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Protein shakeup: Are crickets and lab-grown meat the future of food?

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After buying a 12-acre plot of land in southern Ontario to grow food, Mohammed Ashour and his company could have chosen to raise cows. But they recognized that the small handful of animals would only yield a few hundred kilograms of protein each year. Ashour had much loftier goals.

Instead of cattle, Ashour, CEO and co-founder of Aspire, and his team opted for pinhead crickets, which increase in size 800 per cent over the course of their month-long life.

"Crickets eat a fraction of the food that other forms of livestock consume, but they produce the same amount of protein," he explains.

To maximize the crickets' potential, Ashour's team drew on experts in artificial intelligence, manufacturing and robotics. This year, they will open what is arguably the country's most efficient protein-producing operation: a $90-million, windowless, robot-powered vertical farm that extends 11 storeys high and produces close to zero waste. (It will also sell frass, waste produced by the crickets, which is an effective compost.)

The facility is in London, Ont., on the aptly named Innovation Drive, where farm fields share space with manufacturing and technology outfits, including a pizza factory owned by Dr. Oetker.

When Aspire ramps up to full capacity, it will boast sophisticated sensors that will collect between 27 and 30 million data points each day, helping to optimize conditions to produce an annual protein yield of a whopping 12 million kilograms. The smart system is a high-tech, low-impact effort to help solve the global protein crisis — a crisis that requires a dramatic reimagining of how we get the most out of our farmed land.

"Our planet is rapidly growing in population and appetite. At the same time, it's shrinking in resources with which to produce food," Ashour says. "If we can come up with ways to produce more food with fewer resources, we can have an outsized impact on solving this problem."

The unsustainability of our current agricultural system has been well documented by the United Nations Food and Agriculture Organization, the World Resources Institute and other climate watchdogs. Livestock accounts for 14.5 per cent of all global man-made greenhouse-gas emissions; cattle, which are particularly hard on the environment, are responsible for 65 per cent of that share.

Growing crickets as a protein source uses 12 times less water than raising beef cattle.
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Getting rid of animal-sourced food would make a considerable difference: the UN found that doing so would lower our greenhouse-gas emissions to a third of their current level by 2050. Earlier this year, *The Economist* published an analysis showing that if we cut meat out of our diets, it would free up three-quarters of the world's farmland.

"If we don't want to cause irreparable harm to the world's ecosystems, we're going to have to significantly both change and reduce the amount of our protein we eat from livestock. Plus, we need to massively reduce the number of

cows on the planet," said Evan Fraser, director of the Arrell Food Institute at the University of Guelph.

Neither Fraser nor Ashour is advocating for the disappearance of traditional livestock farming, which employs roughly one billion people worldwide. But to satisfy the world's demand for high-quality protein we need to start looking elsewhere. By 2050, the global population is expected to surpass 9.5 billion people. Already, according to the UN, about one billion people cannot access enough protein to meet their daily needs.

That gap is spurring tech companies, including Aspire, to develop innovative ways of producing protein that are both sustainable and scalable. The good news, food-systems experts say, is that promising startups are cropping up at a stunning rate.

"It's breathtaking how fast things are changing," Fraser says. With these new technologies, "there is tremendous potential to feed the world at a reasonable cost without imposing an enormous impact on planetary health. We're facing a moment of extraordinary, technology-driven disruption."

Meat 2.0

Given the dire state of the world's food supply, it's increasingly tempting to create a new alternative protein. To do that, a growing number of entrepreneurs and scientists are turning to the lab, where they've developed recipes for everything from "no-kill" meat to cow-free milk. It's a field known as cellular agriculture: making meat and dairy products from cells, instead of harvesting them from actual animals.

When it comes to how we feed ourselves, "the shift from farming animals for food to farming cells for food is as huge as our shift from hunting to agriculture 12,000 years ago," says Isha Datar, the executive director of New Harvest, a non-profit dedicated to advancing cellular agriculture. "The implications are huge because we could really change how we use our planet."

The odds of making that shift are more and more likely. In less than a decade, lab-grown protein has become considerably cheaper to produce. Back in 2013, when researchers from Maastricht University in the Netherlands first made cultured meat — in the form of a lab-grown hamburger that creator Mark Post grilled and served before an audience in London — it cost nearly half a million dollars.

In 2020, food-forward Singapore gave its approval to California company Eat Just to sell the world's first lab-grown chicken nuggets. That meal went on the menu at the restaurant 1880 for about $17. The nuggets contain meat that is, on a cellular level, identical to chicken — but it was made in a bioreactor. Although Singapore is still the only country where Eat Just's nuggets are sold, the company is working on gaining approval elsewhere.

Whether diners will embrace lab-grown meat is an open question. Cell samples taken from live animals need a nutrient-rich broth to grow in, so they can divide and multiply in the bioreactor. While plant-based growth serums are increasingly being used, the most commonly used broth involves something called fetal bovine serum, which is costly and, yes, is derived from fetal cows.

"So that system has issues written all over it," says Fraser, the University of Guelph expert. "It is currently proving to be difficult to scale and people will find it challenging for animal welfare or just pure yuck factors."

Then also add in the fact that alternative-protein producers need to replicate the structure and texture of familiar meats. "It's one thing to make mushy protein," says Dana McCauley, chief experience officer for the Canadian Food Innovation Network. "It's another to mimic the mouth feel and toothsomeness of the protein we're used to eating, whether that's pork, beef, fish — you name it."

Researchers at the McMaster School of Biomedical Engineering are working on the issue. They are developing a promising method of stacking microlayers of cultivated muscle and fat cells together to create a cut of meat that more closely resembles a steak. For now, though, cultivated meat, including Eat Just's nuggets, is usually processed with other plant-derived ingredients — think pea protein and palm oil — to create a hybrid product. As Fraser puts it, "the pace of innovation is amazing, but we're still a ways off from having a decent cut of meat come out of a bioreactor."

And while Eat Just's nuggets got encouraging reviews, flavour is almost as tough to replicate in the lab as texture. "To get (alternative meat) to taste natural is not that simple," McCauley says. "You've heard of grass-fed beef and tulip-fed pork for really succulent ribs — so much of that comes from the terroir and what the animal was fed."

Brewed awakening

Cow-less cuts of beef, then, might not

be arriving on our dinner plates quite yet. But cow-less milk and other dairy products are already available for purchase. To make these alternatives, scientists and startups can consult a well-established blueprint: a technique called precision fermentation.

Biochemists can genetically modify yeast by inserting DNA to trick it into producing something we want and then feeding it starch so that it grows. Since the late '70s, "almost all the world's insulin has been produced this way," Fraser says, rather than deriving it from animal pancreases. Chymosin, the enzyme that curdles cheese, is also made this way, in order to manufacture artificial rennet. "We've been using bioengineered yeast to produce the stuff we want for 40 years," he says.

Precision fermentation can now produce an array of possibilities, including whey protein that does not require cows (just the code of their DNA) and egg whites without chickens.

The genius, says Lenore Newman, director of the Food and Agriculture Institute at the University of the Fraser Valley, is in applying an older technology to our newish protein problem. "It's a massively disruptive technology and we already know how to use it — we don't have to invent an entirely new science," she says. In many U.S. states, consumers can simply drop into a grocery store and buy cow-free ice cream, cream cheese and yogurt.

Newman believes fermentation-derived products will be the first cell-agriculture innovations to be widely adopted in Canada. Not only can they scale easily, they're also becoming much cheaper to produce, making them accessible to all consumers. A boom in precision fermentation, she says, would also be a boon to Canadian pulse and grain growers: all that genetically altered yeast will need to be fed plenty of starch and sugar. And it would be beneficial for plant-based food — which Protein Industries Canada forecasts could be a $250-billion industry by 2035 — since the fruits of precision fermentation can make it taste a whole lot better.

In Toronto, Liven Proteins is using precision fermentation technology to make collagen and gelatin, ingredients that can improve the nutritional value and texture of plant-based products. And they do it by feeding the yeast what they refer to as "lost food," meaning starches that would otherwise not be used as a human food source. (Currently most pea starch is used for animal feed or discarded.)

The company is focusing on using peas, which are popular among Western Canadian growers.

"In the plant-based industry, everyone goes after pea proteins," explains Fei Luo, Liven's CEO. "But starch is a larger chunk of the pea that mostly goes into animal feed."

Once Liven has scaled its production, the company will sell its collagen and gelatin to food producers. As a part of a Protein Industries Canada project, it's collaborating with New School Foods to develop Canada's first whole-muscle, plant-based fish fillet.

In Vancouver, Wamame Foods, is also using fermentation in its development of a plant-based Wagyu beef alternative, which they've branded "Waygu."

Blair Bullus, Wamame's president, says his team is working with the University of British Columbia to map the flavour and textural components of real Wagyu beef. "These maps will be guides from which we can apply AI and machine learning to build back flavour and textures using only plant-based ingredients that will replicate Wagyu beef precisely," he says.

While Canadian scientists and entrepreneurs work out the kinks of lab-grown protein and make strides in plant-based meats, a new cast of growers is breaking through a different kind of ceiling. Vertical farms — similar in concept to Aspire's towering cricket facility — using low-cost LED lights to grow produce in warehouses can be found all across the country. (There are more than 150 of them in B.C. alone.)

With the help of custom "light recipes," producers have discovered they can grow greens and herbs with a huge range of custom features, from higher vitamin content to lower nitrates and longer shelf lives in order to reduce waste.

Not only does vertical farming require less water than traditional farming, the facilities can also be built anywhere, which could drastically reduce the costs — both financial and to the planet — of trucking food over long distances.

"If we're able to produce food in a more highly concentrated vertical approach, we could really free up land and reorganize how the planet is used," says New Harvest's Datar. "That's the vision."

When you add in new techniques in cellular agriculture and innovative spins on precision fermentation, the future of food starts to look much more sustainable — and delicious.

*Jessica Leeder writes about technology for*MaRS . *Torstar, the parent company of the Toronto Star, has partnered with MaRS to highlight innovation in Canadian companies.*

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