Like their predecessors, these scientists work to expand the range of the potato into new environments such as the tropics, to find ways of growing potatoes from seed rather than from the root, and to develop ways to preserve its nutrition longer. They hope that one day the potato might feed the peoples of Brazil, Botswana, or Bangladesh as it already feeds the peoples of Germany, Ireland, and Russia.



# 5

# INDIAN AGRICULTURAL TECHNOLOGY

The seaplane dropped out of the clouds to pass over a small cluster of houses on a high bank of the Ucayali River an hour's flight upstream from where the Ucayali joins the Amazon. All the way to the horizon on every side we could see nothing but the endless stretch of high jungle. We circled the village once as the pilot tried to make sure that this actually was the community of Genaro Herrera. His government map indicated that the closest village should be San Filipe and that Genaro Herrera lay farther upstream, and even though this air force captain had fifteen years of experience flying the Amazon and tributaries, he had never been to this particular community. Convinced that even his military maps were inaccurate, the pilot gently set the plane down in the middle of the river as a swarm of villagers rushed to the banks to watch us. This was the first visit by a seaplane in many years, and most of the children had never seen one. After nudging aside a cluster of dugout canoes and hastily devising a makeshift dock, we climbed up the muddy bank to be officially welcomed by the apparently bewildered mayor, who stood barefooted in the mud surrounded by excited children and boys clutching machetes. We had landed in Genaro Herrera, the right village.

Genaro Herrera is a small jungle village like thousands of others scattered up and down the rivers of the Amazon Basin. About a

hundred thatch houses on stilts cluster around a large open field rather euphemistically called *la plaza*, and to the side of it leans a church loosely made of sticks and mud, now empty except for a large statue of the Virgin Mary. The houses are little more than platforms built on sticks and with a roof overhead. The main furniture consists of hammocks hanging pellmell from the roof beams of each house. Each yard contains a large fireplace around which the women toast their daily staple of the slightly sour-tasting cassava flour. Some enterprising families have converted their front rooms into stores where they sell a few cans of imported food and milk in addition to large quantities of noodles, rice, and flour.

What makes Genaro Herrera different from other villages is that a few kilometers back in the jungle from the village, the Peruvian government operates a small research center. Here the government has cleared small patches of land through slash-and-burn agriculture and set up *chacras*, traditional Indian farming plots. Following the techniques taught them by the local Indians, college-trained agronomists, botanists, and foresters scientifically study the natives' collection of crops and plant lore, their agricultural techniques, and even their building and storage methods.

Poking up from the cleared spaces in the jungle, different varieties of cassava strain to reach the sunlight. This tall and lanky bush that resembles an oversized marijuana plant has a calorie-packed root from which the Indians make flour. Called *yucca* in Spanish even though it bears no resemblance to the ornamental yucca plant known to North Americans, cassava originated in this area of the Amazon, and from here Spanish and Portuguese traders spread it throughout the tropical zones of the earth. Some people call it "manioc" or "mandioca," but English speakers most frequently call it "tapioca" and use it to make puddings and baby foods.

The Indians dig up the cassava root, which they peel and put in water for a few days to ferment. The fermented chunks next go into a sack, which is wedged between boards for several days to press out the water. The partially dried pieces now look something like white gravel. The Indians toast them very slowly over a large fire in pans five feet long. The crunchy flour or farina that results from this process resembles granola, and in this toasted





form can be preserved for a long time even in a climate as disposed toward rot and decay as the Amazon's.

Near the fields of cassava plants grow experimental orchards of the trees cultivated by the natives. As parrots dashed overhead from one tree branch to another and noisily watched us, we wandered among the native orchards. One of the trees under cultivation produced fruits the size of large cherries and exceptionally bitter in taste, but it packed in its small fruit several times the amount of vitamin C in an orange. Intermixed with these and other exotic fruits grow several varieties of wild cacao or chocolate trees. The chocolate beans grow inside a large golden-green pod surrounded by a fleshy sweet fruit, which is eaten by the natives with more gusto than the bean.

Swarms of gigantic winged termites dash through the humid air searching for new places to nest. They creep into our ears and noses as well as between the seams of our moist clothes. When we brush them aside or try to extract them, their wings easily fall off and they stay where they are until they decide to look further for a building site. Then they lamely crawl out of hiding to wait a gush of air that will blow their wingless bodies to the ground.

To overcome problems with termites and other insects the Indians have learned to use special forest products, which the scientists now struggle to understand and to reproduce. Some trees produce wood that repels termites and other insects. In some of the jungle *chacras* the botanists now grow special varieties of local trees selected by the Indians as especially desirable for various building purposes. One tree produces wood that effectively repels most insects, another tree makes particularly strong planks, and yet another has durable yet pliable leaves good for thatching. One tree attracts a particular vine that can be moistened and then used to tie together joints. After drying, the vines form a fastener that is stronger than nails and will hold for twenty years, long after nails would have rusted in this humid climate. Still other trees have highly unusual qualities; one produces large quantities of flammable sap very similar to turpentine, and one supposedly produces a sap capable of substituting for diesel fuel in a gas tank.

These unusual plants thrive in their native habitat, but scientists have yet to unlock their many secrets and understand their characteristics or what applications they may have in other contexts. In marked contrast to these plants, some of the nearby fields grow malformed and dying exotic trees such as pine and eucalyptus imported by the Swiss in an unsuccessful effort to grow foreign trees commercially in the Amazon.

Now rather than allowing foreigners to experiment with the Indians by teaching them to raise foreign trees, the government seeks the aid of the Indians to teach researchers how to grow a wide variety of yams, potatoes, and tubers for which there exist no names in either English or Spanish. Like the wood under cultivation, some of the tubers also have unusual properties, such as the ability to make their own bug repellents or to thrive under conditions too wet, hot, or sunny for most plants.

The Indians around Genaro Herrera now teach the scientists how to cultivate and then how to utilize these plants. Traditional agricultural knowledge often lacks an understanding of these plants. For five hundred years, Indian farmers have been teaching others how to grow and process new plants. The American crops required new ways of farming that appeared bizarre to Old World farmers and violated all past agricultural principles of good farming. The scientists working at Genaro Herrera strive to unravel the complex technology of native agriculture and food processing as much as they strive to understand more about the biology of the plants themselves.

The traditional agricultural system of North and Central America centered on the small field called a *milpa*, which was not cultivated by plowing or planting in neat rows. The Indian farmer made a field of small mounds on which to plant the corn. In contrast to plowed rows, the small mound loses less soil to rain runoff and thus helps to stabilize the soil. White farmers in America adopted the practice, known as hilling, and followed it consistently from early colonial times until the 1930s [Sauer, p. 6]. Since the United States abandoned hilling in favor of dense planting, erosion has increased remarkably and thousands of tons of the best soil annually floats away down the Mississippi River system. Future generations may have to return to traditional hilling to preserve their farmlands.





One easily sees these principles in action in many Maya farm plots in the Yucatan today. The farm does not resemble what we might consider a farm but looks like an abandoned area after a forest fire. The field flows like an ink blot across the land. The partially burned trunks of trees and stumps are conspicuous amid the charred earth, and corn, squash, and various bean varieties all seem to be growing at random. Only after talking with the farmers does one see the intricate plan operating here. The broad leaves of the hardy corn plant shade the delicate bean plants from the harsh sun, and the strong corn stalk provides a living stake on which the bean and squash vines grow. The squash vines meander across the ground between the corn and bean plants, providing good cover for the earth and thereby ensuring maximum capture of rain and minimal erosion of the land from wind or water. At the same time the broad leaves and long vines of the squash plant so effectively cover the ground that they prevent unwanted plants from growing. This reduces the need for weeding while ensuring a better harvest. In turn, the beans fix nitrogen in the soil to help the corn and squash grow.

Recent scientific investigation has revealed that the combination of corn, squash, and beans also reduces herbivory, or the destruction of the plants by insects and other pests. The cultivated plants attract predatory insects that prey upon the pests. This limits corn loss without the use of chemical insecticides. Plants that at first appear to be weeds growing around the edges of the garden also attract pests away from the crop plants. Recent studies in modern Mexico have shown that this traditional polyculture increases corn yields by as much as 50 percent over monoculture [Gliessman et al.; Chacon and Gliessman.]

When the first settlers arrived in the United States and encountered this type of *milpa* agriculture, they had to learn farming anew. The European method of regimented lines of a single crop produced in neatly plowed rows proved impractical for either the Indian crops or for the Old World crops transplanted to America. The eastern coast of North America supported one massive, primeval forest filled with deciduous trees that were difficult to fell, and even after cutting they left very large stumps with extensive root systems that defied even a steel plow.

For centuries, however, the Indians farmed the forest through a simple, yet appropriate, technology. To clear a field, the Indian farmer killed the trees by a process of girdling or barking which cut off a crucial part of the tree without extensive chopping and sawing. Within a few months the field was reduced to the hulk of dead tree trunks, which, denuded of their foliage, allowed the sun to penetrate that part of the forest. The Indians then farmed the area for a few years before allowing it to return to forest and restore the nutrients to the land.

The settler farmers adopted the same system, with the exception that they did not allow the land to return to the forest. In due time the trees could be used for firewood, they fell of their own weight, and the root and stump system rotted. Thus after a few generations, the deciduous forest slowly retreated before the advance of *milpas* that eventually became fields suitable for plowing [Sauer, p. 7]. American pioneers opened the country through this adaptation of the Indian *milpa* and tree girdling more than through the ax and plow. Not until the pioneers reached the open prairies of North America and Argentina, where the plow was unencumbered by trees and roots, did it fully come into its own.

Another major innovation that the European settlers adopted from the Indians at first appears to be too minor to mention—the change from sowing seed to planting it. Most of the traditional Old World grains had very small seeds that the farmer broadcast by the handful onto the prepared ground. American Indians knew that corn could be planted only by placing the kernels firmly in the ground. The Indians selected each seed to be planted rather than merely grabbing a random handful of seeds from a bag and throwing them. This process of selecting the seeds allowed the Indians to develop the hundreds of varieties of each plant that they cultivated. Whereas the Old World grains came in only a few forms, the Indians had many forms of dent corn, sweet corn, popcorn, flint corn, and dozens of others. They ranged in color from yellow and red to blue and purple. Some ripened in as little as sixty days and others took several months. Some grew in very wet areas such as Florida and others in the deserts of the southwestern United States. Corn grew in the Andes as well as on the coastal plains, and it grew from Canada to far into South America.





Similarly the Indians grew many varieties of beans and of squashes and other gourds such as chayotes.

This diversity developed through the Indian farmers' profound understanding of practical genetics. To make the corn grow the farmers had to fertilize each plant by putting corn pollen on its silk. They knew that by taking the pollen from one variety of corn and fertilizing the silk of another variety, they created corn with the combined characteristics of the two parent stalks. Today, this process is known as hybridization and scientists understand the genetic reasons behind this process; the Indian farmers developed it through generations of trial and error.

In the case of some plants, it is difficult to determine whether the Indians actually cultivated them or simply gathered them wild. At one end of the spectrum, plants such as corn were definitely cultigens. In order to protect the kernels from pests and weather, the early Indian farmers bred corn to have a husk around it. This husk protected it but prevented it from reproducing without the assistance of a human who could remove the husk. Consequently, corn never grows wild; it can survive only under human care.

Though the cultigen end of the spectrum is obvious, the other end is not so clear. This difficulty in determining which plants are cultivated and which are wild came clearly into focus for me in the case of the prickly pear cactus, which includes several species of *Opuntia*. The fruit of this cactus, called a pear in English or *tuna* by many Indian groups and Spanish speakers, varies from green to yellow and red. Beneath a thick rind the pulp of the fruit is both very sweet and moist, making it a prized treat in the desert. Even today in many of the tropical parts of America with its large variety of fruits, the *tuna* frequently brings the highest price of all the fruit in the market. In addition to using it as fruit, Indian cooks remove the thorns from the fresh young pads of the cactus, called *nopales*, and cook them in a variety of dishes.

Without stopping to consider it, I assumed for many years that the prickly pear, like all cacti, simply grew wild. It puzzled me, however, that the cactus often bordered the yards of Indian homes in a fence of cacti thirty or forty feet out from the house. I had seen this pattern in the southwestern United States, parts of

Mexico and Central America, and right on down through the high deserts of the Andes deep into South America. The pattern held everywhere, but the residents always denied having built their homes deliberately in the middle of a large cactus grove or having planted the cactus into a deliberate hedge as Indians often do with plants such as ocotillo. The mystery cleared up only with lengthy stays in Indian communities. The fruit contains hundreds of very small hard seeds that prove too difficult to remove while eating the flesh and too hard to crack with the teeth. Indians chew the fruit lightly, in effect only mashing it with their teeth rather than masticating it, and then they swallow it. The hard shell of the uncracked seed passes through the human digestive tract and emerges whole and healthy when the person defecates away from the house. The seeds not only emerge in good condition but are surrounded by an immediate source of fertilizer for the new plant. Because people often defecate at a short but consistent distance from their homes, the cacti soon surrounded the home in the form of a perimeter fence.

Even though this does not qualify as cultivation in the usual sense, the cactus certainly does not grow wildly at random. The residents eradicate the cacti that spring up in the middle of the corn patch, too close to the house, or in other inconvenient spots. They confine the plant to long, thin patches that the Indians can easily harvest. In this form they also serve as protection against wind and predators.

Many other plants that at first may appear to us to have been merely wild plants that the Indians exploited often turn out under closer examination to have received some degree of assistance from them. Indians cleared competing plants aside, pruned branches, and sometimes even planted many of these supposedly wild plants. A copse of various fruit and nut trees interspersed with berry bushes may have been viewed as a godsend by many earlier European explorers or pioneers when in fact Indians had carefully tended the plants for generations with as much tender care as an English gardener. Unlike English garden plants, however, the plants grew in what appeared to be a natural arrangement and had not been planted, tied, bent, and pruned into rigid military formations.

**********





As ingenious as the American *milpa* system is, it was not the only farming system developed by the Indians nor even the first one encountered by Columbus and his crew. In South America and throughout most of the Caribbean islands the Indians developed a completely different system of agriculture, called the *conuco* in the Arawakian languages. Unlike the *milpa* and all the Old World systems of agriculture, the *conuco* used no seeds. Instead these farmers had spent millennia perfecting the growing of crops from cuttings and from root sprouts. The plants grown here include cassava, many varieties of sweet potatoes (*Ipomoea batatas*), peach palms or pejibae (*Bactris utilis*), yams (*Dioscorea trifida*), and pineapples (*Ananas comosus*). The *conucos* also contained plants that have not been much used by outsiders, such as the racacha, *Arracacia xanthorrhiza*, which resembles a parsnip; aroids, *Xanthosoma yautia* and *X. malanga*; and arrowroots, such as *Maranta arundinacea* and *Calathea allouia*.

This form of cultivation thrives better in the tropics, where new plantings can be made throughout the year and harvested steadily. By contrast, the Eurasian winter confined planting and harvesting to specific seasons. The Indian farmers had practiced this type of agriculture for so long that in many cases the seeds had virtually disappeared or become vestigial. For the most part these plants of the *conuco* have remained tropical and spread around the world only in the warmer areas without acquiring a market in the temperate zones.

The *conuco* methods have proved quite valuable and have some novel applications, as was recently shown to me on a visit to the farm of Elias Sánchez outside of Tegucigalpa, Honduras. Like many Third World farmers, Señor Sánchez liked the hybrid tomatoes developed in recent years in the United States. Unfortunately, the developers of the hybrids charge high prices for the seeds. Because the plant is a hybrid, each generation of the plant requires the purchase of a new set of seeds. The farmers can produce the tomatoes but they cannot produce the seeds. Mr. Sánchez, however, applied the traditional *conuco* methods to reproduce hybrid tomatoes from cuttings of tomato plants, and at the time of my visit at the end of 1986, he had cloned the original tomatoes for thirteen generations with no degeneration of the plants. The potential for this technologically simple way

of cloning mostly seems appropriate to the poorer countries, where labor is more plentiful than capital, but it probably has a variety of still-undiscovered advantages for temperate-climate agriculture as well.

The Indian farmers who developed these complex ways of reproducing plants through cuttings and through careful seed selection rather than broadcasting could control the variation in their plants and thus manipulate the genetic composition of them. Without question the Indians were the world's greatest plant breeders, and their knowledge rested largely on the techniques they used for planting seeds or cuttings rather than broadcasting the seeds. From this firm and practical base of plant manipulation the modern sciences of genetics and plant breeding have developed. Without the treasure of diversity created by the trial-and-error methods of early Indian farmers, modern science would have lacked the resources with which to start. The limited agricultural background of the Old World would have been far too meager and would have required centuries more of research before science reached its present level.

Together with the genetic development of so many different kinds of plants, the Indian farmers acquired a thorough knowledge of agronomy and ways to manage the soil. Peruvian farmers restored the vitality of the land through fertilizers. None of the fertilizers proved more effective than guano, the droppings of seabirds that littered the coasts of Peru. The Incas protected guano as a prized natural resource. In order to build up the guano deposits, Inca law specified death as the punishment for anyone who killed one of the seabirds or who approached their nesting areas during the laying season. The Incas divided the guano areas into districts clearly marked with boundary stones. A group of farmers was assigned to each of the guano areas. They could enter only the area assigned to them, and no one else was permitted into their area. Each farmer was allowed only as much guano as he needed for his own fields [Vega, pp. 158–59].

Through careful management, the guano fields became virtual mountains of white fertilizer. The Spaniards, however, lacked the historical and environmental perspective of the Incas and permitted haphazard exploitation and destruction of the deposits. In the early eighteenth century the Europeans finally discovered the





value of the guano for their own agriculture when some cunning businessmen under Francisco Quiroz thought to ship a load of it to England for a trial sale. The nitrogenous fertilizer seemed a miraculous cure for the depleted British lands, and it caused a quick escalation in crop yields for British farmers.

Estimates at the time gave the guano a depth of approximately one hundred feet. Between 1840 and 1880, Peru exported to Europe eleven million tons of guano valued at $600 million [Werlich, p. 79]. This bonanza for the Peruvian government gave it the highest rate of exports of any South American country in the nineteenth century and inaugurated an era of prosperity and enlightenment known as the Age of Guano. In this way modern Peruvians arose from the treasured patrimony left them by their Inca predecessors.

The guano stimulated as much excitement among North American farmers as among the Europeans, but Yankee farmers resented the high prices charged by the Peruvian monopoly. Tensions between the United States and Peru reached such a strained point that the two nations severed relations in 1860, and the United States threatened to seize two of the guano islands. Had civil war not broken out in the United States and distracted both the farmers and Washington, there might easily have been a guano war between the United States and Peru [Werlich, p. 90].

Guano entered Peruvian history as the most valuable cash resource that the nation had found since the Spanish had looted its gold and silver and since they had lost Potosí to the newly formed Bolivian Republic. The "discovery" of guano by European agriculture in the nineteenth century initiated modern farming in Europe. The nitrogen-rich substance not only stimulated crop yields but increased research interest in fertilizers as well. The guano age marked the beginning of modern agriculture and eventually led to artificial fertilizers made from other resources.

The Indians understood the workings of other fertilizers as well as guano. They harvested the numerous anchovies off the Peruvian coast, and after eating the flesh, the Indians buried the heads in the ground when they planted their crops. In the twentieth century, this Indian technique has been expanded to a massive scale; the dried anchovies sold as fish meal for fertilizers and for animal fodder constitute a major Peruvian export today.

Indians not only gave the world a whole new set of crops and taught the world how to grow them, but also developed the technology for processing the plants into food. In the case of corn it was drying as a way to preserve it and then grinding it into flour. Drying and grinding formed the basic technologies of food processing throughout the Americas from the freeze-dried potatoes and the jerky meat of the Andes to the peppers and corn of North America, but, as I discovered in the Amazon jungle, this seemingly simple process often needed great elaboration for some products.

Three companions and I had an afternoon in a motorized canoe on the Mamore River near the Brazil–Bolivia border. We had gone four hours without passing a single hut since our last stop, where an Indian woman had fried us a batch of *pacu* fish. In the heat we had become steadily more thirsty and eventually quite hungry. Even though it was not raining that day, it was in the middle of the rainy season and the river rushed along at twice its normal size and was full of floating bushes, trees, and dead animals that together with the sediment in the water made it much too unhealthy to drink.

At long last our guide turned the canoe into a small creek and took us past an inland lake to a high embankment at the top of which was a small Indian village. Because most of the inhabitants were resting from the heat in the shade behind their huts, they did not come out to meet us. Contrary to what most outsiders think of as "the law of the jungle," we knew that that law permitted us to help ourselves to eat any fruit on or under the trees, but forbade us to carry any away without first paying for it or to bother any part of the harvest that was being processed in some way. We immediately picked the large pods of the cacao tree, cracked them against the tree trunk, and started eating them. These pods look like slightly oblong acorn squash in size and color, and the ribbing of the shell pops open to reveal a soft white pulp of flesh which is very moist but tastes nothing like chocolate. The creamy fruit quickly slaked our thirst and curbed our appetites.

Only after we had recovered from the hot trip on the river did we visit the Indian families in the community. The village and the orchards of cacao, oranges, bananas, and plantains all flowed into one another without any barriers between the orchards, the





working areas, and the residences. All of it seemed to be one organic entity. On this day, one Indian couple and their children sat behind their hut curing cacao. The Indians gathered a large pile of cacao fruit, and sitting beneath the trees they split open each pod. Because the seeds, or beans as we usually call them, are so thoroughly intertwined in the fruit of the pod, they are too slippery to remove with the fingers. Instead the members of the family ate the fruits and extracted the seeds with their teeth. They sucked the beans from the slippery fruit and then spat them out into a small pile. One of the children took the growing pile of beans out of the shade to spread them out on a high wooden bench in the sun, where they dry for several days. The bench sat high enough to keep animals away, but insects crawled over them, eating the remaining bits and pieces of fruit still attached. After several days of drying in the sun and being turned regularly to ensure even exposure, the beans were toasted in large pans over an open fire.

The Indian woman toasting the beans that day used a delicate and precise process requiring just the right temperature and just the right speed for shaking the beans. Too much heat would have burned them and ruined the chocolate, too little would have left them raw.

When the toasted beans had cooled, the man fed them into a manual grinder that rendered them into a thick but dry paste. The children then scooped the paste into balls and wrapped the balls into packets of banana leaves. The next time the family went to market, they would take the packets of cacao with them in the canoe to exchange for other foods or manufactured items. For those Indians the chocolate amounted to cash; it was too valuable a commodity for them to eat it themselves. Even the toddlers unable to talk knew to spit out the cacao seeds when eating the fruit.

Though none of these steps demanded very complicated equipment, the processing of the cacao bean still involved a sophisticated technological procedure, from the extraction of the seeds through drying, roasting, grinding, and packaging. Just finding the cacao pods wild in the woods and eating them the way my companions and I did was far removed from making chocolate. It took the Indians many centuries not only to learn to cultivate

the plant but also to develop the appropriate technology for making the fruit into a very different type of product. By and large the Europeans borrowed this technology, and even though they could often improve on it with new tools for grinding and for other steps in the process, the process remained the same. Cacao beans grown today in large plantations throughout tropical South America and the English-speaking countries of western Africa go through the same steps, even though the drying and roasting may be done in large mechanized mills rather than in small Indian villages where people sit around in the shade to make the chocolate. In Hershey, Pennsylvania, I have seen mountains of roasted and ground cacao that surpassed in quantity what a jungle village could produce in a generation, but the final product looked and tasted identical to me.

The extraction of vanilla requires an even lengthier and more complicated process than the making of chocolate. The delicate vine *Vanilla planifolia* has very small flowers, which the Indians early learned to fertilize by hand. The tasteless pods, which are often called beans, have to be cured and then are spread out to dry and age for four or five months in order to release the flavor. The Spanish were much enamored with the plant when they found it, and because of the delicate form and shape of the pod they named it *vanilla*, or "little sheath," a diminutive derivation of the Latin word *vagina*.

Similarly complex technological procedures underlie the processing of many native American crops. In Central America and Mexico the simple tortilla results from a nutritionally delicate and sophisticated process. Indian women soak the corn in water to which they add lime or ashes to produce *nixtamal*. Later the women put the *nixtamal* on a stone metate and grind it with another stone to yield *masa*, which they make into tortillas. Twentieth-century nutritional research has revealed that soaking the corn in a heated alkali solution, as these women have done for centuries, changes it into a form that allows the human body to absorb the maximum amount of niacin in the corn, increases the calcium in the corn, and makes the protein more easily used by the human body [Bryant et al., p. 46].

Many varieties of corn have thick hulls protecting each corn kernel. They are often too difficult to grind and too thick to eat





when boiled; therefore they must be removed. Removing each hull by hand obviously costs too much time and effort, but some ancient Indians discovered that lye would eat away the hull and not damage the interior. Such lye could be easily obtained from wood ashes. Thus the Indian cooks learned to soak the corn in a solution of water and wood ashes. The Indians called the hulled corn *hominy* in the Algonquian language or *mote* in Latin America; it is sometimes called "lye corn" by English speakers. Indians ate the hominy as it was or dried it and ground it to make hominy grist, which became so popular in the American south as grits, a completely Indian dish.

For some reason, people in the north never learned to like either hominy or grits, but they continued to experiment with these Indian dishes. Finally, Dr. Will K. Kellogg of Battle Creek, Michigan, discovered that he could take the corn, flatten it into a flake, and then toast it. This one innovation of flaking the corn rather than grinding it created the first corn flakes and the start of the American breakfast-cereal industry. The corn flake, hominy grits, the tortilla, and the tamale all share a close historical and nutritional position in American society whether one looks at the Americas today or the Americas of a millennium ago.

Indians also developed the technology for tapping the maple tree, extracting the sap, and processing it into syrup and into maple sugar, a process unlike any used in the Old World. From the Indians the settlers learned how to make dried red pepper as well as how to extract the essences of a wide variety of mints, wintergreens, and other spices and flavorings. They developed the long process of grating, pressing, and washing the poisonous varieties of cassava in order to remove the hydrocyanic acid. These same Indian kitchen chemists found that the hydrocyanic acid could be broken down by heating it, and in this state the chemical could partially dissolve hard meats and yet preserve them from rotting. This solution from the cassava plant is still used in the United States in meat tenderizers and sauces.

America made a profound and extensive impact on the world's diet from fruits and nuts to vegetables and oils. But there is one major part of the diet in which the New World made no change: in meat and animal products such as milk, cheese, butter, lard, eggs, and gelatin. Whereas the Old World had domesticated a

large array of animals, including horses, donkeys, cows, goats, sheep, pigs, water buffalo, elephants, camels, ducks, geese, chickens, and pigeons, the Americas were amazingly bereft of such animals. The few large animals in the Americas, such as the bison, bear, deer, elk, and moose, roamed wild and tended to live in the more inaccessible parts of the continent away from the clusters of human habitations. Indians hunted these animals and they traded the meat and fat, but this was only a minor part of the Indian's diet except in the few areas where farming was not practical.

Domesticated animals in America included only the turkey, duck, dog, guinea pig, and llama. Both the llama and the guinea pig were native to the Andes, but the llama found it very difficult to live outside the high altitudes. It does produce milk and meat, but in nothing approaching the volume of Old World cows and goats or even the llama's cousin the camel. In comparison to the llama, a cow is a virtual milk and meat factory.

Residents of the Andes still eat the guinea pig with great gusto, but it lacked appeal to people outside this area. The Europeans never adopted it as a food, because the European rabbit was larger and could live under more varied conditions. The Europeans also had a long-standing aversion to eating rodents except in the most dire of circumstances.

Only the American turkey found some following in the Old World, since it resembled a larger version of the well-known chicken. Even so the turkey never replaced the chicken. The turkey, like the guinea pig, acquired an exotic name reflecting an assumed origin in some faraway place such as Turkey or the Guinea Coast of Africa, although both are exclusively American in origin.

The Incas also kept ranches of domesticated rheas, the South American ostrich. Even though they ate the bird, they raised it for its long, soft feathers and for the leather made from its skin rather than for its meat. The Spanish found little use for the rhea other than hunting it, and the ranches soon fell into ruin while hunters almost made the bird extinct.

The spread of American foods around the Old World began in 1492, when Columbus gathered the first plants to take with him





back to Spain, and the process has not yet stopped. Today in remote spots such as Genaro Herrera on the Ucayali River, the quest continues not merely for new crops but for new food technologies to feed the world. Day after day the local Indians, mestizos, and scientists laboriously gather and catalogue the plants cultivated in the area, plant them in various experimental formations, and try to get a stock of germ plasm which might be sent to other stations for further testing under other conditions. At the same time they catalogue all of the Indian techniques and procedures for using these plants.

At the Talavaya Center in Santa Fe, New Mexico, scientists work to recover some of the high-yield corns that the Hopis grew two hundred years ago. The Hopis became experts in cultivating corn, particularly their blue corn, which grows low to the ground, thus conserving energy and water that would be wasted producing luxuriant stalks or leaves. By channeling all of the plant's energies into the production of the corn cob, the Hopis grew a cob a foot and a half long. Scientists now study the Hopi cultivation technology in hopes of taking this blue corn that grows so well in the deserts of the southwestern United States and trying to find ways to grow it in Ethiopia and throughout the drought-ridden Sahel of Africa. In the same area scientists are looking at the dry-farm melons of the Indians as well as at their red, pink, and turquoise corns.

Scientists keep finding new varieties of plants grown in remote enclaves of land in the least hospitable parts of the Amazon, in high Mexican valleys, on Dakota Indian reservations, and along swampy creeks in Costa Rica. Only in the twentieth century did science begin to unlock the complex reasoning underlying Indian agricultural and food-processing technology. As science turns its attention more fully to these questions, it may turn out that the American food revolution has only just begun.

Despite all the technological innovations of the American Indians and their history as the world's greatest farmers, today few of them benefit from this largess. Too many of them live like the families along the Mamore River who eat chocolate fruits and spit out the seeds for people in richer countries when they should be growing more corn and plantains. International market

trends have warped their world so that it becomes more difficult for them to practice their traditional agriculture.

This showed clearly in the family that I lived with for a short time on the Madre de Dios River in Peru. Hernán and his wife, Viviana, are highland Indians sent into the jungle as colonists after the failure of the agrarian reforms of the government to feed the highland population. Hernán took a piece of jungle an hour upriver from a village of four hundred Huarayos Indians and two days by motorized canoe from Puerto Maldonado, the closest town with a market and such amenities as gasoline and electricity.

After clearing the jungle along the riverbank with a machete and then burning the plants, Hernán built his family a home, a platform raised about a foot off the ground and covered with a thatched roof. Viviana cooks in a hole in the ground, and the family uses the river as toilet, bathtub, and drinking supply even though it teems with caimans, electric eels, sting rays, and piranha. Once he had built a home, Hernán started the laborious clearing of the jungle to plant his crops. A government development scheme that first lured him into the area encouraged him to grow bananas, which were a good export crop.

One night as we sat around the fire chewing chunks of a badger he had killed that afternoon, Hernán explained his situation to me. "The jungle has everything except capital. We have land and water and plants, and I have the labor, but there is no money." The government program offered him capital in the form of a small loan. But he could use the loan only to buy fertilizers, pesticides, and equipment in Puerto Maldonado. To Hernán, the town bankers, government officials, and merchants form one tight and powerful group. He received the government-backed loan but at their insistence used it to buy a pressurized insecticide applicator and a large supply of insecticides imported to the jungle by air from Lima.

The cost of the equipment far exceeded the average annual income of a farmer in the area, but the best scientific knowledge of the modern world backed it up. Today, the insecticide applicator sits like a family icon in a place of honor under the thatched roof. The applicator tank is their only piece of modern technology for a family that would love to have a gasoline motor for their





canoe, a chain saw to cut down the trees, or a pump to haul water up the steep and very muddy riverbanks. Once the initial supply of insecticide had been applied, Hernán never again had the money to buy any more. He produced a fair-sized crop of bananas and plantains, and he had a choice of selling them to a passing canoe or else paying for passage on such a canoe and taking them to Puerto Maldonado to sell them. He chose the second alternative, and sold them for about three cents a kilogram. The bananas brought less money than the insecticide to protect them had cost. He was now in debt to the bank and had used what little money he had on the transportation of the bananas to Puerto Maldonado.

Today Hernán is learning from the Indians how to live in the jungle. Even though he is a colonist sent by the government to modernize jungle agriculture, he now feeds his family by hunting and fishing and gathering the large pods of Brazil nuts that grow in the jungle. But even as Hernán has learned to live from the jungle and river, he is still faced with the problem of paying the several hundred dollars he still owes the bank from his investment in modern farming. His only solution has been to chop down the hardwood trees of the jungle and drag them down to the water, where he can sell them to a passing lumberman. Even he realizes that in chopping down the forest he is destroying the source of his family's food. Already his hunting trips require most of a day to find meat that will last for three days, but without the trees no animals and no Brazil nuts will remain. "We will have to go somewhere else; perhaps we will go up another river to live."

Research projects such as the ones at Genaro Herrera and the International Potato Institute represent isolated attempts to learn from the natives. Hernán and his family represent the much more common situation of the Indian today. They have been given new crops to grow using expensive (and usually petroleum-based) insecticides and fertilizers that themselves require expensive equipment to operate. The results have often been devastating. The Indians used in this manner today often become tied into a complicated network of economic forces that keep them very poor and working to produce food for urban elites and for foreigners.