EXCLUSIVE: THE BEST PE AND VCs FOR STARTUP FUNDING

Inc.

Out of Cash!
How Apple, Tesla, and FedEx survived every founder's nightmare

Female Founders 100

Rewriting the Rules of Business

with

PHYLLIS NEWHOUSE

STACEY ABRAMS

AND 98 OTHER INSPIRING FOUNDERS

The Future of Farming?
Exit 15E, NJ TPKE, Just East of Newark

Hint Water's Kara Goldin:
On Beating the Billion-Dollar Brands at Their Own Game

19 TIPS
FOR OUT-SOURCING HR, IT, AND MORE

UP ON THE FARM: A worker tending tomato plants at Vertical Harvest, one of several startups rethinking agriculture from the ground up—way up.

A group of startups raises lettuce, tomatoes, and berries in high-rise plant factories. The founders aren't farmers; they're technologists who have shown that even the most grounded industry can be radically reinvented.

Farming Grows Up

By Bill Saporito

A LOT OF THINGS have been made in South Kearny, New Jersey, over the past 125 years. At the Federal Shipbuilding and Dry Dock Company, along the Hackensack River, workers cranked out 440-foot Liberty ships during World War II. Before and after that conflict, Ma Bell's Western Electric Company made telephone cable and transmission equipment that was built to last forever.

Too bad Federal and Western Electric didn't last. Neither did a lot of businesses in this swampy New York City borderland, including chemical plants, metal benders, tank farms, warehouses, and manufacturers that spewed who-knows-what into the world before they began to close in the late 1960s.

Which is why it's so hard to fathom that a company called Bowery Farming is growing lettuce, microgreens, herbs, and even strawberries in a century-old building here. That *anything* edible grows in this wasteland is astonishing.

Bowery is among a rapidly growing crop of high-rise urban farming companies that are changing the very concept of agriculture, as well as the way fresh produce gets to us. The pristine white interior and stacked greens of Bowery's South Kearny Farm X building are a jarring contrast to the bleak landscape outside. Tray after plastic tray of greens—a 40-foot-high erector set of stacked plants—are seeded and racked in a tightly controlled, continuously monitored grid that stretches from wall to wall and floor to ceiling. "It turns farming on its head," says Bowery founder Irving Fain, a software entrepreneur from Providence, Rhode Island, who had zero prior experience in agriculture before starting the company.

About 350 miles due west, just outside Pittsburgh, another vertical-farm company, Fifth Season, sits about 100 yards from U.S. Steel's ancient Edgar Thomson Steel Works—**ET**, locally. The location in Braddock, Pennsylvania, next to an 1875 icon of industrialization, is apt, because calling Fifth Season's facility a farm is like calling one of ET's blast furnaces a fireplace. Fifth Season's 60,000-square-foot, shedlike building is essentially a lettuce factory that uses advanced robotics, vast arrays of LEDs, and state-of-the-art systems engineering. "This is smart manufacturing," says co-founder and CEO Austin Webb, who has an

MBA from robotics leader Carnegie Mellon University. "We just happen to manufacture living organisms."

Vertical farms are at the forefront of an industry segment called controlled environment agriculture (CEA), which has attracted billions in startup capital over the past decade. The premise is that, compared with traditional farms, vertical farms grow crops faster with higher yields, while using far less water and no pesticides—all combining to make vertical farms 100 times more productive per square foot of farmland.

For consumers, vertical farms ostensibly produce tastier, healthier products that get to them faster, and with 100 percent traceability. At Vertical Harvest, another company in the space, the farm is built within a neighborhood—a concept co-founder Nona Yehia first brought to life in Jackson, Wyoming. Yehia sees her company as a chain of living local produce stands—with a social mission that provides jobs for underserved populations as well as food education and a community space. "We grow not only better food, but better futures," she says.

There are now more than 50 companies in the vertical-farming category, from New York to California. Several, including AeroFarms and AppHarvest, have already gone public, but the opportunity keeps growing as the technology improves and more geeks and quants find their way to it. Vertical farms supply less than 5 percent of the nation's produce—mostly lettuce, microgreens and herbs today—but the industry's trailblazers hope their produce portfolios will expand as costs decline and their products delight the palates of consumers. "I think you are going to see vertical farming displace a much broader set of crops," says Bernie Engel, associate dean of research and graduate education at Purdue University's College of Agriculture.

And, unlike traditional flatland farms, Bowery and Fifth Season deliver branded goods to retailers such as Kroger, and sell directly to consumers themselves. Bowery counts 850 retail customers and expanded revenue 600 percent last year. Fifth Season began the year supplying 25 stores and will finish with some 500. "We are reinventing the entire supply chain," says Fain. "You can't just be good at growing."

FAIN HOVERS OVER a table examining new herb plants that Bowery is developing in one of its R&D labs. There's a cilantro with a citrusy finish and a basil that can snap your head back. It's the start of what could be a vast expansion in tastes and textures of our produce, thanks to the precise experimentation that's possible in a controlled growing environment. "We are not encumbered," Fain says. "We can look at crop types that have been buried for years"—or invent new ones.

BROWNFIELD TO GREENFIELD Opposite page, Bowery Farming founder Irving Fain checks out a crop of wasabi arugula. Above, Bowery's not-quite-pastoral environs.

Fain was an investment banker underwriting early-stage tech deals when he decided to go into operations. He joined Clear Channel Communications in 2007, and then left to start CrowdTwist, which did loyalty analytics for consumer brands. "Six years in, I realized I didn't want to spend 10 more years on enterprise loyalty," he says. "I wanted to use technology for hard and important problems."

Hence agriculture, a $5 trillion global industry that's been a laggard in digitization and sustainability. Agriculture uses 70 percent of the world's fresh water, six billion pounds of pesticides, and 189 million metric tons of chemical fertilizer annually. And stretched-out supply chains dribble out a shocking 45 percent loss of nutritional value before produce reaches consumers, according to the U.S. Department of Agriculture.

Fain knew that urban farms had been sprouting around the world—often in the form of rooftop greenhouses and community gardens—and he extrapolated from there. "The question for me is, can tech generate scalable opportunities and an exponential increase in outcomes," he says.

Part of the answer came from advances in LED lighting, whose efficiency had doubled in a decade while the price dropped by 85 percent. That made growing thousands of plants in a tall, densely packed cube viable but not necessarily scalable. What Fain and other entrepreneurs grasped is that advances in robotics—A.I. and computer vision, sensors and control systems—could take care of the latter.

The fact that Henry Sztul was one of his first hires tells you something about Fain's approach to vertical farming. Sztul, a physicist, viewed a vertical farm as a massive optimization equation—a matrix in which sensors and cameras could monitor each plant for temperature, humidity, irrigation, carbon dioxide, light spectra, and other variables.

Sztul's team designed a system in which sensors linked to a machine-learning application constantly make adjustments to maintain optimal growing conditions. They added data-tracking systems and new types of automation around seeding and harvesting. They tinkered for a year and a half. "We didn't come into vertical farming with the ideal system in our minds," he says. "We came in with a build-learn-iterate flywheel approach."

And the flywheel, now known as BoweryOS, is flying. Because BoweryOS tends so many plants and can tend them individually, it produces copious data on everything from how much light an arugula plant needs to the perfect moment to harvest it. The system also allows Bowery to explore what-if questions around the variables and change some things immediately to see what happens. "You want to take advantage of the best known option but still be learning," explains Sztul. For plant physiologists, it all adds up to a whiteboard for designing new things to eat, because farming has never before had the benefit of such perfect conditions. In nature, plants withstand drought, heat, cold, disease, and herbivores that nibble at their roots. Take all that away, says Susan MacIsaac, Bowery's head of agscience, and the carbon that plants divert to mount a defense can go instead to growth, among other things. That's one reason yields are higher in high-tech vertical farms.

Companies such as Bowery can also manipulate variables to create distinct flavors. In one lab I visit, a plant biologist is attempting to generate the perfect balance between sweetness and firmness in strawberries that will thrive indoors. (One discovery: Bees do a better job of pollinating strawberry plants than drones do.) And because crop cycles speed up indoors, the company can halve the time

needed to create, say, a new arugula.

"We are just at the tip of the iceberg in terms of how to make use of this information," says Sztul.

IT'S RAINING GREENS in the packing department at Fifth Season. Workers in protective gear monitor trays of freshly picked lettuces—green tatsoi, purple pak choi, and Chinese cabbage—as the leaves make their way up a conveyor belt to be dropped into a machine that will distribute them into plastic boxes marked Bridge City Blend. But the machine isn't mixing the leaves—it is merely packing them.

That's because Fifth Season cultivates entire salads. The varieties grow side by side on trays that spend 18 to 30 days in one of the company's two grow areas in the building, called biodomes. These are 40-foot-tall chambers that each contain 126,000 square feet of stacked growing space.

This is what you'd expect the future to look like: The plants are nourished by violet-colored LEDs and "fertigated" (fertilized and irrigated) by nutrient systems that use up to 95 percent less water than conventional farming would. Sensors monitor the plants' every moment and report back to the computer servers lining the adjacent hallway, opposite a long row of tanks that hold the nutrient blend.

Like Bowery, Fifth Season takes a systems-control approach to farming, referred to internally as the Brain. The Brain knows all and controls all, from seed to store, in a backward-integrated loop that starts with customer orders. As purchases roll in, the Brain prompts robots to precisely seed trays to match.

Within the biodome, the Brain understands the condition of every one of the 24,000 trays under its command. "We take just under 26,000 data points for every tray across the plant's life," says Webb. The Brain can create a breeze to cool down hot spots. It commands an army of robots that fetch and move trays around to fine-tune their environments.

The Brain does not need much help. There are no humans in the biodomes, and 20 people run the entire growing operation, which, on three acres, produces the equivalent of a 200-acre flat farm. It's not just the stacked growing environment that makes the difference. The Brain, says Webb, allows Fifth Season to more than double the return on investment over older vertical farms while cutting labor in half. Creating the Brain, he says, was the key to unlocking the potential of vertical farming.

Webb didn't plan to become a vertical farmer when he arrived at CMU in 2016. "I was a bit industry agnostic," he recalls. "I thought, I'm going to meet people smarter than me, and we're going to join forces and do what CMU calls the classic hacker-hustler combination." One of those people, Austin Lawrence, shared Webb's belief that robotics still had room to disrupt large industries. Lawrence became his co-founder.

The company they formed was called RoBotany, and the idea was to supply technology to the emerging CEA industry. They leveraged CMU's entrepreneurial network for advice, startup cash, and collaborators. Along the way, they recruited Grant Vandenbussche, who would later become chief category officer. He had worked in supply-chain management for big food companies such as General Mills, but wanted to dump food and work in tech. Instead, his knowledge of food brought him to food tech. Webb lured his brother, Brac, an IoT expert from Virginia Tech, to join as CTO.

As purchases roll in, the Brain prompts robots to precisely seed trays to match.

And in Pittsburgh's Robotics Row, a cluster of tech firms along the Allegheny River, they found the talent they'd need. "We've got people who were previously at SpaceX, in the satellite telecom industry, at Google, at Etsy," says Vandenbussche.

As the nascent team looked deeper into vertical farming in late 2017, they realized their robotics-as-a-service model wouldn't scale, because the economics of existing vertical farms were too challenging. One issue was high labor costs. Earlier farms didn't use robots and needed workers who used scissor lifts, which in turn used up space that could have held plants. Another issue: Existing vertical farmers were employing technology without central control or analytics. The result, says Webb, was "wasted space, wasted labor, and disparate, disconnected tech stacks."

The solution, which prompted RoBotany to become Fifth Season, was to create a fully integrated production system, complete with a branded product line of salad greens and salad kits. The team built not only the robots, but also the software that would run them. "We would have beer parties to wire control panels," says Vandenbussche. Who says geeks can't have fun?

Most important, says Webb, is that Fifth Season has a replicable—and profitable—model. The biodomes are designed in Lego-like fashion. The company can build, say, a 600,000-square-foot version for an industrial site like Braddock, but also a smaller version that might attach directly to a supermarket.

THEY'RE NOT ALONE. Fifth Season's biodomes might have to vie for space in some markets with the community-scale farm installations of Vertical Harvest. From her home base of Jackson, CEO Yehia has begun taking her version of a hyperlocal green machine across the country.

Locating inside communities is part of the company's social mission. In wealthy resort towns like Jackson, workers can struggle to find year-round jobs, and they face higher prices for food and housing. Vertical Harvest's Jackson farm—which uses hydroponic technology from Holland to produce a variety of greens, herbs, tomatoes, and berries—clings to the side of a parking structure like a large greenhouse standing on end.

SKI-TOWN FARM
A Vertical Harvest worker prepares microgreens for delivery to restaurants. Right, the company's Jackson, Wyoming, greenhouse.

"It's always been our model to prove it here in one of the hardest places to build and with an extreme climate—then scale and replicate," says Yehia. The company, which seeks out economic incentive packages when selecting locations, is building a second farm in Westbrook, Maine, and a third in Philadelphia.

In Westbrook, the city gave Vertical Harvest the land, but the four-story farm, which will have 200,000 square feet of growing space, shares a half-acre site with a housing development and a parking garage. The farm will give Mainers access to 1.5 million pounds of locally grown greens year-round—no small thing in a region with notably nasty winters. In North Philly, the greenhouse will be part of the Tioga District Preventative Health Hub, part of a federally designated opportunity zone.

As Yehia sees it, food security, better nutrition, and jobs are all connected—and Vertical Harvest's customizable installations allow the company to build to suit the needs of individual communities. That means not only growing different food in different places, but also providing different kinds of work. Vertical Harvest has made a mission of developing employment paths for what it calls "unexpected farmers"—including, for instance, those with developmental disabilities.

Vertical Harvest plans on building 10 vertical farms within five years—and so, it seems, does everyone else. Fifth Season, which has raised $75 million over five years from Drive Capital and from private investors, will begin rolling out new sites this year, most likely near Pittsburgh. Bowery Farming is about to rev up expansion too. It is lushly funded, having raised a $300 million Series C round of investment this summer led by Fidelity, which values Bowery at $2.3 billion. The company already runs a second facility near Baltimore that is 30 times the size of the one in South Kearny. A third, in Bethlehem, Pennsylvania, (another steel town) will begin construction next year.

Having nailed leafy greens, herbs, and tomatoes, vertical farm companies will add fruits and other vegetables to the mix. More berries, certainly, and root crops such as radishes. "Peppers, melons—there's a long list of different types of crops," says MacIsaac, Bowery's plant physiologist. "I really think there's a ton of possibility." And think beyond plants, says Purdue's Engel. Why not close the loop and feed the plant waste to other protein sources, like poultry or fish?

Wherever it goes next, vertical farming will accelerate change. Consider: Farmers have been manipulating plants for more than 10,000 years. Or so we believed. Another school of thought, articulated by Italian botanist Stefano Mancuso in his book *The Revolutionary Genius of Plants*, says the opposite has also been happening: Plants have brought us along on their evolutionary journey, employing us as their means of transportation. They started in the wild and then moved to farms. Now they're living in high-rises, safe from weather, predators, and disease. The entrepreneurs who nurture them, who weren't really farmers when they started, have evolved into the role alongside the plants and the technology. And, as in nature, learning to adapt in business will only raise their odds of succeeding.

—

BILL SAPORITO *is an Inc. editor-at-large.*

80
Cultivating an Industry
Tim McLaurin (right) works at Vertical Harvest, an urban farming startup in Jackson, Wyoming, that employs farmers from various backgrounds, including those with developmental disabilities. The company is one of a new crop of startups growing more sustainable produce in high-tech facilities.