a RethinkX report: "We are on the cusp of the fastest, deepest, most consequential disruption of agriculture in history."

Health-conscious consumers have been the primary market for alternative protein. The coronavirus pandemic accelerated this trend with nearly **one-fifth of alternative protein buyers in 2020 being first-time buyers**. Of those new customers, 92% said they'd continue to buy plant-based alternatives. Nearly 80% of people surveyed in the USA, UK, Germany, India and Brazil said they are willing to try cheese made with dairy proteins produced through PF. **This reflects the growing number of flexitarian consumers:** People who choose to go meat- and dairy-free on a more regular basis according to recent research from Kerry Taste and Nutrition.

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More than 80 companies are working on fermentation-enabled alternative proteins, here are a few to consider:

- **Perfect Day is an animal-free dairy,** making milk proteins casein and whey for use in food products. These have higher nutritional value than plant-based proteins. The company is also producing vegan ice cream. **The company is backed by $360 million from investors including Bob Iger, Walt Disney's executive chairman, Temasek of Singapore and Li Ka-shing's Horizons Ventures**.

- **Germany's Formo is focused on making high-quality European cheeses** using PF to make milk proteins and combining them with plant-based fats and carbohydrates. Their products are on target for a 2023 launch.

- **The Better Meat Co.** in California recently completed a 13,000-square-foot fermentation facility that will produce a **new mycoprotein ingredient it says is cheaper than beef**. It is targeting the Asian market with blended foods containing plant and animal protein.

- **Clara Foods** of San Francisco has partnered the innovation arm of **Anheuser-Busch (AB) InBev to make animal-free eggs on an industrial scale.** Its egg proteins will be ingredients for sports nutrition, baking, and other industrial uses. Brewers not only have expertise in fermentation, they have **hundreds of thousands of liters of fermentation capacity.** That's the scale needed to produce the **millions of tons of fermented protein needed to meet future demands**.

Remarkably PF is able to make protein flour literally out of thin air. California's AirProtein and Solar Foods in Finland feed their microbes CO2 from the air and add some nutrients like nitrogen, phosphorus and potassium. Both companies **use renewable energy to produce nutritionally-complete proteins** and can do so in a matter of days. Both also have substantial startup funding.

In the health and longevity space, Singapore's OsomeFood launched what it says is the **first nutrition-focused and plant-based hard-boiled egg enriched with antioxidants**. PF is **lowering the cost of producing commodity vitamins**

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B2 (riboflavin) and B12. It is also lowering the costs of so-called **"longevity vitamins",** such as nicotinamide mononucleotide (NMN), pyrroloquinoline quinone (PQQ) dihydroquercetin (DHQ) and ergothioneine, that are being introduced into a range of foods and beverages.

The scale of the oil palm industry is staggering: An area more than half the size of California is planted in oil palm trees, **producing 71 million tons of palm oil annually for use in thousands of products.** The industry has been a big driver of tropical deforestation and subject to consumer and company boycotts. **Disruption may be around the corner with a $20 million investment led by Breakthrough Energy Ventures in start-up C16 Biosciences**. PF is used to grow palmitic acid, the primary component of palm oil, with food waste as a feedstock. At scale, this **will be cheaper and produced locally**, the company says.

Since palm oil is often a small component in many products, such as lotions, the switch to a greener, lower-cost, locally-produced alternative will be easier.

Small quantity, high-value components in cosmetics are ideal for PF disruption. Skin-care brand Biossance employs PF to make **plant-based squalane instead of obtaining it from shark livers** as has been done for 100 years. Designer-protein company **Geltor makes various human collagens for cosmetics** using PF instead of from animals.

In the pharmaceutical sector, many biologics are made using PF including Humira (anti-inflammatory), Avastin (cancer treatment) and Avonex (Multiple Sclerosis).

Climate change, food security, health concerns and rising ESG investments are powering the shift to alternative proteins. This, in turn, is fueling research and rapid development of **PF as a keystone in a diverse, bio-based economy**. The speed will be determined by the level of investment, **the shift away from animal-based products is inevitable and necessary.**

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