

# Scientists Greater than Einstein

## *The Biggest Lifesavers of the Twentieth Century*

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### Who Saved the Most Lives in History?!

#### CHAPTER 5

## Norman Borlaug – A Green Revolution to Enhance Nutrition

### *Over 245 Million Lives Saved*

The tall, scrawny man in the checked shirt, brown pants and work boots sat on a small, folding camp stool in the midst of an enormous field of ripening wheat under a broiling Mexican sun. The dust from the fields and nearby road coated his face, while a handkerchief wrapped around his forehead failed to keep the sweat out of his eyes. In one large, weather-browned hand he held a pair of needle-nosed tweezers. The other hand gently encircled a delicate head of wheat, a tiny fleck of white or yellow hinting at the grain that would eventually emerge. With meticulous precision, his hands as steady as a surgeon's, he used the tweezers to probe the barely formed flower and pluck out each tiny stamen – the male part of the plant – being careful not to disturb the plant's ovary, or female part. Then he slid a small glassine envelope over the wheat head, folding over the top and fastening it with a paper clip. In five days

*“A person who has food has many problems. A person who has no food has only one problem.”  
- Chinese proverb*

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*Norman Borlaug in a Toluca, Mexico wheat field.*

he would return to this same plant, remove the paper clip and slip in the stamen of another type of wheat in the hope that the two parts would create a third: a new breed of wheat capable of feeding the world.

Finished with the first plant, he moved his campstool over a bit and started on the second. Then the third. Then the fourth. Day after day, from sunrise to sunset, the man worked, never looking up, his muscles growing tense with fatigue, his eyes red with grit. As night fell, he spread a sleeping bag at the rudimentary field station and heated a can of beans on an open fire for his dinner.

From those painstaking efforts would rise new varieties of wheat, ones resistant to deadly fungal diseases, that would thrive in the varied Mexican climates, in poor, overworked soils in the teeming

lands of India and Pakistan, and in family plots throughout much of the world. From the work of

this man – a farm boy named Norman Borlaug – would come a revolution, a green revolution, one that would feed the world for at least a little while and change forever how we think about the division between nature and man.

## The Early Years: Kidnapped

Norman Borlaug was born in 1914 in the hamlet of Saude, Iowa, on his grandparents' farm. The great-grandson of Norwegian immigrants and the oldest of four children, Borlaug learned early on the meaning of hard work. From age seven, he was an active participant on the farm, tilling the fields, milking the cows, feeding the livestock, mucking out barns and splitting wood. He trekked a mile and half, in the winter in blowing snow, to and from a one-room county schoolhouse, often arriving home with toes, fingers and nose numb.

But Borlaug never thought much of it – he knew that all boys his age in his county worked just as hard. Unlike most boys, however, Borlaug's family had greater ambitions for him than simply plowing fields. As soon as the boy could understand, his grandfather Nels drilled one overriding ambition into his grandson – “Get an education.” His grandfather had received only three years of formal schooling, but had a deep longing to learn. “You're wiser to fill your head now if you want to fill your belly later on,” he told his oldest grandchild. And though he wasn't the greatest shakes as a student, Borlaug had, as his eighth-grade teacher and second cousin Sina Borlaug said, “grit.” She recommended he go on to the Cresco High School, 15 arduous miles from the Borlaug homestead. The added learning, she said, would “make him.”

She was right. Cresco High School became instrumental in Borlaug's life – and not just for the education it provided. In high school, Borlaug was introduced to the world of athletics, eventually

settling on wrestling as his sport. It was during those practices that Borlaug, coached by his high school teacher, David Bartelma, who had gone to the 1924 Olympic games, learned many of the vital lessons that would remain with him throughout his life. For instance, don't just try to overpower your opponent - outthink him at the same time you act. And, most important - “Give the best that God gave you. If you won't do that, don't bother to compete.”

The golden days of Borlaug's youth were abruptly shattered, however, with the stock market crash of 1929 and the Great Depression that followed. Although it was a great financial struggle, the Borlaug family scrimped together enough to allow Norman to finish high school. He graduated in 1932 – when the country had no jobs to offer and his family no money to pay for college. But Borlaug was nothing if not determined. He learned of a scholarship to train a science teacher at the Iowa State Teacher's College in Cedar Falls. There was only one problem: it wouldn't be available for another year. Borlaug spent that year cutting fence posts, and hunting and trapping animals for the meat they provided and the pelts he could sell. He hired himself out to neighboring farms for spring planting and fall harvesting for the princely sum of 50 cents a day, and considered himself rich for the salary. Every penny counted; every penny was one more step on his road to college. By summer he'd squirreled away \$50; soon thereafter he learned he'd been accepted to the college with a partial grant.

Then, as would happen so often throughout his life, fate intervened. A week before he was due to leave for Cedar Falls, Borlaug was kidnapped by a young man who had graduated from Cresco High School two years before and now attended the University of Minnesota. George Champlin had heard about Borlaug from Borlaug's old wrestling coach, Dave Bartelma. He turned up at the Borlaug door to whisk the former wrestler off to Minneapolis and the university's fledgling wrestling team. Here was Borlaug's chance to attend a full university rather than a two-year teacher's college - to go on and get

the rich, higher education he and his grandfather had always dreamed of.

How could he say no?

With \$61 in his pocket, thanks to \$11 his grandfather added to his existing stash, and the mere promise of a job, Borlaug hopped into Champlin's car, made a stop to pick up his high school friend and fellow wrestler Erwin Upton who, by way of Champlin's recruiting, had also been lured to Minnesota, and headed 150 miles away to the big city.

## The True Face of Hunger

Despite the high spirits the boys had during that drive to Minneapolis, Borlaug's hopes were dashed the first week in Minneapolis. Because of differences in the high school education offered in Iowa and Minnesota, he and Upton would have to take an entrance exam. Upton passed easily; Borlaug failed. There was one option left: the university offered him a place at its "General College," which some snide students called the "college for dumbbells." Borlaug could take a broad sweep of subjects and at the end of two years receive a degree. It wasn't what he'd hoped and dreamed of, but he had no other choice. Despite his anger and shame at having flunked the exam, he agreed to enter.

Even before classes started, Champlin made good on his promise to help the two young men find jobs. They worked in a local coffee shop, serving breakfast, lunch and dinner. Their only pay was sitting down to eat those meals. It was during those meals that Borlaug met a pert, pretty young woman: Margaret Gibson, a 20-year-old sophomore in the College of Education. The two quickly bonded, brought together by their similar rural upbringings and their ability to talk about anything. One thing they spoke often about that first semester was Borlaug's frustration with the "remedial" college. "I'm nothing special," he told Margaret one night. "But I know damn well I'm better than that – that place for the misfits they

expect to drop out."

Then get out, she told him. Work harder.

So, as he'd done on the wrestling mat, in the fields, while hunting – in whatever he did – he set a goal and focused on it, allowing nothing to distract him. He worked, as his early biographer Leonard Bickel wrote in a 1974 book, "with an intensity that attracted attention." By the end of the first semester, he convinced the administrators to let him out of the general college and into the College of Agriculture to major in forestry.

Two incidents marked Borlaug during his first year at Minnesota. One occurred soon after he arrived in the metropolis of Minneapolis, when he went to visit the university's agricultural campus on the outskirts of St. Paul. Walking back into town, he happened on a riot instigated when managers at a factory slashed workers' wages in half and the workers struck. The desperation he saw in the workers' faces as they fought against truncheons with their bare hands, trying to feed their families, stayed with him throughout his life, igniting in him a burning desire to eradicate hunger.

The second incident affected him more directly. As a member of the wrestling team, Borlaug often had to fast to lose weight so he could compete in his weight class. One time he went four days without food and with very little water, spending hours in a steam box to sweat away the pounds. On his fifth day without a meal, when he discovered he was still a pound overweight, the normally gentle Borlaug lashed out at another wrestler and would have punched him in the face if his friends hadn't pulled him away. For the usually calm, peaceful Borlaug, such an outburst was, to say the least, uncharacteristic. As he told Margaret that night: "I think I've learned a primal rule of nature. You see, it wasn't me at all. It was primitive, rudimentary. I can't explain how hungry I was. I was starving, and I found out that a hungry man is worse than a hungry beast."

In December 1935, Margaret dropped out of school to get a job. The scrimping and saving were

just too much, she told Borlaug. “I cannot tolerate it any longer.” She got a job as a proofreader and settled into living in a one-room apartment. By now, the two had an unannounced agreement to eventually get married – when they could afford it. Pennies still counted during those Depression days, and Borlaug spent summers working for the U.S. Forest Service watching for fires, alone on Cold Mountain in the Idaho National Forest, the most remote wilderness in the lower forty-eight states. During the school year he was helped by the National Youth Administration program, earning 15 cents an hour for part-time jobs as credit towards tuition.

Then, as he prepared to start his final year of college in 1937, the economic tide seemed to turn. Borlaug was offered a permanent job with the Forest Service as an assistant ranger in the Idaho National Forest once he graduated. Elated, he proposed to Margaret, who immediately said “yes.” A few days later, on September 27, the couple was married in Margaret’s brother’s sitting room, with a few family members in attendance. There was no lavish reception, no honeymoon, just a return to her one-room apartment with the bath down the hall.

But a few days before Christmas and his graduation, Borlaug received a letter that changed everything. Due to budget cuts, his job no longer existed. It would turn out to be the best thing that could have possibly happened to him and millions of people around the world.

## From Wrestler to Protégé

During his final semester as an undergraduate, Borlaug had had a very strange encounter with the head of the plant pathology department, E.C. Stakman, one of the most respected scientists in the field. For years, Borlaug thought the interaction was accidental; yet Stakman, who had seen the “courage and tenacity” Borlaug showed during a wrestling match, had deliberately sought out the young man to test his intelligence. Stakman walked into the

forest pathology lab where Borlaug was examining wood samples under a microscope and, without introducing himself, began peppering the student with questions about the samples. This PhD.-level “pop quiz,” Borlaug later learned, was designed to test his ability to meet challenges head on. Borlaug passed with flying colors.

A few weeks later, Borlaug attended a lecture Stakman delivered on his decades-long research into the challenges of rust diseases in wheat. The parasitic fungi causing the disease were the bane of all farmers, changing their genetic makeup in less than a year to attack previously resistant crops, wiping out a season’s yield in days. “Rust diseases are the relentless, voracious destroyers of man’s food,” Stakman told his audience, “and we must fight them by all means open to science.” Stakman didn’t stop there, however. He warned of another threat to the world’s food supply – man himself. Population growth would soon outstrip food supply, he said, and only one thing could be used to reverse the trend - science. Even there, however, his message held foreboding: “Do not deceive yourselves – ever – that the scientific approach is omnipotent,” he said. “It will make its mistakes, but it will go further than has ever been possible to eradicate the miseries of hunger and starvation from this earth.” If ever a speech was designed to ignite and motivate, this was it. “One day I would like to go back and study under that man if it is ever possible,” Borlaug told Margaret that night.

When the implications of the forestry letter sank in, Margaret gave him his chance. Go to graduate school with Stakman, she urged her husband. They would manage on her income, she said. She would keep working as a proofreader, which she loved.

Buoyed by her support, Borlaug walked into Stakman’s office the next morning and told the man he wanted to spend a couple of months doing graduate work in forest pathology. He might just as well have told Stakman he was ready to begin painting his face and touring with the circus. No way,

Stakman told the young man. You don't dip your toe into the world of graduate work – you jump in. And forest pathology is self-limiting - focus on all plant pathology and you can work with any species.

Borlaug became a Stakman disciple. He received his master's degree in 1940 and went on to study for his PhD, also under Stakman. In late 1941, as Borlaug was completing his thesis, Stakman arranged for his protégé's first professional job. Upon graduation, Borlaug was to work for the chemical company DuPont in Wilmington, Delaware, in its biochemical laboratory group. His salary would be \$2,800 a year. Borlaug accepted, and in early 1940 he and Margaret bought their first car, a secondhand Pontiac, and moved to Wilmington.

## To Mexico

Borlaug had barely begun his professional life when the United States entered World War II. Although he wanted to enlist after the attack on Pearl Harbor, he was told his work at DuPont was considered “too valuable” to the war effort. So Borlaug spent the war years at DuPont. There, he and his colleagues developed camouflage paint, aerosols and chemicals to purify water, among other products. He also oversaw the mass production of a new insecticide: DDT. And he became a father. His daughter, Norma Jean (Jeannie) was born on September 27, 1943.

Then the Rockefeller Foundation came calling. In 1940, the Rockefeller Foundation sent a delegation of agricultural experts, including Stakman, to tour Mexico and report on what was required to help the starving country develop a viable agricultural program. Their recommendation – create an agricultural research infrastructure. It was the only way, the men reported, that Mexico would ever be able to feed its own people without depending on the handouts of richer countries like the United States. The foundation agreed to fund the project and asked Stakman to pick the man to lead it. Stakman

recommended one of his former students, George Harrar. Together, he and Harrar hammered out a plan for Mexico. They would create an Office of Special Studies that Harrar would run in cooperation with the Mexican government. But the Americans were not there to take over. A major goal of the office was to train young Mexican scientists on modern farming techniques so they could run the venture – sooner rather than later. It was a new twist on the “teach a man to fish” parable.

When Harrar needed a plant pathologist for his team, Stakman recommended his protégé, Norman Borlaug. “He has great depth of courage and determination,” he wrote to the Rockefeller board. “He will not be defeated by difficulty and he burns with a missionary zeal.”

Borlaug was intrigued. The idea of improving the quality of life of a whole country was attractive. As Richard Zeyen, professor of plant pathology at the University of Minnesota, who has known Borlaug for decades, explains: “He had that small town farmers-help-farmers-help-each-other spirit. He was strong and he knew he was strong and he knew he could use his strength to help others.” In 1944, thanks to intervention from the Rockefeller people, his wartime designation was lifted. He was free to go to Mexico. Even though Margaret was pregnant again, even though Mexico was 2,000 miles away and still very primitive, Borlaug agreed to go.

He drove from Wilmington to Laredo, Texas, where he met up with Edwin Wellhausen, the corn specialist on the project. From there, they made the three-day, 800-mile journey through the dusty, hot, yet colorful landscape to the agricultural school at Chapingo, 20 miles outside Mexico City. There, Borlaug found a newly built adobe shed with a tarpaper roof surrounded by 800 acres of weed-choked fields. No trucks or tractors. No research materials. No irrigation supplies, gasoline or tires. The war had taken everything – nothing was left for Mexico. And, of course, the Americans had to deal with the frustrating Mexican bureaucracy, which

Wellhausen described as similar to “punching a featherbed.”

“What kind of future is there for me in this strange country?” Borlaug wondered as he went to sleep that first night in his Mexico City hotel.

The three principals at Chapingo – Borlaug, Wellhausen, and a soil expert set to work. They had to do everything from developing roads and underground irrigation to readying the land for planting. To speed things along, they tried to get farmers in the surrounding towns to plant small experimental patches. But they quickly realized that the farmers were too poor, too hungry and too illiterate to take on such a role. Things only got more depressing from there.

Margaret called in early November to say that their baby had been born with severe spina bifida, a condition in which the spinal column does not close properly. Borlaug flew back to Wilmington to see his son, Scotty, for the first and last time. The infant could not leave the hospital and was too fragile to hold. He asked Margaret if she wanted him to look for work locally, but doctors had told her there was no hope for Scotty and she knew her husband’s heart was in Mexico. Margaret stayed behind with the baby, but when it was clear there was no hope, she followed her doctor’s advice and, reluctantly, she and Jeanie took the train to Mexico City, leaving Scotty behind. He died a few months later. It would be four more years before the Borlaugs had another son, born in Mexico City, whom they would name Bill.

## Radically Speeding Up Agricultural Time

The science of agriculture, unlike that of some other disciplines, has few “ah-ha!” moments. There are almost no major moments of discovery, no miraculous recoveries, no sudden breakthroughs. There are only the slow, inexorable seasons, the centuries-old methods of preparing the soil, planting the seed and observing the traits of what grows.

When you’re trying to feed a nation, however, such a pace can be tortuous. And so, out of his need for action and his own frustration, Norman Borlaug sped ahead – and forced the rest of agricultural science to keep up. To find the right types of wheat that would flourish throughout Mexico, he knew he would have to cross thousands of varieties, searching for the plants whose mutations would provide increased yield while also fighting off the fungi causing rust. If he did it the old way, it could take decades of crossing the wheat, planting the new varieties, and waiting to see what happened. In Mexico, where he saw a desperate need everywhere he looked, he didn’t have decades. So he found a way to speed up agricultural time.

The first of three great innovations Borlaug developed in Mexico was shuttle breeding. Rather than planting a wheat crop, waiting for it to grow and harvesting it to see which varieties survived, he came up with the idea of supercharging the process by growing two plantings in the same year. The summer crop would grow in the high-altitude, bone dry, poor soil of the Chapingo region outside Mexico City, and a winter crop would grow over 1,200 miles north in the sea-level, irrigated Yaqui Valley in Sonora, with its more fertile soil and better growing conditions. The differences in altitude and temperature meant the two areas had different growing seasons, so Borlaug could not only grow two crops of wheat in a year, he could see if the plants that grew well in one region also worked in the other. He would harvest seeds in the summer from Chapingo and plant them in the winter in Sonora; and harvest seeds from the winter’s Sonora crop for planting in the Chapingo summer.

This was radically different from how agricultural science was done at the time. His colleagues thought he was nuts. Harrar didn’t want to expend resources in two areas of the country. “It makes no sense to risk a round trip of 2,500 miles through that country,” Harrar said, knowing how hard it was to travel overland in Mexico at the time. “You could lose everything – and for what? The guts of our problem is

***“Don’t try to discourage me, Ed. I know how much work is involved. Don’t tell me what can’t be done. Tell me what needs to be done – and let me do it. To hell with the extra work and strain. It’s got to be done, and I believe I can do it.”***

here, in the poverty areas. . . You’ve got to get that clear!” He enlisted Ed Wellhausen to dissuade Borlaug.

But as Bickel related in his biography, Borlaug thrust his chin out and knitted his brows together. His stance was reminiscent of the powerful wrestler he once was, only this

time his opponent was not another young man, but his boss, and at stake wasn’t a wrestling match, but the stomachs and lives of millions of Mexicans.

“Don’t try to discourage me, Ed. I know how much work is involved. Don’t tell me what can’t be done. Tell me what needs to be done – and let me do it. There’s one single factor that makes the Yaqui effort worth a try, and that’s rust. Breeding two generations a year means beating and staying ahead of the shifty stem-rust organism. If I can lick that problem by working in Sonora, then we’ve won a victory. To hell with the extra work and strain. It’s got to be done, and I believe I can do it.”

Harrar relented and Borlaug managed to get one season’s wheat planted. But a visit the following year by the three-man Rockefeller Foundation team, including Stakman, brought the whole issue to the fore again.

“You’re going to be going in circles with such a program,” one of the visitors, plant geneticist Dr. H.K. Hayes warned him. “One step forward, the next step backward.” Hayes was of the old school belief that plants must be bred where they will be grown. It was thought that there were too many local variables that could affect the plants to do otherwise.

The foundation team voted against the Sonora

planting, and as Borlaug sat across from them, Harrar spoke to Borlaug testily, “I have told you each time the subject comes up that you should concentrate your efforts in the Bajio area (where Borlaug was based). This scheme of yours has been considered twice, at your insistence, and voted down twice. Why can’t you accept that?”

“If this is a firm decision, I also make a firm decision. You will have to find someone else to conform to your rules,” Borlaug told him. “You’re laying down a policy that is wrong. And I can’t go along with it. As of now, I resign. You’ll have it in writing first thing in the morning.”

And with that, he stalked out of the room.

The next morning Stakman convinced Borlaug to go on to work at the Chapingo station, promising him he could turn in his resignation letter at the end of the day. Stakman knew that Borlaug’s plan might just work. So he went to see Harrar. Coincidentally, that very day Harrar received a letter from a farmer in Sonora praising Borlaug and the Rockefeller Foundation for planting new strains of disease-resistant wheat on his land. “I want to say what is happening here with Dr. Borlaug will have a tremendous effect within a short time,” the farmer’s letter finished. After a discussion, no one knows how much influenced by the farmer’s letter, Harrar agreed to allow Borlaug to continue shuttling his wheat and himself between the two regions.

The second major innovation Borlaug brought to Mexico was high-volume crossbreeding. At the time, plant breeders typically only crossed a few plants each season, waiting until the plants were harvested before choosing the best varieties to use for crossbreeding a few more varieties the following year. With this method, it could take decades before a viable new breed emerged. Ever impatient, Borlaug took a different approach. Knowing he had one chance in a thousand to hit upon a winning variety, he collected thousands of wheat varieties from throughout the world and began crossing them simultaneously, hoping to find those that

were most resistant to fungal diseases like rust and could survive best in the various Mexican soils and climates. He also optimized multiline breeding, backcrossing hybrids with a single parent, thus putting multiple disease fighting genes into a variety. Hence the long hours spent under the broiling Mexican sun hand-pollinating his wheat varieties. And when he finished on Friday evenings, he would get in his car and drive the six hours to Mexico City to spend the weekend with his family. Saturday mornings he got up to coach his son's baseball team. It played in Mexico's very first Little League, one that he and Dr. John Niederhauser, another Rockefeller scientist, started. As a colleague later wrote of him during this time: "Work was not just a word to him; it became a code of honor. If genius is 'an infinite capacity for taking pains,' Borlaug had it."

Most importantly, he never sought perfection, only something better. "We don't have time to wait for perfection," he said, thinking of the starving population. To Borlaug, 40 percent better and harvestable this year was better than 90 percent better in five years. By 1952, he had more than 40,000 wheat varieties in his nurseries and more than 6,000 individual crosses – all meticulously recorded. Combined with the shuttle-breeding approach, it cut the time required to develop new varieties in half. By 1956, Borlaug had developed 40 new rust-resistant strains of tall wheat. There was only one problem, but it was a major one. When the farmers began using the large amounts of fertilizer required to increase yields, the wheat grew even taller and began lodging, which is a farmer's way of saying that the wheat had a tendency to flop over in wind and rain, which ruined the crop.

So Borlaug embarked on his third major innovation. He crossed his rust-resistant varieties with a new Japanese dwarf variety of wheat to create

a shorter, stiffer wheat. The results were spectacular – the dwarf Mexican wheat varieties doubled the country's yield, from about 2 tons per acre to just over 4 tons per acre.

## On to India And The Start Of The Green Revolution

By the late 1950's, Borlaug's wheat was so successful that Mexico was self-sufficient in wheat production and had its own scientists to run agricultural projects. It was time for Borlaug to move on and he began negotiating a job with a tropical fruit company to investigate banana diseases. Meanwhile the Rockefeller Foundation found a new crisis to focus upon – impending famine in Asia.

In the early 1960's Asia was undergoing a population explosion and its farmers were not producing enough food to keep up. Experts began predicting mass starvation. Some were actually calling for the US to pull out of India and let millions of people starve in a social engineering attempt to reduce its population. Bestselling books came out, including the Paddock brothers' *Famine 1975!* America's *Decision: Who will Survive?* which predicted that the United State's food export programs could not keep up and policy makers would have to choose who would live and who

would die. The *Population Bomb* made its author, Paul Ehrlich, famous. He proclaimed that it was a "fantasy" that India would ever feed itself, and that "in the 1970s and 1980s, hundreds of millions of people will starve to death in spite of any crash programs embarked upon now."

It was into this crisis that the foundation called Borlaug and other scientists, and sent them on a fact-finding mission to the region. The misery, poverty and hunger the delegation saw there left

*"It would be helpful when you're working on these problems to develop a skin as thick as a rhino's hide, so you don't feel all the darts. Oh, there are lots of critics. If you don't do anything you'll never have critics."*

many of them shaken. But Norman Borlaug was not a defeatist; he attacked problems. In this case he came up with a scheme he called the Kick-Off Approach that would work on three sets of factors to overhaul the agricultural systems - technical, psychological, and economic. The technical work began immediately. The Rockefeller Foundation in 1963 created the International Maize and Wheat Improvement Center in Mexico, known by its Spanish acronym, CIMMYT. Trainees arrived in Mexico from Afghanistan, Cyprus, Saudi Arabia, Libya, Pakistan and other Middle Eastern countries, as well as from 10 other South American countries, to learn every aspect of agricultural development. Conspicuously absent was anyone from India, whose agricultural policy makers were suspicious of the whole endeavor. Simultaneously, Borlaug established nurseries in North Africa, the Middle East, South Asia, and throughout Latin America to find the best possible wheat varieties from the Mexican strains for these countries. Once the trainees learned all they could in Mexico, they returned to their native countries to manage the nurseries and oversee the dissemination of the best varieties.

Borlaug's second tactic evolved from his understanding of farmers' psychology. He knew that the massive famines in The Soviet Union in 1932 and China in 1958 had been partly the result of top down government policy. He believed that government policy was integral, but he also knew that all agricultural advances begin with the minds of individual farmers. "He started with the farmers, always the farmers," explains Richard Zeyen. In Pakistan, for instance, Borlaug planted native wheat in plots next to the new wheat. "Any fool could see the difference," says Zeyen. "Then he'd invite the farmers in and they would get very excited. But Borlaug would say about the new varieties, 'this is like gold. Don't touch it!' Of course, as soon as his back was turned they were taking the heads off the wheat and gathering the seed." In this way, Borlaug built demand for his new wheat from the ground up,

encouraging farmers to put grassroots pressure on bureaucrats to find ways to support them. "Farmers are very intelligent people," explains Zeyen. "They knew that if they could get more yield on the same land with these new varieties of plants, then they could have more money and a better family life."

Borlaug's third approach required governments to radically change their agricultural policies. Because his wheat required new methods of farming, farmers needed a system of credit so they could afford fertilizer and seed in advance of planting. The fertilizer was always a fight. Borlaug's wheat was bred to take up heavy applications of fertilizer and economists at the time did not realize that fertilizer was an investment that would be repaid with much higher yields. But Borlaug insisted that massive amounts of fertilizer had to be used. He also insisted that government money be available for drainage and irrigation improvements, as well as equipment to plant and harvest the wheat. In addition, farmers needed the government to create an infrastructure of roads, bridges, and warehouses to get the wheat from the farms to market. Finally governments had to guarantee farmers fair prices for their future crops in advance. An American showing up on their doorstep, telling them how to run their agricultural policies, met with great suspicion. But Borlaug knew if he just provided them with academic papers, nothing would change. He had to find a way to impress upon government officials that the miracle seed was only the first step to a fruitful agricultural policy.

This was especially difficult in India, which had become independent from Great Britain in 1947. In 1964, the country's first prime minister had died and the fragile democracy was teetering between the Cold War superpowers. There was a very real possibility it would tip towards the Soviet Union. To make matters worse, India's population was starving, thanks to a failed focus on heavy industry instead of agriculture. To show its support for India (and to unload its grain surplus), the US had started a massive Food

for Peace program in the early 1960s, shipping 5 million tons of emergency wheat grain in 1964 and 1965. Canada and Australia also sent wheat in what became the largest food rescue operation in history. But it was like trying to put out a forest fire with a bucket brigade.

As Zeyen recalls, “we were going broke trying to feed these people.” It was critical that India learn to feed itself. That meant moving the technological advancements identified in Mexico to the Asian country. There was just one problem - India didn’t want it. Not only were officials suspicious of non-native wheat, but also they worried that feeding the masses would upset the fragile social order and government by the elite.

Since India never sent trainees to Mexico in those early years, Borlaug and the Rockefeller Foundation began showing India how agriculture reform was progressing in Pakistan – India’s bitter rival. It was in Pakistan that the author of Borlaug’s 2006 biography, *The Man who Fed the World*, Leon Hesser, first met his subject 40 years ago. Hesser was working for the U.S. State Department and was charged with increasing food production in Pakistan, an impossible task until Borlaug showed up. “He simply came to my rescue because at that time my team and I didn’t have a lot to extend to the Pakistani farmers,” Hesser recalls. “What Borlaug did was a real miracle.” As Zeyen appraised the situation, “once a country like Pakistan took off and started heading into self-sufficiency, India had no choice but to participate, itself.”

But when India finally expressed interest, it wanted all the results without the necessary policy changes. Once again Borlaug was forced to use his wrestler’s tenacity. Borlaug had already impressed the Minister of Agriculture, Dr. Shri C. Subramaniam, with his program. Unfortunately Subramaniam had been voted out of government. As a man with deep concern for his countrymen, he arranged for Borlaug to meet the man in India’s government who had the power to change agricultural policy,

Deputy Prime Minister, Ashoka Mehta, the number two man in India’s government. Subramaniam told Borlaug to be frank and explicit about what would be required to change Indian farming. Borlaug prepared himself, but knew it was a long shot attempt, telling a colleague, “I am going to follow Minister Subramaniam’s suggestion and speak very bluntly to Minister Mehta about the government’s disastrous policy on fertilizer, credit and grain prices. The meeting will very likely be stormy and I may be asked to leave the country, so you better keep a low profile. Should that happen, you and Dr. Anderson can keep the wheat revolution moving forward.”

The meeting began quietly but escalated into a shouting match when Borlaug insisted that the government provide fertilizer. “For several minutes there was chaos with both of us talking in loud voices at the same time. A flood of loud angry words was emitted by both of us until we both ran out of breath and began to talk in rational tones once again,” Borlaug recalled.

Every argument the minister made for slow change, Borlaug attacked. He insisted that India import more fertilizer and build fertilizer plants. He provided a list of international agencies that could lend the money to finance doing so. None of these were acceptable to Mr. Mehta. But then Borlaug told Mehta of the farmers. If the new policies were adopted the farmers would dramatically increase production and this would stimulate the whole economy. Borlaug believed India could feed its people.

“As the meeting ended, I think we had re-established mutual respect, if not mutual friendship,” Borlaug related.

Two weeks later India’s newspapers were full of stories on India’s new agricultural policy. The government had capitulated - Borlaug had won – and the farmers could go to work. That year Pakistan and India placed an order for 600 tons of Mexican wheat seed. It took a convoy of 35 trucks to transport the seed from Mexico City to the port of Los Angeles,

where they were held up by the raging Watts riots. At the same time, the bank called: Pakistan's \$95,000 draft to pay for the seed had several misspellings and the bank wouldn't accept it. Borlaug, never a man comfortable with bureaucracy, finally lost his temper. "Get that wheat aboard the ship and send it on its damn way!" he yelled. The wheat was loaded and the ship sailed, but a few days later war broke out between India and Pakistan.

The seed made it to the subcontinent, and farmers, sometimes in the shadow of artillery and within the earshot of gunfire, sowed it in their fields. But it was planted late and much of it had been damaged back in Mexico when it was fumigated, so little of it germinated. Borlaug flew over to view the disaster. He had a thought: "Feed them," he commanded, "feed the seeds." The farmers tripled the fertilizer application and the crop responded. Despite its slow start, the first crop still produced yields 70 percent higher than India had been producing on its own. The next crop showed a 98 percent improvement.

Despite this relatively small start and even with the mountains of grain being shipped by Western countries, not enough was being done. "We'll not cure the damn trouble by filling food bowls," Borlaug warned the Indian agricultural minister. "If this is not to happen again, you will have to fill your fields with high-yield dwarf wheat along with new dwarf rice varieties being produced in the Philippines." India's government finally moved boldly. It ordered 18,000 tons of Mexican wheat seed, chartered two freighters, and had the largest seed purchase in history shipped directly from Mexico across the Pacific to India. The following year, Pakistan ordered 42,000 tons of seed. It was as if they were in a race to succeed. By 1968, Pakistan was self-sufficient in grain production; by 1974, India joined it. In the years that followed caloric intake per person steadily rose as wheat production rose. The percentage of undernourished people in



*Starving mother and child in 1943 Calcutta. Before the Green Revolution India had frequent famines.*

*Bettmann Standard RM  
Collection/ Bettmann/CORBIS.*

India declined from 39 percent to 22 percent. China watched its neighbor and changed its agricultural policies. Their proportion of undernourished dropped from 52 percent to 12 percent over the next three decades. Perhaps just as impressive was that the increased production came with no increase in the amount of land required to grow the crops. Yields increased in India by 150 percent and in China by 300 percent. India practiced double-cropping, a system in which two crops a season were planted – one

watered by the natural monsoon, the other by the artificial monsoon of irrigation, now possible thanks to the enormous irrigation facilities and dams the government had constructed. Without it, experts predicted, the country would have had to plow under another 100

million acres of land – an area about the size of California.

In 1968, United States Agency for International Development director, William Gaud stated, "The rapid spread of modern wheat and rice varieties throughout Asia and other developments in the field of agriculture contain the makings of a new revolution... I call it a Green Revolution, based on the application of science and technology." It was the first time the phrase was used, but it stuck because the effects were so monumental. Thomas

***At one time,  
Borlaug's wheat  
produced 23% of the  
world's calories.***

R. DeGregori, Professor of Economics at Houston University, says, “At the core of the Green Revolution was a grain revolution, with Borlaug’s wheat providing roughly 23 percent of the world’s calories.” Borlaug was not alone in making these dramatic agricultural advances, but it was his extensive plant breeding in Mexico that demonstrated the possibilities and his iron-willed drive to make government officials take action that was the catalyst for much of the Green Revolution.

## It is Nutrition that Saves Lives

Although in the 1960s the so-called experts were predicting mass starvation by the middle of the 1970s, more realistic assessments of food supply

*Studies from Civil War soldiers showed that the taller a soldier was, the longer he lived. Childhood nutrition has a marked affect on height.*

and population projections from the time show that such dire circumstances were unlikely to occur even without the Green Revolution’s increase in productivity. Scholars such as Amartya Sen, a

Nobel Prize winner in economics, have shown that famine due to lack of food was mostly eliminated in the twentieth century. Modern civilization had both the will and the capability to transport mass quantities of food anywhere in the world to avert mass starvation. The real cause of modern famines was distribution failure caused by war, unreliable government policies, or economic problems. While Borlaug’s revolution may not have saved the tiny children with bloated stomachs that form the image that most often comes to mind when famines occur, he did save million upon millions of lives. The true death toll from food shortages is the result of undernourishment.

From the late 1800’s it was known that nutrition is important in warding off specific diseases such as scurvy. But two decades ago Nobel laureate Robert William Fogel, among others, discovered that nutrition also had a dramatic effect on the length of a person’s life. In other words, your mother telling you to eat your veggies as a child actually has an effect on how long you live. His studies showed that 20 percent of the population in pre-industrial Europe didn’t consume enough calories to even do a full day’s work. After all, it takes energy to work and food is the fuel for the human body. However, fuel was only the most obvious benefit of food. Fogel also discussed studies by researchers who found an interesting correlation between the heights of Union Army veterans of the Civil War and their deaths. Records were kept of these men when they joined the Army and throughout their lives as they received veterans’ benefits. It was found that the taller the soldier was, the longer he lived. When researchers examined other populations, similar findings corroborated this relationship. Although height is partly determined by genetics, there is a component that is influenced by environment, especially childhood nutrition. In fact, it has been found that average height has increased dramatically in populations around the globe whenever nutrition has improved. For example, the average Frenchman in 1775 was five feet, four inches tall and is now five feet, ten inches tall. Additional height is an indicator of more robust organs that

*In the Northern Hemisphere people who are born in the months of October, November, and December live a half-year longer on average than those born in other months. This is thought to be because their mothers have better nutrition in the summer due to fresh produce.*

better stave off disease.

Other researchers have found equally interesting correlations. Gabriele Doblhammer and James W. Vaupel discovered that people who are born in the months of October, November, and December live a half-year longer on average than those born in other months. When this study was repeated in the Southern Hemisphere the same was true, but for months that were six months out of phase. By ruling out other possible causes, the researchers determined that the difference was linked to the seasonal availability of fruits and vegetables to mothers when they were pregnant. So it isn't only what you eat; it's also what your mother eats that influences how long you will live.

Recently, new experiments in epigenetics, a revolutionary field involving DNA inheritance, have shown that poor nutrition can affect one's chromosomes such that effects can even be passed on to future generations. Epigenetics involves the study not of the makeup of the DNA molecule itself, but of the chemicals and structures that affect how the genes coded by DNA are expressed. These structures can be affected in a long-term way by environmental influences such as diet. The offspring of some mice can be made healthier and longer-lived simply by changing their parents' diet. In nematodes, the effects of an individual's environment can remain in their descendant's genetic code for many generations. If the same is true in humans, what your grandparents ate might be influencing your current health.

These are examples of how nutrition affects an adult's lifespan. The effects of malnutrition on children

*A child that has mild malnutrition has twice the chance of dying from childhood diseases than a child who is well nourished. One with severe malnutrition has an eight-fold chance of dying.*

are even more severe. Estimates today are that half of all children who die in the developing world do so because of malnutrition. Measuring growth retardation, or stunting, is one way scientists assess the health of children. Stunting is a direct consequence of poor nutrition and is strongly correlated with increased mortality. In 1980, just after the start of the Green Revolution, 47 percent of all children in the developing world were stunted. By the year 2000, it

had dropped to 33 percent. A child who is only mildly malnourished has twice the chance of dying from childhood diseases as a child who is well nourished; one with severe malnutrition has an eight-fold chance of dying. Children's small, developing bodies are simply not robust enough to fight off common childhood infections.

*In 1980, just after the start of the Green Revolution, 47% of all children in the developing world had stunted growth. In 2000 the percent had declined to 33%.*

The Green Revolution laid the cornerstone for adequate nourishment by increasing the available calories and protein of the developing world's people. Since what people eat, what their mothers ate, and possibly even what their grandparents ate all affect how long people live - and whether children even live to grow up - the impact of Norman Borlaug's Green Revolution on saving people's lives has been profound. Our estimates are that Norman Borlaug's Green Revolution resulted in over 245 million lives being saved due to improved nutrition. The most significant measurable change



Henri Bureau/Sygma/Corbis Collection/CORBIS.

*Starving Danakil child in Ethiopia in 1974.*

*When Richard Nixon visited China in 1972 on his critical détente mission Norman Borlaug accompanied him, underlying the promise the green revolution offered.*

was the decline in the death rate of children under the age of five. In addition, the increased nutrition has allowed countless millions of adults to live gracefully into old age.

work had “helped to turn pessimism into optimism in the dramatic race between population explosion and food production.”

For Borlaug, however, the prize was a complete surprise. “You have to understand that Norman Borlaug has no ego,” Zeyen says. “He’s the world’s greatest humanist. He cannot stand to see people suffer.” Borlaug took his entire family with him for the ceremonies in Oslo, Norway (where the Peace prize is awarded; the other Nobel Prizes are awarded in Sweden), and gave a powerful Nobel lecture in which he warned that the continuing race to feed the world’s population was anything but over. “Almost certainly,” he said, “the first essential component of social justice is adequate food for all mankind. Food is the moral right of all who are born into this world. Yet today 50 percent of the world’s population goes hungry. Without food, man can live at most but a few weeks; without it, all other components of social justice are meaningless . . . If you desire peace, cultivate justice, but at the same time cultivate the fields to produce more bread, otherwise there will be no peace.”

He also insisted the Green Revolution was not complete. “Perhaps the term Green Revolution as commonly used, is premature, too optimistic, or too broad in scope,” he said. “The reality is that only some crops have been modified; only some farmers benefited. And most of the benefits have come in irrigated areas.”

## The Nobel Prize

It was October 20, 1970 and Norman Borlaug was doing what he had done at this time of year for the past 26 years – standing in a Mexican wheat plot dressed in mud-splattered clothes, boots and a baseball cap choosing exceptional wheat varieties. Around 10 a.m., he heard the sound of a car bumping along the rutted road at the edge of the Toluca station. When it stopped and he saw his wife emerge, he became frightened, certain something must have happened to one of their two children. He could never have imagined the news she’d come to tell him.

“What’s wrong?” he cried, dropping his wheat samples and running towards her.

“Nothing,” she laughed. “You’ve won the Nobel Peace Prize, that’s all.”

At first, he refused to believe it. Borlaug insisted Margaret return to their house; he still had a day’s work to accomplish. As it turned out, he had about 40 more minutes of toil before the press descended upon him.

What, you might ask, do wheat and bread have to do with peace? Perhaps expecting that question, the Nobel Committee answered it when it awarded Borlaug the 1970 Peace prize. The committee compared Borlaug’s work “to the basic human right of freedom from starvation as recognized by the Charter of the United Nations,” and declared that his

## An Environmentalist

As Borlaug continued his efforts to expand agricultural success, he found himself fighting off critics who began denouncing his methods, particularly the large quantities of fertilizers and pesticides required to achieve the high yields. Surplus fertilizer can run off the fields into streams and rivers, creating algal blooms that remove oxygen from water. An example is the Dead Zone, an area that lacks most life that begins at the mouth of the

*To produce 1999's cereal crop using pre-green revolution methods would have required an additional 3 million square miles to be farmed – about the size of the contiguous United States.*

Mississippi River and extends far out into the Gulf of Mexico.

As Borlaug told his biographer, Leon Hesser: “I was at once drawn into the vortex. As soon as you start to challenge an emotive issue you get attacked

by feverish, committed people. I was subjected to insult, mudslinging, trashy verbal assault. I knew all that would come. But what could I do but accept the responsibility?”

As a man of action in the midst of crises, Borlaug has said, “Some of the environmental lobbyists of the Western nations are the salt of the earth, but many of them are elitists. They’ve never experienced the physical sensation of hunger. They do their lobbying from comfortable office suites in Washington or Brussels. They have never produced a ton of food. If they lived just one month amid the misery of the developing world, as I have for 60 years, they’d be crying out for fertilizer, herbicides, irrigation canals and tractors and be outraged that fashionable elitists back home were trying to deny them these things.”

Recall that Borlaug worked alone in the wilderness in Idaho during his college summers. “To this day,” Borlaug has said, “I enjoy nature, the luxury of undisturbed wilderness, forests, mountains, lakes, rivers and deserts and their wildlife. But I also know that the greatest danger to their perpetuity is the pressure of human population.” In a paper he wrote in 2000 he said, “We all owe a debt of gratitude to the environmental movement that has taken place over the past 40 years. This movement has led to legislation to improve air and water quality, protect wildlife, control the disposal of toxic

wastes, protect the soils, and reduce the loss of biodiversity. It is ironic, therefore, that the platform of the antibiotechnology extremists, if it were to be adopted, would have grievous consequences for both the environment and humanity. I often ask the critics of modern agricultural technology: What would the world have been like without the technological advances that have occurred? For those who profess a concern for protecting the environment, consider the positive impact resulting from the application of science-based technology.”

Borlaug points out that in order to produce 1999’s world cereal crop using 1961 agricultural methods, an additional 2 billion acres would have to be under cultivation - that’s 3 million square miles – about the size of the contiguous United States. Instead this land can be used for other purposes, such as wilderness preserves. As Vaclav Smil, of the University of Manitoba says, “Without the 80 million tons of nitrogen consumed annually (from chemical fertilizer), the world could sustain no more than four billion people, two billion fewer than inhabit the Earth today.”

This type of evidence suggests that Borlaug’s Green Revolution may have saved more land for wilderness than any single environmental organization.

## Workaholism Redefined

The Peace Prize slowed Borlaug not one whit. He continued to be an agricultural ambassador up into his seventies, with his methods becoming widely acclaimed, especially outside of the U.S. But by the early 1980’s he was semi-retired. It was then that a notorious Japanese shipbuilding magnate was struck by images of starvation in sub-Saharan Africa. Ryoichi Sasakawa, chairman of the Japan Shipbuilding Industry Foundation, had had about as broad a career as one can imagine. His past included an association with the Japanese war machine and questionable business practices, along with

international industrial success and being a friend of Jimmy Carter, the first U.S. President to visit sub-Saharan Africa while in office. In the 1980's Sasakawa began donating millions to the United Nations to help fight hunger in Africa. But as the years passed he felt that not only was his money not enough, but that it might be going for weapons, not food. So in 1985, he had his assistant call Borlaug and ask, "Why has there been no Green Revolution in sub-Saharan Africa?" The assistant asked Borlaug to bring his revolution to the last starving continent.

For more than three decades Norman Borlaug had expended a huge amount of his time away from his wife and kids, traveling all over the world. For decades he had physically labored hours on end in

the fields, putting wear on his body matching any laborer. If anyone had earned the reward of retiring, giving an occasional lecture and bathing in the warm social status of sitting on some policy boards, it was Norman Borlaug. He knew little about Africa.

*"You have to understand that Norman Borlaug has no ego. He's the world's greatest humanist. He cannot stand to see people suffer."*

*- Richard Zeyen,  
Professor at University  
of Minnesota*

Caught off guard he told the assistant, "I'm too old to start learning now." The next day Borlaug received a phone call from Sasakawa, himself. The billionaire told him, "I am 13 years older than you are, Dr. Borlaug. We should have started sooner and didn't, so let's start tomorrow!"

Borlaug had never been one to turn away from a challenge to help people. And so, at age 72, he was called back into the battle to combat hunger. He organized a meeting of experts in Geneva, Switzerland to evaluate the issue. Three conclusions emerged. First, the food crisis in Africa was the direct result of the political anarchy that had ruled much

of the continent for decades. Second, as Borlaug asserted, "Lack of infrastructure is killing Africa." He explained that the United States had 13,000 miles of paved road for every million people, while Ethiopia had 41 miles for each million people. How could there exist efficient markets with no way to transport the food? "How can the world justify expending \$900 billion on military operations and armaments and only a pittance on roads and schools?" Borlaug asked. And finally, because wheat could only be grown in some parts of Africa, Africa would require additional food crops bred for better yields.

Jimmy Carter, along with the new head of his newly formed Carter Foundation, Bill Foege, attended that Geneva Conference. There, Sasakawa turned his persuasive powers on the former president, and in late 1985, Global 2000 Inc., was created to address the starving continent. Carter and Sasakawa were co-chairmen, and Borlaug headed the agricultural initiative. Africa became Borlaug's new India.

The organization selected Ghana as its first country of focus in 1987, instituting the classic Borlaug-inspired agricultural initiatives. By 1991, Ghana was producing all its own food, and a few years later actually began exporting food to other countries. One secret to the country's success was a new form of corn: Quality Protein Maize (QPM), a grain that is so nutritionally complete it could be used to wean infants off of breast milk. Obviously, the Ghana experiment has not been reproduced throughout Africa. The main challenges remain lack of infrastructure and warring governments, which turn millions of citizens into refugees and make agricultural production impossible.

## Borlaug Today

As he has aged Borlaug has remained on the world stage, preaching against complacency. As he'd warned in his Nobel speech: "The Green Revolution has won a temporary success in man's war against hunger and deprivation; it has given man a breathing

space. If fully implemented, the revolution can provide sufficient food for sustenance during the next three decades. But the frightening power of human reproduction must be curbed; otherwise the success of the Green Revolution will be ephemeral only.”

Consider: When Borlaug was born, the world’s population stood at about 1.7 billion. When he won the Nobel Prize, it was at 3.7 billion. Today, it stands at 6.5 billion, with an average growth rate of 1.1 percent per year. The population bomb of which he had long been aware exploded during his lifetime. Borlaug asserts, “I am confident that the Earth can provide food for as many as ten billion people – six times the number who lived when I was born – if, and this is a big if, the world’s societies support a steady stream of both conventional and biotechnology research and political policymakers stay attuned to the needs of rural development.”

Norman Borlaug, 94 years old when this chapter was written, continues to try. He’s been working more than 85 years to grow food, first as a farm boy, next as an agricultural scientist, then as a world agricultural diplomat, and finally starting his third career when he was 72 years old, in Africa. Despite his age, the man seems never to rest. “He’s driven,”

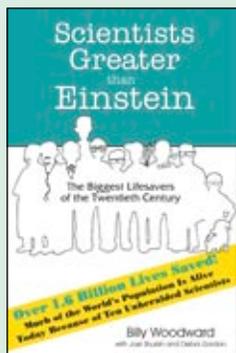
says Hesser. “He obviously doesn’t need the money; he spends hardly anything at all. But it’s just that he wants to accomplish something significant while he’s still here.”

## Lives Saved: Over 245 Million

**Discovery:** Green Revolution

**Norman Borlaug:**

Developed new strains of short-stature, disease resistant wheat and trained scientists, farmers and governments in developing countries all over the world on how to grow the wheat using an integrated technological approach, including continuous breeding programs, fertilizers, pest and weed control, irrigation, and the implementation of profarmer government policies. Enabled countries like Mexico, Pakistan, and India to greatly improve nutrition for their populations and to become self-sufficient in their food production. His revolution then spread to China and much of the rest of the world.



*Scientists Greater than Einstein: The Biggest Lifesavers of the Twentieth Century* began when the author, Billy Woodward, asked the question - Who has saved the most lives in history? His research concluded that scientists have. Realizing that many of the scientists are little known by the general public, the book’s title begs the question of how the popularity of a scientist should be determined. Woodward believes it should be determined on a scientific basis of their accomplishments - which means by measurable evidence. He believes that saving a life is one of the most important accomplishments possible, and that by measuring the number of lives that have been saved, the importance of a scientist to humanity can be determined. Published by Quill Driver Books ©2009

ScienceHeroes.com

The author, Billy Woodward, is also the creator of the website, <http://scienceheroes.com/>. ScienceHeroes.com is an educational website that tabulates the number of lives scientists have saved. The website encourages students to read 1000 science stories and has biographical pages of more than 100 lifesaving scientists, all with real time counters counting the number of lives they have saved.

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