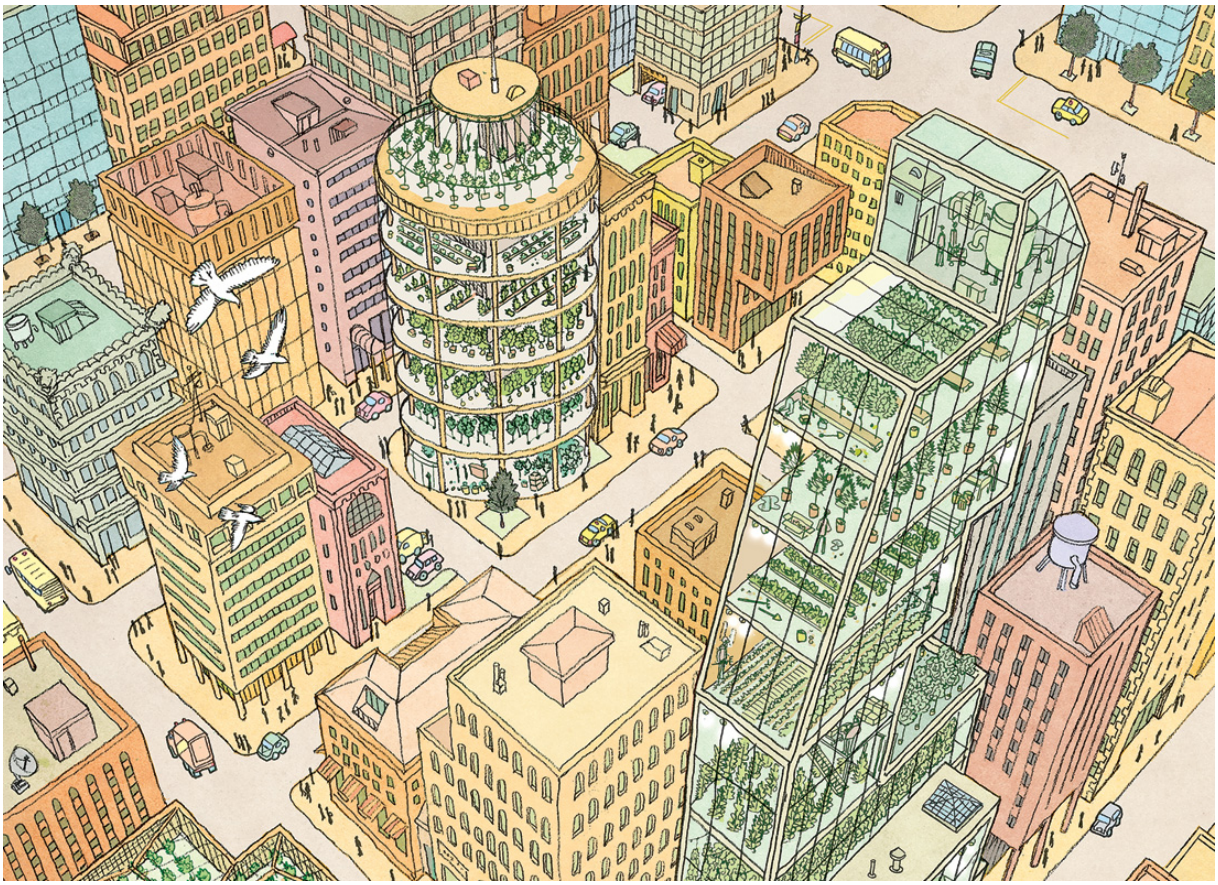
Science & Technology

New Crop City

Can Dickson Despommier’s radical vision for urban agriculture take root in the United States?

By
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|
Fall 2011



John Roman

The English city of Manchester put on a culture festival this summer that was, by any measure, startlingly ambitious. Over the course of three weeks in July, the Manchester International Festival presented newly commissioned works by 28 artists

known more for challenging audiences than for pleasing them: Avant-garde theater director Robert Wilson, performance artist Marina Abramović , and oddball songstress Björk were among the blue-chip provocateurs brought in to shake up and inspire the old industrial city. The whole program was intended to be, according to festival director Alex Poots, a celebration of “risk-taking, the pioneering spirit, and valiant attempts.”

Dickson Despommier ’64PH, a Columbia scientist best known as the progenitor of a concept he calls “vertical farming,” fit right in. He had been invited to announce that the nonprofit organization that runs the biennial festival will soon create a towering multilevel greenhouse inspired by his vision: Alpha Farm, to be located in an abandoned eight-story office building in Manchester, will hold several floors of broccoli, lettuce, tomatoes, onions, carrots, and strawberries, all cultivated beneath huge banks of lights. The idea is that local residents, by growing food in a high-rise, will put less pressure on surrounding farmland and reduce the amount of fossil fuel used to transport fruits and vegetables from as far away as northern Africa.

“I’m not surprised that somebody is actually doing this,” Despommier told a crowd of 300 people gathered in Manchester’s Albert Square on a drizzly Sunday morning. “But I am amazed.”

Alpha Farm won’t be the first vertical farm — similar projects have been launched recently in South Korea, Japan, the Netherlands, Chicago, and Seattle — but it will be the tallest, most fully realized embodiment of Despommier’s vision. It is scheduled to open in 2013, nearly a decade after the professor first proposed planting fields in the sky.

Onstage, Despommier, a tall, rosy-cheeked 71-year-old, wore the peaceful expression of a man enjoying a victory lap. He paused to survey the crowd, scratched his white beard, and then began a lecture that many Columbia students have heard over the years: Farming is the principal cause of deforestation; irrigating crops uses 70 percent of all available fresh water on Earth, and this water — after being contaminated with pesticides, herbicides, fungicides, and fertilizers — seeps into rivers, streams, and aquifers; this toxic runoff is responsible for more ecosystem disruption than any other kind of water pollution; and, partly because of droughts and floods, which are becoming more frequent as the planet warms, only 50 percent of all crops planted in the United States ever reach the dinner table.

The way to fix this mess, Despommier said, is to pack up the farm and move it indoors. A vertical farm generates more crop yield annually than a field with the same acreage, and it uses less water.

When he finished, a dozen people approached the stage with questions: “How can lettuce sales possibly pay for the cost of that building?” “How much electricity will be required to power the lights?” “How heavy is the dirt?” “Won’t it smell awful?” And finally, from a middle-aged woman who runs an organic farm in Kent: “Isn’t this all a bit . . . unnatural?”

“Everybody asks that,” Despommier responded with a jovial laugh. “But what’s so natural about farming to begin with? For 12,000 years we’ve been clearing plots of land from which we’ve tried to eliminate every species except the one we want to eat. Meanwhile, we’ve selectively bred corn, wheat, apples, barley, rice, and lots of other crops to be humongous, so that they barely resemble their original form and lack the genetic variety to withstand any serious climatic changes. There’s nothing *natural* about farming.”

Fresh Start

A microbiologist by training, Dickson Despommier spent the first 30 years of his career holed up in a Columbia laboratory studying a tiny parasitic worm called *Trichinella spiralis*. His major contribution was to describe how this worm, which thousands of people ingest every year by eating undercooked meat but which rarely causes serious illness, can survive in our bodies for long periods by burrowing into muscle tissue.

In 1999, the National Institutes of Health decided that his research had run its course. “I lost my grant support,” Despommier says. “At age 60, I was faced with reinventing myself.”

He then began studying how infectious diseases take advantage of certain environmental conditions. In 2001, he published West Nile Story, a book chronicling how that mosquito-borne virus had gone epidemic in New York State the previous two summers because of successive waves of drought and heavy rains. He also created a new graduate course at Columbia’s Mailman School of Public Health exploring how the use of chemical pesticides and other ecologically disruptive

farming practices affects human health in subtle ways, such as by altering the relationships between parasites and their hosts at various levels of the food chain.

Halfway through the semester, the students rebelled against what they considered their teacher's relentless negativity. "They said, 'Okay, we get it. Farming is bad for the environment. So why don't we figure out how to improve it?'" Despommier recalls. "Their idea was to grow crops right in Manhattan, on rooftops."

Despommier indulged his students, assigning them a group research project in which they were to calculate how much food could be grown if every available rooftop in Manhattan were made into a garden. "It was a purely theoretical hypothesis, really, to imagine that every property owner could be enticed to plant crops on his or her roof," says Despommier. "But it would test the limits of their idea."

The students, after poring over maps at the New York Public Library, became discouraged. Even if every square foot of flat, undeveloped rooftop space in Manhattan were devoted to growing rice — an unusually nutritious and calorie-dense grain — the resulting harvest, they estimated, could feed only a tiny portion of the borough's residents. "This told us that rooftop gardening, for all its benefits in absorbing carbon dioxide and stormwater," Despommier says, "wasn't going to be much of a solution."

The idea of urbanites growing their own food had captivated Despommier's imagination, however. He wondered: Could crops be grown inside some of the vacant buildings he saw on his drive into northern Manhattan every morning? Over the next few years, he returned to the topic each time he taught his course. He encouraged new groups of students to assess the research done by their predecessors and to build upon it, asking increasingly difficult questions, such as, What kinds of crops could be grown inside a building? How would they get sunlight and nutrients? Could this process be energy efficient?

Some answers they found by researching the nascent greenhouse-farming industry, which, since the late 1980s, had been developing rapidly in drought-prone regions such as the American Southwest, the Mediterranean, and the Middle East, as well as in cool areas such as northern Europe. Sensitive crops like tomatoes, lettuce, and strawberries seemed to benefit the most from indoor living. Some greenhouses were also experimenting with a cultivation method known as hydroponics, in which crops,

rather than being planted in soil, have their roots submerged directly in a nutrient bath. These farms boosted their profits: Not only were their crops safe from the elements and capable of growing year-round, but they were maturing faster in the nutrient solutions.



Dickson Despommier in The Sun Works Center greenhouse at Manhattan School for Children. (Jorg Meyer)

“Our vision was to stack these hydroponic greenhouses on top of each other,” says Dennis Santella ’03CC, ’05PH, ’09SOA, a photographer who took Despommier’s course in 2005. “This would maximize space, which was obviously a priority in a city.”

Creating a multilevel greenhouse would introduce new technical challenges, though. Chief among them was providing light to crops in the center of the building, away from windows and sunny rooftops. The students determined that even the most energy-efficient forms of light-emitting diode (LED) lamps would run up an enormous electricity bill.

“We realized this was going to be the main stumbling block,” says Despommier, who was named the 2003 National Teacher of the Year by the American Medical Student Association. “And we didn’t have an answer for it.”

Then, about five years ago, several architects specializing in sustainable design learned about vertical farming from a website the Columbia students created, and they began sending Despommier unsolicited plans to address the lighting problem. Their solutions ranged from the fantastical (a pyramid-shaped building made entirely of glass) to the workmanlike (a conveyor-belt system on which plants would rotate past the building's windows). The designs tended to ignore other economic considerations, such as the expense of a custom-designed building. But they were visually stunning, and, Despommier recognized, public-relations gold. Soon after he posted some of the images online, journalists began to call. The media coverage intensified over the next few years, culminating in a barrage of press surrounding the publication of Despommier's book *The Vertical Farm: Feeding the World in the 21st Century* (St. Martin's Press) last year. Hundreds of newspapers and magazines, including Scientific American, Discover, and National Geographic, have since run articles featuring Despommier's exuberant pronouncements about the future of vertical farming.

"Not all the press has been favorable," says Despommier. "Far from it. The *Guardian* ripped us apart. They said our idea made no economic sense whatsoever."

Nevertheless, the media exposure has galvanized interest in vertical farming among many agriculture specialists. "The idea of growing plants under artificial light isn't entirely new," says Gertjan Meeuws, a bioengineer whose company, PlantLab, created two vertical farms in the small Dutch city of Den Bosch this year. "But no one had ever assessed all the potential social benefits as thoroughly as Dickson and his students did. That helped me articulate a new vision for how my company's greenhouse technology could be useful.

"A few years ago, if I'd asked agriculture officials in my country for help in building a vertical farm, I would have gotten blank stares," says Meeuws. "Now, everybody is familiar with Dickson's book, and they're lining up to help us. Meanwhile, I've received 300 media calls this year to comment on vertical farming. The impact has been huge. My company is now in conversations to create some 20 new vertical-farm projects around the world."

Tossing Seeds

The first vertical farm, in Suwon, South Korea, was established in 2009. The next, in Kyoto, Japan, followed last year. The two Dutch farms in Den Bosch were created by Meeuws's company this past spring. A two-story farm in Seattle and a three-story project in Chicago went up this summer. Most of these farms are located in office buildings converted for the purpose. They don't look anything like the transparent, strangely shaped structures on Despommier's website. They don't need to, partly because LED lamps have become more efficient. Furthermore, PlantLab recently worked with lightbulb manufacturer Philips to produce a new type of LED that shines light only in the blue and red wavelengths that plants need for photosynthesis.

"Incredibly, the plants grow faster when they receive only these wavelengths," Despommier says. "It seems the full spectrum of visible light actually punishes plants a bit."

On a recent trip to the farm in Suwon, Despommier's face took on an eerie pink glow beneath the special LED lamps that illuminated a room full of lettuce. A gentle percolating sound emanated from the plants, as a broth of nitrogen, phosphorus, potassium, calcium, zinc, and many other nutrients circulated through their roots. The air was sultry, and the temperature nearly 85 degrees Fahrenheit. "Just right for lettuce," observed Despommier, his knit shirt darkened with sweat. In adjacent rooms, other types of leafy greens sprouted in their own ideal climatic conditions. On the way out, before changing clothes in a clean room — the farm is hermetically sealed and sterilized to avoid the need for pesticides and herbicides — Despommier grabbed a moist lettuce leaf and folded it into his mouth.

"This place is going to lose money, just as all the first vertical farms will," he remarked later. "These are experimental projects, and it's going to take years for them to become commercially viable. They're already getting annual crop yields that are six times larger than what you'd get from a plot of soil with the same square footage, but even that's not enough to offset the costs of the operation. The lighting technology still needs to be made more efficient. And they need to figure out which crops will be most profitable."

For governments with serious concerns about food security, however, the long-term investment apparently seems worthwhile, as the South Korean and Dutch farms are backed with public funds. "South Korea, like many countries in Southeast Asia, has simply run out of farmland," says Despommier. "They're importing a large share of their food, which is a position that no country wants to be in. The Dutch, meanwhile,

are worried that rising sea levels in the next few decades will saturate their aquifers and their farmland, most of which are just a few feet above sea level. So these countries are hell-bent on making these projects work."

Food fight?

Today, Despommier travels constantly, meeting with proprietors of vertical farms to advise them on pest control and other microbiology issues, as well as to help them raise funds and court the support of politicians. He says he receives 10 or more e-mails a day from people seeking guidance about how to start a vertical farm.

"They ask what crops are easiest to grow, and I tell them: lettuce, tomatoes, strawberries, and bell peppers," he says. "They ask about getting the right LEDs, and I tell them: Call Holland."

Planning officials from a dozen American cities, including Chicago, New York, San Francisco, Seattle, Philadelphia, Los Angeles, Newark, and Jersey City, have asked Despommier to advise them on how to create vertical farms. But the only major U.S. projects to have moved past the discussion stage are the one in Seattle, which is operated by the young company Civesca, and the farm in Chicago, run by the start-up 312 Aquaponics.

"In the U.S., we have lots of farmland and cheap food," says Despommier, who retired from teaching last year. "If vertical farming takes off in this country, it will be because people view it as a moral imperative. It will be because people care about the environmental damage caused by traditional farming and they want their communities to be part of the solution."

Even among scientists who share Despommier's environmental concerns, though, vertical farming has its detractors. One is Bruce Bugbee, a crop physiologist at Utah State University who has been conducting research on indoor farming for nearly 30 years for NASA, with the hope of enabling astronauts to grow food in space. He says the technical challenge of providing light to crops in an energy-efficient manner has proven so formidable that he doubts vertical farming will ever become economically feasible.



Scientists at a vertical farm in Suwon, South Korea, work in a hermetically sealed, clean-room environment. (Courtesy of Insungtec)

“I think there are more realistic things we could be doing to make land-based agriculture more sustainable,” Bugbee says. “For instance, we could invest more public funds into genetic-modification research, in order to develop crops that require fewer pesticides and herbicides. Frankly, I find the whole vertical-farm concept to be a distraction.”

Despommier counters that land-based agriculture will never be able to feed our planet’s growing population without disastrous effects. A landmass the size of South America is currently devoted to growing food, he points out; over the next century, an additional Brazil-sized swath of land may need to be cleared, mostly by flattening tropical woodlands. He says there are already signs that the U.S. agriculture system is breaking down in densely farmed states like California and Florida, where water shortages are increasingly common. “To fix this, we can’t satisfy ourselves with half measures,” he says. “We need to look 100 years into the future and begin investing in long-term solutions.”

Yet Despommier and Bugbee and many other agricultural scientists agree on a crucial point: that farming can be made sustainable only through high-tech agricultural methods. Crops grown in vertical farms, like those cultivated in most hydroponic greenhouses, sprout from seeds that are not necessarily free of genetic modification and are fed chemically refined nutrients to speed their growth. This is sharply at odds with the ethos of organic farming, with its rejection of genetic modification and refined nutrients. But the way many agronomists see the situation, organic farming, while avoiding some of the environmental pitfalls of modern food production, reintroduces problems that for thousands of years hobbled agriculture: low crop yields; a frightful vulnerability to droughts, floods, and pests; and intense demands on human labor. Although organic food is increasingly popular in wealthy countries — where consumers can afford its premium price tag and can find nonorganic options during a bad harvest — organic farming is simply too expensive and too risky, many scientists say, for the majority of the world's population.

Will the preference for organic food in developed countries hinder vertical-farm projects? "That will be a serious challenge, I'd expect," says Bugbee. "There's no reason to think that crops grown in vertical farms are unsafe, but most people dislike the idea of scientists tampering with their food. I think that's partly because a lot of the technology that's involved, like the genetic engineering of crops, has been developed by private corporations that people don't trust with their health. There's also a visceral component: It just feels wrong."

Despommier says he's confident that organic-food advocates will warm up to vertical farming if they learn about its environmental benefits. If he's right, he will have accomplished an unlikely feat: persuading people sympathetic to a back-to-basics food movement to embrace an idea that represents, perhaps, the ultimate industrialization of farming — raising nonorganic crops in a high-rise, without any dirt, using purified nutrients — all in the name of sustainability.

"Farming has a lot of romance attached to it, with its image of simple, hard-working farmers tilling their own land in overalls," Despommier says. "We need to articulate a new vision that's equally compelling. It needs to be a vision that encourages people to embrace technology rather than fear it. And it needs to push agriculture forward, not backward. I hope that vertical farming provides that."

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