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SCIENCE AND COLONIALISM: THE ROLE OF THE BRITISH
ROYAL BOTANIC GARDENS IN EMPIRE-BUILDING

by

LUCILE H. BROCKWAY

A dissertation submitted to the Graduate
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1977

This manuscript has been read and accepted for the Graduate Faculty in Anthropology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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Abstract

SCIENCE AND COLONIALISM: THE ROLE OF THE BRITISH ROYAL BOTANIC GARDENS IN EMPIRE-BUILDING

by

Lucile H. Brockway

Adviser: Professor Daniel R. Gross

The social and political implications of scientific research are examined through an analysis of the botanic garden as an institution regulating the flow of information about plants of economic value. Botanic gardens have played an important but little studied role in the colonial expansion of the West and the growth of an integrated world system based on an industrialized core which extracts raw materials from the colonial peripheries.

The focus is on Kew Gardens (1841-1939) as the center of a network of botanic stations throughout the British Empire, generating and disseminating information on plants "useful to the Mother Country," and actively participating in the surreptitious removal of protected plants from Latin America to establish new plantation crops such as cinchona (quinine bark), rubber, and sisal in the Asian and African colonies. Botanic garden research on species selection and improved methods of cultivation and harvesting was crucial to the success of

these new colonial enterprises.

The collapse of the Latin American markets following these seed transfers is discussed in the context of labor-scarce versus labor-abundant extractive systems and the advantages of formal empire over informal empire when resources are transferable, as plants are. Ethnographic examples are presented to show the alteration of local and regional economies in the colonies following the introduction of these new plantation crops. For example, India was too densely settled to accommodate plantations on a large scale, except in the hill regions where cinchona was well-adapted, but India provided a large pool of emigrant labor for the plantations of Ceylon and Malaya.

In Malaya intensive botanic garden research on rubber was combined under British political dominion with abundant "virgin" land, imported labor, and investment capital to build the world's largest trade in natural rubber, a strategic as well as a commercial resource. Rubber and tin made Malaya the ideal colony.

Research on cinchona yielded dividends in the form of an assured supply of quinine. The demographic, social, and political effects of this anti-malarial drug are assessed. It is suggested that quinine strengthened the British military and civil presence in India after the Sepoy Rebellion, and facilitated the penetration of Africa by European powers.

Attention is given to the parallel activities of the Dutch botanic garden in Indonesia. British/Dutch interaction underscores the supra-national aspects of economic botany.

The imperial botanic garden is seen as an institution in which a small homogeneous scientific elite, in communication with each other

at home and abroad, made and implemented decisions of world-wide implications with the whole-hearted cooperation of the political and commercial establishment. The personal networks of Kew's directors are traced. Their class position, patriotic sentiments, and scientific values all converged to promote the expansion of the Empire. In this study, Kew Gardens and its colonial affiliates emerge as a vital capital asset, transforming knowledge into profits and power.

Acknowledgments

A dissertation does not spring, like Minerva, full blown from the forehead, but is the culmination of directed study as well as independent research and personal idiom. I gratefully acknowledge the wise counsel and warm encouragement of my principal advisor, Professor Daniel R. Gross, who has guided this project from its inception, and of the members of my advisory committee, Professor Jane Schneider and Professor Joan Mencher, all of the City University of New York. As anthropologists, they are at home in any part of the globe, but I have especially benefitted from Professor Gross' intimate knowledge of the many ways of life in Brazil; from Professor Mencher's intimate knowledge of rural South India, past and present; and from Professor Schneider's special interest in long-distance trade and the rise of the European world system. Their combined expertise has guided me in this wide-ranging journey from continent to continent and across academic disciplines.

I thank Professor Paul Wheatley of the Department of Geography University of Chicago, for reading and commenting on the manuscript, thus bringing to bear not only his personal and scholarly experience of Southeast Asia, but the viewpoint of another academic discipline, Human Geography. Professor Charles Tilly of the Center for Research on Social Organization, University of Michigan, has made valuable comments, and Professor Immanuel Wallerstein of the State University

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For the courtesies shown me by the staffs of the Library and Herbarium of Kew Gardens, the Library and Herbarium of the New York Botanical Garden, the Library of the School of Oriental and African Studies, University of London, the Library of the City University of New York, and the Chappaqua Public Library, I am most grateful.

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I

Introduction

This is a historical-anthropological study of the early role of formal scientific institutions in the expansion and solidification of empire or politico-economic hegemony in recent world history. I propose to demonstrate that such institutions played a critical role in generating and disseminating useful scientific knowledge which facilitated transfers of energy, manpower, and capital on a worldwide basis and on an unprecedented scale. More particularly I intend to examine the role of Kew Gardens--along with other botanical and scientific institutions--in encouraging and facilitating plant transfers which had extraordinary impact in parts of the world subject to western imperial hegemony in the nineteenth and twentieth centuries.

I shall focus on three principal cases, cinchona, rubber, and sisal, tracing their removal under the auspices of Kew Gardens from their natural habitats in Latin America to their establishment as important commercial crops in the Asian and, to a lesser extent, the African colonies. More important than the physical removal of the plants was their improvement and development by a corps of scientists serving the Royal Botanic Gardens, a network of government botanical stations radiating out of Kew Gardens and stretching from Jamaica to Singapore to Fiji. This new technical knowledge, of improved species and improved methods of cultivation and harvesting, was then transmitted

to the colonial planters and was a crucial factor in the success of the new plantation crops and plant-based industries.

In the opening years of the industrial era, before the rise of the chemical industry with its synthetic fibers and pharmaceuticals, botanical knowledge concerning useful plants was a counterpart of today's academic-industrial research. At a time when such research was not yet institutionalized but was the work of semi-amateurs, institutions like Kew Gardens were as important in furthering the national welfare as our modern research laboratories today.

I further suggest that the Royal Botanic Gardens at Kew, directed and staffed by eminent figures in the British scientific establishment, served as a control center which regulated the flow of botanical information from the metropolis to the colonial satellites, and disseminated information emanating from them. Much of this botanical information was of great commercial importance, especially in regard to the tropical plantation crops, one of the main sources of wealth of the Empire. Decisions taken at Kew Gardens or implemented with the help of Kew Gardens had far-reaching effects on colonial expansion: if the botanists could suggest where to find a plant that would fill a current demand; how to improve this plant through species selection, hybridization, and new methods of cultivation; where to cultivate this plant with cheap colonial labor; how to process this product for the world market; then the botanists may be said to have had a major role in making a colony a viable and profitable part of the Empire.

The rubber plantations of Malaya, developed from seeds of wild Brazilian rubber, are the best example of the series of events described above, furnishing as they did not only much revenue but a vital strategic resource, whose place in the industrial growth and political hegemony of the West became painfully clear when Southeast Asian sources of natural rubber were cut off in World War II. Cinchona, the Andean fever-bark tree from which quinine is made, underwent a similar development under the leadership of Kew Gardens, and had important demographic and political effects through the control of malaria it afforded, not only in India where the botanical development took place but throughout the tropical world. The colonial penetration of Africa in the late nineteenth century by the European powers was accomplished only after a cheap and reliable source of quinine was available. Sisal, the third case history, illustrates the supranational character of scientific research, which flows easily across national borders to other peoples culturally prepared to use it. When Kew Gardens published the secrets of the carefully guarded Mexican sisal industry, German agronomists were able to find the plants with which to start a modern sisal industry in their East African colony.

Nineteenth century European colonial expansion was characterized by both competition and cooperation among the powers. The Dutch from their botanic garden on Java engaged in parallel activities of plant transfer and development, especially in the case of cinchona, sometimes competing with the British, sometimes cooperating with them, and in the end, fixing the market through cartel agreements. The French copied British and Dutch plantation methods in their rubber

industry in Indo-China. In spite of the internal rivalries in Europe which loomed so large at the time and which ultimately instigated two world wars, the industrializing and imperialist nations of the nineteenth century--England, France, Germany, the Netherlands, Belgium (and later the United States and Japan)--shared common interests against the rest of the world. Europe was achieving a global dominance, extracting and mobilizing the energy of the world for its own purposes. In each of my three case studies, a plant indigenous to Latin America was surreptitiously transferred by Europeans to Asia or Africa for development as a plantation crop in their colonial possessions. Brazil, Mexico, Colombia, Peru, Ecuador and Bolivia each lost a native industry as a result of these transfers, but Asia acquired them only in a geographical sense, the real benefits going to Europe.

In this study we are concerned with the human energy in the form of underpaid labor, and the plant energy extracted by the European core from the tropical peripheries of the world system. Howard S. Irwin, President of the New York Botanical Garden, indicates the way in which energy capture underlies the world political economy:

Long before the advent of man's dominance of the world, plants and animals living and evolving in systems characterized by give and take, success and failure, struck a balance between the energy available to them in their habitats, and the energy they required to carry out their life processes. Those species unable to adjust to the realities of habitat, including fluctuations in energy availability, passed from the scene. Those able to make the adjustment survived.

Man's use of energy is no different: successful societies grow and expand when energy is abundant; growth slows or ceases altogether when energy is scarce. Industry has expended considerable time and research in order to devise

more efficient use of available energy. . . .
 . . . From the ecological perspective, dollars simply represent the amount of energy needed to produce a product (1974).

Our study of the energy flow of one particular historical era will be approached from the viewpoint of human ecology, in which the concept of environment includes not only the physical and biotic elements associated with that term but also the human institutions--technological, economic, political--which affect the use of natural resources (Vayda and Rappaport 1968). The institutionalized accretions of past human activities form a large part of the environment in which human populations interact, becoming external factors which limit the strategies open at any one time, or under favorable circumstances, providing for a greater range of alternate choices.

At the other end of the theoretical continuum lies the individual. Societies expand or evolve; individuals choose. Individuals make the shifts from old patterns of behavior that, taken cumulatively, result in social change. The integration of the ecosystem approach with the individual decision-making model has posed problems in anthropological theory, especially in dealing with complex societies where the variables are numerous and the populations are large and mobile, therefore unbounded. Raymod Firth (1951) made an initial formulation toward synthesis in his concept of "social organization" as the day-to-day individual responses to outside stimuli. Recently Britan and Denich (1976) have proposed a model that achieves a synthesis of environment and choice, in which both local conditions and macroscopic structures shape action possibilities,

and processual change, both rapid and less rapid, is accounted for through the medium of many individual choices.

Robert McC. Adams takes a similar theoretical position:

"Individuals diverge as they continuously make varying choices among alternative 'economizing' strategies, adapting to differing circumstances with a more or less commonly held system of constraints and incentives" (1974:255). Adams suggests that interactive processes such as long distance trading and raiding trigger swift institutional changes, and that trade is not merely the exchange of goods on a beaten path, as its etymology indicates ("trade" is cognate with "tread"), but a form of entrepreneurship--individual goal-motivated behavior--which can lead to abrupt shifts in the patterns of domination and predation to which whole societies must adapt.

In its broadest aspects, then, our unit of analysis is not any one society or empire, but the network of relations emanating from the West that penetrated all societies, binding colonized to colonizers, and colonizers to each other. The mechanism of the Western botanical expansion that is described in our study is a small, homogeneous scientific elite, an "invisible college" in Diana Cranes's phrase (1972),¹ in touch with each other at home and abroad, making and implementing decisions of world-wide implications with the wholehearted support of their government and the commercial establishment.

To support my hypothesis that Kew Gardens and its affiliates had an important role in empire-building by virtue of scientific research

¹Crane uses the phrase as the title of a study of the diffusion of knowledge among modern scientists, but it was originally the name of a scientific club which met at Oxford in the 1640s and later became the Royal Society (Ziman 1976:90).

and the development of economically useful plants for production on the plantations of the colonial possessions, I shall discuss as background matter the nature of Britain's pioneer position as an industrial and colonial power, the place of agriculture in a colonial system, the rise of botany as a science and the general intellectual milieu in which botanic gardens such as Kew were formed. I shall examine the structure and function of Kew Gardens in the nineteenth century, its relation to other branches of government, and the personal networks of patronage, friendship, and marriage of its successive directors, placing them in the social hierarchy of Victorian England. Through an analysis of the effective role of the Kew botanists, a small network of highly trained, powerful and well-backed people, I hope to contribute to the understanding of social change in complex societies and to the dynamics of the present world order.

Today the multi-national corporation is the characteristic instrument of neo-colonialist expansion in the world system, and it has so many sources of scientific information--its own internal organs of research and development, private research firms, the universities, the government agencies--that botanic gardens are less important in this respect than formerly. Indeed, many botanic gardens have turned to the preservation of the world ecology as their major research area. And it must be acknowledged that the dependence of the developed countries on the oil of the undeveloped countries has reduced the flexibility of their economies and the advantages accruing from their technological lead. However, a major goal of the undeveloped countries is the acquisition of that scientific technology which has been, and still is, the cutting edge of the comparative

economic advantage of the Western powers.

Keith Griffin in a paper called "The International Transmission of Inequality" (1974) forcibly argues the proposition that the general behavior of the international economy and the pace and direction of economic expansion cannot be accounted for by differences in resource endowment or capital growth but by rapid technological change and the accompanying monopoly of new knowledge. ". . . it is the growth and accumulation of useful knowledge, and the transformation of knowledge into final output via technical innovation, upon which the performance of the world capitalist economy ultimately depends" (1974:3). He cites United Nations figures showing that 98% of all current expenditure on research and development in non-socialist countries occurs in the rich countries, in per capita terms 135 times as much as is spent in the poor countries (1974:4). The technical knowledge generated in the rich countries has increased the flexibility of their economies by allowing them to reallocate their resources to take advantage of changing opportunities, while the poorer countries, with capital and labor relatively immobile, have had their economies dislocated by the intrusion of the free trading giant companies, which attract scarce local capital, savings, and skilled manpower. Royalty payments on patents, copyrights, franchises, and licenses, all of which constitute a monopoly rent on technology, are a continuing drain on the poorer nations. The inequalities deriving from monopolies on technical information and scientific knowledge tend to be self-perpetuating and cumulative. They have in fact a long history, co-terminous with the rise of the West in the sixteenth to twentieth centuries, during which

time scientific knowledge became increasingly formalized. One of the early formal scientific institutions was the botanic garden, whose role in the colonial expansion of the West and the growth of an integrated world system based on an industrialized core which extracts raw materials from the colonial peripheries is explored in this essay.

II

The British Empire

Thy posterity shall sway
Regions Caesar never knew

--William Cowper (1731-1800)

In Empire we have not merely the key to glory but the
call to duty and the means of service to mankind.

--Lord Curzon, 1908

This chapter presents the basic outlines of British imperialism in the context of the expansion of the West and the integration of the modern world system. From the time Britain eliminated France in India in the mid-eighteenth century to the post-war dismantling of the Empire in the mid-twentieth century, Britain was the world's leading imperial power as well as the pioneer industrializing nation, in both respects a model for other expanding states. The sun never set on the Union Jack; Britain had dominions, colonies, and spheres of influence in every continent and on islands in every sea.

Yet this empire was not undifferentiated and equally valuable in all of its parts. India was the kingpin of the British Empire. In London there was an India Office and a Colonial Office, one administrative bureaucracy for India and one for all the rest of the colonies. From the beginning, Asia was the lodestone of Western expansion. Columbus' goal was the Indies, and the landfall on Hispaniola

an accident. The early English transatlantic voyages were searching for the Northwest Passage; the first colonies in North America were seen as stepping stones to the Indies (Parry 1963). Coveting the riches of Asia, the Western sea-powers started in the late fifteenth century on voyages of discovery and annexation to secure those riches for themselves. In little more than a century Spain and Portugal were effectively pushed out of Asia, but Britain (and Holland) who did the pushing out, not only brought home the gold, silks, gems, spices and other luxury goods of Asia but in time also mobilized the skills of Asian manpower to their own purposes, a much richer prize in the long run. We note that the key plant transfers arranged by Kew Gardens in the nineteenth century were from Latin America to Asia, i.e., from labor extensive societies to labor intensive societies, from regions of abundant land but scarce labor to regions of abundant labor.

In these four centuries of colonial expansion, Britain had more than one finger in the pie. She extracted naval stores from North America in the era of sailing ships; she transplanted African labor to the Caribbean to produce sugar until the land wore out, and in the nineteenth century she fell heir, informally, to the empires of the Iberian powers in Latin America, replacing them in the successor states after independence as the chief supplier of venture capital and recipient of earnings on capital. Yet her interest in Asia was paramount and steady. Harder to conquer, Asia yielded more. The continuing interest of Britain in Asia will be a major theme of this chapter as we substantiate these introductory remarks and

explore the economic and political relations between the West and the rest of the world which culminated in a contemporary world of overdeveloped and underdeveloped countries.

The World Capitalist System

This is a question of enormous scope, subject to increasing debate as new interpretations have come to challenge the old stereotype of many Western historians in which dynamic Christian nations expanded into a near vacuum--a world of pagan illiterates who had no history worth mentioning and to whom the West brought the benefits of civilization (see H. Trevor-Roper, The Rise of Christian Europe, 1965). In this brief analysis I have relied primarily on C. Cipolla (1976), K. Griffin (1969, 1974), E. Hobsbawm (1968), J. Levenson (1967), R. Mukherjee (1974), E. Rich (1967), I. Wallerstein (1974), I. Zeitlin (1972), and A. Gunder Frank (1969).

In a series of articles reprinted in 1969 Gunder Frank explores the concept 'metropolis-satellites,' with all its connotations of inequality as applied to Western-Non-Western relations:

. . . historical research demonstrates that contemporary underdevelopment is in large part the historical product of past and continuing economic and other relations between the satellite underdeveloped world and the now developed metropolitan countries. Furthermore, these relations are an essential part of the structure and development of the capitalist system on a world scale as a whole (1969:4).

This holistic view of "the single stream of world history" is shared by Wallerstein, whose core-periphery dyad corresponds to Frank's "metropolis-satellites." Wallerstein also posits a third category, the semi-periphery, which functioned as a political stabilizer,

preventing the complete polarization of the world system, since the middle tier of states was both exploiter and exploited (1974:405).

The three structural positions in a world-economy--core [Western Europe], periphery [Eastern Europe, the Western Hemisphere, India and Indonesia, coastal Africa], and the semi-periphery [the Mediterranean world]--had become stabilized by about 1640. How certain areas became one and not the other is a long story. The key fact is that given slightly different starting-points, the interests of local groups (landowners and local commercial bourgeoisie) converged in northwest Europe, leading to the development of strong state mechanisms, and diverged sharply in the peripheral areas, leading to weak ones. Once we get a difference in the strength of state machineries, we get the operation of "unequal exchange" which is enforced by strong states on weak ones, by core states on peripheral areas. Thus capitalism involves not only the appropriation of the surplus-value by an owner from a laborer, but an appropriation of surplus of the whole world-economy by core areas. . . . the strength of the state-machinery in core areas is a function of the weakness of other state-machineries. Hence intervention of outsiders via war, subversion, and diplomacy is the lot of peripheral states (Ibid.: 401, 403).

East-West Divergence

Joseph Levenson has asked (1967) why the expansive forces--military, political, economic, and cultural--that made the world a world ran from West to East. Why was there not a "discovery" of Europe and an "Easternization" of the world? In the early sixteenth century when the Portuguese arrived in the Indian Ocean, India and Java had powerful harbor princes and astute merchants, versed in mathematics and bookkeeping, with ample capital to support a complex of shipping and trading in high quality goods, centered on the Malabar Coast (e.g. Goa) and the Gujarati ports of India (e.g. Diu) and in Malacca, the entrepot commanding the straits of Sumatra (Levenson 1967:120). Griffin quotes a Dutch historian of Indonesia:

. . . when the first Dutch merchants and sailors had come to the island world of the Indies, they had been amazed by the variety and nature of its civilization, and the more observant among them had recognized that southern and eastern Asia were far ahead of Western Europe in richness as well as in commercial ability and mercantile skill (1969:34).

Western visitors to Malacca in the early sixteenth century regarded it as the greatest port for international commerce in the world (Moreland 1962). The fabulous riches of India impressed English observers as late as the mid-eighteenth century (Mukherjee 1974:337-339). In addition to the pepper and other spices so much desired for preserving and seasoning meats and the indigo for dyeing fabrics, India produced in her domestic industries cut jewels, fine glassware, paper, objects of gold, silver and brass, and fine silk and cotton fabrics.

China had an impressive record in science with the invention of the compass, movable type, and gunpowder and the potential for far-reaching commerce and navigation. In the early years of the fifteenth century, the Ming emperors sent seven large expeditions each comprised of fleets of several hundred ships under the command of the Muslim eunuch Cheng Ho, with "tens of thousands of officers and flagtroops" to receive tribute from the rulers of "barbarian" kingdoms throughout the Indian Ocean, the Persian Gulf, and as far as the east coast of Africa (Levenson 1967:13-17; Parry 1974). Yet this potential for long distance overseas trade was not developed but smothered by the Confucian bureaucracy. The records of Cheng Ho's expeditions were suppressed (Levenson 1967:86) and the Ming initiative aborted. The use of paper money, an indication of proto-capitalism, also lapsed. China had neither the will nor the need to

expand overseas, nor did India show any active interest in the West. The self sufficiency of these large, settled agricultural populations with their well developed handicrafts in textiles, ceramics, and metallurgy discouraged overseas expansion. Tropical spices and luxuries for the courts were easily found in the Indonesian Archipelago, and their ties to the Muslim world gave them an adequate outlet for exports through Arabia or Egypt. In China, the centralized state rested on an alliance between the monarch and a tax-collecting bureaucracy of gentry and literati, whose cultivated disdain of merchants and manufacturers shut those classes out of power. The government severely regulated their activities, and denied them support and prestige.

By contrast, as Western European peoples struggled to emerge from feudalism, the merchants and manufacturers won the support of the state as a way of making the various nations stronger. Gilberto Freyre traces the rise of the maritime and mercantile interests in Portugal in alliance with the monarchy (reprinted by Levenson 1967: 128-30) and Samson emphasizes the government support of sea borne trade, especially the woolen trade, in Tudor England's rise as a commercial nation:

The Crown and the Government were obliged to pay attention to foreign trade, to legislate for its improvement and control. Trade was a matter of the highest importance in the State, and fifteenth-century politics were much concerned with matters arising from the competition of foreign trading companies. By the end of the fifteenth century--indeed well before the year 1500--it was a commonplace in English thought and a maxim of English policy that England's strength--one might say, her survival--depended upon her seaborne trade. Behind all the romantic exploits of the Elizabethans, the voyages, peaceful or piratical, the clashes of diplomacy and the wars on land and sea, was a

constant urge to find new international markets, to discover what was called a "vent" for English exports (reprinted in Levenson 1967:78).

European Expansion: Technology and Trade

The Atlantic nations had the incentive for overseas trade and the political forms to lend it support. Their rapidly developing technology gave them the means. Advances in shipbuilding and open sea navigation were especially marked:

The gun-carrying oceangoing sailing ship developed by Atlantic Europe in the course of the fifteenth, sixteenth, and seventeenth centuries was the instrument which made possible the European saga. Whenever and wherever the ships of Atlantic Europe appeared, there was no power that could offer any resistance (Cipolla 1976:209).

Exchanging oarsmen for sails and warriors for guns meant essentially the exchange of human energy for inanimate power. By turning wholeheartedly to the gun-carrying sailing ship the Atlantic peoples broke down a bottleneck inherent in the use of human energy and harnessed, to their advantage, far larger quantities of power. It was then that European sails appeared aggressively on the most distant seas (Cipolla 1965:81).

Moslem and indigenous ships on the Indian Ocean sailed only with the monsoons; European ships with their square-rigged mainmast sailed closer to the wind. Moslem ships could not carry guns and still relied on boarding parties in naval battles. After centuries of borrowing from the East, European science was being translated into superior technology--better charts, navigational instruments, ships and cannon--as Asian science was not.

At first the Europeans had nothing but their firearms to trade for the luxury goods of the East, for Europe produced little else that Asia wanted (Cipolla 1976; Levenson 1967; McNeill 1974; Rich 1967). Hindu princes who were resisting Moslem invaders were

eager to buy European guns and Arabian horses transported to India on Portuguese ships. The lack of saleable commodities to trade with the East caused a drain of gold and especially silver throughout the sixteenth and seventeenth centuries, which was only partially offset by the earnings of Portuguese, and later Dutch, ships in the inter-Asian carrying trade, from the Persian Gulf as far as China and Japan. Between 1640 and 1680 the Dutch, with a monopoly on trade with Japan after Japan closed its doors, took annually 1.5 million florins of silver out of Japan in payment for goods and shipping services (Cipolla 1976:214). Much of this they spent on other Asian goods, especially the spices of the Moluccas. Cipolla quotes a Florentine traveller who estimated that the Chinese extracted from Portugal and Spain "more than a million and a half ecus a year in silver, selling their goods and never buying anything, so that once the silver gets into their hands it never leaves them" (1976:216). Part of this silver came directly across the Pacific from Mexico on the Manila galleons, to be exchanged in Manila for silks and other Chinese luxury exports carried there by Chinese junks (Wickberg 1965:33, reprinted in Levenson 1967:66).

But the bulk of the treasure in silver and gold from the New World passed through Europe first before going to the Far East to settle the European trade deficit.

. . . intercontinental trade in the sixteenth and seventeenth centuries consisted essentially of a large flow of silver which moved eastward from the Americas to Europe and from Europe to the Far East, and a flow of commodities which moved in the opposite direction (Cipolla 1976:214).

Braudel (1966:I,569) quotes a Venetian merchant "Silver goes where the

pepper is," i.e., India. The drain of silver from the Mediterranean to the East was long-standing, perhaps dating to Roman times, certainly throughout the centuries of medieval trade through the Levant, but it increased dramatically after the New World conquest. Braudel says:

So during the sixteenth and seventeenth centuries there circulated throughout the vast Asian continent, source of spices, drugs, and silk, the precious gold and above all silver coins minted at Venice, Genoa, or Florence, and later the famous Spanish silver pieces of eight. Away to the east flowed these currencies, out of the Mediterranean circuit into which it had often required so much patience to introduce them. The Mediterranean as a whole operated as a machine for accumulating precious metals, of which, be it said, it could never have enough. It hoarded them only to lose them all to India, China, and the East Indies (1966:I,464).

It was through Seville and Spain, "first rich in gold then in silver, in theory hoarding her treasure but in practice letting it escape" (Braudel 1966:I,466) that American precious metal entered Europe, but it was often in the form of Mark reales or rixdollars that it reached Batavia (see chart in Cipolla 1976:215). To support its Habsburg imperial adventures, the Crown had to buy provisions and supplies for its armies that the rigid and mismanaged Spanish economy could not furnish. Through Genoese financiers, the Fuggers of Germany, and increasingly through Flemish bankers, to whom the Crown was perpetually in debt so that each annual silver fleet was already mortgaged before arrival, Spanish silver flowed throughout Europe, especially northwest Europe, passing from Antwerp to the Low Countries, to Germany and the British Isles. Braudel cites two reports to the monarch written in 1558:

Today there arrived in Antwerp four vessels from Spain, after a voyage of ten days. They are carrying 200,000 crowns in coin and 300,000 in bills of exchange. The last

load of silver from Spain . . . arrived just in time to enable us to pay the German infantry and cavalry we are recruiting . . . (Braudel 1966:I,480).

While the economies of the Iberian powers floundered, in part because they were overstrained by their huge empires, the Dutch and the English were becoming strong manufacturing, trading, and naval powers, making incursions into the Iberian empires in the New World (the Caribbean and Guiana) and in the Indian Ocean, where they supplanted Portugal everywhere except in Timor. The Philippines remained Spanish.

But throughout the seventeenth century, New World silver continued to pay for Asian luxuries, as the records of the British East India Company bear out. Between 1660 and 1700 the percentage of bullion in the total payments made by the company ranged from 66% to 87%. Merchandise amounted to less than a third of the total value (Chauduri 1968:497-98, reprinted in Cipolla 1976:216).

This pattern of trade continued throughout the eighteenth century, when a craze for things Chinese (chinoiserie) and East Indian spread through fashionable Europe. Chinese porcelains, wall-paper, lacquerware, silks, chintzes, and nankeens and Indian muslins and paisleys set the styles. Voltaire, a shrewd observer of the contemporary scene, remarked:

People ask what becomes of all the gold and silver which is continually flowing into Spain and Portugal from Peru and Mexico. It goes into the pockets of Frenchmen and Dutchmen, who carry on trade in Cadiz, and in return send the products of their industries to America. A large part of this money goes to the East Indies and pays for silk, spices, saltpeter, sugar-candy, tea, textiles, diamonds, and curios (quoted in Goodrich 1969:220).

We have dwelt on this point--that Peruvian silver, mediated by

European enterprise, was paying for Eastern silks and spices--to substantiate our suggestion that Europe was mobilizing the whole expanded world to her purposes, and to emphasize the continuity, from the sixteenth to the twentieth centuries, of the European manipulation of Latin American raw materials--first precious metals, then after the mid-nineteenth century, precious plants--to secure the fruits of Asian labor. In the early centuries this Asian labor was highly skilled, producing luxury goods. By the late nineteenth century, the Asian labor available to the English and Dutch overlords was much less skilled, much more impoverished, and more easily exploited. The colonization of the East had taken place in the meantime.

The old patterns of trade which had been mutually beneficial when conducted between sovereign states or their mercantile representatives changed to a pattern of "unequal exchange" (see Wallerstein quote, page 22) as the Western powers gained increasing politico-military hegemony over the Asian states and made forcible changes in the modes of production, the exchange of goods, the ownership of land, and the tax structure. As the native societies of India, Ceylon, Java, and other parts of Southeast Asia were disrupted by the European colonizers, their economies submitted to European pressures, at first mercantile, later industrial. By the nineteenth century an industrializing Europe had substituted its own machine-made products for Asian handicrafts, and preferred to use Asian labor principally in the production of tropical raw materials--e.g., cotton, hemp, jute, sugar, coffee, tea. It is significant that as this process advanced, the luxury handicrafts which had formed a large part of European imports

from Asia came increasingly from China, which retained its nominal independence throughout the colonial period and its actual independence longer than India or Indonesia, succumbing only in the nineteenth century to Western demands for unequal trade.

The Colonization of the Indies

The English and Dutch did not at first become colonizers, but relied like the Portuguese who preceded them on fortified trading posts. But they did introduce a new technique of economic organization to manage their trade monopolies--the chartered trading company, a joint-stock association of risk-sharing merchant adventurers which was nominally independent but whose power was underwritten by the state. The British East India Company dates from 1600; the Dutch East India Company from 1602. After some initial armed contests, they accepted the advantages of regional monopoly, the English acquiring the mainland "factories," the Dutch those on the islands. Compulsion was used to extract the maximum supply of trade goods, primary products, and tribute.

"The Company" became the law in Indonesia, fighting wars against the princes, selling military support to one prince against another in exchange for trade concessions, exacting tribute from local rulers who in turn squeezed village headmen, exacting compulsory deliveries of goods at favorable prices, and imposing forced cultivation of commercial crops, e.g., nutmeg and cloves on certain islands of the Moluccas and sugar, indigo, tobacco and coffee on Java (Geertz 1970). By the eighteenth century the Dutch had turned the once fertile islands into a forced labor camp and the indigenous traders into

pirates, the "Malay pirates" of European history books.

In India, by playing off rival native rulers against each other and the French in a series of pitched battles, the British East India Company extended its hegemony from the coastal trading posts into the interior, becoming the de facto ruler of most of India by the end of the eighteenth century. In addition to outright plunder of gold, silver, and precious jewels, in the form of indemnities,¹ the British succeeded in dismantling India's domestic industries and native handicrafts, e.g., the metal wares of brass and iron, but especially the fine silk and cotton fabrics. At first the Company's agents traded in the calicos, muslins, surahs, and madras cloths (all of whose names reflect their origin in India), so eagerly sought after in England to replace homespun woolens and fustians (a wool-flax mixture), but by the early nineteenth century India had been turned into a captive market for the cheap manufactured cottons exported from the mills of Lancashire. In 1813 Calcutta exported to London cotton goods worth two million pounds sterling; in 1830, Calcutta imported two million pounds sterling of British cotton manufactures (Mukherjee 1974:405). British woolens, and manufactures of

¹In 1757 they demanded £2,340,000 from the nawab of Bengal as the price of installing him in power, and as compensation for the losses to the British trading community in Calcutta, which had been attacked by his predecessor. Most of the British had escaped down the river, but 123 (?) prisoners suffocated overnight in a small room, the "Black Hole of Calcutta," an episode that reinforced British intransigence then and later, becoming a legendary justification for British military rule in India. The new nawab could raise only half the indemnity, which was paid in gold and silver specie and in jewels (Encyclopedia Britannica 1911:408). But according to Mukherjee (1974:347), over the next eight years, successive tribute payments to the Company and successive "gifts" to Company officials from the puppet rulers raised this loot to a total of £5,940,498 from Bengal alone.

copper, lead, iron, glass, and earthenware were also imported with duties of only 2 1/2%, while Indian manufactures had to pay duties of up to 400% valorem on entering England.

Beginning with the Company's capture of Bengal in 1757, and spreading through the rest of India as it came under Company rule, artisans were forced to produce at the Company's orders, for Company wages, and were denied any other outlet. The harsh measures taken to describe this bond slavery--floggings, imprisonments--are described by R. Mukherjee (1974:300-12; 337-40). He quotes, among other eyewitness accounts, that of an English merchant, William Bolts, which was published in London in 1772.

Inconceivable oppressions and hardships have been practiced towards the poor manufacturers and workmen of the Country, who are, in fact, monopolized by the Company as so many slaves. . . . the whole inland trade of the country and that of the Company's investment for Europe in a more peculiar degree, has been one continued scene of oppression; the baneful effects of which are severely felt by every weaver and manufacturer, every article produced being made a monopoly, in which the English with their banyans (Indian agents) and gomastas [sub-agents], arbitrarily decide what quantities of goods each manufacturer shall deliver, and the prices he shall receive for them. . . .

Upon the gomasta's arrival at the aurang, or manufacturing town, he fixes upon a habitation to which he summons the brokers, together with the weavers; whom he makes to sign a bond for the delivery of a certain quantity of goods, at a certain time and price, and pays them a part of the money in advance. . . . upon the weavers refusing to take the money offered, it has been known that they have had it tied to their girdles, and then have been sent away with a flogging. . . . the prices which the Company's gomastas fix upon the [finished] goods are in all places at least fifteen per cent, and in some even forty per cent less than the goods so manufactured would sell for in the public Bazar, or market, upon a free sale. The weaver, therefore, desirous of obtaining the just price of his labor, frequently attempts to sell his cloth privately to others. . . . This occasions the English Company's gomastas to set his peons over the weaver to watch him, and not infrequently to cut the piece

out of the loom when nearly finished. . . .

Weavers, upon their inability to perform such agreements as have been forced upon them by the Company's agents . . . have had their goods seized on the spot to make good the deficiency; and the winders of raw silk, called Nagoads, have been known of their cutting off their thumbs to prevent their being forced to wind silk (quoted in Mukherjee 1974: 302-04).

Indian traders were also forced to buy only from the Company and at higher than market prices, so that the mercantile class was ruined and the Company and its agents, who often carried on a private trade on the side, monopolized Indian internal as well as external trade. The desolation of the formerly flourishing manufacturing towns of Dacca, Surat, and Murshidabad, and the market towns of the states of Tanjore and Madras was noted in eyewitness testimony given before the Committee of Secrecy of the House of Commons (1773 for Madras; 1782 for Tanjore). In 1840 Sir Charles Trevelyan told the House

. . . the population of the town of Dacca has fallen from 150,000 to 30,000 or 40,000, and the jungle and malaria are fast encroaching on the town. . . . the distress there has been very great indeed (quoted in Mukherjee 1974:337-38).

Throughout its career, the British East India Company had shown an efficient and ruthless application of the principles of mercantile capitalism based on monopoly. To buy cheap and sell dear the Company relied on a monopoly of the Indian trade in London and of the European trade in India. As mercantile capitalism in Britain was challenged by the rising industrial capitalists, the Company lost its monopoly at home (1813), and this change was reflected in India as the artisans who had first been turned into wage slaves were discarded in favor of the products of British labor. But money continued to flow into the Company's accounts and into the British economy--two,

three, or four million pounds sterling every year during the century of Company rule (1759-1858).

The idea held by British colonialists that their contact with India was inevitably beneficial to India as well as to England failed to take into account this industrial immiseration of India, and the theory still held by many laissez-faire economists that any expansion of trade must be ipso facto beneficial to both parties is attacked by Griffin over this same sequence of events:

. . . if the expansion of trade is accompanied by technical advantage, as it often was in the past and certainly is today, the consequences for poor and inflexible economies can be severe. Technical change, after all, reduces the demand for certain commodities and certain factors of production, at least in the short run. If the factors so released are unable to find employment elsewhere, the net effect of an innovation may be to reduce rather than to raise welfare. . . . Even as ardent a free trader as Sir John Hicks accepts this. He notes that ". . . the labour that is thrown out (as a result of technical change) may be in one country, and the expansion in demand for labour, which is the effect of the accumulation of capital that results, may be in another. The English handloom weavers, who were displaced by textile machinery, would (in the end after much travail) find re-employment in England, but what of the Indian weavers who were displaced by the same improvement? Even in their case there would be no particular reason why it should be in India" (1975:8).

By the working of comparative advantage and unequal trade, there was every reason why opportunity for re-employment would not be, and was not found in India. The economy no longer had an industrializing sector for the handworkers to go to.

The Ruin of Indian Agriculture

As the Company acquired political power, it turned its attention to the expropriation of revenue from the land, which had to bear the whole burden of taxation as displaced artisans were forced onto

the land to compete with the peasants. Company agents were unscrupulous in exacting the ever-increasing taxes on agriculture, even in the presence of famine (Mukherjee 1974:352, 361). These revenues were not reinvested in the land; on the contrary, existing canals and irrigation works were allowed to fall into ruin. The fertility of the soil decreased through lack of water or from improper drainage. The incidence of malaria rose. Traditional agricultural institutions were upset by the Permanent Settlement, or revenue assessment, announced in 1793 for Bengal and subsequently extended to other provinces, by which the Company fixed the revenue due it at one half the peasant's gross yearly produce, or nine-tenths the landowner's rent. This was later reduced to one-half the net rent from either peasant or landowner (Moreland 1957:335). Harsh as this was, the real significance lay in the changed relationships between peasant and landowner. I quote from the French agronomist, René Dumont:

On 22 March 1793 Lord Cornwallis and the East India Company proclaimed that zamindars and talukhars (the men who had been charged with the collection of tribute) would henceforth be considered as permanent and irrevocable owners of the lands on which they had gathered taxes. The proclamation had far-reaching consequences. Of course, it is easy to see that the East India Company regarded it both as an improved way of obtaining a better return of tributes, and also as an easy means of making firm allies. But they never realized that, in depriving the peasant of his traditional and permanent right to occupy the land, they were making him, throughout the greatest part of India, a slave of new owners; and that exploitation of the peasant now took the place of exploitation of resources. Rural societies were not only compelled to pay taxes, but also rents which demographic development soon made outrageous; some peasants took to running away. A new law gave the zamindars the right to catch them, and this completed the dismemberment of traditional rural society. On the one hand great landowners; serfs on the other; the former with no incentive to improve the land; the latter with no means to do so (1965:139).

Throughout the nineteenth century the rural population suffered a decline in real wages as measured in purchasing power of food. The following table for the Madras Presidency is calculated in seers of rice, the staple food. Throughout the twentieth century food produc-

Table II.1

CHANGE IN REAL WAGES OF AGRICULTURAL
LABOUR IN SEVEN DISTRICTS OF SOUTH INDIA,
AVERAGE 1873-75 to AVERAGE 1898-1900

	per cent
Ganjam	-43
Vizagapatam	-48
Bellary	-20
Tanjore	+29
Tinnevelly	-40
Salem	-13
Coimbatore	-39

Source: Dharma Kumar, Land and Caste in South India, Cambridge University Press, 1965, p. 164.

tion per capita continued to decline, in mid-century being only 58% of the average for 1900 (Griffin 1969:41).

The Rule of Law

As Parliament and the Crown succeeded the Company, British institutions were increasingly imposed on India. The system of justice was anglicized; Hindu codes were frozen on the most orthodox lines so as to preclude their re-interpretation under changing conditions and to suppress the liberal forces inherent in Indian society. All justice was administered by British District Officers, who were bound by stringent rules of evidence developed over the centuries to fit an alien (British) society. Except for a handful of critics, the British

public and the officials on the spot persisted in the view that England had a mission to save a backward peasantry through the Rule of Law "from war, pestilence, famine, injustice, and oppression" (Moon 1944:15). Moon is one of the few British civil servants, with actual experience as a District Officer in India, to have seen through this patriotic screen and to have concluded that the English system of justice as imposed on India was "useless lumber," perverting the peasantry and being perverted itself. The very structure of the economy, as dictated by the British, negated their "civilizing mission." In addition, the alliance of the British rulers with the landlord class made any real agricultural reform impossible, and in combination with their policy of preventing industrial development, ensured mass misery.

Out of a society that was sophisticated, cultured, and wealthy at the time of contact, the British had created underdevelopment and then hindered efforts to escape from it (Griffin 1969; Moreland 1962; Mukherjee 1974). They had done the same in Ceylon, as had the Dutch in Java. My own case histories on cinchona and rubber will provide illustrative material from one sector of the economy, the plantation sector, introduced into India and the Indies after the despoilation of their economies had released a large docile labor force.

The British and China: Opium and Tea

China had remained aloof and impregnable by virtue of its size and strength until the nineteenth century, when the European desire to trade and dominate finally prevailed. British trading interests in India precipitated the forced entry, using opium to subvert China as they had used firewater to demoralize American Indians.

The British East India Company served in the late seventeenth, eighteenth and early nineteenth centuries as an entrepot for the Chinese trade. In order to finance its imports of luxury goods from China--the silks, porcelains, objects d'art, but especially tea¹--destined for England, the Company forced on a reluctant China a trade in opium grown in the Bengal Province of India which it sold at an auction to private intermediaries and on which it collected a transit tax. When Chinese authorities tried to stop the trade in opium, the British Crown stepped in to protect this lucrative source of revenue. By means of gunboats and force of arms (The Opium War of 1839-42) the British insisted on legalization of the trade, and incidentally opened up China to full economic and quasi-political penetration by the West (see Fay 1975, and Fairbank, Reischauer, and Craig 1973:448-460). Thus opium addiction, often cited by Western historians as a sign of Chinese decadence, was forced on China in pursuit of a trade balance.

The Opium Wars also led to a decline of the Chinese monopoly in tea production as the British started cultivating the native teas of Assam. In 1848 China reluctantly but under duress, received a mission sent by the East India Company under Robert Fortune,² a Scottish

¹In English ports, the government collected customs duties of at least three million pounds sterling annually on Chinese tea, a sum equal to half the expense of the Royal Navy (Fay 1975:18).

²On other expeditions under the sponsorship of the Royal Horticultural Society, Fortune brought out to the West the previously unknown wonders of Chinese gardens--azaleas, camellias, chrysanthemums, peonies, new species of roses--all now staples in Western gardens and in the trade in ornamental flowers and shrubs (Wilson 1929).

botanist, to bring back Chinese tea plants to India accompanied by Chinese experts to instruct in tea cultivation. These experts were perhaps more important than the plants. Tea plantations were established around Darjeeling, an area the Company had acquired from the Raja of Sikkim in 1835, so that Indian tea soon supplanted Chinese tea on British tables (Fairbank, Reischauer, and Craig 1973) though the American trade took up the slack in Chinese tea.

The Royle Report

Such a policy had long been urged by a botanist named J. Forbes Royle, whose recommendations had to wait on the willingness of the Chinese to allow their tea plants to be exported. Dr. Royle, Fellow of the Linnean Society and of the Geographical Society, had gone out to India to join "the Honourable East India Company's Medical Establishment" and was Superintendent of the Company's Botanic Garden at Saharanpore. In a published report (1834) Royle reviewed the unsuccessful attempts to cultivate tea in Java, Penang, Ceylon, and Rio de Janeiro, which failed in his opinion because the climate was too tropical. He thought the elevated valleys in the foothills of the Himalayas would be suitable for growing tea, having the same strong contrasts of seasons as in the Fukien Province of China, and having the same botanicals as far as he could tell from the few available reports of travellers. Royle's predictions proved to be sound, and tea became one of North India's principal exports in the latter half of the nineteenth century. By 1905 Assam had 206,000 acres in tea cultivation, and the all-India total was roughly double (Tinker 1974: 32). Ceylon proved to be ideal for tea growing, with 384,000 acres

in tea in 1905, making Ceylon the third largest tea producer in the world.

This is one of the first instances of a botanic garden's influencing the course of empire through the organized transfer of economically valuable plants. It antedates and foreshadows the activities of Kew Gardens, which had only recently (1841) become a state institution.

The one sharp difference between the British removal of tea plants from China and the later removal of rubber and cinchona from Latin America is that the tea removal was not done surreptitiously but as a result of diplomatic pressure and in the aftermath of a war, and the Chinese themselves furnished the expert knowledge of tea cultivation and processing. In the later plant removals from Latin America the British got no help from their victims, but Kew Gardens had by then developed the institutional strength to find new cultivation methods.

The following table shows the rising importance of tea in United Kingdom imports from the colonial possessions (Table II.2).

India was too large and complex a society to be turned into a plantation economy, but in addition to the tea plantations, the British in the nineteenth century also introduced indigo-growing on a plantation basis, and plantations of coffee, cinchona, and rubber, albeit on a small scale. Ceylon was reduced to a plantation economy, and Malaya developed on a plantation basis, as will be described in our case histories. India played a special role in these and all the British plantation colonies, becoming a source of labor. After the

Table II.2

United Kingdom Imports from the Empire, 1854-1929
in £1,000s

	1854	1876	1900	1913	1929
From <u>India</u>					
indigo	1,546	1,809	457	48	8
tea	24	2,429	5,576	7,839	20,087
<u>Ceylon & Malaya</u>					
coffee	1,007	2,681	45	2	--
rubber	--	--	188	11,138	13,055
tea	10	7	4,097	4,179	11,984
<u>British West Indies</u>					
sugar	3,891	4,635	625	698	1,426
rum	1,306	907	341	307	273
coffee	95	311	48	27	28
bananas	--	--	1	133	1,210

Source: Hugh Tinker, *A New System of Slavery: The Export of Indian Labour Overseas, 1830-1920* (1974:36), published for the Institute of Race Relations by Oxford University Press.

abolition of the slave trade (1807) and the emancipation of the slaves (1833), impoverished Indian peasants and landless laborers were recruited by the hundreds of thousands to work under indenture on the sugar plantations of the West Indies and Guiana, of Mauritius, of Fiji, of Natal. They also emigrated under contract to work the coffee, tea, and rubber of Ceylon and Malaya. In 1917, "The labour force on the nearly 2000 tea gardens in Ceylon amounted to 385,000 immigrants from India, together with 89,185 Tamils born in Ceylon but descended from Indian immigrants" (Tinker 1974:33). The harsh conditions of these labor contracts, of which we will have more to say later in connection with rubber, has led Hugh Tinker to call his book describing this Indian overseas labor *A New System of Slavery* (1974). The British made sporadic attempts to regulate the worst abuses of the emigration system,

but for ninety years, 1830-1920, they promoted it, because it answered so well the frantic demands of colonial planters for cheap labor and at the same time reduced the number of underemployed or destitute men for whom the British-directed economy of India had no place. During more than two centuries as plantation owners in the West Indies, the British had become familiar with and their sensibilities hardened to this form of socio-economic organization, in which agricultural products are extracted by a captive or indentured labor force.

The Empire in the New World: Agriculture and Labor

Since the Iberian powers, first upon the scene in the sixteenth century, had conquered the most heavily populated and complex societies in the Americas, the British as colonists were forced onto the peripheries among simple societies which lacked an exploitable labor force and any significant trade items except the furs of the North American Indians. Rich (1967:306) gives a typology based on available labor force:

In the so-called 'colonies of exploitation' [the Far East] the minimum number of European administrators and traders have 'colonized' by adapting the native population to the needs and customs of European trade. At the other extreme, in 'colonies of settlement' European immigrants have themselves supplied the necessary labour. Between the two extremes, the immigrants have not been numerous enough to perform the whole work of production, nor have the native inhabitants been capable or willing to perform these tasks. The immigrants, as settlers rather than administrators, have been faced with the choice either of turning native peoples into their labour force, or of introducing to the colony their own alien labour force.

The British colonies of settlement lay in the temperate zones, especially along the North Atlantic seaboard in the New World where subsistence farming on a family basis was the norm, and later in South

Africa, and Australia. These areas did not become an important source of agricultural imports for Britain until after mid-nineteenth century, but the northern American colonies did play a role in colonial exchange by supplying food to the West Indies. The colonies where the labor force was inadequate and an alien, captive, labor force was introduced were the tropics and subtropics of the New World--the colonial south of the future U.S. with its tobacco, indigo, and cotton, and the sugar islands of the West Indies.

The history of the British West Indies suggests that it was not so much the climate as the crop and its market which led to the plantation system with its labor force of African slaves. Barbados and the Leeward Islands were originally settled about 1630, and Jamaica a little later (1655), by English small-holders and indentured whites who made a living from subsistence farming of wheat and corn, and who cultivated tobacco as a cash crop (Dunn 1973:6 and Rich 1967:339). But in the second generation of settlement, this European peasant society underwent a drastic change.

These infant outposts on the eastern edge of the Caribbean suddenly assumed a new significance in the 1640's when the English planters in Barbados--followed at a distance by the colonists in the other English and French islands--converted from tobacco to sugar production. This switch from a crop with minimum European market value to a crop with maximum European market value made the Barbados planters rich overnight. They consolidated their small farms into large plantations manned by squadrons of black slaves imported from Africa. The Barbadians were greatly helped by knowledgeable Dutch entrepreneurs who showed them how to process the cane, supplied them with Negroes, and bought their sugar to sell in Holland (Dunn 1973:19).

Rich also dates the importance of the West Indies to Britain, France, and the Netherlands to the same time and for much the same reasons:

The small-holding society gave way before the advent of the slave; tobacco and coffee gave way before sugar. The turning point came in the middle of the seventeenth century. The significant act was the withdrawal of the Dutch West India Company from its preoccupation with founding its own tropical colony in Brazil, and its turning to the economic development of the West Indian colonies of other western European nations, on the basis of the shipping, trading, slave-supplying, and sugar-growing techniques which it brought from Brazil (1967:340).

While it was technically possible to grow and process sugar in small family units, as some of the earliest Barbadian and Brazilian settlers did, it proved to be economically impossible to compete with slave labor once it had been introduced. The plantation system made the British West Indies for most of the eighteenth century the richest trading sector of the empire, slave-produced merchandise accounting for one-fourth of the imports into Britain 1713-1792 (Palmer 1950: 270-71). This is not to say that the islands were more profitable than India if plunder and taxation are included in India's net accounts; both the East and West Indies were making Britain rich. Cheap British products left the west coast ports like Liverpool and Bristol, were traded in an unequal exchange for African slaves on the Guinea coast, who were sold at the docks in Jamaica or Barbados, and the sugar they grew sold at a profit in England.

In the nineteenth century, the abolition of the slave trade, combined with competition from European beet sugar and the newly planted sugar tracts in Cuba¹ undermined the "splendid profitability"

¹In 1820 Cuba produced 43,119 tons of sugar; in 1870 726,000 tons (Rice 1975:279) on land which had previously supported cattle ranching and was "virgin" and highly productive of sugar. Puerto Rico also became a major sugar producer in the nineteenth century (Mintz, 1974b).

(in Rich's phrase) of the sugar islands. The East Indians introduced as laborers to the British Caribbean, especially Trinidad and Guiana, found themselves plunged into a desperate struggle for existence with the freed blacks in a declining economy (Tinker 1974). As the islands started to languish, their late-nineteenth century governors beseeched the officials in London for help in establishing a substitute agricultural base. These officials turned to Kew Gardens for ideas, as we shall see in Chapter VIII on sisal, but the scheme fell through, and the islands were forced in the twentieth century to subsist on tourism, though some sugar plantations on Jamaica were turned into consolidated, corporation-owned "overseas agricultural factories" (Mintz 1974a:50). In his extensive studies of the West Indies Mintz has always called attention to the industrial nature of plantation agriculture. Even the old-fashioned family owned plantations were heavily capitalist and tied to a world market.

The nineteenth century industrialization of Britain made it more profitable for her to put overseas investment capital into ventures such as building the railroad and harbor system in Latin America,¹ while buying sugar on the world market. In this, and in many other ways, Britain became increasingly involved in the successor

¹One indication of this heavy investment in the transport system of Latin America can be seen in British locomotive sales. Between 1890 and 1913 Britain sold 3090 locomotives in Latin America, more than in the empire itself, except for India. Sales to Europe were declining (to only 770) as the Western European nations (France and Germany) were also becoming manufacturers and exporters of locomotives. In 1914 foreign and colonial railways accounted for over 40% of British foreign assets, the largest single type of foreign investment (Wolff 1974:26-7).

states to the Spanish and Portuguese New World colonies. We have not outlined the colonial history and the organization of labor in Iberian America, because we have been concentrating on British colonialism. But the socio-economic structure of the nineteenth century Andean republics and of Brazil and Mexico is relevant to the role played by Kew Gardens in advancing the British Empire, since it was from these areas that the British made the seed-snatches of cinchona, rubber, and sisal, respectively, that constitute our case histories. What made the British feel they could violate the laws and the integrity of these countries, instructing their consuls to steal seeds from them? The answer lies in the divergent histories of the two parties (Britain and Latin America) which gave Britain such an advantage in power, prosperity, and stability over the Latin American societies.

Britain had not been colonized since Caesar's time, or at least since 1066, while the Latin American nations were just emerging from four centuries of colonial exploitation into a world political economy which gave all the trump cards to the industrialized nations, of which Britain was the first and foremost, with a strong state machinery, a strong naval arm, a strong and diversified economy, and a high technology with a growing scientific sector. For historical reasons, these structural factors were absent or minimal in the newly independent Latin American nations. After mid-nineteenth century they became, in varying degrees, part of Britain's informal empire, subject to its commercial and financial dominance, a source of raw materials for Britain and of lucrative return on its capital investments and monopoly rent on its technology. Latin America, with its extractive staples--

the nitrate of Chile, the hides and meat of the Argentine, the minerals of the Andes, and the rubber of the Amazon--and throughout the continent the need for a modern transportation system to move these staples, fitted neatly into a dependency relationship with British capital, but this same relationship kept its economies inflexible. There were other foreign investors, but Britain was predominant (Graham 1968, 1969). In the late nineteenth century Britain had reaped the benefits of its early industrialization, was being overtaken in industry by its rivals with newer industrial equipment and practices (e.g., the United States and Germany), and was starting to rely heavily on its entrepreneurial and financial skills and resources (Winks 1976: 547, and see Zeitlin 1972 *passim* for post-Industrial capitalism). Lacking political hegemony, Britain did not find informal arrangements with Latin America entirely satisfactory. There was nationalist feeling; collaborator groups were sometimes swept from power and another set had to be found (for a discussion of the problem of informal empire see Winks 1976). There was a special problem with those products like cinchona and rubber which came from thinly populated and relatively inaccessible areas where the labor force was small and hard to control. But these plants could be transferred--and therein lies my story--to the South Asian colonies where imperial policies had created a huge pool of underemployed labor.

Part of the success of the Empire was due, as Griffin points out in regard to modern developed economies in general (1976), to this flexibility, the ability to shift capital to the sector or region where it would be most productive in light of current demands. We

have seen how over the centuries of expansion, British interest shifted from importing Asian pepper and spices to importing West Indian sugar, then back to Asian tea. When rubber became interesting to industry after mid-nineteenth century, it was natural to the British to think in terms of moving the site of primary production to their own colonies. Their capital was fluid, their botanists were acquiring world-wide experience, and in a very concrete way, seeds and plants are moveable as mines are not. In the next chapter we provide an overview of the many seed-transfers undertaken by the West which have changed the world patterns of plant distribution and contributed to Western economic strength.

Chapter III

Seed and Plant Transfers

The greatest service which can be rendered to any country is to add a useful plant to its culture. . . .

--Thomas Jefferson

Brazilian agronomists from the state of Piaui recently reported that Australia was exporting for sale to the whole tropical world including Brazil several species of forage grass (genus Stylosanthes) which had been taken out of Brazil at some unknown time, improved genetically, and put on the market as Australian grass (Journal de Brasilia, 7 March 1976). The Brazilian response is to initiate a research and development program on their native forage grasses, the base of a cattle industry in large areas of the dry Nordeste. But they resent the expropriation without recompense or acknowledgment of one of their natural resources. There is no reason to suppose that piracy was necessary, that Brazil would have opposed an open, mutually beneficial development of the pasture grasses. But ethical attitudes toward wild seeds have been slow to develop. Botanists and botanical gardens since the eighteenth century have been collecting at will in the name of science, the spread of new cultivars has been generally thought to be in the human interest, and the developed countries have given little thought to the loss sustained by the country of origin of the plant. The above case

is clear-cut, if the report is correct, because the territorial integrity of Brazil was infringed in the deception, and both nations have scientific establishments through which fair arrangements could have been made.

Seeds have been one of the most precious and easily transported cultural artifacts. Long before botanical gardens came into existence, seed and plant transfers were taking place through anonymous culture contact in migration or local trade, or through long-distance trade and voyages of discovery, recorded and unrecorded. Kent Flannery hypothesizes that transhumant bands of food collectors were instrumental in domesticating the first grains in the Middle East over ten thousand years ago by the mere process of carrying them from a niche that was hard to reach, such as the talus below a limestone cliff, to one that was more accessible, such as the disturbed soil around their camp on a stream terrace. In the new niche, the pressures of natural selection were relaxed and human selection was applied (1969:273). This principle underlies all successful seed transfers. In a new environment selected and shaped by humans, the plant's natural competitors and enemies are left behind, and human attention tries to ward off new ones. In the seed transfers discussed in this chapter, many plants were moved on long-ago migrations, many plants were the stimulus for exploration, and not a few for exploitation.

Our purpose here is to describe those seed and plant transfers which contributed to the development of the West and its political and economic expansion into the rest of the world in search of food

supplies and raw materials. In the centuries following the discovery of the Americas in 1492 there took place a transfer of plants from the Old World to the New and from the New World to the Old, aptly called "the Columbian exchange" by A. W. Crosby (1972), which had profound effects on world population through the increase in food supply, on world trade through the new plantation crops, and on world dominion. We intend to make the following points: 1) New food staples increased population on all continents, but with different results. An industrializing Europe was strengthened by a rising population. In spite of the new crops, the old agrarian empires of Asia were strained by swollen populations, and much of their manpower, as well as that of the New World, was harnessed to serve European ends. 2) Except for staple foods, the exchange of tropical plants between the two hemispheres was carried out predominantly by Europeans under the plantation system, a system of commercial agriculture oriented toward export and based on a coerced or servile labor force. In this system of production and marketing, Europeans made all the rules and reaped the profits, thereby accumulating capital for the development of their industrial societies while deforming the societies which supplied the raw materials and labor. 3) In the modern era plant transfers became increasingly formalized. Anonymous diffusion continued, but European governments, chartered trading companies, and private industry made a conscious effort to collect useful plants. Botanic gardens were established or enlarged to receive, nurture, classify, and transship exotic plants. By mid-nineteenth century they were strong enough to take over much of the work of exploring and

collecting, and had acquired the technical ability to improve and adapt plants for commercial production. (4) the European governments competed with each other, each trying to establish botanical monopolies and to break the monopolies of their rivals. Competition was a spur to plant development.

New Food Staples

The basic food complexes of the pre-Columbian world were very old, having been established in the Neolithic era, roughly 10,000 to 2,000 B.C. The domesticated cereal grains of the Middle East--wheat, barley, and the secondary crops such as oats and rye which went along as weeds--spread across the temperate zones of Central Asia as far as China, and eastward across Europe. A separate Asian complex of millet, rice, and pulses spread through China, Japan, and India. From tropical Southeast Asia the Malaysian complex of tree and root crops (coconut, taro, yams, and plantains) was carried overseas to East Africa and then spread into the West African forests, while in the Americas a separate and original food complex based on maize, beans, and squash was spreading both north and south from its centers of origin in Mexico and Peru.

In historic times European agriculture improved in technology but it did not add any significant new staple to its basic cereals--wheat, barley, oats, and rye. The post-Christian era saw the introduction into Europe of rice, sorghum, and buckwheat through Arab intermediaries (Masefield 1967:275). These plants were useful in localized areas, e.g., rice in the Po Valley and buckwheat in Alpine zones, but they did not become true staples in Europe.

On this cereal base European population increased slowly-- until the great post-Columbian exchange of staple crops between continents. Between 1650 and 1850 Europe's population grew from an estimated 103 million to 274 million, that of the New World from 13 million to 59 million, and of the world entire from 545 million to 1,171 million (Crosby 1972:166), a doubling on all the continents except Africa and Oceania. Grigg (1974:6) uses a slightly different breakdown of time periods, but the figures he presents show the same tendencies.

Table III.1
Regional Increase in Population, A.D. 14-1900

Region	14	600	1000	1340	1500	1700	1800	1900
North Africa	11	4	4	5	6	2	5	27
Rest of Africa	12	33	46	65	79	97	95	106
North America	3	7	13	29	1	1	6	82
Latin America					40	12	19	74
East Asia	80	65	80	89	131	201	391	586
South Asia	70	75	70	75	79	200	190	297
South West Asia	34	26	22	22	15	13	13	43
Europe	39	24	44	90	82	112	179	430
Oceania	-1	1	1	2	2	2	2	6
World	256	237	280	378	427	641	890	1651

Wars, plagues, and cultural practices all affect population size, but ultimately an increasing population must depend on an increased food supply. However, in many parts of the colonized world, this was accompanied by a drop in the per capita food consumption. Firm statistics are scarce, but see the table for certain districts of South India on page 36; and Griffin (1969:44) estimates that total food consumption in Algeria in 1863 was perhaps five or six

times what it was in 1954. The French brought new crops to Algeria, principally grape vines and commercial citrus groves, but indigenous food crops suffered under an export-oriented economy.

The Columbian exchange was a two-way street. Wheat arrived in the New World, along with olives, chickpeas, melons, onions, radishes, salad greens, grape vines, sugar cane, and citrus fruits, in 1494 on Columbus' second voyage when he brought seeds and cuttings to Hispaniola. Many of these plants failed in the climate of the Antilles, but by 1600 all of them were being widely cultivated on the mainland (Crosby 1972:67; 106). The significance of wheat in the New World before 1850 is that except in a few areas of the coastal tropics, it fed all the European immigrants, who would not have settled in such numbers without the prospect of their accustomed daily bread. After 1850, when the prairies and pampas were planted, New World wheat began to feed the Old World (see Grigg, 1974:256-283 on large scale wheat production).

Rice, brought from Asia to Europe by the Arabs, assumed a greater importance in the New World than in Europe, both as an item of staple diet for millions in Latin America and as a plantation export crop from which Europe gained profits.

New World Staples in the Old World

The New World food plants brought back in Spanish ships undoubtedly changed the world as much as all the bullion they carried. The most important of these was maize or Indian corn. Columbus took maize (Zea mays) to Spain on his first return voyage; Spanish and Portuguese mariners took it eastwards, where it helped to produce

a population explosion in sixteenth and seventeenth century China, since it enabled the Chinese to cultivate the dry uplands, beyond the reach of irrigation, where rice would not grow. Maize was first mentioned by a Chinese writer in 1555 (Ho 1955:194).¹ According to population studies by Ping-ti Ho (1959), China's population, which had been fairly steady for several centuries, rose between 1540 and 1640 from 62 million to 150 million and reached an estimated 430 million by 1850. Maize, and the American sweet potato and peanut which came the same route, were not an unmixed blessing to China, since in extending cultivation on the hillsides to accommodate the new crops and to feed the increasing population, much old forest-cover was cut down, resulting in erosion for which the government had no control program. Floods, while not new, increased in severity and disrupted plains agriculture. A swollen population at bare subsistence level added to the problems of the Manchu government and made China vulnerable to Western intrusion in the nineteenth century.

In Europe maize became a human staple food in localized areas around the Mediterranean basin, i.e., in parts of Spain, Portugal, northern Italy, Greece, Rumania, Hungary, and Yugoslavia. Because maize grows well on land too dry for rice and too wet for wheat (Crosby 1972:171), it filled an under-exploited niche. Maize is adaptable to many climatic conditions, because of its many varieties, and it was often planted in rotation with wheat in what had been a fallow season. It has the further advantages of a high yield per acre

¹Detailed treatment of New World crops in China can be found in Ho (1955) "The Introduction of American Food Plants into China," American Anthropologist, 57, 191-201.

and a short growing season, and when not eaten by man maize makes good livestock feed, so that Europeans could eat more meat.

The Andean or white potato (Solanum tuberosum) found little acceptance among the Castilian conquerors, but it was known in Spain by 1573 and was cultivated in a private botanical garden in London in 1596 (Masfield 1967:278). Within fifty years it was the staple food of Ireland, grown by peasants whose landlords sold their wheat for export. In England potatoes were first fed to pigs, but in the eighteenth century they became the subsistence food of the poorest stratum, both urban and rural, as they did in Belgium, the Low Countries, the Rhineland and Prussia. The historian William Langer points out that potatoes were the perfect crop for small peasant holdings because potatoes were suited to hand cultivation. They matured quickly and because of their high caloric yield per acre, one acre planted to potatoes could feed a family of five or six people plus a pig or cow for a whole year except for the summer months (Langer 1975:54). Langer concludes that potatoes and maize were largely responsible for the near doubling of Europe's population in the century 1750-1850 from an estimated 140 million to an estimated 266 million (Ibid:51).

William McNeill is another historian who attributes an extremely important role to the potato in providing the increased food supply needed in the industrializing zones of Europe. He cites the reliance of Western Europe on the grain supplies imported from the Eastern European plains, and the general improvement of farming methods, as for example through the use of chemical fertilizers and better seeds,

and then says:

But the spread of two American food crops--potatoes in northern Europe and maize in the hotter and dryer south --was the single most important step in increasing Europe's own food production. In the early stages of the industrial revolution, potatoes were particularly important, since in the climate of northwestern Europe (and especially in sandy soils ill-suited to grain) potatoes yielded up to four times as many calories per acre as had been attainable before. In particular, Germany's industrialization would have been impossible without the burgeoning potato fields that spread throughout the country from the time of the Seven Years' War, 1756-63 (1974:159).

Dr. Thomas McKeown has just published (1976) a comprehensive study of the modern rise of population in which he concludes that improvements in medical and agricultural technology were far less important than has been believed, and that the major factor was the increase in the food supply through the widespread cultivation of the white potato in northern and central Europe and of maize in southern Europe. Dr. McKeown also gives major weight to the decline in infanticide in nineteenth century Europe. The role of infanticide and calculated neglect of children (necessarily hidden from contemporaries and thus from historians) in keeping down family size in pre-modern Europe is now being brought to light. Similarly, the European suppression of infanticide among the peoples they conquered and colonized should also be accounted a factor in the world-wide rise of population in the nineteenth century and the increased pressures on many local environments, often countervailing the effects of the new food crops.

The potato was carried back across the Atlantic, perhaps by the Spaniards to Florida and thence to Virginia, and certainly in 1718 by the Scotch-Irish to New England (Crosby 1972:66). Thereafter the potato

helped to feed the European settlers of the northern hemisphere. Today the United States produces about fifteen million tons of potatoes annually out of a world crop of over 300 million tons (Sokolov 1975:78). These figures give some idea of the impact of just one New World crop, with a limited distribution in the Andes, on northern Europe and its Western offshoots.

Maize, too, fed the early settlers of the future United States, and has become a commercial crop of great importance there, mostly as livestock feed to be consumed in the form of meat.

Tropical Zones

Maize also went to West Africa, as did the tropical Latin American roots, cassava or manioc (Manihot esculenta) and the sweet potato (Ipomoea batatas), carried perhaps on the return voyages of slave ships and planted to serve as a source of food for the slaves on the passage out of Africa. These new crops contributed to the reversal of the decline of Africa's population caused by slave trading and to an eventual increase in Africa's population. Maize is much the most nutritious of the three and cassava the least (only 1% protein), but cassava has the advantage of being easily stored in the ground, growing in poor soil, resisting drought, and of escaping locust damage, so it became a famine reserve crop. Today Africa produces as much cassava as the rest of the world combined (Heiser 1973:147), although farinha or manioc flour is a staple food of millions of Brazilians, both rural and urban. Since the sixteenth century, when Portuguese settlers learned how to grow and process manioc from the Amerindians who presumably first domesticated it, farinha has sustained Brazil's cane-cutters,

goldminers, rubber tappers, cattle herders. Manioc will produce more calories per unit of land than any other staple (Crosby 1972:175), so manioc is a poor man's food, both in its native Amazon regions and in Africa. Cassava plants were grown in the Pamplemousses Gardens on Mauritius in 1736 and in the Calcutta Botanic Gardens in 1794 (Masfield 1967:285). It was not quickly or widely adopted in the East, but today manioc is one of the principal staples in the south Indian state of Kerala, where it yields 11.6 million calories per hectare (Crosby 1972:193), twice as much as rice, and it is the third most important staple in Indonesia, after rice and maize, being planted in soils too poor for rice (Heiser 1973:147).¹

The third New World staple to circulate widely in the warmer zones of the East is the sweet potato. In the last century these three American crops, maize, manioc, and the sweet potato, have increased in importance relative to rice, which alone could not have fed the rapidly growing population.

The sweet potato was carried by the Spanish Pacific fleets to Guam, Malaysia, and the Philippines in the early sixteenth century. From the Philippines it was carried home by Chinese traders, where it helped to prevent a famine in Fukien in 1594 and a century later it went from China to Japan (O'Brien 1972:346). The Portuguese took the sweet potato from Brazil to Macao, and are responsible for its introduction to their many trading stations on the Malabar Coast of India, in

¹Poor soils yield less nutritious crops. In Kerala, South India, studies are underway to determine if the widespread consumption of manioc is causally related to an alarming increase in juvenile diabetes.

Ceylon, the Moluccas, and the Celebes.¹

Today the sweet potato is an important crop in Latin America, the United States Southeast, in China, Japan, and Taiwan. Japan grows ten times as many sweet potatoes as the United States. In addition to being high in vitamin A and minerals, the sweet potato has the advantage in Japan and Taiwan of withstanding the typhoons which destroy the rice crop from time to time (Heiser 1973:144).

Plantains, the starchy non-sweet varieties of bananas (Musa species), are a staple food in many parts of the tropics, providing an easy-to-grow source of carbohydrates, but not much protein (4% by weight). The banana/plantain probably originated in Southeast Asia, and is recorded in India in 500 B.C., although it is thought to have been cultivated long before then (Heiser 1973:158). Alexander the Great brought news of the banana to Europe, and around the time of Christ the banana reached East Africa as part of the Malaysian complex. In 1516, the banana reached the Caribbean Islands via the Canaries and soon spread to the mainland (Crosby 1972:68). It became so well-adapted in tropical Latin America that it is often regarded as an indigenous plant. The Yanomamo Indians at the headwaters of the Orinoco in Venezuela and Brazil have grown plantains as their subsistence crop for longer than they can remember (Chagnon 1968:33), and it is probably due to the plantain that their population expanded so rapidly that it strained their social organization and made them "the fierce people" (Harris 1975:278). Since the plantain was the only

¹The distribution of the sweet potato in Polynesia has led to theories of pre-Magellan contact from the west coast of South America. O'Brien in a careful review article (1972) concludes that the transfer did occur, but probably accidentally.

European-derived cultural item to be adopted by the Yanomamo until the last few generations when missionaries brought the steel ax, this situation highlights the changes which can accompany the introduction of a new staple food crop. But the most important role of plantains in the Americas was to sustain the slave populations on the sugar plantations of the Antilles and the adjacent tropical coasts. Today plantains are an important item in the diet of the peoples in these same areas, but they have not entered the international market to any great extent, as the sweet banana did after mid-nineteenth century, when the North American companies carrying bananas in their refrigerated ships made themselves the paramount investor, employer, and de facto government of several of the Central American republics.

Legumes

Legumes in combination with grains provide the necessary protein where meat is unavailable or too expensive. They were especially important in the pre-Columbian New World where domestic animals were rare but many varieties of legumes were cultivated. Beans appear in the archaeological record as early as 7,600 B.C. in Peru, and soon thereafter in Mexico. The common bean, the tepary bean, the scarlet runner bean, and the lima bean are among the New World varieties brought to the Old World during the period of European expansion. Jacques Cartier introduced the common bean (Phaseolus vulgaris), now often called the French bean, to France on his return from his second voyage to Canada in 1535. All of the New World beans have larger seeds than the Old World beans, and for this reason they were welcomed (Baker 1970: 97).

The peanut (Arachis hypogaea) is another legume transferred from the New World to the Old World, probably in Portuguese ships, to West Africa, India, and China. World production is still centered in these areas, where the peanut is a valuable source of protein.

Containing 38% protein and 18% fats and oils, the soybean (Glycine soya) is one of the most nutritious foods known, and has long been a major source of protein in the Orient, where it is eaten as a paste or curd. The soybean is the most important legume to travel from east to west--from China where it was cultivated in ancient times to the United States in 1804. It did not become a commercial crop until the 1920s, when the introduction of one thousand strains from the Orient allowed plant breeders to select for improved varieties. The introduction of the soybean was the greatest success of the Office of Foreign Seed and Plant Introduction of the Department of Agriculture, established in 1898, which was also responsible for the grapefruit and avocado industries but had many failures among the more than 30,000 varieties and species of foreign plants it imported (Sokolov 1977). Today the soybean is a major US crop, used as animal fodder and vegetable oil, and as a vital ingredient in US foreign policy as the US decides when, how, and where it shall help in feeding a hungry world.

This plant transfer is, strictly speaking, not relevant to the colonial world, but to the neo-imperialism of the post-colonial world. It is a prime example of the application of science to agriculture in an industrial setting, and illustrates the different roles a plant can play in different human ecological systems: bean curds in China; livestock food in the West. The conversion of solar-derived

energy through plant photosynthesis into meat on such a large scale is a luxury only the profligate West can afford.

Forage

One of the strengths of early modern Europe which contributed to its expansion and gave it a special advantage in the conquest and settlement of the New World was its complement of domesticated animals, useful in warfare, as a multiplier of human energy, and as a concentrated source of protein. Winter forage was a necessity in the North European system of mixed-farming in which livestock was valued for traction, manure, and hides as well as meat, milk, and cheese. Seventeenth and eighteenth century husbandry in the Low Countries and England benefitted from the introduction of the turnip as a forage crop and from improved cultivated varieties of Eurasian grasses. Many more cattle could be carried over the winter. With fresh meat available in winter, pepper and the other preserving spices lost much of their importance.

Alfalfa (Medicago sativa) became an important forage crop in North Europe at the same time. According to archaeological evidence dating to 4000 B.C., alfalfa originated in Iran; it was brought to Spain by the Moors, spread northward in Europe slowly, and was taken to America by the early Spanish colonists. As well as providing food for animals, alfalfa and other legumes are valuable as soil builders, since their roots attract nitrogen-fixing bacteria of the genus Rhizobium. Clovers, of the same family Leguminosae, are generally of Old World origin, and have spread wherever European colonists have taken their temperate-zone mixed-farming system.

Mixed-farming, with its built-in dietary balances and animal supplements to human energy, provided a strong base in the European colonies where climate allowed it to get a foothold and social conditions favored it. New England is a prime example. But even there, grasses imported from England saved many colonial settlements from extinction, since their cattle would otherwise have died over the first winters, the native grasses making poor hay. American grasses in the northern latitudes were adapted to a short growing season, but English species from a warmer, moister climate lasted longer in the fall. The famous Kentucky blue grass is of English origin.

Australia and New Zealand are other British colonial offshoots where mixed farming was transplanted. Australia is known as ranching country, but technically speaking, where cultivated grasses are used as pasturage, the system is one of mixed-farming, and that is the case in many parts of Australia today. Both Australia and New Zealand are heavily dependent on cultivated grasses to support their export-oriented grazing economies. New Zealand dairy products, principally butter, come from cows which can graze outdoors all year long--on imported European varieties of grass (Grigg 1974:190). In modern times (post World War II), the Australian government has actively sought out grasses and clovers adapted to arid conditions, sending botanical expeditions to the Mediterranean countries for this purpose (Baker 1970:28). We have already discussed the Australian appropriation of certain Brazilian grasses (page 49), the better to serve their wool and meat industry.

A mixed-farming wheat and alfalfa rotation spread over the

humid pampas of Argentina after 1875, when large estancias were worked by share-cropping tenants, often Spanish and Italian immigrants. The grain and forage crop area reached 2,5000,000 hectares by 1929 and the value of Argentine agricultural exports peaked in that year at \$2 billion in present day dollars (Grigg 1974:279). Since then Argentine meat and wheat have been losing ground in the world market, as agriculture in Europe, its major market, has increased in productivity through the intensive application of scientific technology. Argentina's main competitor, Australia, has also made a greater investment in scientific agriculture, directed to cultivated grasses, wheat varieties, sheep and cattle breeding, and pesticides.

Discussion

The changes in the staple food complexes which took place after the late fifteenth century contact between the Old World and the New led to a marked increase in world population, a doubling by 1850, before mechanized agriculture was applied, and another doubling in the next century. During this time Europeans invaded and settled the two continents of the Western Hemisphere (plus Australasia and South Africa), bringing with them wheat as their major staple, forage crops for their animals, rice, plantains, and certain beans. They accepted the American potato, maize, manioc (locally), and beans. Some of these plants sustained the European settlers, some the American Indians and African slaves who worked for them. Some, like the white potato and maize, went back to change the diet of Europeans, while the maize, sweet potato, peanuts, and manioc went to increase the food supply of the peoples of Africa and Asia from whom the Europeans were trying to

extract wealth either as slaves or in trade goods.

Since medical technology did not improve before 1850, and agricultural technology while improving did not change radically, we are confident that the major factor in this population increase was the advent of new crops in many parts of the world. New crops are effective because they can fill underexploited environmental niches, with their slightly different requirements of soils and seasons, e.g., potatoes in the sandy soils of northern Europe, maize in Egypt, China, the Punjab, upland Java and the Outer Islands, peanuts in the West African arid savanna and in India, or timothy hay in New England. New crops can withstand hazards that fell the standard crops, e.g., the sweet potato root in Japan unaffected by typhoons or the manioc root in Africa safe from locusts, and new crops can add some nutritional elements previously scant in the traditional diet. Both quantitatively and qualitatively, the diet of the world's peoples was enhanced by the post-Columbian exchange of plants described above.

Plantation Crops

We now turn to other foods whose importance was less nutritional than economic, the tropical crops like sugar and spices, coffee and tea, which were imported to Europe to add pleasure and variety to the European diet, and which were usually grown on plantations by a captive or coerced labor force. The plantation as a form of agricultural organization is a mark of European colonialism, both cause and effect of European expansion. Trade in tropical commodities allowed England and the Netherlands to accumulate capital for their later industrial

expansion, and their re-export trade of products from the East and West Indies paid for vital imports from Europe such as timber, naval stores, and high-grade iron ore (Cipolla 1976:270). By the seventeenth and eighteenth centuries, the traditional markets in Europe for English woolen cloths did not have much room for expansion, but the demand for sugar was soaring.

Sugar

The cultivation of sugar cane (Saccharum officinarum) probably originated in India, though perhaps farther east in Indonesia (Deerr 1949). The cane was introduced from India into Egypt and Syria by Arab merchants; from Egypt it passed to Cyprus in the tenth century and to Sicily in the eleventh century (Braudel 1972:I:155). Our concentration on the post-Columbian exchange of plants should not lead us to ignore the contributions of the Arabs, who, in their multiple roles as traders, conquerors, and farmers, brought many plants of Asiatic origin to medieval Europe. Between the fall of the Roman Empire and the voyages of Columbus and Vasco da Gama, the Arabs were the main agents of plant diffusion in the world (Grigg 1977:26). We have mentioned rice, but citrus fruits, cotton, and sugar were also grown around the Mediterranean by Europeans who learned from the Syrians, Moors, and Egyptians with whom they contested the region. Venetian merchant bankers in the fourteenth century invested large sums in sugar and cotton plantations on the eastern Mediterranean islands of Cyprus and Crete, copying Arab irrigation methods and using a slave labor force imported from the Black Sea hinterland or the Balkans. The Cornaro family, the wealthiest family in Venice, owed

its preeminence to its sugar plantations on Cyprus, a base of wealth which allowed it to rise above the level of those who were merely traders (Lane 1973; McNeill 1974). In the fifteenth century, the Portuguese prince, Henry the Navigator, had sugar cane brought from Sicily to Madeira, which had been discovered by his seamen in 1420. Madeira soon became a sugar island, as did the Canaries, the Cape Verde Islands, and the Azores. Braudel describes the effect of this foreign crop and plantation economy on the islands of the "Mediterranean Atlantic":

Madeira, the Canaries, São Tomé were all literally ravaged by the monoculture of cane sugar, as colonial north-east Brazil was to be later. Madeira, which was originally a timber island, rapidly lost the major part of its forest cover to the sugar mills and their need for fuel. This revolution was carried out entirely in the interests of a Europe which was clamouring for the precious sugar and not in the interests of the islands themselves. For the tragedy of sugarcane is that wherever it is grown it prevents the growing of other crops in rotation and restricts the space available for food crops. This new arrival completely upset the old balance and was the more dangerous since it was protected by a powerful capitalism which in the sixteenth century was lodged in many quarters, in Italy, Lisbon, and Antwerp. And it was impossible to offer resistance. In general, the island populations were unable to withstand this drain on their resources. In the Canaries, sugar was almost certainly as responsible as the brutalities of the first conquerors for the disappearance of the indigenous natives, the Guanches. And it was the sugar plantations which generalized the use of slave labor, leading to the enslavement of the Berbers of the African coast, whom Christian pirates from the Canaries would carry off in their raids, and particularly in the slave trade in Negroes from Guinea and Angola, which in the middle of the century, again because of sugar, reached the shores of the Atlantic continent (Braudel 1972:I, 155).

This century of experience in cane cultivation prepared the Spanish and Portuguese for their ventures in the New World, where the Spanish started sugar plantations on Santo Domingo in the 1520s and

the Portuguese at Olinda, on the coast of northeast Brazil, in 1535 (Deerr 1949: Brasil/Açúcar 1972). Sugar cultivation in the New World had the same consequences as on the Atlantic Islands—but on a much larger scale. The native Indian populations, Carib, Arawak, Tupinamba, were wiped out; whole islands were deforested; much land despoiled; and millions of Africans captured and forcibly transported to work the sugar plantations. Europe was avid for sugar, and by the eighteenth century, when British, French, and Dutch production in the Caribbean Islands and on the Guiana coast had been added to the Brazilian production, sugar ceased to be a luxury product and became a common article of trade.

Sugar is also an example of the interdependence of the highly centralized and industrializing core area of Western Europe and the tropical periphery. Production and milling, done with labor imported from Africa and machinery imported from Europe, took place in the New World tropics, but refining and marketing, as well as financial control of the trade, remained in European hands. In 1556 Antwerp had 19 sugar refineries; in 1660 Amsterdam had 60. In 1750 Hamburg had 350 refineries, and England over one hundred (Masefield 1967:293). Warehouses, mercantile houses, banks, and marine insurance companies grew up to serve the needs of the trade.

Sugar also benefited from European research and exploration. The French navigator Bougainville brought back the thick or "noble" canes from Tahiti on his round-the-world voyage in 1767-69. They were planted in the French colonies of Mauritius, the Reunion Islands, Martinique, and French Guiana. From French Guiana they spread to

Brazil, where they greatly increased the production per unit area of this important sugar region. One of the advantages of the new canes was their ability to withstand hard winds that would flatten the thinner stalks of the older variety. Captain Bligh, commissioned by the British government to bring back breadfruit from Tahiti as a possible food for slaves, brought back the thick canes too. The breadfruit experiment was a failure, but the new variety of cane spread from Jamaica through the British sugar islands (Masefield 1967:293).

Spices

The only spices of New World origin to become common in the Eastern Hemisphere are the vanilla bean (the seed pod of an orchid), and the pimento and other varieties of capsicum peppers, taken by Columbus to Spain. The hot varieties of Capsicum, often called chili peppers, are now grown in Africa, India, and parts of China to flavor stews and curries, an indispensable part of the cuisine and a source of vitamins.

Grenada in the British West Indies is called the Spice Island now, producing most of the world's nutmeg, and some cloves and cinnamon. But the story of spices begins in Southeast Asia and India. The spice trade from India, Ceylon, and Indonesia to the West is ancient, cinnamon being mentioned in the Bible and known to the Egyptians and Romans for use in embalming. Pepper was also in much demand for use in medicine as well as in seasoning and preserving foods. Pepper and cinnamon were both grown in the Malabar coast of India as well as on Ceylon. In this ancient trade all the spices from the islands were shipped to the west coast ports of

India, from there taken by Arab traders to Egypt, and transshipped to Rome. The expense of the journey guaranteed that spices were a luxury item in the ancient and medieval worlds. Furthermore, the Arab traders concealed their sources from Europeans throughout the Middle Ages, although the Chinese traded directly with India and Indonesia for spices all this time. European desire for spices, especially pepper, stimulated the late fifteenth century voyages of discovery of the Portuguese and of Columbus. During the sixteenth, seventeenth, and eighteenth centuries first the Portuguese and Spanish, then the English, the French, and the Dutch vied for control of the sources of these spices--India, Ceylon and the original Spice Islands, the Moluccas. In India, which grew much pepper, French competition against the English was effectively ended in 1754, when the French government withdrew the Governor of Pondichéry and the field was left to the British East India Company under Robert Clive. In the islands of Indonesia, the Dutch had prevailed over the other Europeans in the seventeenth century, and had a monopoly on the spices from the island, the only source of cloves, nutmeg, and mace, a spice made from the extra covering over the seed of the nutmeg fruit. In their zeal to regulate the production of spices so as to maintain artificially high prices, the Dutch in 1621 ordered all clove and nutmeg trees in the Moluccas cut down except on the islands of Amboyna, Ternate, and Banda, reducing the crop to one quarter of its previous size (Baker 1970:35). In 1656 they forced natives to plant 120,000 young nutmeg trees on Amboyna, and again in 1692 to cut many of them down (Masefield 1967:289). In 1760 mace and nutmeg were burned in

Amsterdam wharves to maintain prices, an extreme example of monopolistic restraint of trade. Most tropical products like sugar and tobacco starting as exotic luxuries faced problems of overproduction and periodic slumps in prices as new lands came into production. But the Dutch held out for monopoly prices as long as they could.

Eventually, however, smugglers at great risk got spices out of the Dutch possessions and spread them to other parts of the world. Assisting in this process was the replacement of Dutch rule in many areas in the Indian Ocean by British administration, and the replacement of the Dutch East India Company as a trading power by its British equivalent. Thus, nutmeg became established in Penang, in Malaya, and particularly in Grenada, in the British West Indies. Cloves were successfully grown by the French in Mauritius and Réunion in 1770; they were carried from there to the British East African colony of Zanzibar and the neighboring island of Pemba, where the vast majority of the present-day clove plantations are located (Baker:38).

In 1755 pepper and cinnamon were smuggled to Mauritius by the French traveller Pierre Poivre and established in the Pamplemousses Gardens.¹ Fifteen years later, as Intendent of Mauritius, Poivre sent expeditions to the unfrequented coasts of the Moluccas for cloves and nutmeg, which he distributed to the French colonies of Réunion, the Seychelles, and French Guiana. But the French were more or less knocked out of competition by the Napoleonic Wars, and the main sources of the spice trade remained in Dutch and British hands. The British took Ceylon from the Dutch in 1796, thereby capturing the cinnamon monopoly, which they kept until 1832 and the advent of free trade (Masefield 1967:289).

¹Although poivre is the French word for pepper, I have found no indication that Poivre was anything but his natural family name. But, since he went as a young man on a private voyage to the Far East, perhaps his family was in the spice trade and had acquired the name in that way (La Grande Encyclopédie). Pamplemousse, however, does mean "grapefruit."

Beverages: Coffee, Tea, Cocoa

By today's standards the ancient world was poor in beverages, although almost everywhere an indigenous beer or wine was made from the fermentation of any of a myriad of vegetable sources--grains, fruits, the juice of the palm, etc. But the coffee, tea (except in China), and cocoa so popular today had to wait for the post-Columbian Western expansion before they were widely consumed and diffused from their place of origin. Before that, the most notable diffusion was the wine grape, which had spread in ancient times from Southwest Asia to Europe where a flourishing wine trade developed.

The Arabs domesticated coffee (Coffea arabica), a tree native to Ethiopia, and introduced coffee to India, where the Dutch found it and planted it in 1659 on Ceylon and in 1696 on Java (Masfield: 284). One coffee plant from Java reached the Amsterdam Botanic Garden in 1706 and from this one tree most of the coffee plantations of the New World are descended. Seeds from this tree were sent to Surinam about 1715; coffee trees went from Surinam to French Guiana and then in 1727 to Brazil, where a great coffee industry was established (Baker:110). Seeds from that same tree in the Amsterdam Botanic Garden also went to the Jardin Royal in Paris and from there to Martinique in 1723 (Masfield:284).

Even before the New World industry made coffee a common beverage for home consumption, the coffee house as a politically and socially important institution had arisen in mid-seventeenth century England. Here the exotic drink from Arabia was served in public houses to a clientele, exclusively male, who were the opinion makers of their day. While the press was regulated by the government

the coffee house served as a news center. By mid-nineteenth century the English coffee house had lost much of its political importance, but on the continent and in the Near East the café continued to be a meeting place of political and social importance.

Brazil, Colombia, and Java continue to produce the most desired coffee beans on the world market. In the twentieth century West Africa has joined them as a major source of raw coffee, but in West Africa the small farmer predominates over the plantation as the producing unit.

Tea

As a social gathering place the English coffee house was rivalled in the eighteenth century by the tea house, which was open to women as well as men and provided entertainment as well as tea. The popular Vauxhall Tea Gardens were opened in 1732. Tea, made from the young leaves of Camellia sinensis, was a very ancient drink in China, but unknown in the West until the early seventeenth century when the Dutch had the re-export monopoly from their Indonesian bases. The first direct tea shipment to England was in 1669, and the British East India Company thereafter had a monopoly on the English and North American tea trade, which was heavily taxed. In 1703 one hundred thousand pounds of tea were imported into England, and it is estimated that half again as much was smuggled in (Masefield 1967:298). As already mentioned, in 1848 after the Opium War, a British botanical mission succeeded in bringing tea plants to India where large plantations were established with the help of Chinese experts in tea cultivation, and about the same time the British also domesticated the native teas

of Assam. Large estates in Assam were worked with indentured laborers from Bengal and Bihar, while Tamil laborers went to work the tea estates established on Ceylon. India and Ceylon remain today the main sources of the export trade in tea, perhaps because of heavy British consumption. Kenya and Rhodesia have also become significant tea producers, with the right climatic conditions in the highlands, a British tradition of settler-planters, and an African labor force. More tea is drunk today in the world than coffee, but tea has not become a New World crop. Imports are heavy in Canada and the United States, but many Latin Americans prefer local beverages such as maté, a tea made from Ilex paraguensis, popular in Brazil and Paraguay.

Although in general the imported food products which became newly available to the industrializing West after the establishment of the plantation system and the world-wide expansion of its market helped to diversify the diets of fast-growing populations, they did not always result in nutritional improvement. Tea-drinking, which was widespread among the laboring classes of Great Britain as early as the eighteenth century, illustrates the deleterious effects on the diet of two social processes--1) in the southern counties, the agricultural enclosures and the loss of rights to common lands, which often deprived the agricultural laborer of his cow and all its valuable products, including milk; and 2) the industrialization of the Midlands, which was pauperizing the workers drawn into the towns and cities. The upper classes, putting the cart before the horse, complained of the extravagance of the poor in drinking an imported luxury, tea. Hamilton (1948:74) quotes from Davies' The Case of

the Labourers in Husbandry, 1795, in defense of the poor: "Wherever the poor can get milk, do they not gladly use it? And where they cannot get it, would they not gladly exchange their tea for it? . . . Tea-drinking is not the cause, but the consequence of the distresses of the poor."

In 1863 the Privy Council ordered the first national inquiry into British food habits, covering especially the diet of agricultural laborers and the piece-workers such as silk-weavers, needle-women, shoemakers, stocking-knitters, and glove-weavers, who at that time still worked at home on the putting-out system. The published report, Food of the Poorer Labouring Classes (1863), found that in both groups "the average quantity of food supplied was too little for health and strength," that "the use of tea may now be said to be universal," that bread, butter, tea, and sugar predominated in the diet, and that the poorer people became, the more milk was displaced by tea (Hamilton 1948:77-8).

Cacao (Cocoa)

The cacao bean, seed of the small tree Theobroma cacao, native to the lower eastern slopes of the Andes in the tropical forests, had already travelled to Mexico and was used by the Aztecs both as a beverage and a medium of exchange when the Spanish arrived. The Spanish kept a monopoly on cacao beans, allowing export only to Spain until the Dutch settled Curacao in 1634 and had a base from which to smuggle cacao beans out of Venezuela, where the Spanish had made large cacao plantations (Baker:113). The Dutch planted cacao in Ceylon and Indonesia, and cocoa, or chocolate, made from defatted

sweetened ground cacao, became known as a luxury drink. In the nineteenth century the great Brazilian cacao plantations were established and Brazil became the largest single exporter of cacao. By 1900 the New World supplied 81% of the world's cacao beans (Baker:114).

But fifty years later West Africa was the leading producer of cacao, in a greatly expanded world market, in which much of the cacao went into flavoring commercial candies and candy bars. The cacao plant had been carried by the Dutch to the island of São Tomé, off present-day Gabon, and the Dutch plantations were continued by the Portuguese after they took back the island in 1844. In 1878 a native laborer smuggled some seeds to Ghana, on the mainland of West Africa, where its cultivation spread mainly among small farmers. In the case of both coffee and cacao, by the time the European powers had gained political concessions in Africa in the late nineteenth century, the West African peasant export system had proved itself, and won out in the main over the plantation system (Hopkins 1973:213-14).

In both Ghana and Nigeria, Government Cocoa Boards buy the entire cocoa crop from the farmers at fixed prices, and the difference between the world market price and the price they pay the farmers constitutes a heavy indirect tax which has supported these governments in expanding their infrastructure. For the 1974-75 crop, the Ghanaian Cocoa Board paid the farmers \$365 a ton, and sold the cocoa to commodity speculators for \$1440 a ton (N.Y. Times, 31 January 1975). Like any tropical monocrop, cocoa is subject to sharp swings in world market prices.

Non-Food Plants

Plants yielding fibers, dyes, waxes and oils, latexes, medicines and drugs are among the non-food plants that have been transferred from one part of the world to another for economic reasons. Since cinchona, rubber, and sisal, my three case histories, are among these, I shall be as brief and selective as possible, presenting only a few examples.

Cotton

Cotton is the most important textile fiber from a plant source and one that has traveled widely in its long history. The early cultivated forms in Asia, where the fibers were first spun in India, probably derived from a wild tree native to Africa, according to Sir Joseph Hutchinson's exhaustive study and classification of cotton varieties (Baker:58). The Asian forms have thirteen pairs of large chromosomes. The presence in the pre-Columbian New World of both wild and cultivated forms of both small-chromosomed cotton and of the tetraploid hybrids has now been established by plant scientists. The most plausible explanation for these wild hybrid species is a very ancient transoceanic flotation of the wild cotton seeds from the Old World to the New World, rather than anonymous human contact, as used to be hypothesized (Baker:61).

The recent diffusion of the cultivated Glossipium species is more surely known. G. hirsutum, the "American upland" cotton, which is common in the United States, is of Central American origin. G. barbadense, the long-staple "Sea Island" cotton, probably originated in tropical South America, was disseminated to the West Indies and

then to coastal South Carolina and Georgia. G. barbadense also crossed to Africa to become the very valuable "Egyptian" cotton.

In the eighteenth century, slave traders returning from the New World are known to have transported these better cottons to West Africa, where they showed their great superiority over the indigenous diploid cottons. In the nineteenth century, they were carried from West Africa by Arabs to the Sudan, Egypt, and Ethiopia. In the Sudan, in particular, they have replaced the shorter-linted diploids and have formed the basis of the cotton industry in the Gezira (Ibid:62).

Indigo

Plants of the genus Indigofera have been grown since at least 2000 B.C. in India to produce a blue dye, known also to the ancient empires of the Middle East and the Mediterranean, but not imported into northern Europe until the late sixteenth century, when indigo started to displace woad as a blue dye after bitter resistance from the woad producers. Indigo could not be grown in the cold climate of northern Europe and was imported by the British and Dutch East India Companies. In the eighteenth century the French planted indigo in the West Indies and had a thriving trade. A Col. Lucas of Antigua introduced it in the 1740s to his plantations in South Carolina, which he left in the care of his daughter and a slave who knew the technical processes for making the dyestuff. The stems and leaves were crushed and steeped in water to produce fermentation. The solution was then aerated by beaters and the indigotine allowed to precipitate to form a dye. Indigo cultivation spread throughout coastal South Carolina and Georgia but was gradually supplanted by large-scale rice and cotton plantations.

In the nineteenth century India, along with Java, again

became a primary source of indigo, and British West Indian planters went to India to start indigo plantations, bringing with them the "planter mentality." Barrington Moore, Jr. notes the result: "Even the traditionally docile Indian peasants struck en masse and raised the specter of agrarian revolt over much of Bengal in the 1860 s when English overlords tried to force them to grow indigo at starvation prices for the suddenly booming textile market" (1966:474). The Civil War had cut Britain off from the cotton and indigo of the U.S. South, and Britain had intensified production of both plants in India, another instance of the advantage of the flexibility of British capital, although Lancashire workers were still hurt badly, and Indian peasants suffered when the American market was reopened. In the industrialized world, indigo was supplanted in the late nineteenth century by aniline dyes (etymologically, anil is from the same Sanskrit root as the word for indigo), but in the indigenous cloth-making of India and West Africa, indigo is still important as a dye.

Tobacco

Tobacco was widely used as a sacred drug in both North and South America when the Europeans arrived, and was very soon taken to both Spain and Portugal as a medicinal drug and a secular, pleasurable, luxury item. In 1561 the ambassador from Lisbon introduced it to France and its use in England is documented by 1587 (Masefield:278). In spite of heavy duties and taxes, its use spread rapidly throughout Europe and the Middle East, and eventually to almost every corner of the world. Speaking of the Portuguese trade in the late sixteenth-early seventeenth centuries with China and Japan, Charles

Boxer says "The Portuguese imported their religion and their firearms into both the great Far Eastern empires, though neither of these imports achieved the universal popularity of a third one, tobacco" (Boxer 1969:41). Tobacco became one of the most widely dispersed plants grown, being adaptable to a range of climates, though the Cuban, Virginian, Javanese, and Turkish varieties are most favored in the export trade.

Discussion

The Columbian exchange not only provided new food staples that increased the survival rate of many populations, but the new tropical plants afforded many opportunities to the plantation system. This system, and several South Asiatic crops--sugar, cotton, citrus fruits--was familiar to Mediterranean Europeans who had learned from several centuries of contact with Arab farmers in Spain, Sicily, Egypt and Syria.

Where possible, each European nation sought a botanical monopoly. For a short time some were successful, e.g., in the case of spices and cacao, plants which had a relatively small and circumscribed natural habitat and had not already been widely diffused when the Europeans came upon them. Sugar and cotton were too widely diffused, and tobacco too easy to smuggle, though Charles I ordered all tobacco plants in England and Ireland destroyed in order to prop up the Virginia colony's main export. Plant monopolies were short-lived, as competing nations stole plants from one another.

Plant monopolies were also broken, and entire plant-based industries changed hands, when colonies were conquered or changed

allegiance to satisfy European political requirements. Bombay and its pepper trade passed to England in 1662 as part of the dowry of the Portuguese princess, Catherine of Braganza, when she married Charles II. Jamaica was taken from Spain by an English fleet sent out by Cromwell, and its accession ratified by the Treaty of Madrid in 1670. France lost Canada in the settlement of the Seven Years' War (1763); meanwhile, having diverted ships and troops to Atlantic theaters, France was decisively beaten in India by the British. With the French out of the way, Britain was the sole foreign power in India.

France lost another colony in the settlement of the Napoleonic Wars, when Mauritius with its spices and sugarcane went to the British. In the nineteenth century France was forced to start again on the mainland of Indochina to build a Far Eastern Empire. France's ally in the Napoleonic Wars, the Netherlands, lost Ceylon (1796), and South Africa (1814) to the British. But the paradox of the settlement of 1815 is that the British returned to the Dutch the island of Java, which they had taken in 1811. They gave up Java, the most productive island of the East, so that the Dutch could remain strong enough in Europe to serve as a counterweight to the real enemy, France. For the rest of the nineteenth century, and until the Japanese wartime expansion in the 1940s, Britain and Holland quite amicably shared the rich trade of the Indies. There was commercial rivalry, but no thought of war between them. The Pax Britannica covered the Indies too.

This excursion into European power politics has been made in order to explain the central role of the British government botanic

gardens, closely followed by the Dutch, in the nineteenth century seed transfers of cinchona and rubber which we will present in detail to illustrate the contribution of institutionalized science to colonial expansion. In this activity, the French colonial botanic gardens are conspicuous by their absence, but in mid-nineteenth century France's tropical empire had shrunk to a low point. Because of its interest in Algeria, where French troops met with malaria in force, France did send a botanical expedition to the cinchona regions of the Andes. In 1849 this expedition brought back specimens of cinchona trees to the Paris Gardens, and gave some to Kew and to the Buitenzorg Gardens on Java, of which one single tree survived. Thereafter France left the development of cinchona to Britain and Holland. As befits their respective strengths, Britain was the active agent in finding and smuggling out of Latin America the cinchona and rubber seeds, while Dutch botanists and agronomists on Java made significant additions to the twenty-year development process by which the wild plants were adapted to plantation cultivation.

In this over-all summary of seed and plant transfers, we have treated the botanic garden as only one of many instruments in the diffusion of cultigens. But it is well to note that even before their great flowering in the nineteenth century, botanic gardens played a role in plant transfers closely connected with colonial expansion.

The European powers established botanical gardens along the route to the Orient and in the New World possessions. The Dutch started a botanic garden in Capetown in 1694, the French on Mauritius in 1735, the English on St. Vincent and Jamaica and in Calcutta and

Penang in the eighteenth century (Masfield 1967:283). As we have noted, the Amsterdam and the Paris gardens played a major role in the transfer of the coffee tree to the New World between 1706 and 1723, and they worked on the development of many improved varieties of the new tropical plantation crops, as did Kew Gardens from its informal foundation in 1759 as a royal garden.

In 1941 Kew Gardens celebrated its one hundredth anniversary as a public botanic garden, and the Kew Bulletin in its centenary article said: "One of the functions of Kew has been to send plants of economic and horticultural value to all parts of the Dominions and Colonies where conditions might be suitable for their cultivation" (1941:208). Among the plants listed as having been transferred in this manner are coffee, oranges, bananas, pineapples, mangosteen, almonds, tung oil seeds, cochineal cactus, chaulmoogra, ipecacahuana, Artemisia, Pyrethrum, Lonchocarpus, and mahogany. India, with its vast territories and varied climates and abundant labor, was the recipient of many of these experiments. To give an idea of how the British saw themselves in their role as main agents of these intra-empire plant transfers, I quote from Clements Markham, the man who led the cinchona expedition.

The distribution of valuable products of the vegetable kingdom amongst the nations of the earth--their introduction from countries where they are indigenous into distant lands with suitable soils and climates--is one of the greatest benefits that civilization has conferred upon mankind. Such measures ensure immediate material increase of comfort and profit, while their effects are more durable than the proudest monuments of engineering skill. With all their shortcomings, the Spaniards can point to vast plains covered with wheat and barley, to valleys waving with sugar-cane, and to hillslopes enriched by vineyards and coffee-plantations, as the fruits of their

conquest of South America. On the other hand, India owes to America the aloes which line the roads in Mysore, the delicious anonas, the arnotto-tree, the sumach, the capsicums so extensively used in native curries, the pimento, the papaw, the cassava which now forms the staple food of the people of Travancore, the potato, tobacco, Indian corn, pineapples, American cotton, and lastly the chinchona: while the slopes of the Himalayas are enriched by tea plantations, and the hills of Southern India are covered with rows of coffee-trees.

It is by thus adding to the sources of Indian wealth that Eegland will best discharge the immense responsibility she has incurred by the conquest of India, so far as the material interests of that vast empire are concerned (1862:60).

Markham makes no distinction between the new crops in this post-Columbian exchange which the farmer took up to add to his subsistence, and the introduced plantation crops which extracted wealth from his labor. He sees only the blessings of the empire, to colonizer and colonized alike, a view held by virtually all nineteenth century Englishmen, including the botanists of the Royal Gardens. They felt no conflict between the pure aspects of their science--extending their knowledge of the world's flora, its habits of growth, its geographical distribution--and the application of this knowledge to enrich the Empire. Imperialism as a social and political order was not questioned. The intellectual debate of the century was over Darwin's theory of evolution, a debate between science and theology, not between science and the state.

In the next two chapters we will look at the general intellectual milieu in which botanic gardens arose, and at Kew Gardens, the central institution of the Royal Botanic Gardens and the guiding force in plant transfers within the Empire and of the research and development programs necessary to achieve commercial success.

Chapter IV

General Intellectual Background

The rapid communications which Europeans developed, and their monopoly of communications, gave them an ability to know where to go, what to do, and how to do it, in a way no non-European people could match. European rapidity of communication was the astonishment of all the world when other peoples first met them. . . .

Newsletters, then newspapers; scholarly letters, then scholarly journals; institutions organized and maintained permanently where trained men could gather and weigh and find meaning in reports and experiences touching geography, geology, climatology, zoology, botany, and so on--all these and many more things were factors in the rapid and exclusively European exploration of the earth. (Reynolds 1961:414)

In the early days of Western expansion, the self-confidence of its trade ambassadors was that of the adventurer and military man. By the eighteenth century that self-confidence had acquired an intellectual basis. New philosophical ideas and new natural knowledge made the Age of Enlightenment a time of general intellectual ferment in Western Europe, when men of letters engaged each other in a lively converse of ideas, challenging Christian dogma and elevating human reason. Peter Gay (1966) writes of the 'recovery of nerve' among European thinkers after long centuries of religious fatalism or the Renaissance metaphor of the wheel of chance. Francis Bacon had said "Knowledge is power" and "Man is the architect of his fortune"; René Descartes spoke of a practical science that would make men "masters and possessors of nature"; John Locke wrote in his journal that the mind of man is well fitted to

find out new inventions of dispatch to shorten or ease our labors, or applying sagaciously together several agents and patients to procure new and beneficial productions whereby our stock or riches (things usefull for the conveniencies of our life) may be increased or better preserved (quoted in Gay 1969).

The seventeenth century had seen general advances in the physical sciences through the work of such men as Galileo, Kepler, Newton, and Boyle. Using the method introduced by Newton of elaborate and repeated experiments combined with systematic reflection on the laws of the natural world, practical inventions appeared in rapid succession, of which the most important was James Watt's steam engine. Watt was a technician and instrument maker at the University of Glasgow, and was later financed by a metal-goods manufacturer over about fifteen years of experimentation (Owen 1974:310). Coal mines and ironworks immediately adopted the steam engine. At about the same time, late-eighteenth century, a series of inventions, e.g., the flying shuttle, the spinning jenny, the power loom, revolutionized the textile industry and led England into the Industrial Revolution ahead of its rivals.

In addition to such economic factors as abundant supplies of coal and iron, good transportation by water, mobile capital and labor, many skilled craftsmen, there were political reasons why England could translate the intellectual ferment of the times into practical advantage. The Enlightenment was a pan-Western phenomenon, with Frederick the Great of Prussia, the German philosopher Immanuel Kant, the Swedish botanist Carl Linné, the Americans Benjamin Franklin and Thomas Jefferson among its illustrious names, and the French philosophes Voltaire, Rousseau, Diderot, Condorcet, and d'Alembert generally

recognized as its leading spirits. All these men were cosmopolitan and urbane; many corresponded with each other or visited each other. The French gathered in salons and the English in the coffee houses which had appeared in the 1660 s. Yet there was a profound difference between the French philosophes and the English natural philosophers; the French thinkers were fighting a battle that had already been won in England. Having made their political revolution in the seventeenth century, under Cromwell in the Civil Wars and again in 1688 when the Stuart kings were bloodlessly deposed in favor of William and Mary and the Divine Right of kings yielded to a parliamentary monarchy, the English thinkers of the eighteenth century did not have to fight against a political absolutism which included imprisonment, censorship, and other repressions, as the French did. Montesquieu patterned his Esprit des Lois after English constitutional government, and Voltaire was an anglophile as a result of his visits to England in 1726-27. "Where there is not liberty of conscience, there is seldom liberty of trade, the same tyranny encroaching upon the commerce as upon Religion" and "The commerce that has enriched the citizens of England has helped to make them free, and that freedom in turn has encouraged commerce; this has produced the greatness of the state" (Lettre X, Lettres Phil, I, 120). Eighteenth century Britain could approach the Industrial Revolution with a greater freedom from government regulation over both intellect and trade than the France of the Ancien Regime.

Learned Societies

Between the eminent social philosophers, e.g., David Hume and

Adam Smith, whose works are still read today, and the technician with his practical innovations, there was in eighteenth century England a large body of scientific amateurs, as well as a much smaller number of major scientific figures, who joined together in learned societies for their mutual instruction, polite entertainment, and prestigious social intercourse. The universities contributed members versed in mathematics and physics, but few in the other branches of science, since Oxford and Cambridge were still clerical (Anglican) and aristocratic, and natural knowledge was peripheral to their hierarchy of values. The oldest and most influential of these learned societies was the Royal Society of London for Improving Natural Knowledge, commonly called simply the Royal Society.

The Royal Society

The Royal Society was founded in 1660, an outgrowth of weekly meetings held at the Bull-Head Tavern in Cheapside as early as 1645. In 1662 it received a charter of incorporation under the Great (Royal) Seal. This marks the first formal recognition of science by the modern nation-state, though the interest of king and court was nominal at best, and the Royal Society was not a state institution but a private club. The membership consisted of fifty-five persons elected because of their interest in natural or experimental philosophy, professors of mathematics, physics, and the natural sciences, Fellows of the Royal College of Surgeons, plus "persons of the degree of barons," i.e., any member of the aristocracy. Experiments were performed at weekly meetings. Isaac Newton was an early member, as well as Robert Boyle, discoverer of Boyle's Law

of gases. Sir Humphrey Davy and Michael Faraday, pioneers in electro-chemistry, were active members in the early years of the nineteenth century. As early as 1655, the Royal Society started publishing its Philosophical Transactions, in 1830 its Proceedings, and its Catalogue of Scientific Papers (1867 to date) is a valuable aid to contemporary research.

The Royal Society was supported by membership fees, endowments, and bequests, some of these in the form of urban land on which large rents accrued to the Society. It owned a large townhouse as a meeting place, and had a library and a museum. It did not receive state subsidy, which distinguishes it from such institutions as the Royal Academy of Arts or the Académie Française; but its advice was sought by the government on many matters. In 1710 the Royal Observatory at Greenwich was placed under the sole charge of the Royal Society; in 1752 it supervised the change from the Julian calendar to the modern Gregorian calendar; in 1784 it undertook an official geodetic survey of Great Britain; in 1761, 1769, 1877, and 1882 it sent expeditions to observe the transit of Venus, the expedition of 1769 being under the command of Captain James Cook, as was the Antarctic expedition of 1772. In 1769 he circumnavigated the globe and annexed Australia. Sir Joseph Banks, later President of the Royal Society and unofficial founding father of Kew Gardens, shipped on that expedition with Cook. In the nineteenth century the Royal Society sponsored seven other Arctic and Antarctic expeditions. In 1872 the Royal Society sent out the ship Challenger on the world's first oceanographic expedition. It also acquired such quasi-governmental functions as the

right to appoint board members and trustees to some governmental institutions, such as the National Physical Laboratory and the Lawes Agricultural Trust, and it administered a large government grant for scientific research first proposed by Lord John Russell, a prominent Whig politician, best known for his sponsorship of the Reform Bill of 1832, but also a sponsor of Kew Gardens.

Under the presidency of Sir Joseph Banks, who presided from 1778 to his death in 1820, there was a controversy which almost led to the dissolution of the Society. By stressing his own interest in botany, a very young science at that time, over the physics and chemistry which interested most of the members, and by advocating a policy of making membership more restrictive, Banks aroused strong factional opposition, which was eventually overcome. This incident illustrates the tensions, reflected in Banks' person, between the scientific and social aspects of the Royal Society. The honor of belonging to a select body was diluted as the membership increased, yet the new sciences of botany and zoology--which depended on wide geographical observations as the physical sciences based on mathematics did not--had received great impetus in the eighteenth century from the expanding colonial activity of Great Britain and the voyages of exploration such as that of Captain Cook. Banks had participated in one of these voyages and had observed at first hand the novel flora of Australia and the Indonesian archipelago. The threatened schism in the Royal Society was relieved when some of the members joined the newly formed Linnean Society (1788) which was devoted to botany and zoology. In 1847 the Royal Society voted to elect only fifteen new members.

each year, perhaps because the number of ex-officio members drawn from the ranks of the universities was increasing. The right to put the letters F.R.S. after one's name is still a great honor, the letters F.L.S. taking second place.

The Linnean Society

The Linnean Society was preceded by several short-lived societies, which met at various coffee houses. In 1788 a new society of amateur naturalists was founded and named after the Swedish systematic botanist, Carl Linné (1701-1778). Their first meetings were at the Marlborough Coffee House but they soon transferred to the home of James Edward Smith, a wealthy young physician interested in botany who, at Sir Joseph Banks' suggestion, had purchased Linnaeus' collection of books and herbarium sheets from the heirs. This purchase made Smith famous in botanical circles. He travelled widely in Europe visiting other botanists and entertained many European botanists in London. Smith's collection became the nucleus of the Linnean Society's library, which was housed in Banks' London townhouse. The mansion itself passed to the Society after Banks' death. Although Banks never became an official member of the Linnean Society because of his presidency of the Royal Society, his further interest, as well as the scientific value of the learned societies, is shown in this passage from Gage (1938:14).

Before scientific societies came into existence the more or less isolated men of science could communicate their ideas or discoveries to each other either only in correspondence, a slow and restricted method of spreading knowledge, or by publishing books at their own expense or by subscription. The instruments or collections and the literature required for their investigations were difficult

and expensive to obtain. The societies had therefore to serve as a means of direct intercourse between men interested in the same branch or branches of science. They had to endeavour to provide instruments or collections and books for their members. They had to arrange for publication of the investigations made or communicated by their members. When the Linnean Society was founded, although a good beginning had been made in the forming of collections and libraries here and there, neither the Universities nor the State had realised the importance of scientific libraries, laboratories, and museums, and even now as regards the last the State has in recent years had its shortcomings exposed. The Linnean Society from the first was aware of its obligations in those respects, and set about fulfilling them to the best of its resources. In 1780 a committee was appointed for selecting papers for publication. A museum was begun with donations of botanical and zoological specimens, which continued to flow in for many years. A library was started, also largely with donations, chief among the early donors being Banks and Dryander, and early in 1790 the first bookcase was ordered. In that year also the first volume of the Society's Transactions was ready for the press, Banks paying the cost of the plates.

Lt. Col. Gage, on his retirement from His Majesty's service in India, wrote a history of the Linnean Society, in which it becomes clear that there was more than learning and science to this learned society, i.e., there was an element of sociability and ritual, including a ritual phrase of initiation and one for the ejection of members "in cases of pertinacious refusal to pay dues" or "in cases of defamation or dishonor of the Society, or of contemptuous or contumacious disregard of its Statutes or Orders." In such rare cases, the offender's name was erased from the Register. There is a whiff here of the fraternal order, and as a matter of fact, the late eighteenth and early nineteenth centuries were the period when the Masonic Order was at the height of its influence in Europe.

To illustrate what sort of person was attracted to the Linnean Society (and simultaneously to the Colonial Service) and to

show how knowledge and interest in botany flowed in personal and informal channels from the metropolis to the satellites, I quote again from Gage on the career of Alexander McLeay, a Scot who was the second man to hold the Secretaryship of the Linnean Society (1796-1816). That he was a Scot is interesting in itself. Though I do not have figures but merely an impression gained from reading, I would say that Scotland produced more gardeners, many of whom were employed on the great estates in England, and more botanists, both amateur and professional, than its population would lead one to expect. My suggested explanation is that Scotland was provincial, with all the political, social, and economic disadvantages of a province vis-a-vis the metropolis, but Lowland Scotland also was the seat of high culture centered in the Presbyterian Church, with a high rate of literacy throughout the population, and a distinguished university in Edinburgh. Scotland had also attracted many skilled Huguenot refugees during the Counter Reformation. By the eighteenth century Scotland was producing more skilled workers and educated men than its economy could use, so the road to opportunity lay south, and frequently overseas.

In the following passage, note that only about fifty years passed between Cook's discovery of Botany Bay and McLeay's botanic garden at Elizabeth Bay; note also that McLeay got to be Colonial Secretary of New South Wales after a career spent transporting prisoners to Australia. The J.D. Hooker referred to is the son of the first director of Kew Gardens and was to succeed his father as director.

Alexander McLeay (1767-1848) was the first of a distinguished family that continued in Fellowship of the Society for nearly a century, and left to another Linnean Society--that of New South Wales--an enduring and valuable heritage. He was the son of a leading townsman of Wick in Caithness. His first start in life was in commerce, but soon he entered Government service. In 1795 he was Chief Clerk in the Prisoners of War Department, and in 1797 held a similar post in the Transport Board, of which he became Secretary in 1806. On the abolition of the Board in 1818 he retired on pension. Towards the end of 1824 he was appointed Colonial Secretary to the Government of New South Wales, and left for Australia in 1825. He held this office until 1837, when he retired, but continued to reside in Sydney. In 1843, when the Legislative Council of New South Wales was established, he was chosen as its first Speaker, and retained this office until his final retirement in 1846. He died in Sydney in 1848, his end being hastened by a carriage accident.

While in England Alexander McLeay had a great reputation as an entomologist, and is said to have possessed the finest private collection of insects in the country. This collection went with him to Australia. Within a few years of his arrival at Sydney he received a grant of about fifty acres at Elizabeth Bay--then near, but now part of Sydney--and purchased about 15,000 acres at Brownlow Hill, about forty miles out of Sydney. Those acquisitions developed the botanical and horticultural sides of McLeay's interests, on which he spent large sums. He enriched his garden at Elizabeth Bay with plants from all over the world to such an extent that J.D. Hooker--who visited it in 1851, when attached to H.M.S. Erebus as Assistant Surgeon--refers to it in a letter to his father as exciting his unbounded surprise. On part of what was this famous garden the Hall of the Linnean Society of New South Wales stood from 1885 to 1924. As Brownlow Hill fruit and ornamental trees and shrubs were largely cultivated, and the early settlers were greatly indebted to McLeay for his generous distribution of economic and ornamental plants. McLeay was elected F.L.S. in 1794 and F.R.S. in 1809. He was a man of great ability and of a personality that made him many friends (Gage 1938:15)

The Intellectual Context

Arnold Thackray has made a detailed study (1974) of the Manchester Literary and Philosophical Society from its beginning in 1781 to 1850. In spite of its name, science was its principal pursuit, and Joseph Priestley its culture hero.

The Society was especially important as a means of the social legitimization of marginal men--the physicians who, by the canons of the day, felt obliged to prove they were 'gentlemen,' the manufacturers and merchants whose wealth was rising faster than their social status, all of them provincial by London standards, and many of them religious Dissenters, Unitarians or Quakers, who still in the eighteenth century suffered political and social disabilities.¹ "Science was an activity that enabled different elements of the town's aristocracy to come together and to express their cultural solidarity in face of both the local lumpen-proletariat and more traditional English elites" (1974:693)

Science was not only polite knowledge for the highest elite; it was rational entertainment for all cultivated souls. Because rational, it offered possibilities of instruction in self-control not present in less disciplined forms of culture. Thus it could also solve a recurrent problem of parvenu social groups, how best to educate their sons so as to profit from their fathers' wealth without succumbing to the traditional vices of the rich. Time and again in the late eighteenth century, Manchester manufacturers related to one another the disadvantages of education at Oxford and Cambridge, notably its expense, its encouragement to dissipation, and to alienation from their own norms. One alternative lay in the Scottish universities, especially Glasgow and Edinburgh. They were cheaper, more spartan, and more attuned to the alternative values of Dissent and Science. But should sons not be sent away, something must be done in Manchester (Ibid:690).

And so the Literary and Philosophical Society founded as an adjunct a College of Arts and Sciences.

¹Under the Test and Corporation Acts passed in the 1670s Dissenting Protestants as well as Catholics were not allowed to belong to town corporations, i.e., the local municipal government, sit in Parliament, or hold public office. These acts were not repealed until 1828, although they were often evaded in that known Dissenters were allowed to pretend to be Anglicans (Palmer 1950:469).

Tracing out the family histories of the founders of the Manchester 'Lit & Phil,' Thackray found much inter-marriage and an increasing political and religious conservatism in the second and third generations.

By 1850 the only Unitarian joining the [Literary and Philosophical] society was a minister. Manchester's aristocracy of manufacturers, by now legitimated and secure, abandoned both science and advanced religion as appropriate cultural symbols. The great manufacturing families found social issues, practical politics, and the reform of Oxbridge to be matters more congenial to third-generation taste. The sharply lower percentage of manufacturers among those joining the society after the Napoleonic Wars were men of more modest wealth and different type. A significant development in the years after Waterloo was the steady rise of those with a "professional" interest in scientific research (Ibid:696)

A vastly expanded and newly self-conscious grouping of men of science faced an urban clientele that was both audience and patron. That same clientele also sought the role of active investigator. The novel business of creating and regulating the vastly expanded market in theories and information that resulted was a concern in which traditional metropolitan savants could make common cause with emergent provincial professionals. Systematic, factual investigations could safely be delegated to the swollen rank and file of scientific men, while the new scientific masters shaped the British Association [for the Advancement of Science] and the metropolitan disciplinary societies toward the roles of arbiters and entrepreneurs of scientific theory. The launching of new journals, the flood of teaching manuals, the demand for encyclopedia articles and advanced texts, and the creation of private and proprietary laboratories are further aspects of that differentiation and specialization characteristic of an enterprise undergoing rapid evolutionary growth. Within this growth the form and texture of natural knowledge was itself transformed; through its second revolution, English natural knowledge became for the first time the "science" known by "scientists" (Ibid:709).

Although written with specific reference to Manchester, Thackray's analysis of a provincial learned society over the century 1750-1850, based on careful prosopographic research, has general

reference to the changing nature of science in England, especially its increasing specialization and professionalization. The Victorian era saw the development of a science which was fully modern in spirit and method, if we except the strong religious scruples held by almost all members of society which made Darwin's work so controversial. The most tangible expression of Victorian science was its engineering triumphs--the canals, railroads, bridges, sanitation systems, iron steamships, cast-iron buildings--and its culminating symbol the Crystal Palace Exposition of 1851. But the intangible expressions of science, its cognitive aspects, such as the use of science as a means of ordering experience, a rationale for belief in progress, and a mental orientation toward rapid change, were even more important in shaping the new industrial society and coping with the strains it brought. In the end the Victorians accommodated their religion to the new natural knowledge but corrupted Darwin's theory into "Social Darwinism," using it as a justification for their class system at home and increasing imperialism abroad.

Roster of Learned Societies

In addition to the learned societies discussed above, the following organizations were among those active in generating and disseminating scientific knowledge in nineteenth century Britain:

1. Generalized Metropolitan Societies

- a) The Society for the Encouragement of Arts, Commerce, and Manufactures (1754) and the Society of Useful Arts in Scotland (1821), which sponsored innovations in industrial technology.

- b) The Royal Institution, founded by Sir Joseph Banks and others in 1799 for "the application of science to the useful purposes of life," with laboratories in a London townhouse where Faraday and Davy pursued their investigations in chemistry, and with foundations for professorships in the natural sciences, chemistry, and physiology; and weekly meetings, public lecture courses, and a journal. The London Institution (1805) was similar.
- c) The British Association for the Advancement of Science, organized in 1831 to hold annual national congresses of scientists, was the model for many such associations, including the American Association for the Advancement of Science.

2. Specialized Societies

- a) Royal Agricultural Society (1838)
- b) Royal Anthropological Institute of Great Britain and Ireland (1871), succeeding the Ethnological Society (1843) and the Anthropological Society (1863)
- c) Royal Astronomical Society (1831)
- d) Royal Botanic Society of London (1839)
- e) Chemical Society of London (1841)
- f) London Electrical Society (1836)
- g) Geological Society of London (1807)
- h) Royal Horticultural Society (1804). The Horticultural Society maintained public display gardens, held an annual flower show, sponsored plant collecting expeditions, but its interest was confined to flowers and vegetables which could be grown in

Britain. It attracted the avid gardeners, both amateur and professional, thus allowing Kew Gardens to pursue more general scientific goals.

- i) Mathematical Society (1717-1845) and London Mathematical Society (1865)
- j) Paleontological Society (1847)
- k) Zoological Society of London (1826).

The founding of the Zoological Society of London illustrates the interconnection of imperialism and science even more pointedly than in the case of the botanic societies. When Sir Stafford Raffles, who took Java from Holland and governed it for the British East India Company during the Napoleonic Wars (1811-16), was in London after England had returned Java to Holland for reasons of European policy, he discussed with the protean Sir Joseph Banks his desire to found a zoological garden and museum in London. After a term as governor of Sumatra and the acquisition of Singapore for the British East India Company, he was again in London and in 1826 founded the Zoological Society and became its first president. His Sumatran collection became the nucleus of the Society's collections, which are now "the London Zoo."

The Royal Colonial Institute (1868), the Royal Asiatic Society, The East India Society (1866), and the African Society had meetings, libraries, journals, drawing for membership on a large body of active and retired colonial civil servants.

The local societies are too numerous to list. Altogether, the voluntary associations of British professionals and amateurs devoted to science were a significant force in the generation and

spread of new knowledge, and a social institution in which members of the middle class and the aristocracy could cross class boundaries because of a common interest. The personal ties formed through these voluntary associations helped to promote science at the highest levels of government.

Botany and Botanic Gardens

The earliest botanic gardens of the modern world, founded in the sixteenth and seventeenth centuries, were medicinal in purpose and often attached to the Faculty of Medicine of a university. Pisa, Florence, and Padua each had a hortus medicus in 1545, Leiden in 1577, Leipzig in 1579, and Montpellier and Heidelberg in 1593, all university centered.¹ The Jardin des Plantes in Paris was established in 1635 by royal edict for the instruction of students of medicine, at the instigation of the physicians of Louis XIII. The Royal Botanic Garden of Edinburgh grew out of a Physick Garden started in 1690. In 1663 the Society of Apothecaries maintained a botanic garden in Chelsea, London.

Botany started to become a scientific study in the seventeenth century when attempts were made at classifying plants on a systematic basis, rather than merely describing them and their recommended uses in medicine, as had been the case in the late Medieval and Renaissance herbals and in university courses in Materia medica. These early systems arranged plants according to the nature of their fruit and

¹It has been suggested (Lipp 1976:188) that the sixteenth century European botanic gardens may have been modelled on the elaborate royal gardens in Tenochtitlan, whose wonders were reported by Bernal Diaz and other chroniclers of the Conquest of the Aztecs.

flowers; but the system of Carl Linné, or Carolus Linnaeus, as he called himself in Latin, the international language in which he wrote his treatises, superseded all of these because of its facility of application, being based on the characteristics of the stamens and pistils. The binomial taxonomic nomenclature of Linnaeus was adopted throughout Europe and is standard today, although other systems of the arrangement of plants in classes have been developed which are considered more "natural" than the Linnaean sexual system. The French botanists were especially interested in the natural systems based on a more complete morphology. Based on his experience at the Jardin des Plantes in Paris, Antoine de Jussieu proposed such a system in his Genera Plantarum (1789). It was modified by Augustin Pyramus de Candolle (1813) and his son Alphonse de Candolle, who were contemporaries and acquaintances of William J. Hooker, Kew's first director. Robert Brown in his Prodromus Florae Novae Hollandiae (1810) and John Lindley in his Introduction to the Natural System (1830) and his Vegetable Kingdom (1846), two English botanists in Hooker's circle, both advocated and refined the De Candolle system of natural classification. George Bentham and Joseph D. Hooker, second director of Kew Gardens, worked out another system of classification along natural lines in their Genera Plantarum Phanerogamarum. Published in 1862-83, it was widely adopted in England and in some continental botanic gardens, e.g., Paris and Lyons, while Antwerp, Dijon, Montpellier, and the University of Cambridge kept to the system of De Candolle in arranging their collections (Gager 1938). All of these systems dealt mainly with the higher plants, the flowering

or seed plants (Phanerogams). They are called "natural systems" in contrast to an "artificial" system like that of Linneaus because their taxa are based on the multiple correlations of characteristics after Aristotle's dictum in De Partibus that a classification system should "recognize natural groups--each of which contributes a multitude of differentiae and is not defined by a single one, as in a dichotomy" (Cronquist 1968:4). After Darwin's work was known, the principle of phylogeny was added to the concept of "natural grouping" in constructing taxonomies, which are still being revised today. About 2,000 new or revised identifications are made annually by contemporary botanists.

Among European botanists of the early nineteenth century there was wide interest in collecting and identifying mosses, ferns, and other lower plants (Cryptogams), but any great strides in the scientific study of Cryptogams had to await the compound microscope. In 1851 Wilhelm Hofmeister, a German botanist, published his researches on the Cryptogams. Thereafter the lead in scientific botany passed to the German universities, where advances were made in their laboratories in plant physiology, cytology, and embryology. Being late starters in the European industrial competition, because of their political fragmentation until post-Napoleonic times, the Germans relied heavily on academic science as a means of catching up with the British and French. The Jodrell Laboratory at Kew Gardens was established in 1876 on the German model.

Plant Distribution

However, in the eighteenth and early nineteenth centuries

there were no technical impediments to the study of plant distribution. On the contrary, the commercial and scientific voyages of discovery had opened up the whole world in the richness of its botanical species to European botanists. The two Americas, the Far East, the Oceanic Islands, the Australian continent and finally Africa were explored by naturalists like Charles Darwin, Robert Brown, and Joseph Hooker, who were attached to scientific expeditions sponsored by the Crown, the Royal Society, Kew Gardens, private individuals, or a combination of these sources of support. Thousands of plant specimens were brought back for study in the libraries and herbaria. Collection for classification was still a necessity. Of the 340,000 known species of plants in the world, a large majority were identified, and their distribution established, during this period of botanic exploration. The number of botanic gardens grew rapidly. A contemporary estimate puts them at sixteen hundred in Europe alone at the end of the eighteenth century (cited in Encyclopedia Britannica 1910: iv, 300), and many more were founded in the early nineteenth century in Europe and the European colonies, though some of the older ones lapsed.

Economic Botany

This was also an era of economic botany, when the usefulness of new plants to the national economy was prominent in the minds of all but the purest taxonomists. Every new plant was being scrutinized for its use as food, fiber, timber, dye, or medicine. Botanic gardens consciously served the state as well as science, and shared the mercantilist and nationalist spirit of the times. The Calcutta Botanic

Gardens, founded in 1787 by Lt. Col. Robert Kyd, were founded

not for the purpose of collecting rare plants as things of curiosity or furnishing articles for the gratification of luxury, but for establishing a stock for disseminating such articles as may prove beneficial to the inhabitants as well as the natives of Great Britain, and which ultimately may tend to the extension of the national commerce and riches (Kyd, quoted in Gager 1938:262).

Colonial Botanic Gardens

As the "national commerce and riches" was being augmented by trade with the colonies and a growing home market for tropical products, Britain and the other European powers established many small botanic gardens in the colonies, some of them older than Kew Gardens itself. At first they were not much more than collection stations for tropical plants, but in the nineteenth century some of them, e.g., the Calcutta Garden, Peradeniya Garden on Ceylon, and Buitenzorg Garden on Java, became important research centers.

In 1735 the French founded the Pamplemousses Gardens on the island of Mauritius, which passed to the British in 1810, and the Dutch founded an early garden at Capetown. Both of these gardens acted as staging areas for plants being brought from the Indian and Indonesian possessions farther east. In 1764 botanic gardens were started by the British on St. Vincent and St. Thomas in the British West Indies, and in the nineteenth century, six more British West Indies islands received botanic gardens, directed and staffed by Europeans, as were all of these. The Peradeniya Gardens of Ceylon were founded in 1810, and the branch at Kampala in 1876, especially to receive the rubber plants removed under the auspices of Kew Gardens from Brazil (see Chapter VII). The Dutch founded the Buitenzorg Gardens

in Java in 1817, expanding a small botanic garden started during the English occupation of Java. Singapore had to wait until 1859 and Burma until 1917 for its botanic garden. The dates of establishment of these colonial gardens give a rough indication of the extension of empire and "European civilization," just as in Europe the earliest botanic gardens were found in the Renaissance centers of Northern Italy and then spread north to cover the whole continent as the European center shifted.

Two more botanic gardens deserve special mention because of their purely colonial character. The Jardin Colonial de Laeken, attached to King Leopold's palace near Brussels, was established in 1900 for the purpose of obtaining and propagating plants from the tropics, for training probationers for agricultural posts in the Congo, for forwarding plants and seeds to government posts in the Congo, and to help planters choose and ship seeds to their plantations. The entire cost of the garden was charged to the government of the Congo, not to the Belgian planters who were making fortunes in that colony, notorious for atrocities against the native population. In 1908 a similar institution, the Jardim Colonial, was founded in Lisbon.

Roster of British Botanic Gardens

By the early twentieth century there were twenty-two botanic gardens in the British Isles, many of them local and small, but including three national institutions, Kew near London, Edinburgh in Scotland, and Glasnevin in Dublin, funded by the state by appropriations of Parliament. Of these Kew was and is the greatest,

with five and a half million specimens in its Herbarium to Edinburgh's one and a half million (Gager 1938), and the garden most involved with the government botanic stations in the colonies, although Edinburgh also sent many botanists to the colonies throughout the nineteenth century.

The colonial gardens were not tied in any systematic way to each other or to Kew, each being under the jurisdiction of its own colonial government and the Ministry of Colonial Affairs or the India Office, as the case might be. But Kew was the clearing house for the exchange of information, planning, research, and the actual exchange of plant material.

The Appendix gives a list of botanic gardens in the British Empire; it is taken from the Kew Bulletin of 1889 and shows the extent of the informal network of British botanic gardens at a time when the Empire had almost reached its fullest expansion. Only a few East African colonies remained to be formally accessioned. It will be seen that the personnel was almost entirely British, men sent out from home to staff the outposts, many of them trained at Kew. The directors of the larger gardens were Fellows of the Royal Society, while Fellows or Associates of the Linnean Society filled the next ranks. The initials C.M.G. or K.C.M.G. (for the directors at Kew, Fiji, Wellington, and Victoria) indicate the award of the Order of St. Michael and St. George, an honor bestowed for meritorious service "in her majesty's colonial possessions." The several botanic gardens in India are not grouped together but appear in alphabetical order under the name of their separate districts. Outside the home islands, Calcutta

had the largest and best trained staff, including two holders of academic degrees, one of whom, Dr. David Prain, became director of Kew in 1905.

Chapter V

Kew Gardens and the Scientific Elite

Well-ripened seeds of rarities will always be acceptable.
Simply address Hooker at Kew. . . . (from the Director's
Annual Report to Parliament, 1851)

In examining the growth and development of Kew Gardens as the central institution of a global network of scientists specializing in economic botany, I hope to demonstrate the close connection between imperial expansion and government support for science. From its inception Kew Gardens had the support of the royal house and of influential men in the Cabinet and in Parliament. Parliament regularly funded Kew's annual budget and the budgets of the satellite gardens, which were charged to the Colonial or India offices. In the expansive mood of the nation after the Napoleonic Wars and up to World War I, funds for science and colonial activity received high priority. Britain was in a period of prosperity and economic growth, the leading manufacturing and trading nation in the world. Domestically, she had been the first nation to harness capital, technology, and a large labor force in industry and to put her agriculture on a capital intensive, scientific basis. Externally, she used her navy, the world's strongest, to protect her overseas investments and to make new openings for commerce. In 1841, the year Kew Gardens was founded, the navy was battering open Chinese ports and gaining extra-territorial rights for British merchants; other naval ships were

going up the Niger River to plant trading posts. Steamships were just beginning to make communication with India faster and troop transport more secure. Technology was rapidly changing the world, but was still working with natural materials; chemical synthetics were yet to come. New plants therefore were of great economic interest. A national botanic garden filled the need for a systematic research center and a central decision-making institution in the field of economic botany.

The second theme of this chapter is the organization and exercise of power by the small group of like-minded scientists who made up the Kew circle and who had supporters in high places. When bureaucratic jealousy on the part of older government agencies threatened its integrity, Kew could rally friends like Charles Darwin to promote its cause. Patron-client relationships, personal friendships, and marriage ties linked Kew directors to government, commerce, and the other professions. While they attained high social status, these directors did not become wealthy or attempt to join the landed aristocracy, as previous patterns of upward mobility had dictated. A new source of power was emerging in the learned professions which served an increasingly complex commercial and industrial society. In the persons of the successive directors we can see an evolution from the amateur naturalist and gentleman scholar of the late eighteenth-early nineteenth century to the eminent professional of the Victorian era. The high social position of the salaried scientist and administrator who was outside the tight circle of Oxford-Cambridge was a new phenomenon, and reflects the relaxation of barriers when a nation has a need for creativity (Linton 1964; Wilkie 1977).

In the last decades of the century when imperialism was reaching its fullest momentum, these social barriers were lowered a step further to permit men whose careers had been made in the colonies to become directors of Kew Gardens.

Kew Gardens--The Formative Stage

Kew Gardens as a public institution grew out of a private garden started in 1759 by Princess Augusta, mother of George III, on the grounds of a royal mansion lying near the Thames just upriver from London. Sir Joseph Banks, friend of the royal family, president of the Royal Society, founder of the Linnean Society, and wealthy amateur botanist, managed the gardens as unofficial director until his death in 1820, after which time the gardens vegetated. This period of decline came to an end in 1841 when the gardens and two hundred acres of the royal grounds were made over to the state, pursuant to a report by a royal commission. The royal associations continued with further gifts of land and ceremonial appearances which lent the prestige of the Crown to the gardens, which are properly called the Royal Botanic Gardens. Kew Gardens honored Queen Victoria by naming the world's largest water-lily, a plant from the Amazon with a lily-pad up to eight feet in diameter, Victoria regia.

In 1840 botany was just emerging as a separate professional discipline. The transition from royal garden to state institution was effected by the same group who were active in the learned societies--amateur botanists plus certain landed aristocrats who shared their interest in natural science and were simultaneously influential in government. These patrons of botany included several

Whig politicians and cabinet members, notably Lord John Russell, secretary of state for the colonies.

The Royal Commission, under the chairmanship of the botanist John Lindley, urged the establishment of a National Botanic Garden which would coordinate the efforts of "the many gardens in the British colonies and dependencies, such as Calcutta, Bombay, Saharanpore, the Mauritius, Sydney, and Trinidad, whose utility is wasted for want of unity of purpose and central direction" (quoted in J.D. Hooker 1902:xliv). The heart of the report lies in the following passage:

A national garden ought to be the centre round which all minor establishments of the same nature should be arranged. . . . receiving their supplies and aiding the Mother Country in everything that is useful in the vegetable kingdom. Medicine, commerce, agriculture, horticulture, and many valuable branches of manufacture would benefit from the adoption of such a system. From a garden of this kind, Government would be able to obtain authentic and official information on points connected with the founding of new colonies; it would afford the plants these required (quoted in Bean 1908:xvii).

This report, with its emphasis on economic botany, served as a charter for Kew Gardens, there being no formal legislation to guide the first directors other than this. Funding was by annual appropriation of Parliament, and an annual report on the condition of the gardens and the expenditure of monies was required from the director.

The proposal had strong support from the Duke of Bedford, from his son, Lord John Russell, and from Lord Monteagle, the Chancellor of the Exchequer. The Lord Steward of the Royal Household was reluctant to give up part of his personal empire, but the proposal carried in Parliament, and Kew Gardens passed under the direction of

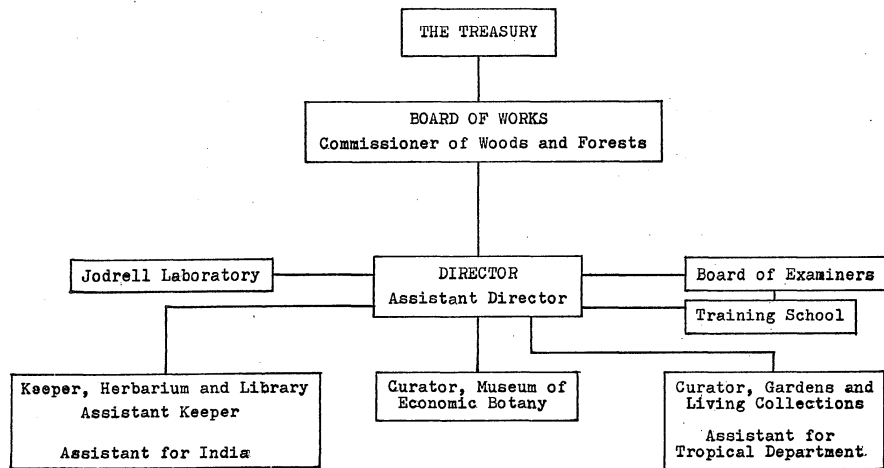
the Commissioner of Woods and Forests. However, it was not to the bureaucracy but to its own directors, who enjoyed a remarkable freedom of action, that Kew owed its success.

The first appointed director, William Jackson Hooker, was one of the few professional botanists of the time. He was Regius Professor of Botany at the University of Glasgow, director of the Glasgow Botanic Garden, founder and editor of several botanic journals, including the Journal of Botany and Icones Plantarum. When he took office at Kew in 1841 he had to refurbish the gardens after years of neglect, recruit staff, and establish policy. As a public garden Kew had multiple functions--displays, research, information storage and retrieval, publication, plant collecting and disbursement. From the first Kew trained botanists informally; later the program was formalized. The following diagram gives the structure.

Display

Today Kew Gardens is a sedate Sunday playground for the people of metropolitan London, who come by riverboat, bus, or subway to see the ornamental flower beds and specimen plantings, the wide lawns, man-made lakes with fountains, the eighteenth century "architectural follies"--a Ruined Arch and a Chinese Pagoda--and the tropical plants displayed in the great Palm House, built in 1844-48 and a prototype of the Crystal Palace.

Kew's popularity with the public was evident from the start. In his annual Report to Parliament of 1851, W.J. Hooker noted that there were 179,627 visitors in 1850, up from 9,174 in 1841 when he took office and Kew became a public garden. Visitors increased after



V.1 Organizational Structure of Kew Gardens, Late Nineteenth Century

the horsedrawn omnibus was supplanted by a railroad. Kew did not depend on public entry fees or public subscription, since it was entirely funded by appropriation of Parliament; but obviously the interest of the public strengthened Kew's position in competing with other institutions for public funds. Kew entered the public consciousness through songs and poems, e.g., the Victorian popular song "Nancy Green on a Trip to Kew" or the refrain "Come down to Kew in lilac time" from a poem by Alfred Noyes.

The display functions of the Gardens helped to make them a popular national institution, but display functions at a botanic garden are only the outer facade for the real work of science. However, all botanic families and all ecozones were represented in the display collections, and even such exotic plants as orchids were arranged to show a variety of specimens of Orchidaceae, a family that contains over 20,000 species in 750 to 800 genera (Ayensu 1974:37).

Research and Publication

One mark of the strength of a botanic garden is the size and range of its reference library and herbarium. Hooker's collections formed the nucleus of what has come to be the world's largest herbarium, with seven million herbarium sheets. The plants must be dried, mounted, described, identified, classified and stored. This identification and description must be published in botanical journals and accompanied by detailed drawings of the plants. Systematic botany and botanical drawing was Hooker's special forte; of the eight thousand plates in his publications, eighteen hundred are by his own hand. As he published more and more, and devoted more time to administration,

he trained and brought to Kew a young Scot named William Fitch, who had been a pattern drawer for a calico printing firm and who became a master botanical artist (Anderson 1975).

Economic Botany: Plant Collection and Distribution

In 1848 Hooker and his colleague John Stevens Henslow set up a Museum of Economic Botany at Kew, where specimens of useful plants were available for study and reference. The voyages of exploration and colonial expansion had greatly enlarged the range of Kew's collections of non-European plants.¹ Earlier Sir Joseph Banks' most important contribution to the future state institution had been his practice of sending out plant collectors. Through his personal ties he had obtained support from government agencies as well as private aristocratic patrons. William J. Hooker as director of Kew reinstituted the practice, but private patrons were replaced by cooperative arrangements with the Navy, the Colonial Office, and the India Office. J.D. Hooker, one of the Kew collectors himself before he became his father's assistant director, describes the practice of sending collectors to distant countries for the purpose of transmitting plants and seeds to the Royal Gardens.

By way of lightening the demand on the Treasury he [W.J. Hooker] on several occasions, with the Commissioner's

¹Shipwreck was common and accounted for many failed missions. Robert Brown's specimens from Australia and New Guinea were lost in Torres' Straits; William Hooker lost all his specimens from Iceland when the ship burned; and a botanist from Kew died of exposure in Captain Bligh's small boat after the mutiny on the Bounty near Tahiti. Lord Amherst was shipwrecked coming home from a mission to China in 1816 but some of his men reached Batavia in lifeboats and a Kew botanist in the party helped found the botanic garden which became the major Dutch colonial garden, Buitenzorg, on Java.

approval, invited the Duke of Northumberland and the Earl of Derby to contribute to such expeditions and share the produce. At the same time, through his influence with the Admiralty, he obtained the privilege of having all packages addressed to Kew coming by the Royal Mail India steam packet sent freight free. By these means Mr. Purdie was sent to New Grenada, and Burke and Geyer to California and Oregon, with the most satisfactory results to all parties; and by similar arrangements with the Treasury, Foreign, Indian, and Colonial Offices there were subsequently sent Oldham and Wilfred to Japan, Formosa, and Corea, Mann to the Cameroons, Gaboon River, and Fernando Po, Baikie and Barter to the Niger, Kirk to the Zambesi with Livingstone, Meller to East Africa and Madagascar, myself to the Himalaya, Bourgeau to Canada, Lyall to British Columbia, Edmonstone, followed by Seeman, to Western and Arctic America in H.M.S. Herald, and the latter to Fiji Islands with Col. Smythe's mission, Macgillivray to Torres Straits in H.M.S. Rattlesnake, Milne to the Pacific in H.M.S. Herald, Spruce to Ecuador for Cinchona seeds, and Hewett Watson to the Azores. The practice was definitely abandoned when the great nurserymen took it up, and liberally shared their proceeds with Kew in exchange for its Director's services in indicating countries worth exploring, giving the collectors letters of recommendation to his correspondents abroad, naming and publishing their novelties and rarities, &c. (J.D. Hooker 1902:lxiii).

Much of the world was still being explored by Europeans in the nineteenth century. Her Majesty's government sent out many ships on exploratory missions, some of them purely scientific, as the voyage of the Beagle, with Charles Darwin as naturalist, had been. On others, a naturalist was attached to an expedition which was laying the foundation for political acquisition. Col. Smythe, mentioned above, was sent to the Fiji Islands in 1860 to advise the government whether or not to accept a conditional offer of annexation. Dr. Seeman, the botanist on the expedition, brought back plants to Kew Gardens, wrote a scientific treatise on the flora of the Fijis (Flora Vitiensis 1865), and a popular account of the islands (1861) which stimulated Australian immigration. The new settlers started plantations, imported laborers from India, and pressed for annexation, which came

in 1879. Baikie's exploratory trip up the Niger and Livingstone's on the Zambezi both led to eventual annexation.

Exploration also had commercial implications. Joseph Hooker was engaged in surveying the border between Bengal and Sikkim in 1847-51 for the government of India while he was collecting the nearly seven thousand specimens of Himalayan plants which he brought back to Kew. His journal notes were published in 1854 and a seven volume scientific treatise, Flora India, was completed in 1902. Among the plants Hooker brought back from the Himalayas were 43 species of showy rhododendrons, which were cultivated in the great estates of England and Scotland, where they became an object of pilgrimage for rhododendron lovers. Their hybridized descendants form the mainstay of business for the commercial nurserymen in modern American suburbs. There is no way to draw the line between science, commerce, and imperialism in the work of the Kew collectors.

Those plants with economic possibilities were propagated in the Kew greenhouses, studied and sometimes improved by hybridization, and then sent out to the colonial gardens and botanic stations for trial and distribution to planters. In this way Kew became a depot for the interchange of plants throughout the Empire. Packets of seeds and letters of advice went out by the royal mail steamers from Kew to the directors of the satellite gardens in the tropics and subtropics around the world.

Projects of plant exchange with the colonies, initiated by William Hooker and brought to fruition by Joseph Hooker include the sending of tea plants and seed to Jamaica, ipecac and mahogany raised from seed at Kew to India, papyrus to India, cork oaks to the Punjab,

an improved variety of tobacco to Natal, both tobacco and cinchona to St. Helena, and Liberian coffee, grown at Kew, to both the East and West Indies. Pineapples were sent to the Straits Settlements, and rubber-yielding vines from Assam to West Africa. Plants of the palm family, yielding copra, oils, waxes, and fibers, were housed for study and display in the great Palm House at Kew, and distributed from one tropical colony to another.

In addition to the exchange projects, the directors of Kew were intimately involved in the affairs of the colonial stations, as can be seen in the correspondence preserved in the Kew Library. I give only one example at this point, a holograph letter to Sir William Hooker from W.G. McIvor, Superintendent of the Botanic Garden and Government Plantations, Ootacamund, Nilgiri Hills, Madras Presidency, South India. On 8 January 1848 McIvor wrote to Hooker saying that the Madras postmaster had questioned his right to the franking privilege, and that he was holding the seeds and specimen plants he was sending to Kew until Hooker had settled the matter.

Another informal prerogative exercised by the Kew director was the right to nominate, and de facto appoint, the directors of the colonial botanic gardens and superintendents of the colonial botanic stations. He was notified when a vacancy was coming up, and his recommendation was followed by the Colonial Office and the India Office, and their representatives in Calcutta, Bombay, Madras, etc. As time went on, more and more of those recommended had been trained at Kew. By the end of the century, there were 700 Kew-trained

botanists and gardeners¹ (Bean 1908:60). The one whose work has had the most lasting significance was Henry Ridley. Trained by Joseph Hooker at Kew, sent out to Singapore to be Superintendent of the Botanic Garden, Ridley improved the Hevea rubber tree and induced the planters to grow it, thereby starting the Malaya rubber industry.

In 1841 Kew was merely an appanage to a palace, where a more than usually extensive collection of living plants was grown. . . . Hooker's work was that of a pioneer, in providing the material foundation necessary for the further study of the science [of botany], not only in this country but in the Empire. He supplied a coordinating center for botanical organization in Britain (Bower 1913:141).

The institutional framework had been set by William Hooker. His son, Joseph D. Hooker, continued after 1865 with even greater emphasis on economic and colonial botany. The major departmental innovation at Kew was the Jodrell Laboratory in 1876 for the study of plant physiology and cytology, an indication of the increasing complexity of science and technology. In 1872 a major threat came to Kew from within the bureaucracy in London. The happy resolution, for Kew, of the conflict shows the power that natural science had won for itself, operating on a commission from the state which society willingly afforded, and illustrates so well the social status of the Kew directors and the workings of their personal networks that I shall discuss it in that context.

¹A few places in the training program were reserved for foreigners, mostly "of the Teutonic and Scandinavian races," says Bean. Dr. Seeman, the expert on the flora of Fiji, was a German by birth who came to train as a student-botanist at Kew in the 1840s. In recent years, the Kew training program has been open to some Asiatics and Africans.

Wardian Cases

One technical innovation deserves mention, since it played such an important part in the success of the plant transfers within the Empire. In 1829, a London physician named Nathaniel Bagshaw Ward, an amateur botanist, Fellow of the Royal Society and of the Linnean Society, put the chrysalis of a Sphinx moth in a covered glass jar to observe its metamorphosis, and found two plants sprouting, one a common grass and one a rare fern. He had discovered by accident the principle of the terrarium, an enclosed glass case in which plants could grow watered only by the moisture which condensed during the heat of the day and returned to the soil at night (Schoenermarck 1974:150). Further experimentation by Dr. Ward led to the "Wardian case," a wooden box with glass top in which plants could safely be shipped on long sea voyages without watering or special care, being placed on deck to receive sunshine while protected from the salt spray. These Wardian cases were immediately put into use by botanical gardens, horticultural societies, and commercial growers. W.J. Hooker imported six times as many plants for Kew Gardens in fifteen years as had been imported in the previous century (Ibid:154). Whereas in 1819 only one plant in a thousand had survived the voyage from China to England, in 1848 20,000 tea plants, collected by the Fortune expedition, were shipped from Shanghai to the Himalayas of India without significant loss, to start the Darjeeling tea industry. Other plant transfers made feasible by the Wardian cases include the introduction of the Chinese banana to Samoa, Tonga, and Fiji. The Wardian cases were essential to the success of the cinchona and rubber transfers, the most significant of all those undertaken by Kew Gardens.

The Scientific Elite

England was a stratified society, with some fluidity. The primogeniture of the English aristocracy, in contrast to continental Europe, meant that younger sons had to find careers off the land,¹ and the Industrial Revolution had redistributed wealth so that many of the rising industrialists and great merchants could buy landed property and become members of the gentry (Newby 1975:152-55). There was a social gap between merchant and tradesman, but a successful tradesman could become a merchant or a successful mechanic an engineer. As science demonstrated its utility to the nation, scientists benefitted from this social fluidity. The most prominent were accorded upper middle class status, and received honors on the Queen's List (knighthoods and other non-hereditary titles)--as much honor, though not as much wealth, as a man could achieve for himself. The achieved status of the professional men was inevitably below the top in a society in which the aristocracy had not yet decayed.

Their own social origins had subtle effects on the precise status they might achieve by their work, and on the public acceptance of that work. Charles Darwin, grandson of the eminent scientific philosopher Erasmus Darwin, and also maternal grandson of Josiah Wedgwood, whose pottery works made the Wedgwood name famous in industrial and artistic circles, had family connections which advanced his early career through his appointment as suitable social companion to the captain of the Beagle (Gould 1976:32-4). Both he and his wife,

¹In the nineteenth century there were 200,000 "nobles" in England, but only 1630 transmissible titles (Guttsman 1963:115). The estates passed with the titles, from eldest son to eldest son.

who was his first cousin Emma Wedgewood, inherited money which freed him from the necessity of earning a living, so that he could devote all his time to observation, research, and reflection. Alfred Russel Wallace did not have a university education, worked as a surveyor for the railroads as a young man, was largely self-taught as a botanist, and earned his living by collecting plants on the Amazon and in the Indonesian archipelago to sell to private collectors. His article, written in a hammock during a malarial attack on Ternate in 1858, expressed the idea of organic evolution through natural selection as clearly as Darwin's paper did, but his work did not have the substantial documentation Darwin could bring to bear. Furthermore, Wallace's lack of social prestige and powerful friends in England would have made the acceptance of his paper extremely problematical if it had had to stand without Darwin's backing.

The Kew Circle: Personal Networks

England was a small country, and the Kew circle a tight circle of people who knew each other personally, corresponded voluminously, and passed their posts to friends or relatives. From 1841 to 1905 the directorship remained in the Hooker family. These personal relationships will be explained below more fully.

Dawson Turner		
WILLIAM J. HOOKER	— Maria Turner	John Stevens Henslow
JOSEPH D. HOOKER	— Frances H. Henslow	
	Harriet Hooker	— W.T. THISELTON-DYER

Kew Directors in caps.

In Kew's late eighteenth and early nineteenth century beginnings, patronage was the norm, tying king and influential nobles to a wealthy amateur botanist, Sir Joseph Banks (1743-1820) and through him to William Hooker and several younger men whose careers as naturalists illustrate the transition to professionalism in botany. Among Banks' protégés who were friends and colleagues of William Hooker were John Lindley (1799-1865), son of a commercial nurseryman whose first teacher of botany was Hooker and whose first employer was Banks. Lindley went on to become director of the Horticultural Society, professor of botany at the new, liberal University College, London, and chairman of the royal commission which recommended state support for Kew Gardens (the Lindley Report). Another was Robert Brown (1773-1858), a Scot from Edinburgh, for whom Banks got a position as naturalist aboard the Investigator under Captain Flinders, exploring Australia and the Torres Straits, as Banks had done with Captain Cook. Later Brown became president of the Linnean Society, and one of Charles Darwin's small circle of intimate friends.

Banks promoted Hooker's early career, publishing at his own expense Hooker's journal of a botanical trip to Iceland and recommending him for the professorial chair at the University of Glasgow, but he gave him less financial aid than he did the others mentioned. Hooker's own family had moderate means, gained in the wholesale woolen trade in Norwich, East Anglia; and Hooker married Maria Turner, the daughter of a Yarmouth banker. Dawson Turner was an Oxford man, an antiquarian who owned some paintings by the grand masters; and an amateur botanist and member of the Linnean Society. In 1814

Hooker accompanied the Turner family on a year's botanical tour of France and Switzerland, where he met the great naturalists Von Humboldt, De Candolle, and Bonpland, with whom he continued to correspond.

After 1820 Hooker's career was completely professional, first in Glasgow, after 1841 at Kew. The move to Kew meant a reduction in income, his starting salary being 300 pounds a year with a housing allowance of 200 pounds, whereas at Glasgow his popularity was such that his lecture fees--the students then paying the professors individually--came to over 700 pounds a year. Moving his household goods and his library cost him 300 pounds, since in those days before the railways he had to hire a fishing smack. He bought a large house with a walled garden stretching down to the Thames, stables, and a coach house (J.D. Hooker 1902:iv). Later a large house on Kew Green adjacent to the Gardens, now used as the Library and Herbarium, became available as the Director's house, and Hooker's salary increased as he solidified his position at Kew.

With a life of comfort, honors, and prestige, Hooker had attained the uppermost reaches of the middle class.

None of these botanists had had a university education, with the exception of Sir Joseph Banks, who had attended Eton and Oxford in the eighteenth century, where he was an atypical schoolboy, seeking out old women herbalists who taught him their lore of medicinal plants, and hiring a tutor from Cambridge when Oxford failed to teach him botany.

The two ancient universities, Oxford and Cambridge, were slow to adapt to the Industrial Age. In the eighteenth and early nineteenth centuries, they had lost, temporarily, the intellectual

preeminence they had once had. Most of the undergraduates spent their time in riotous living, before going out into the world to assume the place to which they were entitled by birth, i.e., in the Church, in Parliament, or on the County Bench, where they handed out stiff sentences to poachers. G.M. Young characterizes the two ancient universities as follows: ". . . they were clerical; they were idle; they were dissipated; they reflected those odious class distinctions by which merit is suppressed and insolence fostered; their studies were narrow, their teaching ineffective" (1964:95). During this time the best education was offered by the Scottish universities, because they did not practice religious exclusion and because they offered a scientific curriculum in addition to the classics, whereas there was no regular scientific curriculum at Oxford and Cambridge until after 1850, and the last religious disabilities were removed only in 1871 (Beales 1969:79).

The exclusiveness of the two medieval universities (Oxford and Cambridge) helped to establish the intellectual dominance of the Scots in English life. . . . Throughout the eighteenth and nineteenth centuries, when Oxford and Cambridge were closed to nonconformists, Scottish universities were able to pursue their cultural work unhampered to any appreciable extent by restrictions imposed by religious tests. The result was profound. More in contact with the social forces of the time, the Scottish universities soon became famous for their work in medicine and science. Edinburgh and Glasgow especially sent their doctors south to England to play a distinguished part in great medical advances then taking place (Hamilton 1948:267).

The same could be said for botany, as the Hookers' careers showed, Joseph D. Hooker being a graduate of Glasgow University with a degree in medicine, obtained while his father was teaching botany there.

Another possibility, after 1836, was University College, London,

a new private venture, liberal, accessible, and utilitarian. "The foundation of the University of London marks the entry of a new idea; the conception of a University as training for a specific profession, for medicine, law, engineering, or teaching, was in England a novelty to which the examples of Germany and Scotland both contributed. But as a seat of instruction University College rose at once to the first rank" (Young 1964:93). As we have noted, John Lindley was a professor of botany there.

This new professionalism penetrated and reshaped many of the older professions, but the Anglican Church remained unregenerate, guarding its alliance with the old landed proprietors, allowing them to fill the village rectorships, called "livings," on a patron-client basis with men who often had no special calling or qualification other than the right social connections.

There was one clergyman in the Kew circle, and none of these strictures applied to him. Reverend John Stevens Henslow (1791-1861) was a professor of botany at Cambridge and a close associate of Sir William Hooker, although he is better known as Charles Darwin's teacher and friend, the man who introduced Darwin to Captain Fitzroy and recommended him for the job as naturalist on the Beagle. In the preface to his published journal, The Voyage of the Beagle (1845) Darwin acknowledged his debt to Henslow, as he never did to any of his other professors, since his formal education "didn't take."

I shall have the pleasure of acknowledging the great assistance which I have received from other naturalists, in the course of this and my other works; but I must be here allowed to return my most sincere thanks to the

Reverend Professor Henslow, who, when I was an undergraduate at Cambridge, was one chief means of giving me a taste for Natural History,--who, during my absence, took charge of the collections I sent home, and by his correspondence directed my endeavors,--and who, since my return, has constantly rendered me every assistance which the kindest friend could offer.

Henslow had been ordained in the Anglican church, as Darwin thought of doing while at Cambridge, and as was common in the early nineteenth century for educated young men who needed an undemanding job as the basis for a life of the mind. Henslow eventually got "a living," and unlike some who treated it only as a sinecure, was an exemplary clergyman. Still, his religious beliefs and social position did not prevent him from being open-minded about Darwin's new theory, which was anathema to most churchmen, who clung stubbornly to Creationism. Henslow was not converted, but firmly supported Darwin's right to a fair and dispassionate hearing.

Henslow's interests as a young man ranged over all of natural science--conchology, entomology, minerology, geology. He taught geology at Cambridge for a while before settling on botany, and took the chair at Cambridge in 1827. He was interested in scientific farming, in experiments in hybridization, in the geographical distribution of plants, and in their functions. His interest in economic botany shows in the museum at Kew that he and William J. Hooker started.

Henslow had another firm tie to the Hookers. His daughter, Frances Harriet Henslow, married Joseph Dalton Hooker (see chart, page 123). Thus Joseph Hooker, like his father, married a botanist's daughter, tying his personal life to his professional life.

The Second Generation.

The second generation, that of Joseph Hooker (1817-1911), inherited an established professional domain, and validated it by their contributions to science and the state. In this generation, a university education was common, and the important relations were between near equals and friends. Joseph Hooker grew up surrounded by botanists, and in his thirty years (1855-1885) as assistant director and director of Kew, he was at the center of the world of botany, his reputation unequalled by any other botanist. His most important friendship was that with Charles Darwin, eight years his senior. During their long association, each was able to help the other at a crucial point in his career. Charles Lyell, whose Principles of Geology (1830) with its novel theory of natural causes for geological phenomena ("uniformitarianism") had influenced Darwin's thinking during the years on the Beagle, stood up with them on these occasions. Lyell and Hooker were both important to Darwin as personal friends, supporters in battle, and sounding-boards for his ideas.

Joseph Hooker first became aware of Darwin by 1839 through the Lyells, old family friends of the Hookers in Scotland. Charles Lyell of Kinnordy, father of Charles Lyell the geologist, sent the proof sheets of Darwin's Journal of Researches, not yet published, while Hooker was studying for his medical exams at Glasgow before setting out as surgeon-naturalist on the Erebus for three years in Antarctic and Australian waters. Hooker's copy of Darwin's Journal was much read by all the officers on the Erebus. Before sailing, Hooker was introduced to Darwin through a chance meeting in Trafalgar Square, when Hooker was in the company of a former shipmate of Darwin's

on the Beagle (de Beer 1965:113).

Hooker became one of Darwin's intimate circle, his photograph stood over the mantel in Darwin's house at Down, and Hooker has described a lively visit there noting Darwin's hearty manner and his "thorough enjoyment of home life with friends" (de Beer 1965:118). This was in spite of Darwin's semi-invalidism, thought now to have been caused by Chagas' disease acquired through the bite of a beetle in 1835 at Luxan, in the Argentine Andes (de Beer 1965: 115).

In his published account of the voyage of the Beagle Darwin supplemented his own observations and journal notes with the results of his correspondence with specialists in every branch of natural science--geology, mammalian zoology, birds, fishes, reptiles, shells, plants. Writing of the Galapagos Islands, he says:

The botany of this group is fully as interesting as the zoology. Dr. J. Hooker will soon publish in the 'Linnæan Transactions' a full account of the flora, and I am much indebted to him for the following details. . . . Dr. Hooker informs me that the Flora has an undoubted Western American character, nor can he detect in it any affinity with that of the Pacific. . . . If we now turn to the Flora, we shall find the aboriginal plants of the different islands wonderfully different. I give all the following results on the high authority of my friend, Dr. J. Hooker. . . . The species of the Compositae are particularly local; and Dr. Hooker has furnished me with several other most striking illustrations of the differences of the species on the different islands. He remarks that this law of distribution holds good both with those genera confined to the archipelago, and those distributed in other parts of the world (Darwin 1845: 392-97).

Darwin considered Joseph Hooker the best authority on the geographical distribution of plants, and a reading of Darwin's Beagle journal shows how important such fact-gathering could be as grist to

Darwin's mill. His constant reflections on the meaning of the distribution of species and the local variations within species--reflections out of which he was to make his theory--arose not only from what he saw with his own eyes up and down the coasts of South America, but from the comparisons he could make with similar flora and fauna of North America, South Africa, Australia, and the Oceanic islands, thanks to the reports of the many naturalist-explorers who had gone to sea in His Majesty's ships over the previous fifty years. In Darwin's theory we have the scientific payoff for this immense government subsidy to natural science.

In 1844 Darwin made Joseph Hooker this first confidant on his theory of the origin and transmutation of species by allowing him to read his 230 page "Essay," on which Hooker made some handwritten notations. Hooker strongly urged Darwin to publish,¹ although he himself, as late as 1853 in his introduction to his Flora Novae Zelandiae argued for the permanence of species and begged the whole question of origins (Appleman 1970:19-23).

But when Alfred Russel Wallace's letter from Ternate in the Moluccas came like a bombshell to Darwin in June 1858, both Joseph Hooker and Charles Lyell, Darwin's "best and kindest friends," stepped in to handle the crisis. Darwin wanted above all to do the decent thing, that is, to offer to get Wallace's essay published, as his first letter to Lyell shows. But within a week he was writing again

¹Darwin did not publish until his hand was forced fourteen years later, perhaps because of his desire to supply further documentation, and his reluctance to challenge the prevailing religious beliefs, which his wife held strongly.

to Lyell and Hooker, agitated and depressed, and asking their advice. He stressed that his priority was established by the 1844 copy of his "Essay" with Hooker's handwriting on it, and by a letter to Asa Gray of Harvard. But still his conscience troubled him about publishing, even jointly. In the end he followed his friends' suggestion that his short essay and Wallace's paper be published by the Linnean Society. The very next day, Hooker and Lyell arranged for the public reading, forwarding the two articles with a letter of explanation and an extract both from Darwin's Essay of 1844 and from the letter to Asa Gray (Appleman 1970:67-69).

Hooker was converted to Darwin's theory by this time, and in 1859, immediately after the Origin of Species was published, there appeared Hooker's Introduction to his Flora Tasmanica in which he states his belief that species are mutable and derived from earlier species, using examples from his own observations on plant species in Australia and Tasmania, and acknowledging Darwin's work as having prompted him to change his mind (Appleman 1970:308-12). Hooker was the first scientist to do this, and Darwin welcomed Hooker's work, for the conclusions were based on observations on plants, for which no Lamarckian views of modification through use or disuse or voluntary habit patterns could be adduced (de Beer 1965:158).

In a letter to Wallace, January 25, 1859, Darwin wrote: "Dr. Hooker has become almost as heterodox as you or I, and I look at Hooker as by far the most capable judge in Europe (Appleman 1970:69).

Hooker, Lyell, and Henslow continued to champion Darwin in the storm of attacks that came after the publication of the Origin.

Hooker was on the platform, and Henslow in the chair, at that famous meeting of the British Association for the Advancement of Science, held at Oxford in 1860, when Bishop Wilberforce ridiculed Darwin's "proofs." But it was their younger friend, Thomas Henry Huxley,¹ who triumphed that night when he took up the challenge the Bishop threw down in asking whether it was through his grandfather or his grandmother that Huxley claimed to be descended from a monkey. With this personal attack, Huxley saw his chance. In the course of a grave and reasoned speech, he chided the Bishop for introducing personalities into a scientific discussion and made his famous retort, variously reported but in essence that "he was not ashamed to have a monkey for an ancestor but that he would be ashamed to be connected with a man who used his great gifts to obscure the truth" (Leonard Huxley 1901:Ch. XIV). History remembers Huxley, for this and other spirited defenses of Darwin, as "Darwin's bulldog." But a letter from Hooker to Darwin, who did not attend the meeting because of illness, shows that Hooker was also in fighting mood that night. Although the pugilistic references are not to be taken literally, the passage shows Hooker in a light not revealed elsewhere.

My blood boiled. . . . I swore to myself that I would smite that Amelekite, Sam [Bishop Wilberforce] hip and thigh if my heart jumped out of my mouth . . . so there I was cocked up with Sam at my right elbow, and there and then I smacked him amidst rounds of applause. I hit him in the wind at the first shot in ten words taken from his own ugly mouth; and then proceeded to demonstrate in as few more 1) that he could never have read your book, and 2) that he was absolutely ignorant of

¹Thomas Huxley had also studied medicine and had sailed on one of Her Majesty's voyages of discovery, aboard H.M.S. Rattlesnake. Alfred Russel Wallace was another naturalist who took part in a voyage of discovery paid for by the Crown.

Botanical Science. . . . Sam was shut up--had not one word to say in reply, and the meeting was dissolved forthwith, leaving you master of the field after 4 hours' battle (de Beer 1865:166).

Hooker, Lyell, and Huxley, whom de Beer calls the greatest botanist, the greatest geologist, and the greatest zoologist in Britain then (1965:159), had won a battle for Darwin, but the hostility persisted, not only in the church but in the scientific bureaucracy. In 1872 Kew Gardens was drawn into this overall attack on the Darwinian party; and Darwin, Lyell and Huxley came to Hooker's rescue. In the scientific community, the attack was led by one of Darwin's bitterest critics, Sir Richard Owen, a leading anatomist and paleontologist, who was Superintendent of the Natural History Departments of the British Museum. Owen had shown personal animosity towards Darwin, and by extension towards Darwin's friend Hooker, ever since the publication of the Origin of Species, of which he wrote a savage anonymous review in the influential Edinburgh Review (1860). Darwin himself characterized this review as "extremely malignant, clever, and . . . very damaging" and wrote that Owen "misquotes some passages altering words within inverted commas" (de Beer: 164).

Later in the same year [1872] Hooker was in trouble with his superior, the First Commissioner of Works, Action Smea Ayrton, an ambitious politician without any knowledge of science, who subordinated Hooker as Director of the Royal Botanic Gardens, Kew, to the Secretary of the Board and the London Director of Works. As a result Hooker was subjected to the gravest indignities and obstruction in his work. A full statement of the case, setting out the overbearing behavior of Ayrton, was drawn up over the signatures of Lyell and of Darwin, and nine other distinguished men of science and sent to Mr. Gladstone, who was then Prime Minister. A report on Kew had been circulated by Ayrton without previously submitting it to Hooker for comment; the report had been written by his and Darwin's bitter enemy [Richard] Owen for the purpose of discrediting Hooker

and of securing the transfer of the collections at Kew to the British Museum where, of course, they would have been under Owen's hand. The matter was raised in both Houses of Parliament, and Ayrton was rebuked by a Treasury Minute which laid down that, in all scientific matters, Hooker was master in his own house (de Beer 1965:261).

De Beer emphasizes the split in the scientific community between Darwinists and anti-Darwinists, chiefly Richard Owen.¹ But a more important issue was the degree of Hooker's autonomy or of his subordination to Ayrton, i.e., the relation of science to the state. De Beer indicates that Hooker, with the backing of Darwin et al., won a clear victory for scientific autonomy. But what was "a scientific matter" and what was a budgetary matter? Kew Gardens was, after all, supported entirely by the state.

Roy McLeod (1974) has dug deeper into the complex issues of the Ayrton/Hooker controversy and presents a slightly different interpretation than de Beer. He acknowledges the importance of Kew's botanical collections, research library, and plant transfers and says "through its work with foreign and colonial ministries on the selection of officers, and through its advice to the Admiralty, the India Office, and the War Office on the control of useful plants, Kew acquired vast imperial importance" (1974:52). But he points out that

¹ Another light on this struggle for dominance in the scientific community is suggested by Michael Ruse (1976:352-353): "My suspicion is that the Darwinian party, particularly Thomas Henry Huxley and Joseph Dalton Hooker, effectively excluded from significant advancement many would-be biologists who would not toe the Darwinian line. Indeed it should be remembered that in the 1870s Hooker was president of the Royal Society and Huxley was secretary, so they had strong influence in the policies and attitudes of the most prestigious scientific society in England. Also they were members of the so called 'X-club,' which openly boasted of controlling British science." Further investigation of the X-club is indicated to see how Hooker and Huxley used their position of power in the scientific community.

Key was almost a family preserve of the Hookers, for whose imperial connections and exotic tastes Ayrton had little sympathy. To the radical iconoclast Ayrton, who had made his career by opposing all government spending as extravagance and all extravagance as corruption, Hooker's Kew stood "like a semi-autonomous satrapy within his first ministerial domain" (Ibid:52). In reality, Kew was not expensive, its budget of £12,000 being only 1% of the £1,200,000 appropriated annually for public works under Ayrton's ministry. But to Ayrton "the maintenance of a huge park, which despite the protestations of scientists, seemed chiefly recreational, made a mockery of the Government's policy of retrenchment" (Ibid:52). Beginning in 1869 when Ayrton became Minister of Works, he repeatedly interfered, often in an underhanded way, in Hooker's management of Kew. Hooker's heated response was in part personal, since he regarded Kew as a legacy from his father as well as a trust for the nation, and had long been accustomed to independence from administrative control. Finally in 1871 Hooker went over Ayrton's head to his powerful friends in the Cabinet, including Lord Cardwell at the Home Office and the Duke of Argyll at the India Office, who sympathized but kept their support tacit, and to Gladstone himself, who temporized. As Prime Minister, Gladstone's efforts were directed toward domestic reform and economy in government; and though he respected Charles Darwin and had had friendly relations with Hooker, his difficulties in reconciling his religious scruples with the new scientific theories made him uncomfortable with scientists.

Hooker's cause was taken up by the scientific establishment,

which supported him almost unanimously, with the conspicuous exception of Richard Owen. Leading scientists in every field took Hooker's case to Parliament and to the public. By 1872 the battle lines were drawn between the scientists and the politicians, who closed ranks around Gladstone. John Tyndall, the physicist, said "They shall know that men of science can use a sledge hammer" (Ibid:61). The sledge hammer was a "memorial" or memorandum, complete with documents and official correspondence, setting forth Hooker's position and signed by eleven of Britain's most prominent scientists, which was leaked to the press before being presented to Parliament, a tactic not unfamiliar today. For a month, July 1872, the London papers excoriated Ayrton and praised Hooker. Resolutions of support came from the Royal Zoological Society, the Royal Horticultural Society, where Hooker's son-in-law, William Thiselton-Dyer was secretary (director), and from the Royal Society of Edinburgh. The head of the West India Committee wrote to Gladstone telling him that Kew Gardens was so important to the planters and merchants that Hooker's resignation would be a national misfortune (Ibid:64).

But when the "horrid discussion" finally took place in the House of Commons, Gladstone stood by his Minister of Works, saying in his speech that scientists were men of "extreme susceptibility," too proud and touchy for their own good (Ibid:67). Hooker was asked to withdraw his statement against Ayrton, or resign. He did neither, but stood his ground, maintaining that scientists should not be subject to laymen in scientific matters. In McLeod's view, there was no settlement but an armistice. The central question of departmental

control versus scientific autonomy had been raised and vigorously fought, but without a clearcut victory. It was to come up again, and in 1918 scientists won privileged access to Parliament through their Research Councils, an arrangement that enabled close and secret communication between science and the highest circles of government in World War II, when scientific advances, e.g., the development of radar, helped to overcome British military unpreparedness.

In one particular, and a very important one to Kew Gardens, Ayrton was completely defeated by the scientific community which rallied around Hooker, and by the public support they received. If, as de Beer suggests, Ayrton and Owen hoped to dismantle Kew Gardens in favor of Owen's British Museum collections, the attempt backfired. Owen's critique of Kew, which was published in the Parliamentary Blue Book, for all to read, had accused Hooker of self-aggrandizement, of overpaying staff, of neglect, and of keeping an expensive herbarium for "attaching barbarous binomials to dried foreign weeds" (quoted in McLeod 1974:62).¹ As we have seen, the press refused to take up this invitation to anti-scientific know-nothingism, and instead chorused that Kew Gardens was a national treasure. Had Ayrton and Owen

¹There was a small sequel to this important contest of wills in which all participants showed their characteristic propensities. In the last years of his life, Darwin made a generous offer to pay for the compilation at Kew of an index to the names and authors of all known botanical species and genera. When Hooker informed Ayrton, still his nominal superior, of Darwin's offer, Ayrton replied that he couldn't countenance any further expense to the Board of Works. Hooker proceeded with the project and published the Index Kewensis, though Darwin did not live to see it. The Index is still a valuable reference tool, containing 375,000 specific plant names.

prevailed, and Kew been stripped of its collections and library, it would have ceased to be a scientific center, and become merely green space with flowers. The threat to Kew was averted by the concentrated action of a group of scientists who had won national reputations and could thereby challenge the bureaucracy. This could not have happened fifty or a hundred years previously, and marks a new era in the relation of science to the state. Science was necessary to the state; ergo, scientists must be accommodated.

The furor over Kew Gardens hastened the collapse of the Gladstone government, troubled with other issues also. Hooker had better relations with the next Prime Minister, Disraeli, who was greatly interested in the overseas empire. The intellectual climate of late Victorian England continued to be favorable to science, perceiving its utility in the race for commercial superiority and political hegemony against increasing competition from France, Germany, and the United States. In 1876 Joseph Hooker made a signal contribution to the Empire by putting the weight of Kew Gardens into the development of a new strategic resource, plantation rubber.

The Imperial Stage

If, by analogy with the ancient empires, we call the period under William Hooker's directorship the Formative Stage and the period under Joseph Hooker the Classical Stage, what follows is the Imperial Stage, not just for its content, because imperialism was the goal being served throughout, but for its style.

In 1885 Hooker was succeeded as director of Kew Gardens by his son-in-law, W.T. Thiselton-Dyer. Harriet Hooker Thiselton-Dyer,

granddaughter of both William J. Hooker and John Stevens Henslow, was a link in a dynastic chain of Kew directors which stretched from 1841 to 1905.¹

Thiselton-Dyer was a somewhat different sort of man from the Hookers, reflecting in his demeanor the more rigid and conventional society of late Victorian England, which took its cues from an ageing Queen and Empress, and which had a position to uphold vis-a-vis the world, rather than a position to make or create, as had been the case earlier in the century. He was educated at Christ Church College, Oxford, the first of the Kew directors to have received the peculiar social stamp of an Oxford education. In 1891 when he was knighted, he hyphenated his name, a practice sometimes followed in England among those with social pretensions. He was known as something of a martinet and an autocrat, rather distant from his staff. When a group of suffragettes burned down a refreshment pavilion he had built at Kew in the shape of a Swiss chalet, his indignation was unbounded (Turrill 1959).

In 1887 Thiselton-Dyer started the Kew Bulletin of Miscellaneous Information, a publication still of great influence in botanical circles. The Kew Bulletin was an effective instrument in circulating information throughout the entire imperial network of botanic stations, printing articles on every tentative trial of a plant and on the plant resources of every colony.

As Assistant Director under Joseph Hooker, Thiselton-Dyer

¹She was also an accomplished botanical artist, pressed by her father into professional service in an emergency (Anderson 1975), and she might have had a career if careers had been open to women then.

had been in charge of many of Kew's colonial activities, including personal supervision of the introduction of rubber plants propagated at Kew to the Peradeniya Gardens in Ceylon in 1876 and of cacao to Ceylon in 1880. He continued to supervise such activities, appointed a regular "Assistant for India" to his staff at Kew, established closer connection between Kew and the Colonial and India Offices, and formalized the relations between Kew and the botanical stations in the colonies (Turrill 1959: 35). During his tenure of office the empire was at its peak. The entire Indian sub-continent had been pacified and was under British rule, with the Queen proclaimed Empress at a magnificent durbar in 1877. Burma and Malaya had been accessioned. Lord Lugard and Cecil Rhodes were consolidating into formal colonies the pieces of Africa seized by Britain. On his retirement in 1905 Thiselton-Dyer wrote an introduction to a history of Kew done by a staff member, which reveals his vision of Kew's role.

There are some sixty distinct governments under the British Crown (1908) and in any technical difficulty all have resort to Kew. It did what was possible when coffee-leaf disease brought financial disaster to Ceylon; the fortunate identification of a single leaf started the rubber industry of the Gold Coast; Kew sent tea to South Africa; it gave cinchona to India, and a dose of quinine can be purchased at any Indian post office; it transferred the South American rubber plants to the East, with results which have been described as fraught with 'wealth beyond the dreams of avarice.' A chain of Kew-trained men dot the course of the future Cape-to-Cairo railway. Scientific members of the Kew staff hold important positions in India and in the Transvaal, and a former assistant director has done noble work in restoring agricultural prosperity in the West Indies. India has recognized its debt by supplying Kew with a director (W.T. Thiselton-Dyer in Bean 1908: xviii).

The curious phrase "India has recognized its debt by supplying Kew with a director" reflects the prevailing attitude that India

was indebted to England for the blessings of civilization and is a graceful way of acknowledging his successor's (Lt. Col. David Prain's) colonial background, perhaps intended to deflect the prejudice among insular Britons that a career made in the colonies, however useful, was bound to be second rate.

But in the decade before World War I, when Britain with forty million people was ruling one quarter of the earth, Britain had need of the experienced colonial at home.¹ Both the new director and his assistant for India had long experience in the colonies. Mr. Chipp, the assistant director, had served in the Gold Coast Gardens and the Singapore Gardens, where rubber was being developed. Col. Prain came to Kew from his post as Superintendent of the Calcutta Botanic Gardens, an important research center of tropical botany, and at its Mungpoo and Darjeeling branches, the site of government cinchona plantations. He was the author of a botanical survey of the Indian sub-continent, part of a thirty-seven volume botanical survey of the Empire. This major undertaking summarizes the knowledge gained by British botanists over a century and a half of imperial botany under the aegis of Kew Gardens.

In his colonial background Prain symbolized the ultimate rationale for Kew: "aiding the Mother Country in everything that is useful in the vegetable kingdom," as the Lindley report had laid down in 1840. In another way, Prain represents an older strain in botany. By birth, he was a Scot from Edinburgh, another Scot to find opportunity

¹"When . . . it is imperative to appoint technically competent people to fill important positions the ascriptive criteria for their selection will be de-emphasized" (Mary E. Wilkie 1977:69).

abroad, and he had been trained in medicine and had served in the medical corps of the British army in India before he turned to botany, a reminder of botany's origin as an adjunct to medicine, before it became an adjunct to commerce.

Chapter VI

Kew and Cinchona

Since then [the seventeenth century] the importance of the bark as a medicinal agent has been gradually on the increase, and at the present time the recognition of its virtues and its use as a febrifuge are commensurate with the bounds of civilization. To England, with her numerous and extensive Colonial possessions, it is simply priceless; and it is not too much to say, that if portions of her tropical empire are upheld by the bayonet, the arm that wields the weapon would be nerveless but for Cinchona bark and its active principles (Bidie 1879:15).

G. Bidie, Surgeon-major in the British Army and Superintendent, Government Central Museum, Madras Presidency, gave this opinion in an autographed pamphlet on cinchona culture in India which he sent to Thiselton-Dyer, then Assistant Director of Kew Gardens. It succinctly expresses the theme of this chapter--the utility to the Empire of the botanic network, as exemplified by the case of cinchona, the source of the wonder drug that cured malaria. I shall trace the transfer of cinchona from the Andes and its development as a plantation crop by Kew and the Indian satellite gardens, and discuss the consequences for the Empire both in Asia and in Africa.

Malaria is a disease of great antiquity, responsible for more illness and death than any other single disease in human history. Since the early seventeenth century there has been knowledge of a specific cure for malaria, to wit, quinine, a product of the bark of

the cinchona tree, native to the Andes. For the next two centuries the application of this knowledge was only sporadic because of the opposition of entrenched medical beliefs, but by mid-nineteenth century the use of quinine in treating malaria was quite firmly established in Western medicine. The demand for quinine was especially strong in those nations with imperial interests in zones of endemic malaria, e.g., the British in India, the Dutch in the East Indies. These nations separately undertook to transfer seeds of cinchona from the Andean regions to their own colonial possessions, and to establish cinchona plantations which would be under their complete control.

Since cinchona was the source of a life-saving drug, the service performed by Kew had its humanitarian aspects, its economic, social, and demographic effects, and above all, a political and military rationale, for the British raj in India needed strengthening at that moment.

The Effects of the Sepoy Revolt

In 1858 when the India Office put out its call to Kew to obtain cinchona, the British Army in India were still shaken by the Revolt of 1857, when their authority had been challenged by a rebellion of native troops in the Bengal regiments. This revolt is called the Sepoy Mutiny in Britain and the West, thus diminishing its import by refusing to acknowledge that a people were rebelling, not just a few disaffected soldiers, as the term mutiny implies. Although the precipitating factors in the rebellion lay in British Army orders and practices which violated cultural, religious, and caste taboos (e.g., the introduction of cartridges greased with pig

or cow fat), the soldiers were expressing the unrest of traditional India, both Hindu and Muslim, over the displacement of native rulers, harsh land practices, and rapid Westernization--in a word, colonial bondage.

In the hundred years in which the East India Company had been operating as a politico-military force in India, all India had been conquered, either by force or guile. The native princes who remained (about 40% of Indian territory remained nominally in their hands) had been reduced to dependents on the British, paying subsidies to the Company or furnishing troops. In the period immediately preceding the Revolt, Company policy was especially directed toward annexation of native states, either by escheat, whereby a native state fell to the Company on the death of a ruler without natural heirs, or by invasion on some pretext. The conquest of the Sikh kingdom of the Punjab in 1845 was followed by the annexation of the populous state of Oudh in 1856, thus consolidating British control of the entire Upper Gangetic Plain. Oudh was the chief recruiting ground for the Bengal Army, and its annexation fanned the spirit of resistance to further denationalization.

This was by no means the first revolt in India. In keeping with their emphasis on disaffection among the troops and denial of popular protest, British sources, e.g., the long article on the Mutiny in the 1911 edition of the Encyclopedia Britannica, acknowledge several earlier mutinies among the sepoys: "As early as 1764 it was necessary to stamp out mutiny by blowing thirty sepoys away from guns"; up to "In 1844, . . . no less than seven native regiments broke into open mutiny" (1911, vol. XIV:446). From an Indian source like Mukherjee

(1974:282) one learns of a long series of peasant revolts and popular uprisings against the oppression of the Company, including the Santhal Insurrection of 1855-56.

This general ferment found its last and greatest expression in the Revolt of 1857, which spread from garrison to garrison across the Ganges Plain. Delhi, Lucknow, and Cawnpore were occupied by the rebels for several months but each fell in turn to British siege guns. The British called on reinforcements from England, and relied heavily on Sikh troops, Pathan levies, and Nepalese Gurkhas, i.e., hill peoples were used against plains peoples. The fighting spread to Central India; all told, the "Mutiny" lasted eighteen months. Many Indians regard it as the first major independence struggle, and claim it was well planned. It failed primarily because of quarrels among the many leaders.

Atrocities were committed on both sides; relations were thereafter embittered and racial lines hardened. The Revolt was a great psychological blow to Britain, felt at home as a humiliation, an outrage, and a threat.

What happened at Cawnpore [the slaughter of a British garrison, including women and children] in July 1857 was like a red-hot poker thrust into the face of the Englishman. It outraged his racial pride, his rough-and-ready sense of fair play, his standards of sexual morality (owing to current rumours), and the obsessive triumph with which he regarded British achievements in India (Burn 1965:84).

England reacted with a pride of race "stern, hard, immovable," and a belief that this obduracy was what had pulled her through the crisis. This attitude affected all subsequent relations with non-white colonial subjects.

In essence, the Revolt and its suppression marked the end of

British commercial capitalism in India, under the aegis of the Company, and a shift to industrial capitalism on the part of the British masters. From this time on, India became more and more a supplier of raw materials, e.g., cotton, indigo, coffee, and a market for Lancashire finished goods. As a result of the Revolt, a major political reorganization was carried out in India in 1858. The British East India Company was abolished and replaced with the Crown, acting through a Council for India and a Secretary of State for India, who was given a cabinet post and ruled from Whitehall. The bureaucracy was greatly enlarged and took more and more part in the direction of Indian affairs, e.g., through land tenure regulations and the courts of justice. Taxes were increased to cover the suppression of the Revolt, taxes on the poor as well as the rich. "The suppression of the Mutiny increased the debt of India by about 40 millions sterling, and the military changes that ensued augmented the annual expenditure by about 10 millions" (Encyclopedia Britannica 1911, vol. XIV:415; see also Romesh Dutt 1960).¹

¹The Indian debt was the major rationale for the heavy taxes assessed by Britain on Indian cultivators--over 50% of the yearly rental on their lands (Dutt 1960:x). "When the East India Company ceased to be rulers of India in 1858, they had piled up an Indian debt of 70 millions. They had meantime drawn a tribute from India, financially an unjust tribute, exceeding 150 millions, not calculating interest. They had also charged India with the cost of Afghan wars, Chinese wars, and other wars outside India. Equitably, therefore, India owed nothing at the close of the Company's rule; her Public Debt was a myth. . . . Within the first eighteen years of the administration of the Crown, the Public Debt of India was doubled. It amounted to about 140 millions in 1877, when the Queen became the Empress of India. This was mainly owing to the cost of the Mutiny wars, over 40 million sterling, which was thrown on the revenues of India" (Dutt 1960:xii). By 1900, when Dutt was writing, the Debt was up to 224 million, and India was remitting annually to Britain over 20 million pounds sterling, to support the civil and military establishment and to pay interest on the debt.

The military changes that ensued were these: realizing their vulnerability and the need for combat-ready troops of unquestioned loyalty, the British reorganized their armies in India, raised the ratio of British to native troops, and restricted the artillery to Britishers (Thompson and Garrett 1966).

Now more than ever there was concern for the health of the troops in India, for their dependents, and for the increased number of civil servants who brought their families out from England to the dangerous "climate" of the new Crown Colony. Cinchona bark, which could control malaria, could be imported from South America, but why not grow it in India? In 1858 the cinchona transfer, which had been recommended for some time, acquired funding from the India office, and the project got under way.

Malaria

In the contemporary world malaria is a disease of the tropics, much reduced but by no means eliminated by the mosquito-eradication programs of the World Health Organization, and by the use of quinine and its modern derivatives. In fact, the hopes entertained in the 1960s of conquering malaria have come up against biological, environmental, and financial limits.¹ As the incidence of malaria starts

¹The Indian Council of Medical Research reports that there were an estimated two million cases of malaria in India in 1974 and 4.5 million cases in 1975. In April 1975 the World Health Organization announced that malaria, the largest single cause of death and debilitation in the world today, was spreading in such countries as Burma, India, Nepal, Sri Lanka, and Thailand, where eradication had gotten off to a good start in the early nineteen-sixties. Increased resistance of malaria-bearing mosquitoes to DDT, dieldrin, malathion and other insecticides was also found in Latin America (NY Times, April 15, 1975).

to increase again in certain countries, quinine is also making a comeback. Quinine is not only cheaper than the modern synthetic drugs which had largely replaced it, but the malaria plasmodium seems to be developing, through genetic mutation, a resistance to chloroquine, while quinine remains effective. Ruanda has obtained a \$1.8 million credit with which to increase its cinchona plantings, with a goal of 1000 tons of cinchona bark by 1987 (Newsweek Sept. 7, 1976). India, which has never completely abandoned its cinchona plantations, has announced plans to increase production of cinchona bark, both in the Himalayan foothills of West Bengal and in the southern mountains of Tamil Nadu State. Tamil Nadu at present has 2429 hectares under cinchona cultivation and plans to increase this area by 1180 hectares per year for five years (Hindu, May 12, 1976). Thus the history of cinchona bark which I shall present in this chapter has re-acquired a relevance which it had lost in the heyday of DDT and the synthetic anti-malarial drugs.

Malaria is not a tropical disease per se but was once prevalent in the temperate zones also. Malaria has been endemic around the Mediterranean since ancient times (Angel 1966; Klein 1969), and various haemolytic adaptations, such as thalassemia, sickling, and favism have arisen there in the affected populations (Allison and Blumberg 1965; Giles 1962). It was also present in England and France in the seventeenth century, and recorded in the nineteenth century in the Mississippi Valley as far north as Indiana and Illinois and in the Jersey Meadows (Sauer 1962)—wherever the vector, *Anopheles* species could find enough still water, either natural or man-made, in which to breed. Hence the early name "marsh fever." "Intermittent fever" and

"the ague" are other early names, drawn from the symptoms of fever, chills, and tremors. "Malaria" comes from the Italian for "bad air," thought for a long time to be the cause of the disease, since a connection was made with breathing the night air. But this was overlooking the fact that mosquitoes are more active in the evening.

It was not until late in the nineteenth century that the etiology of the disease was discovered. In 1880 a French physician, Dr. Charles Laveran, saw the parasite under the microscope in the blood of Algerian soldiers who had malaria. Several Italian investigators demonstrated the connection between mosquitoes and malaria in controlled field experiments in hyperendemic zones of Southern Italy. Sir Patrick Manson, discoverer of the cause of filariasis and schistosomiasis, suggested the vector theory to Ronald Ross of the British Army in India, who worked out the life history of the malaria parasite. Again, it was a group of Italian investigators who pushed this work to completion and proved conclusively that malaria was transmitted by the bite of the female Anopheles. By 1900 mosquito-eradication programs were underway, stagnant pools of water in marshy areas being sprayed with oil. But thanks to quinine, a cure was known long before the disease was understood.

Cinchona Bark

Alkaloids present in cinchona bark interfere with the reproduction of the malaria parasite and make cinchona the most specific plant remedy known and one of the very few specifics in the whole pharmacopeia before the sulfa drugs and penicillin of World War II. This natural specific against malaria was discovered in the temperate zone

of the Northern Andes, the sole natural habitat of trees of the genus *Cinchona*, whose bark yields quinine and the related alkaloids quinidine, cinchonine, and cinchonidine. Quinidine and cinchonine are also effective against malaria, but somewhat less so than quinine. The genus includes over thirty species, which grow in scattered clumps in the montane forests of Colombia, Ecuador, Peru, and Bolivia between latitudes 10 N and 20 S at elevations from 800 to 3400 meters (2600' to 11000'), with optimum conditions at 1200 to 2500 meters (4000' to 8000') (Fosberg 1945; Bidie 1897). There is great variability in quinine yield between species, and alkaloid content of the bark varies greatly within species according to micro-climatic conditions--sun, rain, soil and elevation. It also varies according to which part of the tree the bark is taken from--stem, shoots, or roots. This variability was to cause many problems in the acceptance of the "Peruvian bark" in European medicine, because at first sometimes it cured and sometimes it did not.

The first mention in Spanish is in a chronicle of the Order of St. Augustine written by a monk in Lima some time before 1633 (Duran-Reynals 1945:24). The remedy was brought to Europe around 1640 by the Jesuits in a powdered form known as "Jesuit's powder" or "Polvo de la Condesa," after the Countess of Chinchon, wife of the Viceroy at Lima, whose spectacular cure by means of the powdered bark is probably apocryphal, but whose name in altered form was later taken by Linnaeus as the name for the genus. Seventeenth century medicine in Europe leaned heavily on bleeding and purging, to expel the corrupt humors, after Galen's dictum in the second century A.D. So the new

fever bark had to overcome this prejudice as well as failure to cure other fevers (typhoid, the plague), and in some quarters, fear of the Jesuits (the Popish Plot). But in 1678 Robert Talbor was named physician apothecary to King Charles II of England because of his success in curing the king's malaria with a secret formula. The next year the secret formula was purchased by King Louis XIV of France, who gave Talbor 2000 louis d'or, a title, and a large pension. When it was later published, it turned out to be merely the powdered Peruvian bark in wine. Cortex Peruanus entered the official London pharmacopeia and its use became more common.

Indigenous Use?

The question naturally arises, "Did the Jesuits learn of the fever bark from the Indians?" Although there is no documentation, the answer must surely be yes. Indigenous curers habitually treated fevers with bark infusions and were cognizant of the properties of the native botanicals, as Europeans were not. One of the indigenous general febrifuges, "quina-quina," was at first confused by Europeans with quinine, though it has now been identified as the bark of Myroxolon peruviana (Fosberg, 1945). Plant-based medicine was more highly developed among the peoples of the New World than it was in the Europe of that time, and reports from New Spain stimulated European interest in herbal medicine and prompted the foundation of botanic gardens attached to medical schools.

Did malaria exist in the pre-Conquest Americas or was it brought there by the Spanish or perhaps by their African slaves? Again there is little documentation. Intermittent fever was noticed by the

Conquerors in Mexico, and "marsh fever" is mentioned by the late sixteenth century Peruvian codex Nueva coronica y buen gobierno by Guaman Poma de Ayala, an hispanicized Inca noble. But Frederick Dunn, a physical anthropologist, has made a careful study (1965) and makes a strong argument that malaria did not exist in pre-Columbian America, but was brought by the Conquerors and re-introduced many times by later arrivals. This point has no direct bearing on the question of indigenous discovery; a century passed between Pizarro and the Jesuit promotion of the bark, during which time indigenous curers noted that their cinchona bark infusion was remarkably successful against the new fever, distinguishable from other fevers only because it came and went at regular intervals.

One objection often raised to the indigenous discovery of cinchona is that when the naturalist Alexander von Humboldt was exploring the Andes in 1799-1804, he reported that the natives in some areas had a prejudice against treating fevers with the bitter brew of the bark and preferred to use an aromatic infusion of lemon or lime. "This was true at Loxa [Ecuador], a center of the bark industry, but at Malacotas, the bark peelers in time claimed to have confidence." This point was cited by Dr. George Dock (1931:154) in his paper for the conference held in St. Louis to celebrate the 300th anniversary of the discovery of cinchona.

I suggest that this objection is irrelevant, since it does not reflect aboriginal practices, but the practices of Indians who had been subjected to two and a half centuries of Spanish contact, and it also depends on the use of introduced citrus fruits. What it does in

fact reflect is the hot/cold theory of medicine brought by the Spanish from the Old World,¹ as we deduce from an observation recorded in 1860 by Richard Spruce, a distinguished botanical explorer of South America who was also a "Kew collector" of cinchona seeds. Spruce wrote in his journal that to the Indian mind, cinchona bark is heating, therefore not good for fevers, which they treat with cooling drinks (*frescoes*) (1908:272). Clements Markham, leader of the Kew expedition to collect cinchona seeds, repeats this observation in his *Peruvian Bark* (1880:5), but neither Spruce nor Markham connected it with the hot/cold theory of the Spanish. Spruce also noted that even in Guayaquil, physicians prescribing for malaria wrote "alcaloide végétale," by which the pharmacist understood sulphate of quinine while the patient remained ignorant.

Europeans thus missed the true implications of these observations, i.e., that Indian curing practices had been supplanted by the medical beliefs of their Spanish conquerors. Instead they implied that Andean Indians were unable to appreciate a valuable natural resource in their midst, and in so doing, gave a rationale for their own appropriation of that resource in the cinchona transfer. The false trail laid down by von Humboldt not only tended to deprive the Indians of credit for what may be one of their most important medical

¹This concept, rooted in ancient Greek humoral theory, was prevalent throughout Europe and its colonies until the nineteenth century. It is now a major element of the folk medicine of Spanish-speaking Americans, and has been discussed by many anthropologists who have worked in Meso-America and Andean America, e.g., R.N. Adams, Margaret Clark, R. Currier, George Foster, John Ingham, Oscar Lewis, Robert Redfield, and Arthur Rubel.

discoveries, but it further inflated the European sense of superiority to think that the bark-cutters were ignorant of the true medicinal properties of their native trees.

Reasons and Rationales

It was the commonly held opinion, first stated by von Humboldt and repeated by Royle, by Markham and Cross, the Kew collectors, and as late as 1931 by the Kew Bulletin, so that it has become accepted as an article of faith in the literature, that intervention by the Europeans was necessary to save the cinchona trees from extinction because of overcutting and wasteful practices in the Andes. There, under the instigation of such South American governments as Bolivia and Peru, cinchona bark had become a major export by the mid-nineteenth century. "The chief circumstances leading to the demand for cultivating cinchona were the destruction of native South American forests owing to the methods of collection, and the consequent growing scarcity of the bark" (Kew Bulletin 1931:113). When Europeans saw the bark-cutters fell entire mature cinchona trees, they were convinced that this would kill the industry. There was one source in English which might have corrected this impression--a doctoral dissertation "On Cinchona" written in 1839 by William Dawson Hooker, son of William Jackson Hooker, then Professor of Botany at Glasgow, later Director of Kew Gardens. William Dawson Hooker wrote that it was all right to cut the trees to the ground instead of taking strips of bark, because otherwise insects would eat up the barkless trunks, and that in six years new shoots sprouting from the roots were ready for cutting (1839:15). But William Dawson Hooker died young, and his paper was presumably

forgotten, even by his father. In point of fact, his method, called "coppicing," was later adopted with added refinements by William McIvor, the Scots gardener in charge of cinchona cultivation in India; so we may conclude that the Andean bark-cutters knew what they were doing. The habit of growth, in scattered clumps throughout dense forests, made it hard for Europeans unfamiliar with the terrain to find the trees, and confirmed them in their belief that they were scarce. But in view of the fact that the Andean Republics exported an estimated 2,000,000 pounds of cinchona bark in 1860 (Markham 1962:572), it is hard to believe that they were on the verge of extinction. And in fact the South American exports rose to 9 million kilos (19.8 million pounds) in 1881, only to fall to 2 million kilos (4.4 million pounds) in 1884 (Duran-Reynals 1945:206; Klein 1976:19) because of British and Dutch competition from Asian plantations.

The Cinchona Transfer

Sir Joseph Banks (d. 1820) had had the idea of transferring cinchona trees to India years before, but nothing had come of it then. Peruvian bark therapy was not in very high repute in the early years of the nineteenth century because of failures from inability to control the dosage. In 1820 two French chemists isolated the alkaloids of cinchona bark, and quinine compounds were manufactured in Europe which gradually gained acceptance. Now with increasing need for quinine in India, with the technical problem of long-distance plant transportation resolved by the Wardian cases, with Fortune's tea transfer as a model, and with a favorable report in 1852 from Dr. John Forbes Royle, of the East India Medical Board, who had been similarly

consulted on the tea transfer, steps were taken. Royle's instructions to British consuls in South America to assist the cinchona project came to nothing, because of the "jealousy" of the South Americans, who would not sell to the British. Royle's next attempt was also abortive. Kew Gardens and the Edinburgh Botanic Garden both possessed a few specimens of C. calisaya Weddell, brought back from Peru by Dr. Charles Weddell who had been there with a French botanical expedition. In 1855 Royle arranged with Kew and Edinburgh to ship six young trees of C. calisaya in Wardian cases in a mail coach across Arabia to Calcutta. But the trees all died in the damp of Calcutta.

In 1858 the Secretary of State for India in Council endorsed Royle's view, seconded by Dr. Thomas Anderson, Superintendent of the Calcutta Botanic Garden, that the only solution was to send a botanic collector to the Andes. Royle had written the Secretary of State for India of the difficulties that might be put in their way: "It is evident that such a measure could not be adopted without exciting considerable attention, and I think jealousy, if we consider the late proceedings of the Bolivian government."¹ But an agent who had some other object in view might safely carry out his operations along the whole coast" (Parliamentary Blue Book, Cinchona, 1852-63:3).

Such an agent was found in Clements Markham (later Sir Clements Markham), a junior clerk in the India Office, who volunteered, saying he knew Spanish and Quechua, knew three species of cinchona by sight, and was well acquainted with many landowners along the eastern

¹He refers to the establishment of a state monopoly on cinchona export.

slopes of the Cordillera. In his letter putting himself forward, he reminded the government that it was costing £53,000 yearly to purchase quinine for India, and he proposed an ambitious plan to prospect for eight valuable species of cinchona in four separate areas of the Andes (Parliamentary Blue Book 1852-63:32). In 1859 the project got officially underway; Markham was charged by the Secretary of State for India with the collection of seeds and plants of cinchona species, with the help of Kew Gardens. It was agreed that the expedition's expenses would be charged to the India Office, and a budget was set up at £500 for each area. William J. Hooker of Kew approved the plan, and wrote to recruit Richard Spruce, a friend and colleague who was then collecting botanical specimens in Ecuador, having come up the Solimões and Pastaza Rivers from the Amazon basin, where he had been collecting since 1849. In his years of collecting in South America, Spruce sent back over 7000 specimens to various commercial collectors, and a complete set for the Kew Herbarium. Hooker also sent Robert Cross, a Kew gardener, to help Spruce, and despatched fifteen Wardian cases with him, although as it turned out, the terrain in the Andes was too rough for the glass.

By paying \$400 (local currency) to the local lessee, Spruce arranged to get the collecting rights on large tracts of land in the Quintonian Andes owned by the Roman Catholic Church and by a former President of the Republic, General Flores, who had been deposed fifteen years previously and was now actively engaged in counterrevolution. With several Indian helpers, Spruce and Cross established themselves in a secluded hut, an abandoned trapiche, or primitive

sugar-cane mill, and found extensive stands of C. succirubra, the "Red bark" of commerce, in the bottoms of ravines at about 4000'. From June to September they collected the ripe seed pods and also planted about 1000 seeds beside their camp, later transferring the seedlings to improvised Wardian cases, using moistened calico instead of glass, for the journey across the mountains and the trip by raft to Guayaquil, made hazardous not only because of the terrain but by the presence of armed bands of soldiers and revolutionaries. On December 31, 1860 they loaded nearly 100,000 dried seeds and 637 young plants on board ship for England and transshipment to India (Spruce 1908: 260-309).

In three months the plants reached Ootacamund in the Nilgiri Hills. 463 seedlings had survived, and the seeds proved to be in good condition, becoming the nucleus of a new industry. Spruce lost his health in these labors and was never able to walk again.

Meanwhile Markham, assisted by a Kew gardener named Weir, had worked with greater despatch but to less effect in the Carabaya region of Bolivia and southern Peru, collecting seeds of C. calisaya, the "yellow bark." He also hired an Englishman resident in Peru, named Pritchett, to go after the "grey bark" in northern Peru, making a total of five collectors at work. In light of the fact that most of Markham's seedlings later perished on their journey through the Red Sea in the summer heat, Markham's adventures in Peru, with which he immediately jumped into print (1862 and again 1880), had little practical effect except to stir up local hostility. He hadn't timed his excursion for the season when the seeds would be ripe; he hadn't

thought aheadabout the best season for transshipment, and instead of paying for rights, he relied on bribery and persuasion. Because of the resentment of the local population, he resorted to active measures of subterfuge.¹

I found things at Sandia in a very alarming state; most of the people had been excited by letters from Quiaca to² prevent me from continuing my journey with the chinchona plants, and a sort of league had been made with other Juntas Municipales to protect their interests, and prevent foreigners from injuring them.

The tactics which were adopted would have succeeded in their object but for a great piece of good luck. I was prevented from hiring mules, except to go to Crucero, where I knew Martel was stationed, with the intention of raising obstacles to my further progress until the plants had been killed by the frost. I meditated setting out on foot, with all the four bundles of plants on my own mule, when Don Manuel Mena told me confidentially that, if I would give him my gun, he would get an Indian to supply beasts, and accompany me to Vilque, on the road to Arequipa. I willingly agreed to this bargain, and sent Mr. Weir and the lad Pablo to Crucero, so as to throw Martel off the scent, while I hurried the plants down to the coast by the most unfrequented line of country.

An alarm had, however, been spread through all the villages bordering on the chinchona forests, both in Caravaya and Bolivia, and I ascertained that effectual measures had been taken to prevent my return for seeds in August. Martel had also written to the towns and villages between Crucero and Arequipa, to put obstacles in the way of my retreat, so that I found it necessary to avoid entering any town or village, and to shape a direct compass-course over the cordilleras from Sandia to Vilque. I also reluctantly abandoned my intention of returning to collect seeds in August. But I made

¹In 1853-54 the Superintendent of the Dutch Botanic Gardens on Java, Justus Charles Hasskarl, had entered this same Caravaya region searching for cinchona plants and seeds with even greater resort to subterfuge. Hasskarl traveled under an assumed name and conducted his business in secret and through bribery. Local indignation was still strong over this episode when Markham arrived in 1860. This made his presence immediately suspect. Hasskarl's specimens all died, except two, before they reached Java, and the seeds he brought out yielded valueless trees, so that Dutch interest in cinchona sagged for a decade (Duran-Reynals 1946:174-75).

²This is not a misprint. Markham always used this spelling as being more accurate, but could not get the Linnaean spelling changed.

arrangements to obtain a supply from selected trees, through a reliable friend, in the ensuing year (1880:200-201).

. . . From Sandia to Arequipa is a distance of nearly 300 miles. No opposition was made to my departure from Arequipa, although the local newspaper had something to say afterwards, and on June 1st the plants were safely deposited in the Wardian cases at the port of Islay.

But the difficulties of getting the plants out of that country were not entirely ended by my escape from Martel and the Juntas Municipales of the interior. The Superintendent of the Custom-house of Islay refused to allow them to be shipped without an express order from the Minister of Finance and Commerce at Lima. He had probably received intelligence respecting the contents of the cases from Vilque where all news centers at the time of the fair. This obliged me to go to Lima to obtain the necessary order from Colonel Salcedo, the Minister of Finance, which I succeeded in doing, and returned with it to Islay June 23rd.

That Markham used bribery and persuasion is indicated by a letter to Lord John Russell, then Foreign Secretary, from C. Wilthew, consul at Islay, detailing Markham's troubles in getting the plants out of Peru. "On his return from the Montana, an order arrived from one of the petty authorities to seize all the plants, as they were not allowed to be exported." He describes the trouble with Customs at Islay, protests this "molestation," which he attributes to "feelings of jealousy," and reveals that the Finance Minister in Lima had "some scruples" about releasing the plants (Parliamentary Blue Book, Cinchona, 1852-63:56).

The legality of the operation in Peru is unclear and seems dubious at best. Taking the plants from Bolivia was clearly against the laws of that country, where all export of cinchona was a government monopoly. In Ecuador Spruce and Cross brought out the plants a few months before the Law of May 1861, which made it illegal to export plants. But Cross returned to Ecuador in 1861, bringing out a second

large batch of seeds that fall. A letter from Cross in Loxa, Exuador, November 9, 1861, to the Secretary of State for India shows that the British Government was not deterred by the knowledge that it was contravening the laws of the Andean Republics.

It was stated to me that the Government of Ecuador had passed an edict prohibiting the exportation of either seeds or plants of the quina tree, under a penalty of 100 dollars for every plant, and for every drachm of seed. However, after consulting with Mr. Mocatta [the British vice-consul], I undertook to go to Loxa and make a collection of seeds of the C. Condaminea (Ibid:170).

Cross, the gardener sent by Hooker from Kew, went on to become the most active cinchona collector of all five of the original team, losing his health in the process, as Spruce had. He made two long expeditions to Colombia, one in 1863 and again in 1868-70, sending valuable species of "Crown barks" to Kew, where C. pitayensis was selected as the best variety and a good supply sent on to India (Markham 1880:242).

Clements Markham was not a man to give credit to others when he could take it for himself, so that his accounts tend to de-emphasize the role played by Kew Gardens. On the other hand, the official reports by the Director of Kew Gardens, and the histories of the Gardens (Bean 1908; Turrill 1959; Kew Bulletin 1931 and 1941) omit any reference to the difficulties or illegalities attendant on the transfer of the cinchona trees, but consistently point out the great importance of the enterprise. I quote from Joseph Hooker's biographical article on his father, in which William Jackson Hooker appears to take a more active role than Markham allots him, and which includes the relevant portions of Hooker's Director's Report for 1861. The

forcing-house (greenhouse) mentioned contained at one time as many as 10,000 cinchona seedlings, some destined for transshipment, some held as a reserve supply (Parliamentary Blue Books, Cinchona, Madras, 1860-97).

The years 1860 to 1862 were notable for the successful efforts in introducing the Peruvian barks into India and our tropical colonies. Mr. (now Sir Clements) Markham had induced the Indian Government to undertake this measure which had been urged upon it by Sir Joseph Banks more than half a century before, and by various botanists since. Mr. Markham himself went to Peru, and brought to England living plants, which, after a short nursing at Kew, he took on to India and established in the Nilghiri Hills. Meanwhile my father, to whom the Indian Government applied for advice, not trusting wholly to the risky transport of living plants, urged that collectors should be sent to Ecuador and Bolivia for seeds of the different species, recommending at the same time the employment in Ecuador of Mr. R. Spruce, an able botanist and collector, who happened at the time to be in that country.

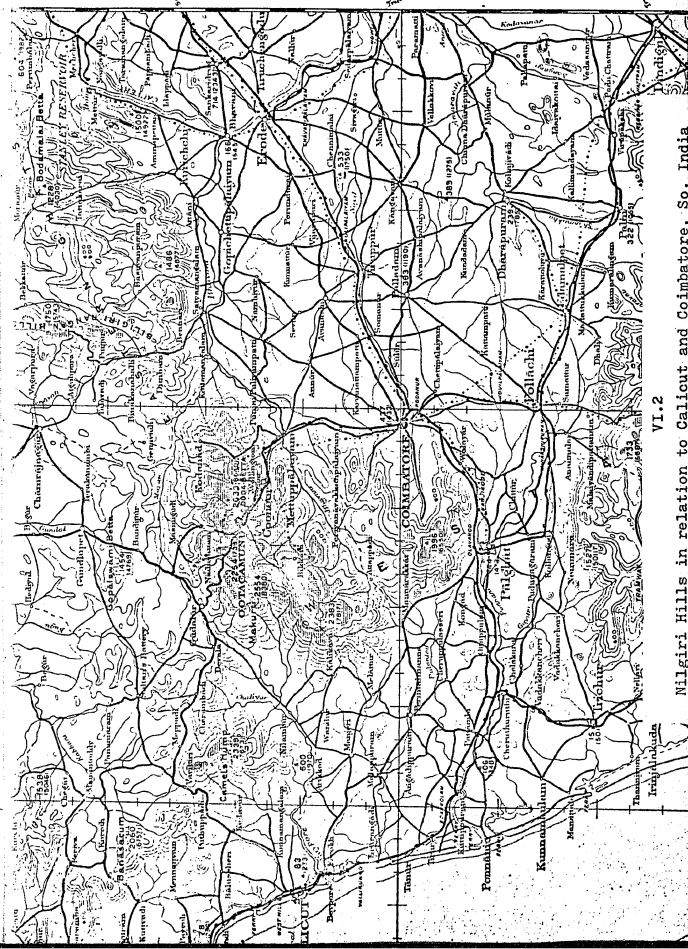
In the Report on the progress and condition of the Royal Gardens during the year 1861 it is stated that:--The means adopted for introducing Cinchonas (trees yielding quinine) into the East Indies and our tropical colonies rank first in point of interest and importance of the works of the past year. In my Report for 1860 I mentioned the erection, at the desire of the Secretary of State for India in Council, of a forcing-house, especially for the cultivation of the Cinchonas, with the view of establishing plantations of them in India. Upon the Royal Gardens devolved the duties of receiving and transmitting the seeds and plants to India, of raising a large crop of seedlings, of nursing the young stock, lest those sent on should perish or the seeds lose their vitality, and of recommending competent gardeners to take charge of the living plants from their native forests to the hill country of India, and to have the care of the new plantations there. Further, with the sanction of the Indian and Colonial Governments, it was arranged that our West Indian colonies and Ceylon should be supplied with a portion of the seeds (Hooker, Annals of Botany, 16, 1902:LXVII).

The official association between Kew and the India Office on the cinchona transfer was completed by 1862, with a letter of thanks to Kew from the India Office. Thereafter any seedlings brought out were to go to Kew.

Kew's continuing influence was felt in the advice given through correspondence with the directors of botanical gardens in India. One of the Hookers' most valuable subordinates and co-workers was William G. McIvor, Superintendent of the Botanic Garden and Government Plant Station at Ootacamund, Nilgiri Hills, South India, from its opening in 1848 to his death in 1879.

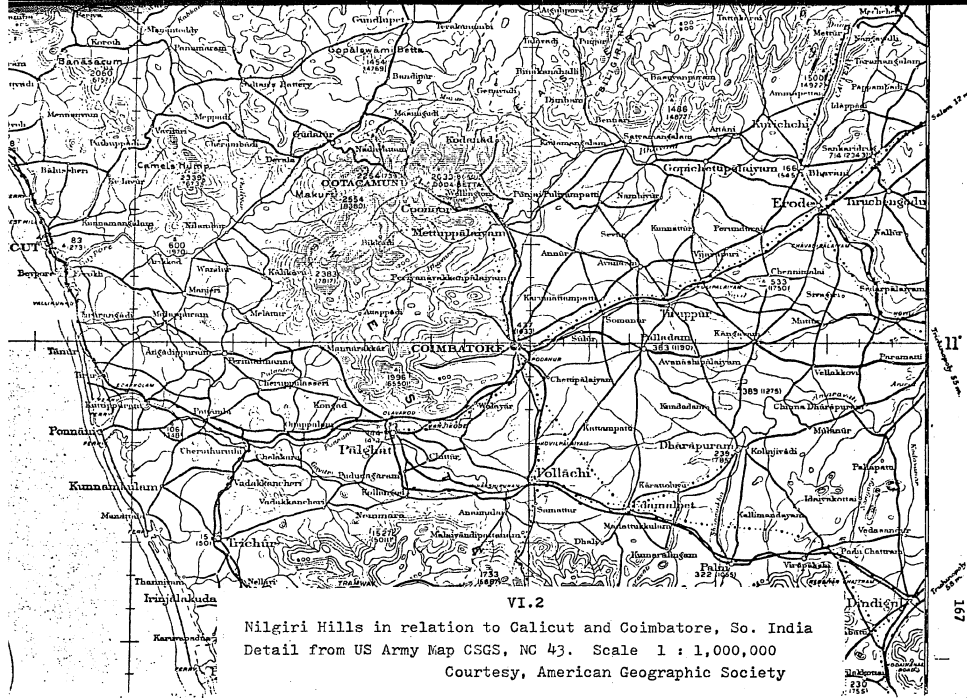
From Wild to Cultivated: The Development Process

In 1860 the Nilgiri Hills were chosen as the site of the first cinchona plantations and McIvor was made Superintendent of Cinchona Cultivation for all India except Bengal, which remained under the Calcutta Botanic Garden. McIvor's first task was the selection of a site for the government plantations. He tried to match as closely as possible the edaphic and climatic conditions, such as the amount and distribution of rainfall, the general humidity, the hours of sunlight, and the comparable plants in the vicinity, which had promoted optimum growth in the Andes. The sites he chose for the first two government plantations, Dodabetta and Nedivattum, were in wooded ravines 7450' [2210 meters] above sea level, rather more elevated than in the Andes but 2 degrees nearer the equator. Robert Cross had written from Ecuador suggesting that the ravines be fenced "to prevent the burghers [Badagas] and todahs [Todas] from feeding their cattle among the cinchona trees" (Parliamentary Blue Book, Cinchona, Madras 1852-63:177), but it was not deemed necessary to follow this advice. The Madras government made a grant of Rs2000 for clearing the land and transporting seedlings by oxcart from the port to Ootacamund in the Nilgiris. Convict labor was used to clear the land, and later the jail was used



VI.2

Nilgiri Hills in relation to Calicut and Coimbatore, So. India



as a drying shed for the bark, while native labor ("coolies") was used on the plantations (Parliamentary Blue Book, Madras 1860-97:1).

McIvor also experimented with growing the young trees in full sun or partial shade, with pruning and manuring, but his greatest contribution came when he developed a method of increasing the amount of the bark to be harvested, called "mossing." One and a half inch strips of bark were taken several inches apart, the trunk was then wrapped in moss under which the new bark grew for a year before the moss was removed. Alternate strips of natural bark and renewed bark were harvested in alternate years. Although alkaloid levels (quinine, quinidine, etc.) varied with temperature, rainfall, soil, and sunlight, the renewed bark consistently gave better yields than the natural bark, and the terms "renewed" or "mossed," and "natural" became fixed commercial terms. The trees were also coppiced, or cut back to the ground every six to seven years, since the bark on the new shoots was found to be higher in alkaloids. This finding was consistent with the native Andean harvesting practice which had been so condemned by Europeans, though that fact went unremarked. This bark from new shoots was known as "quills" in the trade.

The years 1860-79 also saw much experimenting with hybridizing, in India as well as at Kew. As early as 1862 cinchona seedlings were sent to Ceylon, where Dr. Thwaites, Superintendent of the Royal Gardens at Peradeniya, established government plantations with the help of a Kew gardener, and corresponded with McIvor about his experiments. McIvor also corresponded with DeVrij, a Dutch quinologist who worked on the Ledger strains of cinchona at the Buitenzorg Gardens in Java.

McIvor and DeVrij finally concluded that the highest yields of quinine came from the Crown barks (C. officinalis and C. pitayensis) gathered by Cross in Colombia, and from the hybrids C. calisaya Ledgeriana and C. pubescens, a hybrid of C. Ledger and C. succirubra, which yielded twice as much as C. succirubra alone.

The exchange of seeds and scientific information between McIvor and DeVrij is interesting in view of the commercial rivalry that was developing between British and Dutch planters. The Ledger species were developed by the Dutch on Java from seeds purchased from an English trader in Peru named Ledger, whose Aymara servant had smuggled them out of the Carabaya region of Bolivia in 1865. Previous Dutch attempts had failed, so they bought after the British government declined. The native servant was imprisoned by Bolivia for his treason. Ledger and his brother received six hundred gulden for the seeds, and the Dutch government an inestimable treasure, a high-yielding species which thrived on Javanese soil, although it required elaborate precautions against disease. DeVrij used the best trees as grafting stock, and by 1874 plantations on Java were well established.

Unfortunately for the British, the Ledger strains did better on Java than in India, perhaps because of the rainfall patterns, as predicted by Alfred Russel Wallace in his notes to Spruce's journal (1908:311). They also proved to be susceptible to root disease. This may account in part for the Dutch capture of the world market in the twentieth century, when up to 20 million pounds of bark was exported annually from Java, and a Dutch combine called Kina undercut any Indian competition which sought to charge less than the artificially high

Dutch price (Biswas 1961).

Richard Klein has recently published an article on cinchona (1976:18-19) in which he asserts that the British propagation of the red cinchona (C. succirubra) was a complete and costly fiasco, yielding so little quinine that the growers could not compete with the South American barks, and that the Dutch captured the market because of the superior yield of their Ledger species. While it is true that the Java plantations eventually accounted for 80% of the world market, and we can speculate that the British were unlucky when most of Markham's calisaya plants died on the journey to India while Spruce's succirubras survived, the difference in species is not a sufficient explanation, and the commercial race was not all. The Dutch in South East Asia had no large army to maintain, as the British did. To a large extent they sheltered under British power and could therefore concentrate wholly on commerce. But the British wanted primarily to protect their troops from malaria, and only secondarily to provide planters with a cash crop and to make cheap quinine available to the Indian masses. These last two goals proved to be incompatible, and in pursuing both the British fragmented their efforts. Having achieved their major goal, the protection of British troops and bureaucrats, they let the rest go. The Indian-manufactured "poor-man's quinine" with its admixture of alkaloids could not compete commercially with the purer quinine made from the Ledger barks. However, had the Netherlands in the late nineteenth-early twentieth century been a strong, independent, European power which Britain feared, the British would not have been content to let the Dutch grow the cinchona for sale in Amsterdam,

processing in England, and reshipment to the colonies. In quinine as in rubber, the two empires cooperated when market forces favored cooperation, and in the scientific sphere the cross-fertilization of plants and ideas was helpful to the development of both.

For these reasons, the British scientific development of cinchona is an experiment in imperial botany that is worth telling. The British did not treat cinchona as an ordinary article of commerce, but stressed its public health aspects. In the first flush of excitement they sent seeds and seedlings as gifts to other imperial carriers of the white man's burden--the Portuguese, the French, and to Emperor Maximilian for use in Mexico. They called their whole botanic network into play and planted cinchona trees in every suitable British colony.

Experimental cinchona plantations were established at one time or another after 1860, with the cooperation of Kew Gardens and the local botanic gardens or government stations, in the British possessions of Mauritius, Fiji, St. Helena, Tanganyika, the Cameroons, Burma, Trinidad, Tobago, and Jamaica, where 30,000 trees were planted out by 1867 (Kew Bulletin 1931:117). But the British effort was concentrated on South India, especially the Nilgiri Hills, British Sikkim near Darjeeling, and Ceylon. Each of these areas had government plantations under the direction of the Superintendent of the Botanical Gardens at Ootacamund, Calcutta, and Peradeniya, respectively. Government quinine manufactories were set up to process the bark in the first two locations, but not in Ceylon, where all the bark went to the London auctions.

The Nilgiris

The Nilgiri government plantation got off to a fast start because of McIvor's intensive work. In a letter to William J. Hooker, April 25, 1863, reporting on his progress he says that from the four plants sent by Mr. Cross, he took 837 young side shoots to plant out. In this way over 250,000 young trees were planted out in the first three years. In the 1870s a third government plantation was established, named after Hooker; and by 1880 there were 569,000 cinchona trees in 847 acres of government plantations. In addition there were 4000 acres planted to cinchona in private hands in South India, which includes the Wynad and Coorg as well as the Nilgiris (Markham 1880:iii). By 1891 there were an estimated 1,800,000 cinchona trees on the government plantations of the district (Misc. Government Reports, Cinchona, Madras, 1885-1900:17).

Private planters were encouraged in the Nilgiris and other mountainous districts of South India newly opened to European settlers. Most of them grew coffee, with 19,600 acres planted to coffee in the Nilgiris alone (Markham's estimate) and many of these coffee planters also grew cinchona, Markham says, "Of the 85 persons who had purchased land on the Nilgiris, under the Waste Lands Rules of March 6, 1863, as many as 50 had undertaken cinchona cultivation (1880:327).

The quinine powder manufactured in the Nilgiris was not put on the open market but was sold at cost to the Government Medical Department of Madras, Bombay, and Colombo, for distribution to government employees, including the army, and to private planters

for mass treatment of their "coolie" laborers. The Rangoon Times (1891) criticized the government of India for its refusal to sell South Indian quinine to the general public and charged that English quinine makers stood in the way of sales to the public because they feared government competition. The Government of India debated the idea of public sales, but instead decided to let Burma grow its own cinchona, and provided expert advice in starting plantations at Tenasserim, and in training "Karen lads" to work them (Misc. Government Reports, Cinchona, Madras, 1860-97).

Bengal

Only in Bengal was the quinine produced on government stations, in the Mungpoo Valley near Darjeeling, under the direction of the Calcutta Botanic Gardens, offered to the general public, i.e., available to the people of India as well as the British army and civil servants. In 1878 the Sikkim manufactory produced 7007 pounds of febrifuge, which could be purchased in five grain packets at post offices for a nominal sum (Markham 1880:iv).

Ceylon

While the government of Ceylon was buying quinine powder from the Nilgiri factory, its botanic garden had distributed by 1877 an estimated five and a half million plants to private planters, all producing for the London market. A coffee leaf blight in the 1870s had ruined the coffee market, and planters eagerly turned to cinchona as a substitute cash crop. Over 5500 acres of cinchona trees covered the mountainous interior of Ceylon, and the trees were so familiar

they were thought to be indigenous (Markham 1880:iii).

In 1887 Ceylon produced 13 million pounds of the red bark (Duran-Reynals 1945:207). But it was increasingly hard to find a market. The Dutch Ledger barks sold at the Amsterdam auctions, at five times the price of red bark, were preferred by European chemists, because they were easier to process into sulphate of quinine, a purer quinine than the Indian-made totaquine with its mixture of other alkaloids. Sulphate of quinine was necessarily much more expensive, though not more effective.¹ It was taken up by Europeans because it had a more constant composition and the dosage was more easily regulated. This "rich man's quinine" made the red barks superfluous except as the government of India would buy them, and Ceylonese planters switched to tea. The government continued its production of totaquine in government factories in Bengal and Madras for the domestic market in India, but it was not prepared to expand sufficiently to save the private planters nor to meet the whole need of the Indian populace, or even a fraction of it.

The magnitude of the problem can be seen from figures supplied by Surgeon-Major Bidie, head of the Medical Board, Madras

¹In an early example of metropolis-satellite cooperative statistical research, a British quinologist and maker of quinine compounds was sent in 1862 to Madras by the Secretary of State for India to determine the relative efficacy of the several alkaloids present in cinchona bark. He tested 2472 subjects chosen from the worst malarial regions, and found that quinidine, and cinchonine were almost as effective as quinine, i.e., totaquinine worked well. In 1934 the Malaria Commission of the Health Organization of the League of Nations endorsed totaquine as the drug of choice in a world wide campaign against malaria, and until the outbreak of World War II the League fostered the re-establishment of red cinchona plantations (Duran-Reynals 1945:230-31).

Presidency: in 1872 there were 222,843 deaths from fever in the Madras district alone; in 1877 there were 469,241. The number of non-fatal cases was many times larger. It was the object of the government, Bidie wrote, to get a moderately cheap product in every bazaar in the country, but because of the expense, "not one individual out of every 100 who suffers from fever is fortunate enough to secure the necessary supply of the healing bark" (1879:21).

This was the reality, quite at variance with the ideal; but it was only the ideal and humanitarian aspect of the cinchona transfer which is commemorated in public print by the botanists at Kew Gardens and their historians (see quote from Thiselton-Dyer, page 141 "a dose of quinine can be purchased at any Indian post office.") Joseph Hooker, in his biographical article on his father (Annals of Botany, 16, 1902) says:

Manufactories of quinine have been established in the Sikkim Himalaya and the Nilghiri Hills. The most signal proof of the experiment is, that a dose of five grains of quinine in a paper bearing a Government stamp may be bought at any post office in Bengal for half a farthing. This supply is from the Sikkim manufactory.

And in an article (1931) celebrating the tercentenary of the discovery of cinchona, the Kew Bulletin points to the same "signal success"—the packet of quinine at half a farthing. It also reprints a letter to the London Times from an unnamed individual, Dec. 22, 1930: "In about 1901 I was speaking at Sunningdale with Sir Joseph Hooker, my god-father, and knowing a little of the commercial results of some of his activities, I asked him which he thought had been most important. He replied with emphasis, 'Quite certainly the getting of cinchona into India, the result is that anyone can get at any post office a dose of

pure quinine for a little less than half a penny'" (1931:117).

Markham was even more euphoric: "In future years the introduction of the fever-dispelling cinchona tree will be one of the measures for which British rule in India will be entitled to the gratitude of the people of India" (1880:iv). ". . . few greater blessings have been conferred on the human race than the naturalisation of these trees in India and other conquered regions, so as to render the supply more certain, cheaper, and more abundant" (1880:1).

This is how they remembered the cinchona transfer, and how they wanted to be remembered. While there was truth in it, it was not the whole truth. Not everyone in India could purchase the cure for malaria at any post office; only in Bengal, and only if he had the price. Even in Bengal the greater half of the quinine production went to the Government Medical Stores to strengthen the British raj, and in Madras almost all of it did.

South American Market

What had the cinchona transfer accomplished? There is no doubt that in turning a wild tree into a cultivated tree, botanical science produced better yielding varieties, though these varieties would have flourished even better in their natural habitat in the Andes than in India if science had been independent of political considerations. But the Royal Botanic Gardens were supported by the British government, and the British government wanted a secure supply, under its own control.

As it was, the South American market for cinchona bark was undercut after 1885, not as a result of wasteful harvesting practices

as the Europeans predicted, but as a direct result of English and Dutch competition and control of the market. The large government investment on the part of the British and Dutch in research and development, both for growing and processing the cinchona bark, meant cheap seedlings and free advice to colonial planters as well as eventual entry into a vertically integrated marketing system, the cinchona cartel. The cartel absorbed the little South American bark that was gathered.

The two world wars brought a short-term revival to the South American trade, especially when the Japanese overran Java in 1942. Production in the Andes had sunk to near zero, but sprouts from felled trees were used to reestablish the industry briefly, for the use of the armies of the United States. In two and a half years 18,000 tons of cinchona bark were harvested in the Andes (Fosberg 1945:91), or 1.44 million pounds a year, and then it lapsed again. In any case the era of synthetic anti-malarials had arrived. The total loss of revenue over the years to the four Andean states is incalculable, as is any question of "what might have been," but it is certainly large.

Quinine an Arm of Empire

Because British troops were deployed in both world wars in malarial zones, in the African colonies, in the Southeast Asian colonies, and around the Mediterranean (Malta, North Africa, the Middle East, Turkey), quinine was of critical importance to their war effort. In World War I the entire production of the British cinchona estates in India was "saved" by officials in London from going to the India Office --and hence was unavailable to the people of India. In World War II again the government would not release any quinine for the private

market in India, but stockpiled it against a possible emergency, so that the Indian public was deprived of quinine and urged by the authorities to buy English-made quinine at a very high price (Biswas 1961:76). A million and a half cases of malaria on Ceylon in the 1942 epidemic received scarcely any medical care (Duran-Reynals 1945:231). It is quite likely that the unavailability of quinine played a role in the tremendous numbers of deaths in the 1942 famine in Bengal and Assam, a famine without precedent in modern times.

Even in peacetime, as we have indicated above, the bulk of Indian production for the home market was directed toward the British establishment, both military and civilian, enabling the British officer and his Indian soldiers to resist malaria and stay in fighting trim, enabling the British civil servant and his Indian assistants to perform their duties in good health, without the ravages of periodic bouts of fever, and enabling the British sahib to bring his wife and children to live in India. From its accession to the Crown in 1858, after the one major attempt at revolt (the Sepoy Rebellion of 1857) had been crushed, until after the first World War, India was the kingpin of the Empire, the largest entity, and a stable and lucrative source of glory and revenue. Quinine was one of the essential tools in attracting to India the large bureaucracy necessary to govern it, the second-sons who found it easier to make a name and fortune in India than in London, but who had lost the spirit of wild adventure of the seventeenth and eighteenth centuries, when men went to the West Indies to make a fortune in sugar and the fever be hanged.

The late nineteenth century influx of English women into India

would not have occurred without quinine, and it had the effect of exacerbating an already strong racism. With larger numbers of Europeans and with family ties, the white traders and administrators congregated separately more than was their former custom. No longer was the white man a temporary bachelor who sought company and often a wife among the natives, as he had done in the seventeenth and eighteenth centuries. He was now a Victorian family man who had a tradition to uphold and a taboo to enforce by distancing himself from the native populations in his own residential compounds and clubs. Concurrently, the prestige of Anglo-Indians dropped sharply. They became near-outcasts whereas previously they had enjoyed much prestige and influence. The racial tensions left by the Sepoy Rebellion made intermarriage difficult and the position of Anglo-Indians untenable. But the British solution to this Indian show of resistance, i.e., the formal incorporation of India into the Empire under a greatly strengthened bureaucracy, could not have been as successful as it was if British life in India had not been safeguarded by quinine.

Quinine and the Penetration of Africa

I propose that the availability of increased stores of quinine under British control had a similar facilitating effect on the British colonial expansion into Africa in the late nineteenth and early twentieth centuries. Because of its tropical diseases, Africa had been known as "the white man's grave," and trade had been conducted from coastal trading posts, contact with the hinterland being left to African middlemen. West Africa was the deadliest malarial

environment in the world, with falciparum malaria, the worst form of the disease, hyperendemic in many localities. It seems more than coincidence that West Africa was penetrated by significant numbers of Europeans only after they had established a quinine industry. This hypothesis has not been fully explored, but I shall present what evidence I can to support it.

Co-existence or co-variation does not establish causation, and I do not claim that quinine was a cause of this colonial expansion into Africa, but that it was an enabling factor. For causes we have to look at the situation in Europe. The financial slump starting in the 1870s and lasting to the mid-nineties marked the end of the first phase of British industrialization, when Britain had had a commanding lead in the world market. Thereafter Britain faced severe competition from Germany, the United States, France and the smaller industrializing countries such as Belgium, the Scandinavian countries, and a newly unified Italy. Between 1890 and 1895 both the United States and Germany surpassed Britain in the production of steel (Hobsbawm 1968:127). In Hobsbawm's analysis, Britain was unwilling to abandon free trade or to modernize the industrial technology and management methods on which she had relied for so long. "This left her with only one major way out--a traditional one for Britain, though one also now adopted by the competing powers--the economic (and increasingly the political) conquest of hitherto unexploited areas of the world. In other words, imperialism" (Hobsbawm 1968:131). Richard D. Wolff (1974:1-29) discusses the economic importance of the 'new Empire' in Britain's commodity trade.

The main thrust of this intensified imperialism was in Africa, where trading posts were rapidly expanded into de facto and then de jure colonies. The speed with which Britain acted to acquire new territories in Africa was dictated by the pressure of competition from Germany, France, Portugal, and Leopold of Belgium, who were making a maximum effort in the same direction at the same time. The "scramble for Africa" followed immediately on the Berlin Conference of 1884-5, when the European powers divided up their spheres of influence with the proviso that if a country made a claim to a territory, that territory must be actually occupied (Bohannon 1964:121).

To cite one example of this rapid colonization, in what is now Nigeria the first formal cession of land to the British took place at Lagos in 1861, when the British made the local king "an offer he couldn't refuse." Soon thereafter when French trading companies under the protection of their government established themselves in the Niger Delta, threatening long-established British traders who were doing over a million pounds of trade a year, mostly in palm oil (Schwarz 1968:79), George Taubman Goldie came out from England as the head of the United Africa Company, with the power to make treaties and a fleet of gunboats. He consolidated all British trading companies and forced out the French. In 1886 his company, renamed the Royal Niger Company, was given a royal charter granting it political authority over all the territories it conquered or acquired by treaty, i.e., most of present southern Nigeria. In order to cope with French military forces on the west and to the north, and German pressures from the east from their protectorate of Cameroon, the British government

took over the company's territories in 1900, and added the even larger Protectorate of Northern Nigeria. It took Lord Lugard three years to subdue the Fulani emirs. The colonization of Nigeria was thus accomplished in less than fifty years.

Sir George Goldie, the trader with the gunboats, expressed most succinctly the motivation behind this intense colonial activity, which was pursued in East Africa as well: ". . . with old established markets closing to our many factories, with India producing cotton fabrics not only for her own use but for export, it would be suicidal to abandon to our rival powers the only great remaining underdeveloped opening for British goods" (quoted in Schwarz 1968:79).

The deterrent effect of malaria per se on European penetration of Africa is hard to document, since early figures do not separate one "fever" from another. But the severity of the tropical African disease environment is attested to in a series of statistical studies ordered by the British government in 1835 and prepared by Major Alexander Tulloch from military records. Philip Curtin, a historian who has studied the slave trade intensively, says these studies were carried out "with a scientific care that was only then beginning to be applied to statistics" and "they are by far the best data we now have, or are ever likely to discover" (1968:203). The following table, taken from these studies, and quoted by Curtin in his article on the epidemiology of the slave trade, shows the extremely high mortality of British troops in the West African stations (483.0 per thousand from disease alone in Sierra Leone and 668.3 per thousand in the Gold Coast). Compare this with 12.0 per thousand in South Africa, or

even the 85.0 to 138.0 per thousand recorded for the West Indies. Credence is lent to this table by the fact that the figures for Ceylon (75.0 per thousand) and for Tenasserim (44.7 per thousand) both in the Indian Ocean area, agree well with the figures cited by Baikie (1857) for Bengal (73.8 per thousand), Bombay (50.8 per thousand), and Madras (38.5 per thousand) for the overlapping period 1830-50.

Table VI.1

Death rates per thousand mean strength per annum, among British military personnel recruited in the United Kingdom and serving overseas, from all causes, 1817-36, unless otherwise noted

Eastern Frontier District, South Africa (1818-36)	12.0
Nova Scotia and New Brunswick	14.7
Cape District, South Africa (1818-36)	15.5
Malta	18.7
Canada (Quebec and Ontario)	20.0
Gibraltar (1818-36)	22.0
Ionian Island	28.3
Mauritius (1818-36)	30.5
Tenasserim (1827-36)	44.7
Ceylon	75.0
Windward and Leeward Command, West Indies	85.0
Jamaica Command (1803-17, War Office data)	127.0
Jamaica Command (1817-36)	130.0
Windward and Leeward Command (1803-16, War Office data)	138.0
Sierra Leone Command, deaths from disease only	483.0
Cape Coast Command, Gold Coast (1823-26)	668.3

Sources: Parliamentary Papers, 1838-38, XL [138], 5-7, 44-45; 1839, XVI [166], 4-7, 6a, 15b, 22a, 25b, 39a; 1840, XXX [228], 4b, 7, 19, 19b; 1842, XXVII [358], 5-7, 44-45. (Curtin 1968:203). Reprinted with permission of the Political Science Quarterly.

Curtin also says, on the basis of other data he has gathered and presents in The Image of Africa (1964:483-87), that "The early nineteenth-century mortality of newly arrived Europeans varied between about 350 and 800 per thousand." Europeans lacked both genetic and acquired immunity to the diseases they encountered in tropical Africa.

Obviously, neither settlement nor administration of such lethal environment was feasible.

To return to our example of Nigeria, there is evidence that malaria delayed the British penetration of the hinterland. Even the course of the Niger River remained a mystery until 1830 when the Lander brothers succeeded in sailing downstream and establishing the course of the lower river, i.e., the Oil Rivers were the mouths of the Niger. A trader named Macgregor Laird sent the first trading expedition up the Niger two years later. Nine of the forty-eight British members returned, the others having died of malaria (Davidson 1961:259). In 1841 an expedition of traders and missionaries sponsored by the abolitionist African Civilization Society set off up the river in three paddle-steamers furnished by the British navy. The British government was then engaged in the active suppression of the slave trade and supported the abolitionist dreams of opening the entire Niger basin to peaceful trade, of inducing the Africans to produce tropical staples themselves, thereby undercutting the need for plantation labor in the Americas. The expedition got as far as Egga, just upstream of the confluence of the Niger and the Benue, but was forced to turn back because of sickness and mortality. Fifty-one Europeans died on this expedition (Rice 1975:247). Schwarz says they carried quinine "but used it only when patients showed signs of recovery: more than a third of the members died of malaria" (1968:73). The failure of this expedition, which had received so much publicity in England and upon which so many hopes had been pinned, led to a reassessment of medical practices in relation to the treatment of malaria

(Curtin 1961:100-110). Although Peruvian bark (cinchona) in wine had been prescribed by many eighteenth century British physicians, after 1790 its use declined, mainly because the dosage was too low to be consistently effective and because medical men could not distinguish between the various tropical fevers. Since cinchona had no effect on yellow fever, its apparent failure rate was high. As a result, the favored treatment in the early nineteenth century was once again bleeding (up to 50 ounces at a time out of the body's supply of 180 ounces), blistering, and purging with calomel, a mercury derivative which compounded the dehydration of malaria. These treatments could kill a healthy man, let alone one who was suffering from malaria, so the "deadly climate" became fact as well as fantasy. Gradually after 1830, when quinine started to become available, some naval surgeons tried quinine prophylaxis, quinine being more palatable than Peruvian bark. The major impetus to the change came from the experience of Dr. T.R.H. Thomson on the Niger expedition of 1841. He used quinine in wine on himself, and had no malaria until he stopped the treatment on his return to England. By experiment on himself he found that he got maximum protection with a dose of six to ten grains daily. His findings, published in the Lancet (1846) influenced Dr. Alexander Bryson's official Report on the Climate and Principal Diseases of the African Station (1847).

As a result of this work, the navy changed over to quinine as the usual prophylactic and new orders were issued extending its use by shore parties. At the end of 1848 the Director-General of the Medical Department of the Army sent a circular to West African Governors, advising quinine prophylaxis. The knowledge immediately became almost universal among Europeans on the Coast, and it was already spreading even before official notice had appeared. By the early part

of 1848 it had become common practice for Europeans on the Gold Coast to keep a bottle of quinine on the side table, to be taken at the slightest feeling of danger (Curtin 1961:109).

In 1854 another expedition up the Niger under Dr. William Baikie¹ ensured the survival of all its members by using quinine, following the medical orders prepared by Dr. Bryson (Curtin 1961:109; Davidson 1961:259). This success fixed the value of quinine prophylaxis in the public mind, although no one yet understood the nature of malaria. Officials reported "a marked improvement in the climate" in the 1850s. After 1857 regular annual expeditions up the Niger were undertaken and regular trading stations established at Onitsha and Lokoja. Lokoja, at the confluence with the Benue, was made a British consular station in 1860. "But the deadly climate discouraged the first efforts of the British government and . . . the consulate of Lokoja was abandoned. It was reestablished a few years later to meet the still steadily growing requirements of British trade up the river" (Encyclopedia Britannica, Eleventh Edition, 1911:XIX,681).

Although the numbers of British officials, soldiers, traders, and missionaries involved in the penetration of the West African Coast was small in relation to those in India, their need for quinine must have added to the pressures being felt in London to provide a safe, assured supply. In the fourth quarter of the nineteenth century, cinchona bark grown on plantations in India, processed in England, and shipped to West Africa as quinine powder was an important factor in British colonization there. Curtin says:

¹Baikie is mentioned by Joseph Hooker as one of the "Kew collectors" from whom his father received plants and botanical information (see page 117).

Between 1819 and 1836 the average annual death rate per thousand mean strength of European troops on the West African coast was 483 for enlisted men, and 209 for officers. Between 1881 and 1897 the annual average death rate for officials was 76 in the Gold Coast and 53 in Lagos. . . . since there were no further medical reforms between the 1850's and the 1880's comparable to quinine prophylaxis or the abolition of dangerous treatments, it is fair to assume that the medical reforms of the 1840's reduced European mortality on shore by at least half and perhaps more. . . . Whatever other influences were at play in the second half of the nineteenth century, the history of tropical Africa would certainly have been very different if European mortality had continued at the old rate (Curtin 1961:110).

Marvin Harris supports my general hypothesis in regard to quinine and the partition of Africa when he says: "The vulnerability of the Africans was intensified by the neutralization of one of their strongest allies, the malaria plasmodium. This occurred as the result of the isolation of quinine as the active ingredient in cinchona bark and the establishment of large-scale plantations in the Dutch East Indies at mid-century" (1972:221). Harris sets the date a little early and ignores the British-made quinine which circulated in the British military and civilian colonial establishments, but the concept of malaria as an ally to African autonomy until late nineteenth century is valid, even when its high price in African mortality is taken into account.

We have suggested that the use of quinine by the British in India was a factor in isolating them from Indian society, by virtue of the sheer numbers of Britishers who then found life in India attractive, dared to bring their wives and children, and started to live in segregated residential compounds. It seems likely that malarial control in Africa evoked a similar response--social distance. The

example below is not completely à propos because it does not mention quinine, but it is illustrative of the changing position of Europeans in Africa as the nineteenth century gave way to the twentieth. Arthur Porter in a study of Freetown, Sierra Leone, states that until the end of the nineteenth century no particular area of the city was reserved for the English residents:

However, by the beginning of the twentieth century, it was decided that owing to the difficulty of making the whole of Freetown free from malaria, it would be more feasible to drain a small area and keep it under control. Thus, Hill Station to the west of Freetown was chosen as the site for this experiment and was turned into a reservation for the European population, which from then on was no longer housed in houses rented from the liberated Africans in Freetown. In this way, geographical distance was turned into social distance (Porter 1963:98).

In sum, quinine was an essential arm of mature British imperialism. In war and in peace it served the military and bureaucratic establishments in India, Burma, Malaya, and British Africa, as well as the lesser colonies. At one time, from about 1875 to 1900, the British and the world had within their grasp, in the form of the India-manufactured totaquine, a public health tool that might have cured many times the number of people afflicted with malaria than the more expensive quinine sulphate. But capitalist market forces pressing toward cartel formation favored the more profitable drug. The British did not have the commitment to the people of India to sustain the totaquine program, no matter how little it cost per capita. Not until the People's Republic of China, operating outside the world capitalist economy, do we find a modern state which has systematically chosen the less sophisticated, less expensive, technologically simpler solution to medical problems, in the name of availability to all rather than the

few who could pay.

Today cinchona bark is being grown again in India to counteract the resistance of mosquitoes to modern insecticides and the resistance of the malaria plasmodium to modern drugs. The poor man's quinine may get a second chance.

Local Effects of Cinchona Plantations

As we look toward Kew's next major seed transfer, that of Hevea rubber, which was a definite commercial success and also supplied the empire with a vital strategic resource, we introduce here a sub-theme of this essay: the effects of the plantation system on Asian cultures and eco-systems. These effects were not monolithic, but varied locally. By comparing several examples of the labor organization associated with the new nineteenth century plantation crops introduced into Asia through the auspices of the botanic gardens, I hope to present the human implications of "imperialist" tropical agriculture.

My research on the impact of British cinchona plantations in the Nilgiri Hills of South India, home of the Todas and the Badagas, reveals an unanticipated situation--the growth of the population and the prosperity of the Badagas--which places it at the benign end of a continuum and calls for an explanation. Why do we not find the expected immiseration of the local population?

Our general working hypothesis is that European powers favored the colonial plantation over the natural products of South America because it afforded them complete control of land, labor, and the organization of production. The cinchona cascarillos who cut

the bark in the Andes were Indians of the montane forest and the local governments were hostile to outsiders. Labor was scarce in South America, abundant and cheap in Asia, where European intrusion had generated a large landless labor force, available for employment in European enterprises, a labor force made mobile by its need for employment. Indians emigrated to East Africa and to Trinidad and British Guiana to work as plantation hands, as well as to the Asian plantations we are discussing.

We further propose that plantation systems vary according to the extent to which the incoming planter capital eliminates all other crops which might provide alternative employment or an independent food supply. In a "closed" plantation system, there is no work except as a plantation hand. This system is "opened" somewhat if the plantation laborers are allowed subsistence plots on which to grow their own food, and opened further where local smallholders are allowed to enter the cash market to supplement the estate output. Cinchona cultivation on Ceylon and Java was all on the estate pattern, and only one in a series of plantation crops which had already transformed the economy of those islands, and will be discussed in the next chapter in conjunction with the rubber plantations. But the Nilgiri Hills and their cinchona plantations present a different pattern, a microcosm where social change can be observed as the traditional economy is drawn into a wider market.

The Nilgiri Hills were a geographical and cultural isolate, barely opened to British settlement when cinchona and coffee plantations were introduced in the 1860s. The Hindus of the plains found

the Blue Hills forbidding and venerated them from afar, rarely venturing up the steep slopes which set the plateau off from the plains. The whole Nilgiri District comprised about 400 square kilometers (or almost 1000 square miles) at an elevation averaging between 1800 meters (6000') and 2300 meters (7500'), with some higher peaks. In their mountainous seclusion, the pastoral Todas, the agricultural Badagas, and the artisan Kodas had evolved an integrated regional ecosystem, exchanging goods, services, and ritual gifts. Although very few in number (683 Todas in the 1871 census, compared to the Badagas' 19,000 as reported in Brecks 1873:4), the Todas were at the top of the social and ritual hierarchy, receiving gifts from the Badagas and Kodas (Rivers 1906).

When the British in the 1820s explored the passes and discovered this wooded land, wet and cool, reminding them of home--"such beautiful English rain, such delicious English mud" wrote Lord Lytton, Viceroy for India, on his first visit to the Nilgiris--they established a hill station at Ootacamund which became the summer capital for the Madras Presidency. Similar hill stations were established in the Himalayan foothills at Simla for Delhi and the Punjab, and at Darjeeling for Calcutta and all Bengal.

Hill stations removed much of the irritation of Indian life, reconciling Englishmen to a life of permanent exile, but only by isolating them almost entirely from contact with Indian society. During the cool months Englishmen enjoyed a fabricated English life on the plains; during the hot months spiritual isolation was reinforced by physical isolation as well (Hutchins 1967:105).

Because of the salubrious climate, the Nilgiris became a "Sanitorium," or in modern parlance, a Rest and Rehabilitation area for military and civilians. By 1855 there was a considerable British

colony with settlements at Ootacamund, Kotagiri, and Coonoor, a telegraph line, military barracks, several hotels, boarding schools, shops, and those typical British institutions, a club, and a botanical garden, the latter started by private subscription to provide seeds and plants for ornamental gardens. In 1857 it became a government botanical garden, and in 1861 the first cinchona plants arrived and its director, William McIvor, started the government cinchona plantations. Tea and coffee planters also settled in the hills.

This influx of Europeans, as they always called themselves, although they were all either English or Scotch, led to changes in land tenure. According to a "Manual of Instructions for the guidance of revenue officers of the Coimbatore District, in their disposal of Applications made to them for Lands upon the Neilgherry Hills, 19th Dec. 1849" (reprinted in Baikie 1859:Appendix VI), the government reserved to itself the right to protect the hills from deforestation, not only because of the timber (especially teak) but in order to protect springs and streams. This forest preservation policy put a brake on the infant tea industry, because the tea planters wanted forest land, not grass land, for their tea plantations, and the government got its pick of virgin land for cinchona plantations. But soon this preservation policy, though never completely abandoned, had to contend with settler pressure¹ and higher government fiat. The Waste Lands

¹"Following the grant of shola (government forest) lands all around Ootacamund for cinchona and tea cultivation, the Forest Department experienced considerable trouble in managing the forests," i.e., they could not stop the smuggling of firewood, because wood as fuel was a necessity not only to the natives but to large numbers of English (Stebbing 1924:118).

Rule of 1863, applicable to all India, declared all land "waste" and subject to disposal at public auction "in which no rights of private proprietors or exclusive occupancy exist" (Griggs 1880:342; his *italics*). The legal fiction that land not under continuous cultivation was "unoccupied" and subject to expropriation had been used for centuries by English governments to wrest land from Irish kings and chieftains, and by the colonists in North America against the Amerindians. Governor John Winthrop of Massachusetts "declared in 1629 that most land in America fell under the legal rubric of vacuum domicilium because the Indians had not 'subdued' it and therefore had only a 'natural' not a 'civil' right to it. Such natural right need not be respected in the same way as a civil right; only the latter imposed the obligations of true legal property" (Jennings 1975:82). In 1830 the United States Secretary of War Lewis Cass justified the expropriation of the Cherokee homeland with the excuse that they had "traversed but not occupied" the land, although it was well known that the Cherokee were sedentary and agricultural (Ibid:81). The concept of "waste lands" was a convenient axiom in European "international law" in the centuries of expansion, and a prime example of what Jennings calls, in the subtitle of his Invasion of America (1975), "the cant of conquest."

In the Nilgiri Hills the Waste Lands Rule did not alienate as much land as might have been expected, for two reasons. First, the British government respected the Toda villages, Toda munds (sacred dairy sites), and other "spots held in peculiar veneration by the Todas," and interdicted grants of land on or near these sites. It

ruled that the Todas had only "rights of pasturage" on their grazing land, and could transfer only such rights, a measure which should have protected them from alienation. But there was a loophole: "if the land be required for cultivation, it must still be disposed of, under the rules in force, by public auction, for that purpose" (Grigg 1880: 342). So Toda land was in fact alienable, and even land near the sacred sites was sometimes sublet to the Badagas for market gardens and potato fields to supply the European settlements with food. But forty years later Rivers found, in his monograph on the Todas, that Toda culture was essentially intact, and the census of 1901 showed that their population had increased slightly, to 807 (Thurston 1909:I,63).

The Todas are, in fact, available for study today because the British civil servants found their highly unusual culture fascinating, as anthropologists have done since. But the Badagas remained and prospered on the Nilgiri plateau because they were useful to the British, partly as plantation laborers but principally as food providers. Therefore the land settlement with the Badagas is of much greater real import, from the point of view of acculturation studies.

The Badagas, by religion a Hindu offshoot sect called Siva Lingayat, had probably migrated up from the plains some time between the thirteenth and the sixteenth centuries, bringing with them their caste system, their water buffalo, goats, chickens, and their knowledge of intensive agriculture. They grew barley, wheat, rice, lentils, onions, garlic, and other grains and vegetables. According to an early seventeenth century account by a Portuguese priest (in Rivers 1906: 721-730), they practiced rotation of crops, and their home fields were

walled and manured. They also practiced shifting cultivation. The British respected the home fields under plow, but the land under shifting cultivation was a tempting target both to the settlers and to the government which wanted the higher revenue from "improved land." Just before the Waste Lands Rules were promulgated, the government made a compromise settlement with the Badagas: in return for giving up "the shifting privilege," the Badagas were allowed a lowered assessment on the land they agreed to pay taxes on. In this way the Badagas "took up" 11,522 acres of land in 1862 and increased their legal holdings to 35,000 acres (Grigg 1880:322).

When Thurston described them forty years later, their population had risen to 34,178, an increase of 71% over 1871, and they were an integral part of the modern economy on the Nilgiris, living in villages of tiled houses, surrounded by their terraced fields.

Though the primary occupation of the Badagas is agriculture, there are among their community, schoolmasters, clerks, public works contractors, bricklayers, painters, carpenters, sawyers, tailors, gardeners, forest guards, barbers, washermen, and scavengers. Many work on tea and coffee plantations, and gangs of Badagas can always be seen breaking stones on and repairing the hill roads. Others are, at the present day, earning good wages in the Cordite Factory near Wellington. Some of the more prosperous possess tea and coffee estates of their own. (Thurston 1909:63)

The British presence had created a demand for labor in both the private and the public sectors and for market produce which the Badaga could meet because their traditional farming techniques were well developed and because of their familial division of labor. As regards market produce, the food complex mentioned above suited British tastes, especially with the addition of the white potato, probably introduced

by the British. It was a familiar staple in their home diet, and another reason why the Nilgiris were attractive to the British, since it could not be grown in the heat of the plains. The Badagas were able to feed the British as well as themselves because Badaga women did the everyday agricultural work, releasing the men to work for cash wages.

Among the Badagas, the position of the women is somewhat different from what it is among most peoples. Every Badaga has a few acres to cultivate, but he does not mainly occupy himself with them, for his wife does all the outdoor farm work, while he is engaged otherwise in earning hard cash. To a Badaga, therefore, his wife is his capital. Her labor in the field is considered to be worth one rupee per day, while an average male Badaga earns merely three annas. A Badaga woman who has not her own acres to cultivate finds work on some other lands (quoted in Thurston 1909:77).

Badaga men prepared the fields; their enterprise and adaptability is shown in the following passage from a letter to a local newspaper, 1907.

Nobody can beat the Badaga at making mother earth produce to her utmost capacity, unless it be a Chinese gardener. Today we see a portion of the hill side covered with rocks and boulders. The Badagas become possessed of this scene of chaos, and turn out into the place in hundreds, reducing it, in a few weeks, to neat order. The unwieldy boulders, having been rolled aside, serve their purpose by being turned into a wall to keep out cattle, etc. The soil is pounded and worried until it becomes amenable to reason, and next we see a green crop running in waves over the surface. The Badagas are the most progressive of the hill tribes, and always willing to test any new method of cultivation, or new crops brought to their notice by the Nilgiri Horticultural Society (quoted in Thurston 1909:76).

As regards wage work, the plantations provided most of the jobs in the cash sector. The cinchona plantations required labor for planting out the seedlings, trenching, manuring, mossing, and debarking. The coffee plantations expanded faster than the cinchona plantations, since they did not present all the difficulties of a new and experimental

crop. Grigg estimated that there were about 12,000 acres in coffee on the Nilgiris in 1876, producing 4,500,000 pounds of coffee; Markham puts the figure at 19,000 acres (1880:327).

Canarese and Tamil laborers were also brought up from the plains to work these plantations. Grigg noted serious disease and cases of malnutrition among these lowland workers, who had to contend with low wages, an unfamiliar cold and damp climate, and sometimes barracks living. Their situation was typical of other plantation workers, "coolie labor," under the system that was spreading through South and Southeast Asia as the English, Dutch, and French introduced tea, coffee, cinchona, rubber, tobacco, and other plantation crops. The Badagas, having their own homes and farms, fared better. For them, unlike the Tamils and Canarese, the plantation system was 'open.'

This British/Badaga economic mutualism, in which the British were masters and the Badagas servants, but freer than the servant class in Britain, rests at bottom on the British desire to put other values ahead of commercial exploitation on the Nilgiri Hills. In trying to reproduce a little England there, the British followed a policy of "environmental protection," much as rich "summer people" now try to protect the natural beauties of their chosen vacation spot. This policy applied also to some of the cinchona and tea-growing areas of the Indian Himalayas, which by reason of climate and altitude were summer refuges for large settlements of Britishers. Plantation economy did not everywhere ruin local ecosystems and devastate local populations. Here and there the colonial overlords thought to protect an

environmental niche for their own relaxation and enjoyment. Such pockets where the system was relatively benign also depended on the fact that the commercial aspects of cinchona were not a priority with the British, who undertook its cultivation primarily to facilitate the expansion of their military and civil services in India. In addition, the British found it economically advantageous to expand tea cultivation in the Western ghats to the south, in the "native" state of Travancore, where they held indirect rule.

For the more usual impact of the plantation system in Asia, we look to the example of Hevea rubber, which was strictly a commercial enterprise, turning Malaya into a vast plantation worked by exploited labor, much of it imported from China and India, as imperial Britain, having rearranged the politics and economies of Asia, sucked up their human energies.

Postscript: The following glimpses of the perduring but waning British presence on the Nilgiris, 125 years after initial settlement and 25 years after Independence, are taken from a BBC film documentary shown in 1974.

In a general exodus of British planters "because of currency restrictions," one landowner was selling his 19-room mansion and 20,000 acres in teak forest. This land, a grant "as far as he could see," had been awarded to an ancestor for his part in the suppression of the Mutiny of 1857. This would seem to indicate that the forest preservation policy had been at least partially successful. There were only a few British tea planters left on the Nilgiri plateau;

most tea estates were owned by Indians.

The Indian government (State of Madras) brings its staff up to Wellington Barracks every summer, just as the British did.

In the most prestigious sphere of social intercourse, "society" in the everyday sense, racial integration has taken place. The "Ooty Hunt," the Flower Show, and the Club all have Indian members. Britons and Indians follow the hounds together, dance the twist together at a Club Ball, and together contend for the gold cups the Governor's wife passes out for winning entries in the Flower Show. But one Englishwoman at the Flower Show, speaking of the Indian (Badaga?) assistants, told the interviewer: "They make muddles, you know. You cannot rely on these people. And the young ones are insolent."

Chapter VII

RUBBER--A NEW PLANTATION CROP AND INDUSTRIAL RAW MATERIAL

The cinchona transfer had demonstrated how the Royal Botanic Gardens could be of service to the Empire and had added a new cultivar and a new plantation crop to the world list. A second and more powerful application of Kew's scientific technology on behalf of imperial expansion occurred in the rubber transfer. In 1876 the British removed wild rubber seeds from Brazil to start plantations in India, Ceylon, Malaya, and other suitable colonies. By 1913, Ceylon's exports of rubber were worth £4.5 million and rubber exports from the Malay peninsula £3.1 million. In addition to supplying Britain's rubber needs, by 1913 crude rubber had become Britain's foremost re-export, important for her balance of payments with industrial trading partners, like the United States and Germany (Wolff 1976: 20-22). By 1934, in the last decade of the colonial era, over 1,090,000 tons of crude rubber was coming from the British, Dutch, and French plantations in Southeast Asia, and only 14,000 tons from all other sources (H. and R. Wolf 1936:151). Every one of the millions of trees which produced that rubber was descended from the few hundred seedlings that survived the journey from Brazil to Kew to Ceylon and Singapore; and 75% of them from twenty-two seedlings sent from the Ceylon Gardens to the Singapore Gardens in 1877. Rubber became a multi-billion dollar industry, and even in the 1930s

the large tire companies were multi-national. Dunlop, the English tire firm, had its own plantations in Malaya, its own steel and cotton mills in England, its own manufacturing plants in England, Ireland, France, Germany, United States, Canada, India, South Africa, Australia, and was part owner of companies in Hungary and Japan.

The methods of planting and caring for the trees on which this industry depended, of "calling the rubber" and of treating it for shipment, had been worked out in the 1880s and 90s in the British colonial botanic gardens by botanists who taught the early planters. Their work was not superseded during the colonial era, although improvements were made in the manufacturing processes. Other factors contributing to the successful outcome of the rubber transfer were the unquestioned political sovereignty exercised by the colonial powers over the rubber lands, and the abundant cheap labor. This plantation system was still an extractive system, as the wild rubber trade had been, but these three factors--scientific input, political support from seed to finished product, and abundant labor--made it a more efficient extractive system, capable of enduring and expanding even in the face of synthetic rubber to meet a current world demand for natural rubber of 3.1 million metric tons (World Almanac 1974:189), three times what it was in 1934.¹

¹Airplane tires are made from 100% natural rubber, and radial tires for autos contain 40% natural rubber. Today the demand for natural rubber is increasing because of the escalating cost of the petroleum that goes into making synthetic rubber. The National Academy of Sciences has just recommended that the rubber industry take another look at guayule (*Parthenium argentatum*), a desert shrub that grows in southwestern U.S., as a possible replacement for synthetic rubber.

Brazil, which in recent years has produced 0.5% of the world's

We will compare the two systems--the wild rubber trade centered in the Amazon basin and the Southeast Asian plantations which supplanted it--with special attention to the role of the Royal Botanic Gardens. And as we follow this shift in the rubber trade, like the trade in cinchona bark, from Latin America to Southeast Asia, we will look for clues to the general position of Latin America and of Southeast Asia in the capitalist world system, of informal empire based on capital investment versus formal empire with its control of all means of production.

The Cinchona Model

The rubber transfer of 1876 shares many features with the cinchona removal of the 1860s, and presents some of the same cast of characters. Again, Kew Gardens joined forces with the India Office, which paid transportation costs and collectors fees, a total of £1505 (Collier 1968:37), a very small sum, which was both literally and figuratively "seed money" for a great new plantation industry. Kew found the collectors, nursed and propagated the smuggled seedlings in its greenhouses, and distributed them to the Royal Botanic Gardens in the colonies, keeping a reserve stock at Kew. As with cinchona, Kew supplied the trained botanists for the colonial stations and orchestrated their research effort.

rubber, down from 98% at the turn of the century, has become a rubber importer, importing about 40,000 tons annually, mostly for its automobile industry. But Brazil is now undertaking a long range plan to become self-sufficient in rubber. The plan calls for planting 200,000 hectares to new rubber trees, and rehabilitating 30,000 hectares of existing native rubber, under the direction of modern agronomists and agricultural technicians, some of whom are being trained now at the School of Agrarian Sciences of the State of Pará (Brazilian Bulletin, vol. 25, #595, December 1976).

Despite the similarities in the planning and execution of the plant removals, there were important differences between cinchona and rubber. Rubber lacks the wider medical and demographic implications of cinchona, but as a commodity on the world market, its economic importance has been very much greater because of its much greater volume. As a plantation crop, rubber was much more important in the economic development of tropical Asia than cinchona was, and the daily lives of many more workers were shaped by the labor code of rubber plantations, and by the factory codes of tire towns like Akron, Ohio and its European counterparts. The collapse of the wild rubber boom in Brazil, a direct consequence of the plant removal, was much more costly in milreis than the loss of the cinchona market to the Andean republics. Rubber gathering has also been the cause of much greater human misery than fever-bark collecting. Rubber was responsible for the deaths of whole peoples, like the Wuitotos, the Boras, and Andokes, and the Ocainas, who lived between the Caquetá and the Putumayo Rivers which feed the Amazon in Colombia-Peru (Hardenburg 1912, British Government Blue Book 1912, 1913, Whiffen 1915, H. and R. Wolf 1936, Collier 1968), the enslavement of many other Amazonian Indians, and the literal decimation of hundreds of villages in the Congo under the concessionaire system of forced labor by which King Leopold of Belgium amassed his millions (British Government White Paper, Africa #1, 1904, Morel 1906).

The quinine extracted from cinchona bark was useful predominantly in the tropics, and at least some of the population of the producing areas were able to benefit from it. But rubber was purely an export product, essential to the motorized societies of

the West, which, in the first half of the twentieth century, consumed all but a fraction of the total output. A developed society is a society on wheels. And in the great European wars and the global military conflicts of the century, especially in World War II, rubber was more crucial than life-saving quinine. Men could be replaced, but the war machine could not run without rubber. The market for Amazonian wild rubber, like Andean cinchona, was revived in wartime, when the Western forces were cut off from Southeast Asia.

The Botany of Rubber

Botanically, rubber is much more complicated than cinchona, which is restricted to one genus and one natural habitat, the Andes. We have seen how much time and effort was spent by the colonial botanic stations in determining which species was superior in quinine yield. With rubber, the problem of finding one or a few species which by natural superiority would capture the market was much more complex, but in the end had a simpler answer, Hevea brasiliensis.

Trees, shrubs, and vines possessing the specialized cells that produce the rubber hydrocarbon in their latex vessels occur in several different botanical families, especially the Euphorbiaceae and the Moraceae, and in many different genera, e.g., Hevea, Ceara or Manihot, Castilloa, Hancornia, Funtumia, Clitandra, Landolphia, and Ficus. The geographical distribution is wide. Rubber-bearing plants of some commercial value have been found in the tropics and subtropics of Africa, Madagascar, East India, the Indonesian archipelago, as well as Mexico, Central America, and the Amazon Basin, and in dry as well as wet environments. Experimental quantities of rubber have

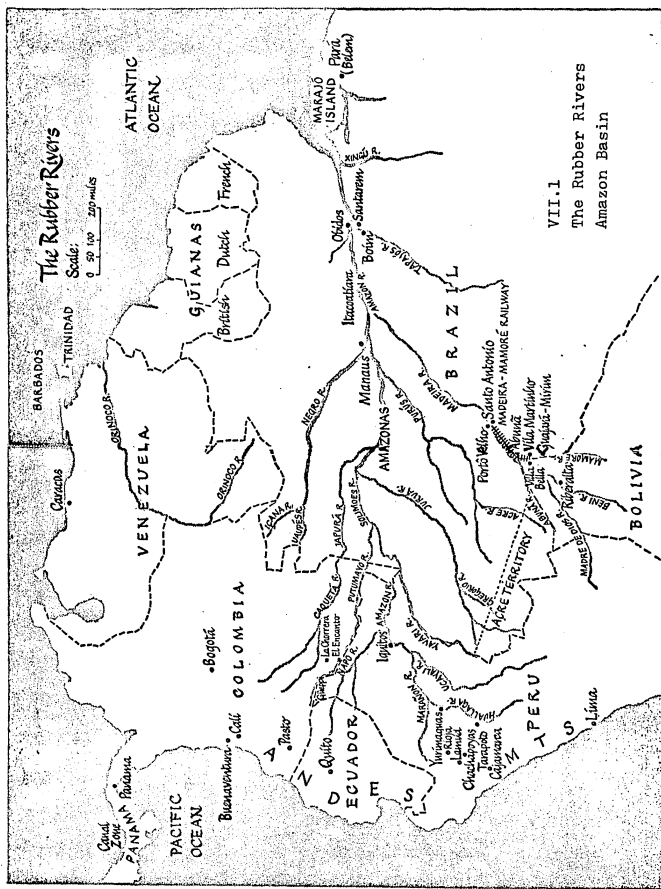
been obtained by rubber scientists from as many as five hundred different plants, some of them growing in the temperate zones, but none from the temperate zones has proved commercially viable in spite of extensive experimentation by the United States and Russia in an effort to become self-sufficient in this essential war material. Because of the petroleum crisis, the United States will probably try again to develop rubber from guayule (see footnote, page 201).

Wild Rubber

Many regions had some natural source of rubber, but only the New World Indians recognized its possibilities and learned how to treat the milky fluid exuded by certain of their forest trees (Castilloa or Hevea species) and to fashion useful articles from it. To prevent mold and fermentation, the latex was slowly smoked over an oily fire, and collected on a paddle into a large ball. The pyrolytic acids of the burning wood coagulated the latex, darkened the rubber, and brought on a translucence (Baker 1970:129-30). Rubber made by this smoke ball method was used by Indians from the Amazon to Arizona. The ball-courts of the pre-Columbian Aztecs, Maya, and Toltec peoples can still be seen in the excavated ruins of Tikal, Chichen Itza, and other Meso-American sites, where the ball game had a ritual significance. The Indians also made torches, jars, containers, syringes, toys, breastplates and quivers, raincoats and shoes, and rubber-headed drumsticks. Rubber was used in applying feather decorations, and the gum was used in healing cuts and bruises. An oil extracted from the gum was taken internally to stop hemorrhaging (H. and R. Wolf 1934:20-21).

The early Spanish chroniclers, e.g., Pietro Martyre, Salahan, Oviedo, Herrera, and Torquemada, gave accounts of these uses of rubber in Mexico, but neither the Spanish nor the other Europeans regarded rubber as more than a curiosity until the eighteenth century, after the publication of the scientific travel notes of Charles Marie de la Condamine. Condamine was a member of an expedition sent to South America by the Paris Academy of Sciences to measure an arc of the meridian on the equator, much as Captain James Cook was sent some thirty years later to the South Pacific by the Royal Society to observe the transit of Venus. In both cases the original task has faded into historical insignificance in comparison with the immense amount of scientific knowledge brought back to Europe of the areas explored along the way. Condamine left Quito after seven years of taking geodetic measurements, and made for home by way of the eastern slopes of the Andes and the Amazon River. This was not the first such trip by Europeans, but Condamine was a better observer than Francisco de Orellana, whose tales of female warriors encountered on his voyage down the river in 1541 gave the river its name. In eastern Peru Condamine observed the collection of latex and brought home some samples of crude rubber. In French Guiana he became acquainted with an amateur botanist, François Fresneau, who later sent him a detailed account of rubber-tapping, and some manufactured articles. Condamine had influential friends, including Voltaire, and as an Academician in the century of Enlightenment, he had a receptive audience. His publications brought rubber to the attention of Europe. His reports on cinchona, based on observations made during his years near Quito, were also the first of scientific importance.

Alerted by Condomine's information on rubber, other Frenchmen found rubber in Africa. Pierre Poivre, who had broken the Dutch monopoly on cloves and nutmegs while Intendant of Mauritius, discovered a rubber-bearing plant on that island. In 1805 the Lan-dolphia genus was found in West Africa, a genus which was later to be exploited in the Congo by Leopold of Belgium and throughout West Africa by others who followed his example. James Howison, a surgeon with the British East India Company, accidentally found a rubber-bearing vine on Penang, off Malaya, in the 1790s and in 1810 the botanist William Roxburgh discovered Ficus elastica in Assam, along the Brahmaputra River. A trickle of wild rubber started coming from Africa and Asia in the early nineteenth century, but only a trickle compared to the trade in wild rubber coming from Pará, Brazil. The real story of wild rubber belongs in the New World where it had been discovered and developed by the indigenous peoples, and where the best varieties of wild rubber grew, although the botanists were unable to classify and name them until after the Kew collectors had brought seeds out in 1876. Hevea brasiliensis, in a big arc south of the Amazon, and Hevea benthamiana north of the Amazon, were the sources of "fine hard para," which commanded the best prices on the rubber market, followed by the "caucho" from Castilloa, a tree found throughout the Amazon forests, but especially important as a source of rubber in Central America and Mexico. Unlike the Hevea tree which could be tapped daily for years, the Castilloa gave its entire yield, about 100 pounds of latex, which it was chopped down, so that the caucheros had to go into the most remote districts. In the Amazon Basin, however, even the Castilloa was never



From The River that God Forgot by Richard Collier. Copyright (c) 1968 by Richard Collier. Used by permission of the publisher, E. P. Dutton.

exhausted, and the Hevea supply was self-renewing. Tapping the Hevea did not interfere with its regeneration. This quality, combined with its pure latex, made the Hevea the wild rubber tree of choice, providing 80% of Brazil's rubber exports.

Amazonian Rubber on the World Market

The export trade in wild rubber through Para City (now called Belem) increased steadily from 156 tons in 1830. In 1839 Charles Goodyear discovered the vulcanizing process which kept rubber from getting sticky in the heat and hard in the cold. By the five year period 1909-1913, the first years of Henry Ford's Model T and the last years before plantation rubber from Malaya caused the price to drop and the wild rubber trade to collapse, the average annual export was 42,000 tons a year (H. and R. Wolf 1936:34, 48). In the pre-automotive era, rubber was used for waterproof garments and overshoes, for hoses, driving belts and rollers for industrial machines, for engine and boiler packing, and for bicycle tires.

The first boom in wild rubber took place in the 1850s, when Brazil opened up the Amazon River to international trade and the Amazon Steam Navigation Company was formed. Organized by the Brazilian entrepreneur Viscount Mauá, the steamship line and a million acres of Amazon basin land were sold to a British company he had promoted for this purpose (Graham 1969:30-31). Such collaboration was common between Brazilian nationals, whom Graham calls "sepoys" after their counterparts in India, and British investors. Local capital was also involved on a more intimate level, though it had to be supplemented later by foreign capital, as shopkeepers in Para

advanced goods and tools to the Indians and Amazonian peasants on the delta islands and the Tocantins and Tapajós Rivers. Richard Spruce recorded in his journal that "the extraordinary price reached by rubber in Pará in 1853 at length woke people up from lethargy. . . . The mass of the population throughout the Amazon and principal tributaries put itself in motion to search out and fabricate rubber" (1908:507), twenty-five thousand people in Pará province according to his estimates. Townsmen and farmers joined the stampede to rubber-tapping, and agriculture was abandoned locally. Farinha, sugar, and rum were imported from outside the rubber districts. Subsisting on credit advanced by the townsman, and dependent on him to buy his smoked rubber, these tappers soon fell into debt. A general pattern of debt slavery spread throughout the reaches of the Amazon as steamships made the upriver areas accessible to world commerce. Great commercial houses backed by foreign capital sprang up in Pará and Manaus, selling the rubber to foreign brokers and supplying the middlemen in the port cities who in turn supplied the patrão who "owned" a rubber estate in the forest or managed it for a large company. The value of this estate lay in the marked paths between the rubber avenues or estradas,¹ and in the labor force the patrão could bring under his control through intimidation and debt entrapment.

The Rubber Trade and the Indian Population

No other economic activity in the Amazon basin approached

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Because the seed pods of Hevea explode with force enough to send the seeds many yards into the forest, there are only three or four Hevea trees to an acre, mixed in with other heavy forest growth. The tapper's twice daily round was long and arduous.

rubber in its deleterious effects on the native Indians. The dislocation of aboriginal life was severe, as traders spread up the tributaries bringing disease, subjugation, and warfare, and demanding that the Indians supply them with rubber. Many groups were annihilated; some, like the Mundurucú (Murphy 1960; 1970) who had already been collaborating with the Brazilians in warfare against other tribes, survived the destructive contact with reduced numbers and a culture much changed. They moved north from their homeland on the savannah-mixed forest zone to be on the rubber rivers (in their case, the Tapajós and Cururú); they became part of the extractive and consumer economy, their chiefs appointed by the trader who bartered cheap trade goods for the rubber and farinha they brought in to the trading post. Their marriage and residence rules shifted, so that they became matrilineal, centering around groups of female farinha processors, while the men were dispersed through the forest, tapping rubber singly. Murphy estimates (1960:8) that 1250 Mundurucu survive out of an estimated 5000 a century ago. Tocantin's estimate was 18,900 in 1875.

Other groups could not make this accommodation and became extinct, their remnants absorbed into neighboring tribes or the life of the backwoodsman. Of 230 indigenous groups surveyed by Darcy Ribeiro (1967:91), eighty-seven had become extinct between 1900 and 1957, fifty-nine of them as a result of contact on the "extractive front" (i.e., mostly rubber) as contrasted with Brazilian pastoral or agricultural expansion. Ribeiro sees the high proportion (45.7%) of the tribes becoming extinct in the extractive areas as

reflecting both the violence with which the groups of tappers of standard and substandard latex and the nut

collectors and other gatherers of forest products have come into conflict with the Indians, and the conditions of life that the former have imposed upon tribes with whom they have established pacific relations.

Little tribes, which soon after their first contacts with civilization--just before or shortly after 1900--succumbed to various epidemics, are the principal contributors to this high rate of group disappearance from the scene. In the area between the telegraphic line opened by the Rondon Commission from 1907 to 1913 and the course of the Guaporé River exclusively, about 18 tribes became extinct within a few years. All 18 had been virgin to contact before the twentieth century. Virulent epidemics alone cannot explain so high a rate of extinction. Various factors appear to have acted cumulatively, among them the docility with which some tribes spontaneously approached civilized men who came to them with the all powerful attractions of metal instruments, porcelain beads, guns, and other marvels. After their first meeting with the officials of the Rondon Commission, many tribes, entranced by their prodigal welcome, sought contact with rubber collectors in the belief that the latter were the same people. The consequences were fatal; within a few years one tribe after another was exterminated, and those who survived suffered such substantial reductions in numbers that today their ranks constitute infinitesimal fractions of the former population (1967:97-98).

Ribeiro does not discuss tribes extinct before 1900, but the period 1900-1913 was the most frenzied rubber boom of all, with the greatest demand for labor. By that time the rubber trade reached up all the Amazon basin rivers, to include the Xingu, the Tapajós, the Madeira and its tributaries, the Mamoré and the Madre de Dios, the Purus, and Jurua, the Ucayali, the Marañon, Napo, Putumayo, Caquetá, the entire Negro drainage, and the upper Orinoco. Sampling the Handbook of South American Indians, vol. 3 on Tropical Forest Peoples, for instances of the impact of the rubber trade on native populations we find the following:

Nimuendajú reports that by 1896 the Yuruna on the Xingu had fallen into servitude to the rubber collectors and only a remnant had escaped; the Shipaya on the Xingu were depopulated and scattered (1948:219); the Arara were

"cruelly persecuted by rubber tappers" (Ibid:223). Of the Maué he says: "At the beginning of the twentieth century, all but one of these villages on the tributaries of the Tapajós were destroyed by the rubber gatherers of Itaituba who took possession of the land" (Ibid:246).

Metraux says of the Mato Grosso-Upper Madeira area: In the nineteenth century, the Paressi also were molested by rubber gatherers" (Ibid:350). "Their isolation did not protect the Torá from the rubber gatherers, who captured them as crews for the navigation of the Madeira River. . . . They were decimated by various epidemics of small-pox, measles, and influenza, and by harsh treatment in the rubber gatherers camps. In 1927, there were only twelve Torá left" (Ibid:399).

On the Mojo: "At the end of the nineteenth and the beginning of the twentieth century, the Mojo were in great demand as boatmen and peons for the rubber companies. A great many were taken into virtual slavery; others died as a result of the mistreatments to which they were subjected" (Ibid:410).

Of the Shipibo-Conibo groups in the Upper Ucayali-Juruá-Purus basin, Lathrap says: "All were completely caught up in the rubber boom during the first decade of this century. Individual family groups came under the total domination of particular patrones and there was a great displacement of population during this period. After the rubber boom had collapsed, communities established themselves in their old homeland, usually growing up around the nucleus of a school or mission station" (1970:180).

Even those tribes inhabiting the uplands between the rivers could not escape the effects of the rubber trade, especially depopulation from disease and warfare, as riverine groups fled their home territory and pushed against other tribes.

The labor force of Indians and backwoodsmen had been much augmented after the great drought of 1877-78, when thousands of small farmers and cattlemen from the northeastern states of Ceará and Maranhão signed up with recruiters from the rubber companies and were taken to the frontier districts of Matto Grosso and the Acre, where the protective force of the law was non-existent. In 1903 Brazil defeated Bolivia in a short war over the Acre Territory and

acquired the tax revenues from this rich rubber district. Since it was made a Federal Territory, the export taxes went to the Federal Government rather than to the state governments, but in neither case were any services provided for the tappers. They lived in isolation in the forest, tapping from dawn to noon, sitting over the smoke fire the rest of the day, waiting out the rainy season in idleness. Their only human contact was on the seasonal trip to the trading post, where they were underpaid for their rubber and overcharged for their trade goods. Beriberi was common because many of them spent no time growing food but lived off imported canned goods. Malaria was endemic but quinine was a luxury they could not afford. During the boom around 1910, it sold in Manaus for 2 pounds, 10 shillings for a shilling bottle (Collier 1968:26). Debt slavery was the means of keeping the seringueiros at their posts and bringing in their quota of smoked rubber, about 2000 pounds a year in the newly opened upriver districts, and about 500 pounds a year in the older districts.

Final Boom and Bust

Henry Ford's first Model T came off the assembly lines in 1908. The steadily increasing demand for rubber soared. In 1910, Pará shipped 16,680 tons of rubber and an equal quantity was shipped from the port of Manaus, a federal customs port one thousand miles up the Amazon, while Iquitos, another thousand miles upriver in Peru, also shipped in quantity (H. and R. Wolf 1936:67). Amazonian rubber accounted for over over half of the world's 83,000 tons of wild rubber, with Africa and Mexico sharing the rest, and only 11,000 tons yet coming from the plantations of the East. Some of the ships

carried a cargo worth £1 million each to London or New York. The United States was taking 30% of the Amazonian rubber, but Britain was still the best customer. Its imports of Brazilian rubber far surpassed its other imports from Brazil--in the period 1905-09, Britain imported £33 million worth of rubber out of a total £45 million in imports from Brazil (Graham 1968:75).

Britain had long been the principal supplier of capital to Brazil, as to Latin America as a whole, with an estimated nominal value of British capital invested in Latin America in 1913 of £999.3, of which £223.9 went to Brazil (Graham 1968:5). British capital provided the infrastructure on which Brazil's modernizing effort rested, especially the strong coffee export industry in the South. In the Amazon basin, British steamship lines had pioneered, British capital had backed the export houses, provided the transatlantic cable lines and the marine insurance, and had built the \$40 million floating docks at Manaus. There were increasing investments from other Western capital: French investors improved the Pará docks, and an American railroad magnate built the 226 mile Madeira-Mamoré railroad, which cost over 6000 lives (Collier 1968:209), but never shipped any rubber before the bust.

From July 1909 to April 1910 there was such wild speculation in rubber stocks on the London Stock Exchange that the chairman proposed closing the exchange so that brokers and clerks could keep up with the orders. One office boy made a coup of £19,000 in rubber shares. These wild cat investors neither knew nor cared whether the rubber was to come from Brazil, Mexico, Africa, or Malaya. Many new

Malayan plantations were capitalized at this time, but in the four or five years before their rubber could come on the market, the Amazonian boom continued. The rubber barons of Pará, Manaus, and Iquitos were convinced that wild rubber would never be supplanted. The price in 1910 reached \$3.06 a pound, although fluctuations of around a dollar a pound had been usual in the sixty years of the wild rubber trade. Rubber was Brazil's second export in volume after coffee, but in those prosperous years it brought more tax revenue to the federal government and the states than did coffee (H. and R. Wolf 1936:48). Rubber was like gold, and the port cities were like gold rush towns with frenzied spending on luxuries and rapid social advancements for the lucky few, and the most ruthless exploiters of human labor.

The worst abuses and the greatest profits occurred in the private empires carved out of the upriver regions where Bolivia, Peru, Colombia, and Brazil exercised nominal sovereignty, often disputed, but where the only effective power belonged to the rubber baron who first put his gunboat on the river. The Suarez brothers of Bolivia controlled sixteen million acres of rubber lands, and the Peruvian, Julio César Arana, directing his affairs from Manaus and later from London, controlled eight million acres in the Putumayo district. His fifteen hundred armed section chiefs, who were paid only by a commission on the rubber they sent downstream, and his six hundred gunmen used murder, starvation and torture, including burning alive, to extract record amounts of rubber from the Wuitotos, the Boras, Andokes, and Ocainas. In his best year Arana got 1.42 million pounds of smoked rubber out of his domain (H. and R. Wolf 1936:91). Sir Roger Casement, British Consul General at Rio, who was sent on

an investigative mission in 1911, reported that in the previous five years the Indian population in the Putumayo had fallen from 50,000 to 8,000 (British Government Blue Book 1912).

In 1908 Arana had gone to London, seeking capital, and had parlayed his family business, J.C. Arana and Brothers, into the Peruvian Amazon Company. London financiers gave him shares in the new company with a book value of \$2.75 million for assets which in reality consisted only of squatter's rights to land in the Putumayo district and a slaver's claim to Indian labor. He also got \$500,000 in working capital from the underwriters of the new company, and a \$300,000 bank credit from the London Bank of Mexico, one of whose officers he put on his board of directors. The English directors of his Peruvian Amazon Company were his willing dupes, knowing nothing about the business and asking no questions. Arana used them solely as a source of capital, prestige, and respectability. One of these directors, Sir John Lister-Kaye, was Groom-in-Waiting to King Edward VII. For three years Arana hoodwinked his British dummy directors, who refused to believe the charges of atrocity which began to appear in the crusading press. Exposure finally came in Parliament, and Arana's genocide was documented by a British Select Committee (British Government Blue Book 1913). The bankrupt company was liquidated, its directors disgraced, and Arana went home to pick up the pieces of his Putumayo empire. Ten years later he was a Peruvian senator, with legal title to 14 million acres in the Putumayo, extending from the Japurá to the Napo River (H. and R. Wolf 1936:101).

The British government had been able to investigate Arana's personal empire only on the technicality that he employed some Barbadian overseers, who were British subjects. Since the abolitionist movement of the early nineteenth century, a strain in British public opinion had always reacted strongly against the worst abuses which unregulated capitalism imposed on the laborers who produced what they consumed. Such abuses jarred the ideal picture of their "civilizing mission to the backward races" through trade and peaceful penetration. The British government had taken the lead in exposing Leopold's genocide in the Congo (White Papers 1904, 1909). The Cadbury family, Quakers and chocolate manufacturers, had recently secured an investigation of the slavery still persisting on the Portuguese islands of San Tomé and Príncipe, off the coast of West Africa, and were demonstrating to the world that cacao could be produced profitably without such labor excesses. Between scandals, the nation went back to business as usual, but the exposure of crimes such as Arana's influenced the placement of investment money. Arana had given wild rubber a bad name, and henceforth capital steered toward companies doing business under the British flag, i.e., in the colonies of Southeast Asia.

The British abolitionist movement and these related exposures were indirectly aimed at French, Belgian, Portuguese and South American competitors, and thus had the backing of capitalists as well as moralists, in a convergence of positions. Moral fervor made it easier for British investors to cut their losses in the Amazon and turn to the Asian plantations, where a completely different

labor picture was presented, one in which coercion was built in by high population densities and did not have to be organized from without, with the same degree of self-destructive brutality. And except for the Manaus docks, much of the British capital in the Amazon trade was not fixed but moveable--e.g. the steamships could be routed to the East.

There is no doubt, however, that the panic of 1913 was costly to all concerned. Plantation rubber from Malaya and Ceylon overtook wild rubber and drove the price down, and the whole inflated credit structure of Amazonian rubber collapsed. Commercial houses in Pará and Manaus went into bankruptcy; public servants in Manaus were not paid for eight months. The Opera House was empty; the yachts, the diamonds and Steinway grands were sold for what they could bring. The little rubber towns along the rivers went back into the jungle. Seringueiros starved because supplies did not arrive, and deserted when they could. Production continued during the war years 1914-1919, and then fell off to a trickle. The Amazon was finished as far as rubber was concerned. Singapore was henceforth the rubber port for the world.

In 1912 the President of Brazil announced an ambitious plan, A Defesa de Borracha (The Defense of Rubber), which would offer subsidies to modern plantations and rubber factories. A million dollars was spent, mostly on organizing a bureaucracy, and the plan was abandoned within a year. The only other attempt to make rubber plantations in Brazil was also a failure. In the 1930s Henry Ford got a concession of three million acres on the Tapajós River and invested

over eight million dollars in his Fordlandia before giving up. He could not make Hevea in Brazil competitive with its descendants on plantations in Southeast Asia. Ford had both a political problem and a labor problem, compounded by his own idiosyncracies. Jealous of their interests, the states of Amazonas and Matto Grosso confiscated thousands of young Hevea plants that were destined for his plantations. He won his lawsuit against them, but a whole planting season had gone by. His workers would not tolerate the regimentation he brought from Detroit--a prohibition on liquor, spying on "immoralities," standing in line at American-style mess halls. Nor would they allow him to import labor from the West Indies, the sort of imported target labor that was the basis of the plantation system in the East.

Wild Rubber Assessed

It is rare that nature provides a plant resource that can withstand the demands that the nascent automobile industry placed on wild rubber. But resource depletion was not a problem with Hevea in the Amazon. The Hevea trees never ran out. The vast distances in an undeveloped land undoubtedly posed a problem, but water transportation was cheap and the river system an asset in a region of heavy forests. Fabulous private fortunes were made, but nothing was reinvested in services to the rubber tappers. The real problem lay in the exploitation of the labor force, scarce enough to begin with, with a population density of less than one person per square mile over the 2.5 million square miles of the Amazon basin. From the beginning of the wild rubber export trade to its collapse

sixty-five years later, this human resource was treated as if it were expendable. Eventually, capital followed labor to the Far East, in a transfer made possible by Kew Gardens.

From Wild to Cultivated

British interest in rubber as a possible plantation crop goes back at least to 1855 when Thomas Hancock, a pioneer rubber manufacturer of such articles as rubber hoses, waterproof garments, and driving belts and rollers for industrial machinery, suggested to Sir William Hooker of Kew Gardens that rubber should be cultivated in both the East and West Indies. Hooker pledged his support to anyone who undertook such a project, but it was not until after the cinchona transfer was completed that active steps were taken in regard to rubber. The first efforts failed. In 1873 an Englishman named Farris, resident of Cametá on the Tocantins River, brought 2000 seeds to Kew. Only a dozen of them germinated, and all the half dozen plants taken by Sir William King, Director of the Calcutta Gardens, died after planting. Hooker then got in touch with Henry Wickham, his correspondent in Santarém, who had once tried his hand at rubber gathering in the Upper Orinoco (Wickham 1872). Wickham's first two shipments of seeds also failed to germinate. Success came only in 1876 when Wickham chartered an English ship going up the river on a newly opened Liverpool-Manuas run. He filled it with a quantity of Hevea seeds estimated at 70,000 which he had hurriedly collected with the help of Tapuyo Indians in the forests of the Tapajós basin. At Pará, Wickham successfully hoodwinked the Brazilian customs official and got his contraband cargo safely out to sea, and to Kew.

We were bound to call in at the city of Pará, the port of entry, in order to obtain clearance for the ship before we could go to sea. It was perfectly certain in my mind that if the authorities guessed the purpose of what I had on board we should be detained under plea of instructions from the Central Government at Rio, if not interdicted altogether. I had heard of the difficulties encountered in the Clements Markham introduction of the Cinchonas in getting them out of the Montana of Peru. Any such delay would have rendered my precious freight quite valueless and useless. But again fortune favoured. I had 'a friend at court' in the person of Consul [Thomas] Green. He, quite entering into the spirit of the thing, went himself with me on a special call on the Baron de S-----, chief of the Alfandiga, and backed me up as I represented to his Excellency my difficulty and anxiety, being in charge of, and having on board a ship anchored out in the stream, exceedingly delicate botanical specimens specially designated for delivery to Her Britannic Majesty's own Royal Garden of Kew. Even while doing myself the honour of thus calling on his Excellency, I had given orders to keep up steam, having ventured to trust that his Excellency would see his way to furnish me with immediate dispatch. An interview most polite, full of mutual compliment in the best Portuguese manner, enabled us to get under way as soon as [Captain] Murray had got the dingy hauled aboard. . . .

I got Murray to put me ashore at Havre, and there posted over to Kew, saw Sir Joseph Hooker, so as to enable him to dispatch a night goods train to meet the Amazonas on arrival at the Liverpool docks.

June 1876 was a time of commotion at Kew, as they were compelled to turn out orchid and propagating houses for service, and to make room for the sudden and all-unexpected inroad of the Hevea; but Sir Joseph was not a little pleased. The Hevea did not fail to respond to the care I had bestowed on them. A fortnight afterwards the glass-houses at Kew afforded (to me) a pretty sight--tier upon tier--rows of young Hevea plants--seven thousand odd of them (Wickham 1908).

There are two points of interest in this account. In talking to the Alfandigo (Chief Customs Officer), Wickham invoked the name of the Queen to good effect. The royal associations of Kew Gardens were more than an empty formality in this case. The connivance of the consul was commonplace, and his presence might not have carried enough weight. The second is Hooker's ability to hire a freight train at a moment's notice, and his decision that it was worthwhile

to do so. After the previous failures, every effort had to be made to ensure the germination of these seeds.

It is probable that Wickham exaggerated, and that 70,000 seeds is too many, although the sheer quantity of seeds as well as the speed of the operation was a factor in its success, since the germination rate was so low. It is also probable that 7000 seedlings is too high a count, but there were enough to fill thirty eight Wardian cases with 1900 young plants, which were sent in the care of a Kew gardener to the Peradeniya Gardens in Ceylon (Ludowyk 1967:205). Robert Cross, the veteran Kew collector, returned to Kew from Brazil that fall with 1000 rubber plants, some of which were sent to Ceylon, and may have formed part of the parent-stock of the Singapore rubber plants.

The monopoly on wild rubber had been broken, but the results were not to be seen for many years because of development problems.

The Experimental Years

Hooker and the India and Colonial offices chose Ceylon as the center of propagation, experimentation, and distribution of Hevea seedlings because of their earlier failure to survive in the Calcutta Gardens, and because the planters on Ceylon were eager for a new crop to replace their coffee trees, blighted by a leaf disease, Hemileia vastatrix. Plants were also sent in smaller quantities to the Botanic Gardens in Singapore, India, Burma, Borneo, and some to the Dutch Buitenzorg Gardens on Java, another instance of British/Dutch scientific collaboration (also an indication of the measure of

independence for the botanical establishment, since the commercial/ industrial interests of the colonial powers were in competition).

Hevea's superiority was not at first apparent. Time was wasted in the Ceylonese Gardens on Ceara, grown from seeds brought out by Cross. But Ceara was a plant adapted to a dry climate, native to a drought state of Brazil, Ceará. For years the British in India tried plantations of Ficus, the vine native to Assam, and Ficus was transplanted to Egypt and to the region around Lagos in West Africa. The Dutch on Java spent years of work, 1877-1910, on Ficus, Ceara, and Castilloa before switching to Hevea. Plantations of these and other rubber-bearing plants were tried in every tropical or sub-tropical colony by all the major powers, including the United States in the Philippines.

The botanists in the Ceylon Gardens working on Hevea could not find the tapping methods to release the latex in quantity. But the Botanical Gardens network had an institutional strength--multiple centers of research. What was not accomplished in Ceylon was finally done in the Singapore Gardens. In 1888, Henry Ridley, a young man trained at Kew by Hooker, was sent to Singapore as Director of the Botanic Gardens. With a budget of only £100, he started an intensive course of experimentation with the Hevea plants there, and worked out a method of tapping called "wound response," in which a thin slice of bark is pared off the edge of the preliminary cut every day so as to release fresh latex. This was the significant breakthrough; at last commercial quantities of rubber latex could be taken without damage to the trees. Ridley also found that the trees could

be tapped at age four to seven years, instead of the twenty-five that had been assumed. In 1895, he interested the first rubber planters in the Malay States in rubber production. In addition to his demonstration gardens in Singapore and Perak, Ridley travelled about, stuffing rubber seeds into the pockets of planters, persuading and teaching. His enthusiasm earned him the nickname "Mad Ridley" or "Rubber Ridley" and a reprimand from the Governor, but he had the continued support of Hooker at Kew, and persisted in his work on rubber (Allen and Donnithorne 1962:109-10).

Another important discovery, made by John Parkin at the Ceylonese Gardens, was the acid method of coagulation, replacing the smoke process. This meant clean rubber. It also meant that the latex gatherers no longer did the initial processing, and was a step toward the separation of labor's functions into discrete operations, on the model of industrial practices.

Further experimentation led to planting the trees in straight rows of two hundred to the acre, and thinning them to eighty per acre (H. and R. Wolf 1936:188). This was far more than the three or four to an acre in their natural state in Amazonia, and Henry Wickham kept protesting both the crowding and the abandonment of the smoke process. He was ignored. The botanists treated the plant as an experimental substance, and by trial and error finally achieved an output from one acre which approached the seasonal output per man in wild rubber tapping. Seven hundred pounds of crude rubber per acre per year was usual on the better estates. This was done without extra capital investment, except for the scientific work. Weeds were kept

down and trees were checked for disease, but no machinery was introduced. Efforts to use gasoline tractors and steam logging machinery for clearing forest were abandoned in favor of cheaper hand labor. In processing the crude rubber, especially on plantations owned by American or British tire companies, some industrial machinery was used. In 1918 the Dutch made their only contribution to improved rubber yield. Three botanists at the Buitenzorg Gardens on Java perfected the bud-grafting method. This cost sixty dollars an acre, but allowed a yield of 1300 pounds an acre where it was adopted.¹ On the large plantations of the twentieth century, the manager kept records on each individual tree, and the best producers were used for new plantings, either through seed selection or bud-grafting. Emphasis on yield had shifted from the gatherer, with his quota of wild rubber to bring in, to the amount per tree. Rubber production had become rationalized, but it never became mechanized. Manpower was still the key.

Labor

It took over twenty years of experimentation and about five years for the young trees to come to maturity after planting before plantation rubber appeared on the world market in quantity. In 1905 the price of wild rubber was high because of manipulation of the Brazilian market, and the pioneer plantation owners in Asia reaped a windfall profit from their rubber. Planting started in earnest then.

¹Henry Ford was one of those who did so, bringing bud-grafting clones of Hevea from the East to plant in his Fordlandia on the Tapajós, from which their ancestors had been smuggled sixty years previously.

Tea bushes were ripped up in Ceylon, and large areas in the lowlands were put into a plantation crop for the first time, some of them by a new class of Sinhalese capitalists, all of them worked by Tamil labor. In Malaya rubber planting was even more extensive. In the years 1905-1912 two hundred thousand acres were planted to rubber in Malaya, Ceylon, and Sumatra; and in 1913-15 another two hundred fifty thousand acres annually, mostly in Malaya and Sumatra where there was more "virgin forest" (H. and R. Wolf 1936:173-74). By 1915 Malaya had over 703,000 acres planted to rubber trees (Tinker 1974:33).

Capital flowed in as companies were formed and shares sold on the London market to a public caught up in the rubber boom (see pages 215-16). A similar craze on the New York market led many small investors to lose their savings in Florida plantations which never produced, or in the many plantations in Mexico which were very promising until their higher labor costs made them noncompetitive with rubber from Southeast Asia (H. and R. Wolf 1936:170-71).

Neither Malaya nor Sumatra had a labor force equal to this demand. Their native cultures ranged from a few hunting and gathering groups to simple agriculturalists and fishermen to sophisticated states of traders and warriors, but they had not been colonized nor been subjected to the agricultural exploitation of the Culture System as Java was. British presence in Singapore dated only from 1819. The Straits Settlements were made a Crown Colony in 1867, and the Federated Malay States, "under the protection of Great Britain," were formed only in 1896. The British had gone into the interior from their coastal trading posts in the early 1870s ostensibly to settle tong wars among the Chinese in the tin fields (the Perak Wars). The

native sultans were left in symbolic sovereignty, but soon the tax revenues on tin were going to Great Britain, and by a regulation of 1879 to the effect that "no land should be allowed to lie idle if anyone is willing to work it, and the owners of metalliferous land must submit to its being worked" (Seng 1969:112) private concessions on tin mines and "agricultural industries" were acquired, and plantations of coffee, sugar, and pineapples started. This "Waste Lands" concept had been promulgated in India in 1863 and on Java by the Dutch in 1870. Malaya had much land, few indigenous laborers, but already a tradition of imported labor from China in the tin mines, as well as a large number of Chinese traders and middlemen.

Clearing and planting the rubber plantations in Malaya was done mostly by Chinese, often imported on the indenture system direct from Chinese coastal cities by brokers who contracted with the planters. The planters took the ten dollar passage money out of the 2 1/2 cents a day they paid the coolie (H. and R. Wolf 1936:198). Return home was impossible under these conditions, and the Chinese stayed to become Malaya's largest ethnic group, outnumbering the Malays in some states.

Once the heavy work of clearing the forest was done, most of the tapping and weeding was assigned to Tamils from South India, brought in under contract in a government-sponsored immigration system, with a penal code that provided for jail sentences for breaking a contract or failure to pay debts incurred. These debts were often inflated by planters and by recruiting agents or overseers (usually the same persons), who found the immigrants easy prey (Tinker 1974:180).

By 1915 there were 144,000 Indians on the Malayan estates (Tinker 1974:33), and in 1927, the peak year, 120,000 Indians were brought to Malaya to work rubber (Cady 1964:449).

The recruiting was done in small lots by men of their own nationality--kanganies sent into India by the managers of the Ceylon and Malaya estates where they were employed. In theory it was a patriarchal system, the kangany supposedly being the head of a family group and being held responsible for the debts of all the laborers he brought in. Employers liked it because the joint debt responsibility made all gang members vigilant in seeing that all the others worked, and in coffee days it is said to have functioned fairly well¹ [see footnote below for another opinion]. The booming demand for rubber and tea workers proved too much for kangany morals, however, and they went into large scale recruiting outside their own families, into chiselling advances which never reached the laborers, and into piling up huge debts against the laborers on estate books (H. and R. Wolf 1936:198).

Opening up the forest always caused malaria to increase dramatically. In one of the Malay States, Negri Sembilan, the death rate increased from 85 per thousand of imported estate laborers in

¹Coffee plantations were opened up on Ceylon in the 1840s on the same large scale as rubber seventy years later. "The story of the immigrant cooly in Ceylon during those years is melancholy reading. They swarmed across the strait from South India in catamarans and rafts to ports in North Ceylon. The rigours of the progress from there to the highlands, the conditions in which they lived and worked on the plantations and their own ignorance, which made them victims of their desperate compulsion to save what they could in the year or two they spent in Ceylon, worked havoc among them. Ferguson put the death rate among the immigrants during the forties at 250 per thousand. . . . The government was unwilling to provide what in its view the planter should have undertaken. As for the planter, a devotion to his own interests blinded him to his responsibilities. . . . When the government did intervene to regulate relations between planter and cooly in Ordinance 5 of 1841, the effect of this "first piece of labour legislation" was to enable the planter to hold the cooly to his contract. . . . Those who fell sick on the plantation and were unable to work were driven out on a charge of idleness and left to die by the roadside and be buried by the Police--according to Tennant in his dispatch to [Lord] Grey of 21st April 1847" (Ludowyk 1967:196).

1909 to 195 per thousand in 1911 (H. and R. Wolf 1936:201). When the government required that each estate have its own infirmary some of the planters at first objected that there was "no healthy site," but eventually quinine was dispensed routinely to the workers, and sanitation was enforced in the camps. In the areas where malaria persisted, only the Chinese and Javanese would work, the Tamils refusing in spite of higher wages. During the depression a speed-up was instituted to compensate for staff cuts. Many decrepit Chinese were repatriated, and thousands of Tamils and their dependents were deported to India by the FMS Labour Department, "an extreme example of the export of unemployment" (Allen and Donnithorne 1962:124).

Collusion between the British business community, which held an estimated \$260 million in investments and \$82 million in bonds, and friendly British government agencies prevented any effective application of accepted minimal standards for fair treatment of laborers. Chinese capitalists, also holding an estimated \$200 million in equities, were completely unregulated in their exploitative treatment of fellow Chinese laborers and Malay debtors (Cady 1964:454-55).

In 1938 the Congress Party of India finally succeeded in getting legislation that ended the wholesale recruiting of Indians, though the penal clause had been struck in 1921, and indenture had been stopped in 1910 in favor of "free labor."¹

¹Ravindra K. Jain in South Indians on the Plantation Frontier in Malaya (1970) has done a detailed ethnographic study of a modern European-owned rubber plantation in coastal Malaya which shows the persistence of these labor patterns. Ninety-eight percent of the population of this plantation are South Indians, most of whom migrated in the first half of this century from the old Madras Presidency. Their Malayan-born children make up the rest of the labor force. Men, women, and children (age 16 up) work either as tappers or as weeders, under the direction of kanganies. The upper supervisory and clerical force, which was European before the war, is now made up of Asians, with one sole European, the manager. The workers live on the estate in "lines" or attached bungalows.

In sum, Tamils provided the main source of labor on rubber plantations in Ceylon, Malaya, Burma, and the Malabar Coast of India. Javanese were the principal tappers on Sumatra and Borneo. Only on Java, and later in French Indochina, was there enough population pressure to fill the demands of the rubber planters with indigenous labor. The old agricultural empires, India and China, had men to spare, and Java had recently undergone an agricultural involution under the Dutch Culture System which resulted in a fourfold increase in population in three generations (Geertz 1973:69-70).

Western rubber technology spread beyond the confines of the rubber plantations, with the blessings of the colonial governments. In time there were many small-holders in Malaya and Sumatra--Chinese, Malays, and Javanese--who used family labor and hand rollers to process the latex in pans made from kerosene drums. After 1913 Malays were allowed to buy land cheaply on Malay reservations. On Sumatra after 1920 Javanese who could find no land to buy on Java took advantage of the Dutch offer of free land, free seedlings, and free advice on northeastern Sumatra.

It was with respect to rubber that the small-holder export economy of the Outer Islands really took off. . . . Rubber is a tropical forest product par excellence, a tree crop as readily integrated into a swidden complex as sugar was into a sawah complex, and hence spread easily and rapidly from its east coast beachhead through most of Sumatra, to parts of Borneo, and to a lesser extent, to the Outer Indonesia sections of Java; by 1938 an estimated 60 percent by weight came from nearly 800,000 small holders (Geertz 1973:113-14).

Without the fixed overhead of the plantation, the small-holder could enter and leave the market at will, depending on price fluctuations, although his rubber, being inferior in quality, could

never command the same price as the plantation product. The success in rubber stimulated other commercial crops in the Outer Islands under the leadership of indigenous entrepreneurs like the Minangkabau (Geertz 1973:114-123). The depression actually favored the small-holder, since the planters, both British and Dutch, entered into quota agreements to restrict production in the hope of holding prices, and the small-holder resorted to smuggling (Allen and Donnithorne 1962:120-126).

The Japanese capture of Singapore in 1942, and soon thereafter of Java and Sumatra, put an end to the colonial era in rubber. Both plantation rubber and peasant-produced rubber continue to be a leading export product of the new nations of Malaysia, Indonesia, and Sri Lanka, along with other industrial raw materials such as tin and petroleum.

Rubber and the Empire

Imported men, an imported plant, and imported quinine to control malaria all combined to make the Malay States an embodiment of the ideal colony, and to make rubber the most satisfactory plantation crop in all of British-controlled Southeast Asia. From 1877 to the Japanese invasion, there was no challenge to British authority in Malaya, no overt labor unrest, only steady production. Prices fluctuated, but the overall growth of the automobile industry put rubber in the class of vital necessities. British investors were happy with their rubber shares, and the British government knew that 75% of the world production of a strategic resource was in the hands of its own nationals, 69% of it on its own territory.¹

¹Some British capital had entered Java and Sumatra. The United States Rubber Company also had large holdings on Sumatra.

Some British capital had been lost, as well as much Brazilian capital, in the panic of 1913 when plantation rubber undercut the wild rubber trade in the Amazon, but the transfer of the rubber trade from informal empire in Latin America to formal empire in Asia had served Britain very well. As long as she could keep the sea routes to Asia open, her entrepreneurs enjoyed congenial conditions under the colonial governments, with the support of the administrative framework and the courts in making, interpreting, and enforcing land and labor laws favorable to them. Brazil as an independent nation, with its own entrepreneurs, had demanded more in taxes than the few remaining sultans did. In labor supply, Latin America could not match the East, where if one colony, e.g. Malaya, did not have an oversupply of labor, its neighbor, India, did, so that the labor problem was easily solved, with measures that were harsh but not brutal enough to come to the attention of the world as the Putumayo scandals had. By enforcing sanitation, supplying quinine, and building workers' huts, estate managers treated labor as an investment, just as they did the Hevea trees.

The Royal Botanic Gardens were responsible for every phase of the development of cultivated Hevea rubber. No other wild plant has since been domesticated with comparable commercial results. Kew supplied the plant and the basic botanical work. The colonial gardens functioned as agricultural experimental stations, doing the developmental work, educating the planters by personal contact and published bulletins. This crucial flow of information was not difficult in a tightly integrated colonial society. In our next and last case history, we will look at an unforeseen result of Kew's

dissemination of commercially valuable botanical information, this time on an international scale--the German East African sisal plantations.

Chapter VIII

Sisal and the Kew Bulletin

Like present-day monopolies based on patents, copyrights, and industrial secrets, botanical monopolies based on plant embargoes were often circumvented. The Spanish colonial monopoly on cacao was broken by the Dutch from Curaçao in the sixteenth century, and the Dutch monopoly on spices in the Indies was broken by the English and French in the eighteenth century. These actions were part of the intense competition for trade and colonies which often led to war among the European powers. The situation was different when the British broke through the protective laws and policies of Bolivia, Peru, and Ecuador in the case of cinchona. Vis-a-vis Britain, these were sovereign but quite ineffectual powers. They were unable to undertake any effective counteraction. Military retaliation was unthinkable, and their economic dependence on Great Britain as the main source of investment capital precluded any strong political action. But the feeling of humiliation and resentment in Latin America was strong and the memory long. After the rubber coup of 1876 Kew Gardens did not undertake any organized expedition in contravention of clearly defined laws prohibiting the export of Latin American plants, but Britain still urged her consular officials to send home specimens of protected plants and reports on their propagation and processing, and Kew Gardens continued to seek such

plants for study and to print such trade secrets in the name of science.

A case in point is the sisal industry of Mexico. Since 1887 when Thiselton-Dyer, Director of Kew Gardens, had started the Kew Bulletin of Miscellaneous Information the Bulletin had been printing "such information as could be obtained" on agave fibers. The key article was published in the Kew Bulletin of February 1892.

Frequent inquiry has been made at Kew, in regard to the plant yielding the best qualities of Sisal hemp, and information has been sought by official and other bodies to enable them to judge of the suitability of the plant for cultivation in other countries. The position taken by Kew in this matter is a very simple one. The various varieties and forms of Agave rigida Mill, the species from which the several sub-species and varieties yielding Sisal hemp are supposed to have sprung, have been carefully studied, and living specimens have been added to the collections in the Royal Gardens. In this respect, the collections at Kew are probably as complete as any in the world. Further than this an effort has been made to furnish from time to time in the Kew Bulletin such information as could be obtained respecting the methods of cultivation and the incidental conditions of the industry likely to be of general interest (1892:21).

One does not learn from the above quotation that many of the specimens and much of the information were surreptitiously obtained, designed to undermine a Mexican industry and enrich the British Empire. As matters turned out, the first empire to be enriched was the German Empire, in its newly acquired colony in East Africa, in a transaction in which the Kew Bulletin article was a catalyst. Various British possessions also became sisal producers but, having published the information, Kew Gardens could not control its use, and the information entered a world system in which such scientific knowledge was coupled with the capital of the Western

powers. Armed with both capital and technology, they proceeded to develop their colonies and to supply the metropolitan markets with primary products at a low price. In this chapter I propose to describe the Mexican sisal industry and the plant removals that eventually led to severe competition which restricted its sphere of the world market, but my primary aim is to show how botanical imperialism had shifted by the end of the nineteenth century from organized plant raids to the diffusion of information among the scientific and technological elites of the world, as exemplified by Kew Gardens' published articles on sisal.

The Commercial Agaves

Sisal, from Agave sisalana, and henequen, from A. fourcroydes, are valuable hard fibers used principally as binder and baling twine by combine operators, peasant proprietors, and small farmers to bind their sheaves of wheat or bale their hay for market. Many farmers find sisal twine preferable to wire for baling, as sisal will not harm cattle if ingested. The short fibers are used in making carpets and upholstery. In common usage today, "sisal" is the generic term for the product of both the above-named closely related species, while "henequen" is reserved for the fiber of the latter only. Both species are native to Central America, and throughout most of the nineteenth century Mexico was the only producer for the export market and the industry was centered in Yucatan. The fiber was shipped out on schooners from the old port of Sisal on the northwest coast of the peninsula, thus earning its name in the trade. Little distinction was then made between the two plants or their fibers, though

"henequen blanco" (now known to be from A. fourcroydes) was the source of most of the fiber exported from Yucatan, while "henequen verde" (A. sisalana) was more commonly grown in Chiapas. The importance of this distinction will become apparent later, since probably by chance rather than design, it was only the latter species which was removed and made the basis for a new industry outside of Mexico. Common sisal (A. sisalana) now far outstrips henequen in world production, accounting in 1966 for 75% of all hard fibers, while henequen (mostly from Mexico) accounted for 12%, and manila hemp from the Philippines (made from Musa textilis, a banana relative) accounted for 13% (Lock 1969:326).¹

Agave sisalana differs from the other agave species in that it usually, though not always, lacks the thorny edges or "side teeth" along the leaf margins, but all species share a similar habit of growth. They are xerophytic plants with thick lance-shaped leaves about 4 to 5 feet long with a spiny tip, the leaves growing in a rosette cluster around the base. The plants have a dense root system which can withstand prolonged drought. Dormant in drought, the plants revive with the first rainfall. A commercial crop cannot be expected under desert conditions, but neither will a planter be wiped out by unseasonable drought. Modern research for the Tanzania

¹Jute, a plant of the genus Corchorus, produces a softer and weaker fiber, which can be used for some but not all the purposes of hard fibers. India, especially Bengal, produces most of the world's jute, which is processed into burlap fabric, twine, and sacking. Under the British much of Bengal's good rice land was diverted to growing jute. The easy availability of jute may have been one reason the British allowed sisal to slip out of their grasp; while the fact that jute was not a "hard fiber" accounts for their interest in sisal.

Sisal Grower's Association shows that optimal leaf growth occurs when there is 50-60 inches of rainfall, well distributed seasonally (Lock 1969:14), but sisal is grown in many parts of the world where the rainfall is less than 30 inches, as is the case in Yucatan. And in Yucatan, much of the annual 20-30 inches of rainfall quickly runs through the limestone surface deep underground and is unavailable to the plants.

Sisal plants are provided by nature with two means of reproduction, and both means are used by commercial growers, since field trials have shown no special advantage to either method (Lock 1969). When the plant is between 4 and 7 years old, it sends up a large flower-bearing stalk, or "pole" about 15-20 feet tall, after which the plant dies and the bulbils which form in the spent flower fall to the ground where they may take root. The bulbils may then be transplanted either to a plant nursery or to the field. One plant may have as many as 2500 bulbils (Kew Bulletin 1892:28). The plant can also reproduce by means of suckers which grow up around the base and which can then be transplanted. New plants are ready for harvesting in 2 to 5 years for A. sisalana and from 4 to 8 years for henequen, depending on conditions of rainfall, soil, and amount of care given. Under growing conditions in Brazil the sisal plants have a harvest life of five to seven years, but under scientific farming practices of the East African growers, replacement of plants is done every 2 to 3 years. About 4% of the leaf by weight is a long, lustrous, creamy white fiber (Lock 1969; Gross 1970). The separation of this fiber from the leaf is the most

arduous part of processing sisal.

As a botanical research station Kew tried to acquire complete and accurate information on the basic botany of all the agaves, of which there are many species and varieties other than those mentioned here, and whose identification had at that time been done only on a piecemeal basis. There was always the possibility that some other species might prove to have more commercial promise than those in use in Mexico. The reader has already been given more certain knowledge about sisal than Kew Gardens had in the 1890s, e.g., Kew then thought that both Mexican sisals were varieties of the same species rather than separate species. Because this botanical education was interwoven with the history of plant removals, it had best be told chronologically. Knowledge about sisal was gained, lost, regained. I will try to show not only what happened, but how knowledge was gained and distributed; who knew what, when, and how they knew it.

A Yucatan Hacienda

The Spanish colonists learned to cultivate the xaxqui or sacci from the Mayans they conquered. The pre-Columbian peoples of Central America were familiar with various uses of the agaves. The genus includes the aguey or century plant (A. americana) whose sap gives the fermented drink, pulque. The short fibers of agaves were pressed into paper and the long fibers woven into hammocks. The spiny tip of the leaf made a needle, which was threaded with the long fibers for coarse sewing (Baker 1970:9).

The hacienda system imposed by the Spanish endured after Mexican independence in 1821 and set the social and economic framework

for the Yucatan sisal industry in the early nineteenth century, when the United States began to be a steady customer for naval cordage after Spanish tariffs were lifted. We have a good description of this plantation system in the work of John L. Stephens, who with the artist Frederick Catherwood, made an extensive trip through Central America, Chiapas, and Yucatan in 1839-41. It is a valuable record of the social life of Central America during a time when revolution was challenging the old regime. Yucatan in 1840 was trying to establish a precarious independence from Mexico, but the political upheaval did not impede Stephens' journey from Mérida to Uxmal, where he studied the ruins. En route by horseback and "coche," a litter carried by Indians, the party stayed at haciendas owned by wealthy families in Mérida, who almost never visited the haciendas but left their operation to mestizo overseers. Each hacienda had its own stone-built reservoir, or water-tank, the only source of water for men and cattle in the dry months, and the means by which the Indians were tied to the haciendas. Once the whites had appropriated the water holes, either man-made or the natural limestone sinks called cenotes, independent village life was impossible.

The Indians are of two classes: vaqueros, or tenders of cattle and horses, who receive twelve dollars per year, with five almudes of maize per week; and labradores, or laborers, who are also called lunares, from their obligation, in consideration of their drinking the water of the hacienda, to work for the master without pay on lunes, or Monday. These last constitute the great body of the Indians. When they marry and have families, and of course need more water, in addition to their work on Mondays they are obliged to clear, sow, and gather twenty mecates of maize for the master, each mecate being twenty-four square yards. When the bell of the church is struck five times, every Indian is obliged to go forthwith to the hacienda,

and, for a real a day and a ration of three cents' worth of maize, do whatever work the master or his delegate, the major domo, may direct. The authority of the master or his delegate over them is absolute (1949:II,350-51).

Slavery had been abolished, but Stephens describes the system of debt peonage by which an Indian could change masters only if he could find one to assume his debt to the hacendado. In practice, such debts were not and could not be paid off.

Stephens does not describe the actual cultivation or harvesting of the sisal leaves, but he noted at one hacienda a shed "built by Don Simon since his return from the United States as a ropewalk for manufacturing hemp raised on the hacienda" (Ibid:342) and large carts "drawn by mules five abreast and loaded with hemp, bagging, wax, honey, and ox and deer skins" on their way to the ships at Sisal (Ibid:336).

Nelson Reed, in his Caste War of Yucatan (1964:8-12) confirms this account of the system of debt peonage that provided labor for the henequen plantations around Merida in the northwestern part of the state and for the sugar plantations in the better soil of the southern part of the state, and of the transformation of the common land and water rights into private property under the Republic with its new mercantile interests. These strains on the body politic, and many others, led to prolonged civil war--between Yucatan and Mexico, between Mérida and Campeche, and most seriously, between the Mayan Indians and the Ladinos in what is called the War of the Castes (1847-1855). The need for the revenue a cash crop would bring in led to the expansion of henequen plantations even during the war (Ibid:147). After the war, with the corn fields and sugar

plantations destroyed, and the market for cordage growing, henequen plantations were extended over the whole state, so that even corn had to be imported. Refugees, Mayan prisoners of war, and even rebel Yaqui Indians from Sonora were impressed into labor on the henequen plantations.

Most of these people, prisoner or free, quickly learned the debt system. Men were kept in barracks and marched to work by armed and mounted guards, encouraged by majordomos with whips, marched back, and locked in at night. The easygoing days of the past were gone. Whatever charm there had been to hacienda life was over. These places were vast agricultural factories with tens of thousands of acres under cultivation, run along scientific lines, geared for total output. One thousand henequen leaves, the harvest of a ten-hour day, were worth seventy-five centavos to the worker. A good majordomo was one who got the greatest production at the least expense (Ibid:233).

The narrow gauge portable rail running between the plants, which increased the traction power of the oxen or mules, the newly invented decorticating machine to separate the useable fiber from the waste pulp, and the wide gauge railroads to take the fiber to the ports were all financed by US banks through agents in Mérida who took 9% (Reed 1964:231). But there was profit enough for all; the hacendados retained ownership of their land and also built new town houses in Merida. From 1880 to 1900 Mérida, like Manaus on the Amazon, became an opulent city, having paved streets, streetcars, and electric lights even before Mexico City, and with much display of private wealth.

This then was the industry that attracted the attention of Kew Gardens. We may question Reed's opinion that it was run on scientific lines, at least as far as horticultural practices were concerned. The plant variety had not been improved, and the plants

were not regularly replaced, being allowed to produce for 40-50 years. The Kew Bulletin (1887:6) states that the pole was cut to prevent flowering and seed-setting, a practice which must have led to diminishing returns, and which reflects the lack of competition. But there can be no doubt of the prosperity of the industry. Here is what the Kew Bulletin disclosed in its major articles of 1892: at that time the Yucatan industry comprised 200 estates covering 105,000 acres and employing 12,000 Indian laborers. The cultivating, processing, baling, and marketing of the fiber cost 2 1/2 to 3¢ a pound and the market price was 5¢ a pound (1892:271-77). The total value of sisal hemp exported from Yucatan jumped from \$710,000 in 1875 to \$6,872,000 in 1889 (Ibid:25), a growth which reflects the expansion of wheat-growing on the plains of the United States Midwest and the increased use of the McCormick binder-reaper. Such a spectacular growth invited competition, and by publishing these details of the industry, Kew stimulated that competition and broke the Mexican monopoly, or perhaps it would be more accurate to say, the monopoly of Mexican growers and North American investors. Europe had been getting most of its binder twine from the Philippines while buying some henequen from Mexico. It wanted a source more directly under its control.

Plant Removals

We will now turn to the plant removals, of which there were several, but all abortive or nearly so, until Kew's catalytic articles (1887, #3; 1892, #62 and #71). The first plant removal took place under North American auspices. In 1827 President John Quincy

Adams sent a circular to American consular officers, asking them to procure useful plants which might be cultivated in the United States. Dr. Henry Perrine, who was consul in Campeche, Yucatan, from 1827 to 1833, sent many reports to the Treasury, State, and Navy Departments, especially on the fibers, which were of interest to a navy of sailing ships. He proposed to Congress that he be given a grant of land in South Florida on which he would establish a station for the introduction of tropical plants. In 1838 Congress finally granted him a township on Biscayne Bay, site of present-day Miami. But while waiting for this grant and for the Seminole Wars to be over, Perrine settled with his family on Indian Key (now called Lower Maticumbe) and started a plant nursery eventually containing over two hundred species and varieties of useful tropical plants, among them figs, mango, indigo, mulberry, tamerinds, and especially an agave from Yucatan which he named A. sisalana Perrine, and published in the Congressional Record in 1838.¹ Perrine never occupied his mainland grant, being killed in a Seminole raid on Indian Key in 1840. His

¹When a botanist identifies a new plant, or wants to correct a previous identification, he publishes a detailed description of the plant in Latin, following prescribed rules, and furnishes detailed drawings or a dried specimen. He is called the "author" of that identification, and his surname, often abbreviated as in HOOK for HOOKER, LEM for LEMAIRE, or MILL for MILLER (see page 236) is appended to the genus and species name he gives to the plant, as in the above example. Thereafter the first published name is followed in all botanical publications and on herbarium specimens, unless and until it is demonstrated that the author was incorrect in his designation. Sometimes whole genus names are changed, e.g., Spruce's first samples of rubber trees from the Amazon were called Siphonia brasiliensis or S. elastica. Later they were moved into the same genus as other Heveas, and called Hevea brasiliensis, etc.

family escaped but his records were lost. His plants grew wild, and spread to the mainland (Kew Bulletin 1892:25-26; Small 1921: 216-17).

In a biographical sketch of Perrine by John H. Barnhart (reprinted in Small 1921) Barnhart states that local officials in Yucatan were very much opposed to Perrine's removal of these plants, but he suggests that they finally gave permission because of Perrine's great personal popularity. He was "the most popular physician in Campeche" and gave his services free when a cholera epidemic struck the community. This explanation is at least possible; healing often evokes reciprocal gifts. John Stephens relates how their party gained good will in Mérida in 1841 when one of them, a physician, cured several citizens of strabismus, cutting the eye muscle of the patient while he lay on a couch in full view of the crowd, many of whom were demanding their turn (1963:I, 58-64).

Because conditions were not propitious for white settlers in south Florida for many years--the census for 1870 gives fewer than two persons per square mile, most of them in Key West--the United States government did not capitalize on Perrine's botanical introductions.¹ Perrine's sisal plants not only spread naturally but were often transplanted by the early settlers as ornamental or hedge plants, and they were the subject of a United States Department of Agriculture report in 1891. But a sisal industry never developed in

¹Much later, after 1910, a commercial mango industry was started in Florida from descendants of Perrine's plants. The mango (*Mangifera indica*) originated in India but was well established in the New World subtropics, including Mexico, in colonial times (Sokolov 1975:82).

Florida, although some effort was spent on A. decipiens, or false sisal, which gave an inferior fiber. The United States remained content to import henequen from Yucatan where labor was cheaper.

Bahama Hemp

After 1840 there were, then, two sources of sisal, one wild in Florida and the Keys and one in the protected industry in Mexico. Sisal plants from both these sources reached the Bahamas, where their origins were forgotten and the plant became known as "Bahama sisal" or pita. In the late 1880s an infant industry sprang up on the islands, Kew's interest was aroused in the genus Agave, and we have the space of articles in the Kew Bulletin which revealed the details of the Mexican industry and traced the history of the introduction of sisal to the islands. A brief account follows.

From south Florida and the Keys it is only a short distance to the Bahamas, which are part of the same limestone and coral outcrop. According to Perrine's daughter (Kew Bulletin 1892:30), some of her late father's plants were taken to the Bahamas about 1845 by the thirty-six family heads who had been brought over to settle his mainland grant but who were frightened off by the Seminoles and returned home. The same Kew Bulletin article brought to light an early introduction of sisal plants from Yucatan not cited in the secondary sources. It quotes a letter appearing in the Trinidad Agricultural Record written by a former governor general of the Bahamas who states that a Col. Nesbitt, former Colonial Secretary, "forty-five years ago, viz., in 1845 procured from Sisal, Yucatan, a few hundred plants of this Agave and had them set out at his country

residence three miles from Nassau" (Ibid. 30-31). Colonel Nesbitt also tested his plants for fiber, placed samples in the Nassau Museum, and sent specimens to commercial dealers in England in 1851.

Kew seems to have been unaware of these sources of sisal within the Empire until the 1880s when the local industry was called to its attention by the Governor, Sir Ambrose Shea, who was very enthusiastic about the possibilities of sisal for his islands. Once Kew's interest had been aroused, Kew requested British consular officials in Mexico to send specimens. The record shows the mistakes, confusions, and failures which attended the eventual acquisition of knowledge about Mexican sisal.

Through the kind offices of the late Mr. Augustus Baker, Her Majesty's Consul at Vera Cruz, a large plant with a tall stem and flowering panicle was received at Kew in May 1890. The plant was dead on arrival, but it has since been prepared as a museum specimen, and is now deposited in Museum II. . . . In addition to the large plant received from Yucatan there was received two lots of small plants. . . . A set (of the first lot) has been retained at Kew, and the plants will be determined later. The others were all distributed to the Botanical Gardens at Singapore and to the Botanical Stations at Fiji and Antigua. The second lot of small plants from Yucatan arrived at Kew on December 16, 1890. On arrival there were 30 dead and 11 alive. The latter were, however, so small and sickly that, weakened by the cold to which they were exposed, it was impossible to save them. This attempt to introduce a representative collection of Agaves from Yucatan, in spite of considerable sum paid for expenses, was singularly unfortunate (Kew Bulletin 1892:22-23).

Working with such plants as he had, Mr. J.G. Baker, Assistant Keeper of the Herbarium and Library, concluded that the common sisal plant in Yucatan was the thorny-edged variety, since the accounts of the industry stated that an Indian woman customarily went along behind the sisal cutter, taking off the thorny edge of the leaves. Baker named that plant A. rigida elongata Baker, and published it in the Kew

Bulletin of 1892. Baker had already published the smooth-edged variety in 1889 as A. rigida sisalana Baker. What Baker and Kew did not realize for some time was that these were not two varieties of the same species, as these scientific names indicate, but were separate species, which had already been published as A. fourcroydes Lemaire in 1864, probably from specimens of agave grown as ornamentals on the Riviera, and A. sisalana Perrine in 1838, respectively.

Kew's taxonomic error and the subsequent corrections are still recorded on the data sheets of all herbaria which have sisal specimens. But in the practical field, Kew's information on the two different plants was very important. Kew established that the sisal already on the Bahamas and in Florida, all of it of the smooth-leaved type, gave a fiber which was at least equal in quality to the Mexican henequen and much easier to handle and process. Both Perrine and Nesbitt had removed this less common but superior type of agave, whether by design or forethought is not known. From now on our account will concern only the dissemination of the thornless A. sisalana, since the world sisal industry which developed after 1892 used only this plant, and left the spiny henequen to Mexico, the only supplier today of what is considered to be a slightly coarser and inferior fiber to common sisal.

Although the Bahama industry did not last long and is now defunct, it is worth a brief consideration because it illustrates the relations between the Colonial Office and Kew, sitting at the center in London, and a colonial backwater. In the late nineteenth century the British West Indies were in the doldrums, with the sugar

industry in decline and underemployment of the former plantation labor force a social and economic problem. Tourism was not yet on the horizon. Only the hardest travellers on urgent business braved the tropical heat, discomfort, and diseases of the Caribbean. The Bahamas especially seized sisal as the answer to their problems, and in 1889 the Bahama legislature took steps to ensure its own monopoly. Writing to the Kew Bulletin (1892:141-43) Sir Ambrose Shea extolled the new industry and said: "In a spirit of self-defense, the Legislature has extended for five years an Act now three years in existence, which prohibits the export of fiber plants from the colony. This must affect the competition." Actually the competition, i.e., the other British West Indies, had taken the initiative by ordering plants from Florida. According to that same round-up article of 1892 in the Kew Bulletin, the curators of the Botanical Stations of St. Lucia and St. Vincent had bought 5,000 and 2,000 sisal plants from Florida, respectively, and had planted them out in nursery beds. And the Annual Report of the Superintendant of the Royal Botanic Gardens, Trinidad, for the year 1891, reprinted in part in the same Kew Bulletin article, gives the name of the supplier: "During the year we obtained from Messrs. Reasoner Bros. of Manatee, Florida, 10,000 bulbils of this plant (Agave rigida, var. sisalana), and 2,000 from another source" (1892:34).

Kew continued to publish directions on cultivation and processing of sisal for the benefit of the Bahama planters. The Colonial Office kept a watch on sisal development and used Kew as an information center, as shown by a request from the Colonial Office,

reprinted in the Kew Bulletin (1894:189-90), for Kew to send a description of the decorticating machine mentioned in Sir Ambrose Shea's letter to the botanical station in Fiji. Kew obliged by printing in the Bulletin descriptions of several machines of American manufacture, some of which could clean as many as 50,000 leaves a day, as well as descriptions of simpler machines requiring more human labor. In connection with the primitive raspador in use in Yucatan, which it had pictured in its article, the Kew Bulletin remarks, "The conditions existing in Yucatan, where clumsy and wasteful machines have hitherto been adopted with apparent success, are of a peculiar character. Labour there is so cheap that cultivators can afford to carry on the industry under circumstances entirely unsuited to other parts of the world" (1892:38). But the following excerpt from Sir Ambrose Shea's letter shows why sisal was attractive to a colonial governor whose subjects expected better wages than the Yucatan Indians, who had fought and lost their war for independence:

One of the many attractions of this remarkable industry is the fact that strikes are all but impossible, for they will have no plausible basis. The crop may remain unharvested for months without injury, and the good sense of the people may be safely relied on to recognize this fact, and also to make them feel, as they do now, that men of means coming to the colony to engage in its fortunes are its benefactors, and this is being brought home to them by the improvements in their condition arising from the operations in which capitalists are already engaged (Kew Bulletin 1892:142-43).

In sum, in 1892 it looked as if the British West Indies, and perhaps India, Fiji, Mauritius and other parts of the Empire would soon have a sisal export industry, and that Kew had fulfilled the functions laid down in its charter:

A national garden ought to be the centre round which all minor establishments of the same nature should be arranged, receiving their supplies and aiding the Mother Country in everything that is useful in the vegetable kingdom. Medicine, commerce, agriculture, horticulture, and many valuable branches of manufacture would benefit from the adoption of such a system.

Kew had gathered information on sisal, evaluated that information, disseminated it in the Bulletin, which in its first five years of life had published all that could be learned about sisal. Yet the chief effect of this extensive publication was to spur the creation of a sisal industry in the colony of a competing world power, the German Empire. In discussing this new industry, I will again give particular attention to the dissemination of information, as well as the transfer of plants. My research leads me to believe that the Kew Bulletin article of 1892 was even more crucial in the transfer of sisal to German East Africa than Kew itself realized or was willing to admit in print.

In 1908 the Kew Bulletin published a short factual account on sisal production in German East Africa; in 1934 when Tanganyika was safely British, the Bulletin published a short piece "The Early Introduction of Sisal in East Africa" in which it merely says that "a German businessman" bought plants in Florida (1934:137). The fuller facts are these, following Lock (1969) and a pamphlet issued by Barclay's Bank on sisal and other hard fibers (1963, cited in Gross 1970).

The "German businessman" was Dr. R. Hindorf, an agronomist employed by the German East Africa Company (Deutsch Ostafrikanische Gesellschaft). Since 1885 when Germany had acquired a protectorate,

as a result of the Berlin Conference, in the area now called Tanzania which had been penetrated by German traders, the Company had been largely responsible for the development of the colony. When Dr. Hindorf read in the Kew Bulletin of 1892 the articles on the sisal industry in the Bahamas, he decided that sisal might be a suitable crop for the dry coastal plains around Tanga. He sent to Mexico for bulbils, but Mexico would not export them. Hindorf, however, had noted in the Kew Bulletin the reference to Perrine's plants brought to Florida in 1836. Accordingly, say Lock and Barclay's Bank, Hindorf arranged for a shipment of 1,000 bulbils from Florida to Hamburg. The two hundred which survived were transshipped to German East Africa, and of those the sixty-two which arrived in good condition were planted in the Company's nurseries in 1893 and became the parents of an East African industry which has grown to be the largest sisal supplier in the world.

We are left to wonder how Hindorf found his plant supplier in Florida. Since Lock states (1969:2) that Hindorf bought his plants from Reasoner Bros. in Florida, I think it is an inescapable conclusion that Hindorf had found the name and address of this supplier in the Kew Bulletin (1892:34), where it appeared, as we have mentioned, as the source of the Trinidad Botanic Garden's bulbils. Kew had furnished all the necessary information.

By 1898 Hindorf's 62 bulbils had multiplied to 63,000 in the Company's Kikogwe nurseries and a plantation was laid out. The following year decorticating machinery was introduced, and by 1908 the company had machines capable of processing over 100,000 leaves a

day and over one million sisal plants growing (Kew Bulletin 1908: 300). Lock says that Hindorf received another shipment of bulbils from Florida in 1900 and that the only other introduction of sisal plant material was made by the Westdeutsche Handels and Plantagen Gesellschaft, later the Amboni Estates Ltd., in 1906 "when they imported one thousand bulbils direct from Mexico through the medium of Kew Gardens; these turned out to be the same species as those originating in Florida" (1969:2). This is astonishing if true, and would seem to be an error. It is highly-unlikely that Kew could have procured 1000 sisalana bulbs from Mexico in 1906. On this point it is better to follow Kew's own account (1934:137) in which the managing director of the plantation in question states that he personally purchased 5,000 bulbils from a company named "Horticulture Coloniale" in Brussels, and that the bulbils were probably from Florida.

Under the German East Africa Company the sisal plantations flourished; sisal spread into the interior along the railroad lines, and sisal gradually replaced Ceara rubber, one of the dry-adapted rubber species (see page 224), which had been the major economic crop of the colony (H. and R. Wolf 1936:165; Lock 1969:3).

In 1903 the Department of Agriculture of Kenya first obtained some sisal bulbils from the German East Africa Company, and a small consignment from the West Indies. In 1907 the Department made a much larger purchase from German East Africa--160,000 bulbils. And that year two brothers privately bought 375,000 bulbils from German East Africa (Lock 1969:4). Thereafter the German government

imposed a prohibitive duty on sisal plant material, but the Kenya industry was well started by that time. And of course, after World War I Britain inherited all its sisal plantations, under a mandate from the League of Nations. The colony was renamed Tanganyika.

Thus by 1920 Britain had a sisal industry in East Africa which could challenge the "pernicious monopoly" over Mexican-henequen exercised at the turn of the century by the New York market. In export products like sisal and coffee the white planters of the highlands validated the "new imperialism" launched in the 1880s by which Britain sought to retain its leading position in the world market against the threats of industrial competition from other developed nations. In 1895 Lord Salisbury, the British Foreign Secretary, had declared to the members of Parliament in a speech on British intentions in East Africa: "In a few years it will be our people that will be masters, it will be our commerce that will prevail, it will be our capital that will rule. . . ." And it had come to pass. Entering the area originally under the guise of suppressing the Arab slave trade, a strategy successful earlier in the Persian Gulf, and another instance where British popular morality and British commercial interests went hand in hand, once political power had been wrested from the sultan, the colonial administrators set about determining what crops to plant where. A long campaign of land alienation, hut taxes, poll taxes, anti-vagrancy laws, and a pass system for native laborers had by the 1920s generated an adequate labor force of dispossessed tribesmen for the white planters (Wolff 1974). Through the Department of Agriculture the colonial administration gave expert

advice to the white planters, and graded their crops for export to the London market. This technical help was not available to native farmers.

The sisal industry continued to grow; East Africa in the 1960s was producing 38% of the world's hard fibers (Gross 1970:133).

Since the German introduction of the industry at the turn of the century, the sisal industry in East Africa has always used the most up-to-date scientific methods of propagation in the nurseries, cultivation in the fields, cutting, decorticating and cleaning the fiber. Modern machinery is used; worn-out fields are bulldozed and the plants replaced. The Sisal Growers' Association employs a research director. Although highly rationalized, the estates have been kept to a medium size, between 1200 and 2000 hectares, in contrast to the vast estates on Java before 1941, where batteries of decorticators turned out sisal fiber (Lock 1969:5). The Javanese industry was virtually abandoned during World War II and has not been revived in the post-colonial era.

Sisal in Brazil

The East African industry can also be contrasted with the Brazilian small farm or peasant production. Brazil is now the world's largest sisal producer after Tanzania. Though some of Brazil's sisal is plantation grown, the peasant production is of greater interest since all the other sisal sources so far discussed have been plantation systems.¹

¹In 1936 Mexico's haciendas were divided up into ejidos, lands held in common by peasant villagers, but the rasping mills

Florida was the probable source of Brazil's initial sisal bulbils, brought there by an American firm in 1903 (Gross 1970). The industry was slow to grow, but after 1924 when the coffee pest and the "sugar mosaic" were damaging those crops in Paraiba, some plantation owners substituted sisal. And in Bahia and other north-eastern states with large areas of sertao (land subject to severe cyclical drought), sisal often replaced cattle-raising and small-farming, especially when World War II cut off supplies of manila hemp from the Philippines and demand soared in the United States. In Bahia sisal bulbils were distributed by the state experimental farm, and after a lapse of four years for the plants to mature, Brazilian sisal entered the export market in 1946. Demand and prices have not kept steady. Brazilian sisal that sold for \$600 a metric ton in 1951 sold for \$170 in 1969. But once the sisal was planted, it could be eradicated only with the greatest difficulty. The Brazilian small farmer who switched to sisal had no bulldozers at his disposal, and he was virtually locked into sisal production. Having given up subsistence farming, he was dependent for food and all the requirements of living on a cash economy in which he could influence neither output nor price. To process his fiber he was dependent on access to a portable decorticating machine which was usually owned by a large landowner or by a local middleman who had sources of credit, through contacts with town-based entrepreneurs, were first left to the hacendados, then seized by the government, and returned to the former owners in 1942. In 1955 the ejidos gained local control of the processing plants, but the ejidos have had a constant struggle against government corruption and the machinations of the former owners (Reed 1964:265-69; Labrecque 1975). In addition, the market for henequen was dominated by U.S. giants like International Harvester, a part of the Morgan Trust.

which were beyond the peasant's reach. Often the machine crews refused to harvest small crops. Many farmers turned to the only alternative, becoming permanent field workers. "In this way, sisal created its own labor force" (Gross 1971:51).

The peasant who had to sell his raw labor on the decorticating machines received wages which would not feed his family. To maintain his own energy expenditure for this strenuous work, and by Gross' measurements the residue man lifts and carries 1225 kilograms (2700 pounds) an hour (Gross 1971:52), the laborer had to have a caloric input in the range of 3650 calories a day. A disproportionate amount of the meager household budget went to sustain the breadwinner in his job, and his dependents suffered from malnutrition. Nutritional studies in one sisal-growing area of Bahia undertaken by Gross and Underwood (1971) show that the generation of children growing up after the switch to sisal is shorter in stature and lighter in weight than the previous generation, and the children of sisal workers lag behind the children of shopkeepers and motor-workers in average body weight for age, and fall below national and international standards. Gross estimates that in 1966 there were 50,000 people working on decorticating machines in northeastern Baazil and 300,000 people dependent on them for a living (1971:727). Many of these dependents are unwittingly but systematically subject to caloric deprivation.

Gross' work on sisal in Brazil has exposed the mirage of development through cash cropping when subsistence requirements are ignored and former subsistence farmers are thrown into both a labor

market and a food market in a proto-industrial system. The GNP may grow, but the figures often hide an increasing misery and physical deterioration of the population.

Summary

If we distinguish between henequen and sisal, a distinction valid both botanically and commercially, we may consider sisal to be a new industry dating in effect to the Kew Garden articles of 1892, which accomplished two things: they clarified the difference between henequen and sisal, showing the commercial advantages of the latter, and they drew sisal to the attention of the German East Africa Company, an organization endowed with the capital and the agricultural expertise to make the most of Kew's information. The Bulletin had not only described the Mexican industry, its botanical base, its technology, its labor structure, its price structure, but Kew had also printed the name and address of a plant supplier in Florida, outside the Mexican monopoly. Because there was an alternate source of plant material in Florida, sisal did not become a British colonial monopoly, nor did it become a quasi-monopoly that the British had to share with the Dutch, as in the case of cinchona and rubber. The early and continued success of the German plantations had a demonstration effect. In all the various colonies in East Africa from Uganda to Mozambique, Africans were drawn from their farming or their herding to work on sisal plantations, and were thrown into the labor and commodity market much as the Brazilian peasants were. On Java and Sumatra, sisal was added to the list of plantation crops in which British, American, and Dutch capital was invested.

Sisal prices, like those of other primary products, have been kept low through economic and political pressure exerted by the metropolitan core, and have not reflected the true costs of production in human energy. Consumers of cereals and meat in the developed countries have benefitted from the underpaid labor of East Africans, Mexican Indians, Indonesian and Brazilian peasants. This extraction of energy from the colonial areas of the world and its transfer to the metropolitan account has also been one of the sources of the capital accumulation necessary to underwrite the budgets of such great scientific institutions as the Royal Botanic Gardens, Kew.

Chapter X

Kew and Empire: Conclusions

Some Architectural Symbols

To call the Crystal Palace of 1851 the concrete symbol of mid-Victorian England would be a solecism, since it was made of glass and iron ribs. But in its use of this new material, cast-iron, also being used to build steamships, railroads, railroad bridges, railroad stations, and in its purpose, which was to house the Great Exhibition of new industrial goods to which visitors came from all over Europe, the Crystal Palace expressed the spirit of the age, with its emphasis on science, technology, industrial production and expanding trade. This great building, 1608 feet long with 300,000 glass panes and 5000 iron ribs, like a giant greenhouse, had been designed by a gardener, Joseph Paxton (later Sir Joseph). Paxton was head gardener and estate-manager to the Duke of Devonshire, who maintained a palatial mansion, Chatsworth, and a great park with formal landscaping in a beautiful unspoiled enclave in Derbyshire in the heart of the industrial Midlands.

Paxton's career is the most outstanding example of the upward mobility of the new professional and entrepreneurial class that I have come across, perhaps because he combined professional and business activities, highly unusual in itself. He attended a local grammar school and was apprenticed at the age of fifteen to the gardening staff of the Duke of Devonshire. Ten years later he was a

member of the Royal Horticultural Society, and a few years later a Fellow of the Linnean Society, signal marks of honor for a young gardener of no class background. As head gardener and manager of the Duke's estates, he constructed a fountain with the second highest water jet in Europe, and two large conservatories, in one of which, at Sir William Hooker's request, he successfully grew the great Amazonian water-lily, Victoria regia, whose first flowering in England, after Kew's failures with the exotic plant, was an event exciting great curiosity (King 1976:112). Paxton's experience in building glass houses for flowers led him to submit plans for the Crystal Palace and his success with that building led to a knighthood. It is hard for us, jaded with World's Fairs, to feel the excitement that the Great Exhibition caused. Lewis Mumford has called it "England's cockcrow of triumph" (1934:154), celebrating free trade, free enterprise, and free access to the world's markets. The Crystal Palace was immediately copied for an industrial exhibition in New York. The building stood in what is now Bryant Park. Sir John Summerson, eminent art critic, has called Paxton's Crystal Palace "a structure not designed by an architect and unstigmatized by style, the only Victorian building that was a complete and absolute success. In due course it was upended, rocketed skywards, and called the Seagram building" (1971:117).

Sir Joseph Paxton went on to become a successful business man, both in his field of horticulture, where he also published a botanical journal, and in the rapidly expanding field of the railroads—he was a railway tycoon. He organized the Army Work Corps

in the Crimean War, and was elected to Parliament in 1854, where he served until his death. However remarkable his personal gifts, however "modern" his career, it also had a lingering touch of the eighteenth century in that his patron, the Duke of Devonshire, was such a great magnate that one of his servants, but not one of a lesser man's, could rise out of the servant class to knighthood, a seat in Parliament, power, wealth, fame, and respectability.

Paxton's Crystal Palace, housing an industrial exposition but modeled on a hothouse, plaything of a Duke, is also symbolic of the convergence of interests of the old landowners and the rising industrial class in Britain. A case in point is that same Duke's investments in railroads and real estate, e.g., his development of Eastbourne, at the end of a railroad line, as a popular summer resort complete with hotels and flowered esplanades. For every landed aristocrat who was actively investing in urban or industrial real estate, there were many more who passively lived off such new revenues from their lands made valuable by the extension of industry and urban settlement, and were thus motivated to vote for free trade. This convergence of interests helped to make England different from France and the lesser continental powers, to give her a head start in the export of manufactured goods, and to consolidate her lead as a world power. Under Bismarck, Prussia was to copy in a conscious way this English economic alliance between landowners and industrialists (Henderson 1975).

What is not so well known is that there was another forerunner to the Crystal Palace--the great Palm House at Kew Gardens,

a glass and iron-ribbed building constructed in 1844-48 by Sir William Hooker on plans drawn by Decimus Burton, who had helped Paxton with the Chatsworth conservatory. The Palm House was one of the many projects undertaken by Hooker in the first years of his directorship, as he reorganized the Royal Gardens. Since the early voyages of discovery, trees of the palm family had had great interest for British botanists, but they could not be grown without protection from the elements. The Palm House had an elevation of 100 feet in its central section, to allow palms, bamboos, bananas, and other large tropical trees to flourish. I am using the Palm House at Kew as a symbol, like the Crystal Palace in the industrial sphere, of the importance of Kew Gardens to Britain in its relations with the non-European world, the tropical world, the world of the colonies, a necessary complement to the home island as a source of wealth and raw materials. Kew was a place where all sorts of tropical plants could be grown, studied, and disbursed to the colonial stations, a center of plant transfers on the scientific level, and of the generation and publication of knowledge about plants. This essay has been an attempt to describe, analyze, and assess the Royal Botanic Gardens in this light.

We have seen that the botanic garden network had three roots: the oldest and deepest being the alliance of botany and medicine, with a Greco-Roman heritage and a revival in the hortus medicus of Renaissance universities. The first garden at Kew, started by George III's mother, had been a garden of herbs. The medicinal herbal strain in botany became submerged but never died out, as our cinchona example

shows, or the careers of many botanists like Sir David Prain, who went from the Indian Army Medical Corps to the Calcutta Botanic Gardens and on to Kew as director.

Next came the interest in pure science fostered from the late seventeenth century on by the learned societies, which constituted "a series of interrelated information networks," in Hunter Dupree's phrase. These prestigious voluntary associations drew together in social discourse certain powerful nobles, the few professional botanists, numbers of the rising middle class plus wealthy amateurs like Sir Joseph Banks, privy counsellor to the king, president of the Royal Society, founder of the Linnean Society, patron of botanists and explorers, who catalyzed the whole scene in the years when he was unofficial director of the royal gardens at Kew.

Most important of all for the future botanic network were the voyages of exploration and territorial acquisition dating from the post-Columbian expansion of the West and continuing through the nineteenth century. To get at the spices of the East, the coffee and the tea, to capture the trade and break the monopolies--whether held by Arab traders, native princes, Portuguese, Spanish, or Dutch trading companies--was a consuming passion of English merchants and trading companies for centuries. The British East India Company's interest in useful plants led it to establish botanic stations and to maintain a department at its headquarters in London devoted to tropical plants under Forbes Royle, who recommended both the tea and the cinchona transfers. In mid-nineteenth century the government assumed to itself all the territorial gains made by the trading companies in India, Ceylon, Penang, etc., and the botanic stations

there and at the transit points, e.g., the Cape of Good Hope, became part of the national botanic network.¹

Just as private and governmental enterprise cannot be rigidly separated in colonial expansion, neither can pure and applied science be separated on the voyages of exploration and in Kew's later activities. Captain Cook and Sir Joseph Banks, using a combination of Royal Society money and private money (Banks'), explored, botanized, bringing back 17,000 plant specimens, observed the transit of Venus, visited the Society Islands which Cook named after the Royal Society, and acquired Australia for the Crown, all in one voyage. Captain Bligh, commissioned by the government to bring breadfruit from Tahiti as food for slaves in the West Indies, also brought the "noble canes"

¹The one big exception was Java, captured for the British East India Company from the French in 1811 by Sir Stamford Raffles. If the government had not returned Java to Holland at the Congress of Vienna in 1815, in pursuit of a strong Holland to help keep the balance of power on the continent, Britain would have had the richest island in the East. Java's sugar, spices, tobacco, coffee, tea, cinchona, and rubber might have all been British, instead of constituting its chief commercial competition in these tropical plantation crops. But perhaps such riches would have been too much to swallow and digest. And British/Dutch competition was stimulating, as we saw in the case of rubber and cinchona, when their botanists and planters borrowed ideas from each other. Java did turn out to be more suited to high-yielding quinine cinchonas than India or Ceylon. It is hard to say what might have happened if Dutch cinchona had not undercut the British planters, i.e., if Javanese cinchona had been British too. One actual result was that in World War I, because of Dutch neutrality, the Germans had access to large Dutch stocks of cinchona stored in Amsterdam, whereas otherwise they would have had no way of acquiring quinine for their armies. Except for this, we can treat post-Napoleonic Dutch/British colonialism as symbiotic, with the Dutch sheltering under British arms. The view that competition in the colonial arena was a stimulus to development is consistent with Wallerstein's analysis of the emergence of European capitalism in a competitive multi-state economic system, as contrasted with the older world empires (1974a, 1974b, and see Frederick Lane's review of Wallerstein, 1976:519),

which were to improve the sugar yield so significantly, and he also brought over ninety other plants to Kew to add to its study collections, as is shown by the Kew Records Book of 1793 (King 1976:14).

Joseph Hooker collected hundreds of plants in the Himalayas, most of them new to Western botanists, while he was surveying boundaries for the East India Company in Bengal. Charles Darwin benefitted not only from his own observations on the voyage of the government ship, Beagle, but from the observations of all the other naturalists who had shipped on these mixed purpose voyages, which enabled him to have a mass of facts about the natural world on which to base his theories. I have dwelt on these exploratory voyages of the eighteenth and nineteenth centuries to which naturalists were attached, of which there were many more than have been mentioned here, because they constitute an almost unrecognized government subsidy to natural science, as important as any more formal government subsidy to science in our own time, both for its contribution to Darwin's theories and through the economically useful plants discovered, studied, and transferred.

These naturalist-explorers also evolved into "Kew collectors" once Kew was established as a government botanical center, and a mission like Captain Bligh's to get breadfruit or Robert Fortune's to collect tea plants in China was a model for Kew's rubber and cinchona seed transfers, and the many other plant transfers Kew directed, the mahogany, cork oak, papyrus, ipecac, varieties of coffee, tobacco, bananas, etc., which were moved into British colonies or from one colony to others.

Kew brought two new factors to the previous ad hoc plant transfers: centralized direction of the information flow, and professional development of the plants to be disbursed. The satellite gardens in the colonies provided the system with multiple centers of research, a point I consider important. The selection of Hevea as the most promising rubber source, out of many species, the new methods of cultivating, tapping, and semi-processing Hevea rubber, were developed not only at Kew, or in Ceylon, or in Singapore, or in other places since forgotten, but through the efforts of men in all these places. The size of the botanical network, coupled with the flexibility and informality of its operation, allowed duplication of research effort, which was an asset, as our own experience in multi-centered scientific research in the United States confirms.

Knowledge flowed from center to periphery along this network, from periphery back to center where it could be redistributed, and from satellite to satellite through personal contact. This knowledge was stored for later retrieval in the libraries and herbaria, principally at Kew but also in the larger colonial botanic gardens like Calcutta. It was transmitted, in increasingly formalized fashion as the century unfolded, through the human resources of the botanists trained at Kew, by the many botanical journals, more than can be supported in today's economy and, after 1887, by the Kew Bulletin, official organ of the Royal Garden network. Our sisal chapter shows how the institutionalization of information disbursement made knowledge easily available to international rivals, to the immediate detriment of the British West Indies' sisal industry,

although Britain's cumulative strength enabled her to recoup this particular loss by winning back the German East African colony and its sisal industry at the Versailles Treaty. With the colonial scramble over, with the increasing internationalization of knowledge, and with synthetic substitutes for some plant products, it is hard to imagine the critical role played by Kew in information dispersal in the past.

At very little cost to Britain, Kew had searched for economically useful plants, most often in South America, had improved them, and transferred them to Asia, thus participating in extending the plantation system to Asia. Kew also introduced some plantations to Africa and tried unsuccessfully to shore up the plantations of the West Indies with new crops to replace sugar, but the Asian plantations were most significant in Kew's part in empire-building. In mid-nineteenth century Kew stepped in to help the empire make use of the displaced peasants thrown onto the labor market by the plunder of Asia, especially the immiseration of India's commerce, industry, and agriculture. For the next hundred years, England extracted human energy from Asia in the form of plantation labor which tended the introduced plants. By diverting some of India's excess labor to Ceylon and Malaya, the plantations served as a safety valve against peasant unrest as well as a source of profit and strategic raw materials. One of those raw materials, cinchona bark for quinine, affected social relations between Europeans and the colonized peoples by allowing more Europeans to survive in the tropical colonies as army officers, bureaucrats, plantation managers, and missionaries, and by allowing them to bring their families with them, increasing both

social distance and racial snobbery. Quinine also was vital to Europe in wartime, as was rubber.

Thus the activities of Kew were in some measure related to the conditions of human labor in much of the tropical world. We have seen that these conditions could vary, depending on many variables, but above all, on the constraint or lack of constraint imposed by the state on capitalistic excesses, and the degree to which inflowing capital allowed, or more commonly removed, alternative employment opportunities or sources of food from the laborers.

At one extreme, we have found small groups who lived in environments that Europeans wanted to protect for their own enjoyment, e.g., the Nilgiri Hills of South India, and who could be useful to Europeans as food producers, so that they had this alternative or supplement to family income. But even there, much of the plantation labor was imported from the plains and was coerced by poverty and lack of alternatives.

Another favored group were the Malay, Chinese, and Javanese smallholders producing rubber in Malaya and Sumatra. Here the heavy demand for rubber and the lack of pressure on land led the colonial governments to adopt a policy of development that was partially extended to subject peoples.

However, the bulk of labor on tropical cash crops was debt-coerced. On the great new plantations of Asia Tamils, Canarese, Malays, Chinese, Javanese and others worked the rubber, tea, coffee, cinchona. The Asian workers were often indentured and thus working away from their home communities, living in barracks, tied to the

plantations by debt and by the lack of alternative employment. Only a few escaped into labor-bossing, shopkeeping, or into the cities.

East African sisal workers can be placed in this general category, leaving their home communities to seek white man's wages in order to pay white government head taxes. The tea and coffee plantations in the East African highlands also recruited their labor in this way.

Through debt coercion backed by penal laws and the whole force of the administrative machinery, the North Atlantic powers created a disciplined labor force for the newly developed plant products in their Asian and African colonies.

None of these examples matched the depredations of the wild rubber industry of the Amazon basin where a scarcity of labor, the isolation of the tappers, and weak government supervision led to debt coercion in its most extreme forms, often backed by armed guards. The worst abuses were committed against the Indians, by the private armies of rubber barons who were so powerful in the provincial capitals of Iquitos and Manaus that their genocide of upriver Indian tribes was easily hidden. In the frontier districts, terrorism was used to corral a scarce and unwilling labor force, just as Leopold of Belgium used terrorism in the Congo basin, to satisfy a strong new raw material demand and the greed of unregulated capitalism.

Having had the foresight to remove rubber plants to their Asian possessions, the British could afford to play the role of international policemen and expose these labor brutalities. In their Asian possessions both capital and labor could be manipulated without

the inconvenience of dealing with a third party, i.e., the independent states of Latin America. As the plant transfers of rubber and cinchona show, when the British had the opportunity, as with plants and animals,¹ both moveable as mineral resources are not, they chose formal empire over informal empire as a source of raw materials. Britain could then concentrate its investments in Latin America in those domains where her financial, managerial, and technical skills were most advanced, e.g., finance banking, insurance, shipping, railways, industrial machinery.

Kew's role was much more than smuggling seeds. Through its scientific development of the plants transferred, Kew converted knowledge to profit and power, for the Empire and for the industrial world system of which Britain was then the leader. Kew gave wholehearted support to its mission, and shared the nation's spirit of crusading imperialism, as is shown by the words of one of its curators, who wrote a history of Kew at the peak of imperial expansion.

In the industrial development of British colonies and possessions, the Kew man has always been among the earliest workers. As soon as the pax Britannica has been established, and often before, he appears. He founds botanic stations where useful plants are grown for distribution, and he gives demonstrations of the best methods of

¹During the unrest of the Napoleonic era, both Britain and the United States had been able to obtain from Spain the very valuable merino sheep. The merino breed became the predominant wool-bearer in the dominions of South Africa, Australia, New Zealand, and in Argentina, often called the Sixth Dominion in the nineteenth century. By mid-twentieth century, Australia came to have a monopoly on ever-perfected merino breeds. I wonder if the British woolen industry did not find it increasingly rewarding to deal with a development-minded Australia rather than the dependence elite and the compradores of Argentina, and if the channeling of scientific research funds did not favor Australia over Argentina, and play a part in the diverging prosperity and stability of the two nations.

cultivating them. He fostered the tea industry in India and Ceylon; he also started the cultivation of cinchona there; he helped largely in the regeneration of the West Indian Islands, and at the present time Africa is dotted over with stations he is managing, each one a nucleus of what will probably develop into the most important industries of the continent. Often he suffers the fate common to pioneers: he sows that others may reap. Many a Kew man has laid down his life in the conscientious performance of his duty, as genuine a sacrifice to the cause of empire and humanity as any soldier or missionary has ever made (Bean 1908:68).

Conversely, Kew received the whole-hearted support of the political and commercial establishment, cognizant of the services it was receiving from the botanical gardens. Kew even enjoyed an independence of action unusual for an institution totally financed by the government. This can be attributed to the general prestige accorded science in the Victorian era, but more specifically to the personal networks of Kew directors. In spite of the adventure of world travel and exploration, their life styles at home, and their class values, were properly conservative. But through personal, family, and intellectual friendships they allied themselves with the great scientific innovators of the times, especially with Charles Darwin. And the Darwinians won the battle of minds. Hooker helped Darwin in gestating, publishing, and defending the Origin of Species and Darwin helped Hooker in his contretemps with the scientific bureaucracy, appealing straight to the Prime Minister.

Such a small circle could not have comparable power in a democratic society today, though influential cliques exist in science as in other domains. Nor could one family keep the directorship of a major scientific institution for sixty-five years, as the

Hookers did at Kew. Even in Britain, and much more in the United States, the scientific establishment is just too numerous. In 1975 9000 scientists served as government advisors under the umbrella of the National Academy of Sciences and 22,700 other individuals served as consultants on government advisory panels (Chronicle of Higher Education, 20 September 1976). Out of such numbers diversity must surface and controversy be aired publicly, so that policy may be made by an informed public.

These numbers give some indication of the ever increasing importance of science and technology in the post-industrial world. It is suggested by Paul Goldstone (1977) that science as a potential countervailing force to the corporate business structure is the dominant political reality of the late twentieth century. It is not simply the organized technical knowledge based on systematic research that is vital to the modern corporation, but scientific decisions of a higher order of complexity. Such power carries responsibility.

Science has never operated in a social vacuum, but it has not always had full social awareness or a consciousness of its role and power. Our examples from the nineteenth century show an unquestioning acceptance of the basic tenets of Victorian philosophy, especially as regards imperialism. In the United States from the start of World War II to the late sixties debate over Vietnam, American science served the government and a corporate structure intent on extending American political, military, and economic hegemony in a Pax Americana, successor to the pre-1914 Pax Britannica. In some cases, grantism, careerism, and patriotism--or at least an unreflective

support of government policy--overrode independent judgment and ethical considerations. In the social sciences, and with special reference to anthropology, this led to involvements, damaging to the profession and to international trust and good will, in such secret enterprises as Project Camelot, a study financed and organized by the Office of Research and Development, US Army, although a contract with the Special Operations Research Office of the American University, Washington, D.C. served as a cover (Horowitz 1967). The mission of Project Camelot was to develop a social systems model which would enable the Army "to predict and influence politically significant aspects of social change in the developing nations of the world. . . . [and] to devise procedures for assessing the potential for internal war within national societies" (from a document released December 4, 1964 by SORO, American University and quoted in Horowitz, 1967:47). The first target for Project Camelot was Latin America, where social scientists working for the US Army were to identify and analyze social unrest so that its expression could be forestalled and contained by counterinsurgency. The exposé of Project Camelot and of similar secret research in the Himalayas (Berreman 1969) and in Thailand (Wolf and Jorgensen 1970) raised important ethical and policy issues to professional and public scrutiny.

Salutary lessons were learned from these incidents. Among social scientists, there is now a greater concern for the protection and anonymity of informants and closer cooperation with institutions and colleagues in the host countries; among all scientists there is a harder look at the possible hidden biases of agency-directed

research. Today there is a more explicit recognition on the part of the scientific community and the public of the impact of science on social policy, especially in the fields of atomic energy, industrial pollutants, and biomedicine. Questions are being asked and thrashed out in public. The public looks to science to resolve the energy crisis by coming up with alternate forms of energy to supplement fossil fuels, but it does not give carte blanche. Substantial segments of the public and of the scientific community, e.g., the Union of Concerned Scientists, have challenged government assertions as to the safety of existing atomic energy plants and modes of disposition of atomic wastes. In biomedicine, science is policing itself. In 1974 at the Asomilar International Conference of Molecular Biologists on Recombinant DNA Molecules, a majority of the biologists convened publicly asked their colleagues to postpone further experiments in gene transplantation on animal viruses, especially tumor viruses, until special laboratories with containment facilities could be built to ensure against the escape into the environment of genetically altered bacteria. Research on recombinant DNA, with all its promises and its hazards, is now subject to NIH safety guidelines, but is still being fiercely debated in the scientific community and by the public (Bennett and Gurin 1977). The new technology of genetic engineering may revolutionize biology, but the work will not go forward without careful evaluation of its dangers.

In a less controversial field, the botanic gardens, including Kew Gardens, are concerning themselves with the conservation of species, the preservation of the environment, and the ecology of the

biosphere. In all these research areas, the public detects its self interest.

But the role of science in converting knowledge into power for the core nations of the industrial world system is not as widely recognized, and its implications are resisted. In the post-colonial era this system continues to drain money, talent, and energy from the undeveloped countries in the form of information monopolies, patents, licenses, fees and other rents on technology, gross inequalities between buyer and seller in the tropical commodities markets, and underpaid labor. Resource exploitation of the third world continues. Robert Merton's theory of cumulative advantage, which he calls the "Matthew effect" after the passage in the Book of Matthew which runs roughly "to him who has shall be given and from him who has not shall be taken away," applies in the larger eco-political sphere as well as in the reward system of social and scientific institutions (Merton 1973:447-459). Citibank, a global institution with headquarters in New York, has 5% of its assets invested in Brazil but draws 13% of its profits from Brazil (New York Post, 13 April 1977). Meanwhile, Brazil spends an estimated 2 billion dollars a year, all told, to buy foreign technology (Veja, 13 April 1977), and sees its resources developed according to the needs of foreign corporations and the dictates of foreign markets. "We have not had a real transfer of technology, but only the purchase of instructions, projects, and equipment tending to perpetuate a state of dependency" says the Brazilian physicist Dr. Cerqueira Leite, coordinator of a government sponsored research institute which plans to develop and market a home-

grown technology suited to Brazil's needs.

Most developing countries are not in a position to generate their own scientific technology or to take a bargaining position in the face of the information monopolies held by the technically advanced countries. If the Third World is to achieve real development instead of modernization, if it is to alter its relationship to the power centers instead of becoming a more profitable area for them to exploit, or so desperately frustrated as to furnish an occasion for another world war, further questions must be asked about the role of scientific technology in the world power system. It is my hope that this historical study of a period only a century ago, when Britain was marshalling all its institutions and scientific expertise toward the imperial goal, and British botanical science energetically furthered British expropriation of the world's plant resources, will add to the modern perspective on the social and political implications of scientific research.

Appendix

List of the Staffs of the Royal Gardens, Kew, and of
Botanical Departments and Establishments at Home,
and in India, and the Colonies, in
Correspondence with Kew.¹

Royal Gardens, Kew

Director	W. T. Thiselton Dyer, C.M.G., F.R.S., F.L.S.
Assistant Director	D. Morris, M.A., F.L.S.
Clerks	John Bliss and F.W.P. French
Keeper of Herbarium and Library	Prof. Oliver, F.R.S.
Principal Assistant	J.G. Baker, F.R.S.
Mycologist	Dr. M.C. Cooke, M.A., F.L.S.
Assistant for India	W.B. Hemsley, A.L.S.
Assistant	N.E. Brown, A.L.S.
Assistant	R.A. Rolfe, A.L.S.
Assistant	C.H. Wright
Attendant	J.T. Jeffrey
Curator of Museums	John R. Jackson, A.L.S.
Office Assistant	J.M. Hillier
Preparateur	G. Badderley
Curator of the Gardens	George Nicholson, A.L.S.
Assistant Curator (Tropical Department)	William Watson
Foremen:	
Arboretum	William Truclove
Herbaceous Department	Daniel Dewar
Greenhouse and Ornamental Department	F. Garrett
Temperate House (Sub- tropical Department)	W. Bean

Bangalore - Government Botanic Gardens, Lal Bagh:
Superintendent Mr. John Cameron, F.L.S.

Barbados - Dod's Reformatory, Botanical Station:
Superintendent Mr. J. R. Boylill

¹Source: Kew Bulletin 1889: 122-126.

Bombay - Horticultural Gardens and Parks:

Oodeypore	
Superintendent	Mr. T. H. Storey
Poona (Ghorpuri)	
Superintendent	Mr. W. Shearer
Lecturer on Botany, College of Science.	Mr. E. M. Woodrow
Bombay - Municipal Garden	
Superintendent	Mr. G. Sarstensen

British Guiana - Botanic Gardens:

Georgetown	
Superintendent and Govern- ment Botanist	Mr. G.S. Jenman, F.L.S.
Head Gardener	Mr. J. Waby
Second Gardener	Mr. R. Ward
Berbice	
Keeper	Mr. Richard Hunt

Calcutta - Royal Botanic Gardens Department:

Superintendent	Dr. George King, LL.D., F.R.S., F.L.S.
Seebpore	
Curator of Herbarium	Dr. David Prain, F.L.S., F.R.S.E.
Curator of Garden	Mr. W. McHardy
Assistant	Mr. R. L. Proudlock
Mungpoo	
Superintendent, Government Cinchona Plantations	Dr. George King, LL.D., F.R.S., F.L.S.
Resident Manager	Mr. J. A. Gammie
1st Assistant	Mr. R. Pantling
2nd Assistant	Mr. J. Parkes
3rd Assistant	Mr. G. Gammie
Darjeeling	
Curator, Lloyd Botanic Garden	Mr. W. A. Kennedy
<u>Cambridge</u> - University Botanic Gardens:	
Professor	Charles C. Babington, F.R.S., F.L.S.
Secretary to Botanic Garden Syndicate	Dr. Francis Darwin, F.R.S., F.L.S.
Curator	Mr. R. Irwin Lynch, A.L.S.

CanadaOttawa

Dominion Botanist

Prof. John Macoun, F.R.S.C., F.L.S.

Director of Government Experimental Farms

Prof. Wm. Saunders, F.R.S.C., F.L.S.

Montreal

Director, Botanic Garden

Prof. Penhallow, B.Sc.

Cape Colony - Gardens and Public Parks:Cape Town

Director

Prof. MacOwan, F.L.S.

Head Gardener

Mr. H.J. Chalwin

Grahamstown

Curator

Mr. Edwin Tidmarsh

Port Elizabeth (St. George's Park)

Superintendent

Vacant

King Williamstown

Curator

Mr. T.G. Sim

Graaf Reinet

Curator

Mr. J. C. Smith

Mitenhage

Curator

Mr. H. Fairey

Caylon - Royal Botanical Gardens Department:

Director

Dr. H. Trimen, F.R.S., F.L.S.

Peradeniya

Head Gardener

Mr. P.D.G. Clark

Clerk and Foreman

Mr. J.A. Ferdinandus

Draughtsman

Mr. W. de Alwis

Hakgala

Superintendent

Mr. W. Nock

Clerk and Foreman

Mr. H. M. Alwis

Henaratgoda

Conductor

Mr. A. de Zoysa, Muhandiram

Anuradhapura

Conductor

Mr. T. de Silva, Arachchi

Radulla

Conductor

Mr. D. Guneratne

Dominica - Botanical Station:

Curator (temporary)	Mr. J. Hartley

Dublin - Glasnevin Botanic Gardens:

Scientific Superintendent	Dr. McNab, F.L.S.
Curator	F.W. Moor, Cor. Mem. R.H.S.

Trinity College Botanic Gardens

Professor	Dr. E. Perceval Wright, F.L.S., Sec. R.I.A.
Curator	Mr. F. W. Burbidge, F.L.S.

Edinburgh - University Botanic Garden

Professor	Dr. Isaac Bayley Balfour, F.R.S., F.L.S.
Curator	Mr. Robert Lindsay, F.R.H.S.

Fiji - Botanic Station:

H.E. Sir John B. Thurston, K.C.M.G.

Glasgow - University Botanic Gardens:

Professor	Dr. F.O. Bower, F.L.S.
Curator	Robert Bullen, Cor. Mem., R.H.S.

Gold Coast - Botanic Station:

Curator	

Grenada - Botanical Garden:

Curator	Mr. Wm. Elliott

Hong Kong - Botanical and Afforestation Department

Superintendent	Mr. Charles Ford, F.L.S.
Assistant Superintendent	Mr. A. Westland

Jamaica - Public Gardens and Plantations Department:

Director	Mr. William Fawcett, B.Sc., F.L.S.

Hope Gardens

Superintendent	Mr. W. Harris

Castleton Garden

Superintendent	Mr. W. Cradwick

Cinchona (Hill) Garden

Superintendent	Vacant

Kingston Parade Garden Superintendent	Mr. W. Campbell
King's House Garden Superintendent	Mr. E. Campbell
Bath Overseer	Mr. W. Groves
<u>Lagos</u> - Botanical Station: Superintendent	Mr. James McNair
<u>Madras</u> - Botanical Department:	
Ootacamund Government Botanist and Di- rector of the Government Cinchona Plantations Curator	Mr. M.A. Lawson, M.S., F.L.S. Mr. A. Jamieson
Madras - Agri Horticultural Society:	
Secretary	Sir Chas. Lawson
Superintendent	Mr. F. M. Gleeson
<u>Malta</u> - Botanical Garden: Director	Dr. Gulia
Mauritius - Department of Forests and Botanical Gardens:	
Pamplemousses Director Assistant	Mr. John Horne, F.L.S. Mr. Wm. Scott
Curepipe Overseer	--
<u>Natal</u> - Botanic Gardens:	
Durban Curator	Mr. John Medley Wood, A.L.S.
Pietermaritzburg Curator	Mr. R. W. Adlam
<u>New South Wales</u> - Botanic Gardens:	
Sydney Director	Mr. Charles Moore, F.L.S.

New Zealand

Wellington - Colonial Botanic Garden:

Director	Sir James Hector, K.C.M.G., F.R.S.

Auckland

Curator, Domain Garden	Mr. Wm. Goldie

Niger Territories - Botanical Garden:

Asaba

Head Gardener	Mr. Geo. Woodruff

Northern India - Botanical Department

Saharunpur

Director	Mr. J. F. Duthie, B.A., F.L.S.
Superintendent of Garden	Mr. W. Gollan

Lucknow

Superintendent	Mr. M. Ridley

Cawnpore

Assistant Director in charge of Experimental Station	Sayyed Mahammad Husain

Oxford - University Botanic Garden:

Professor	Dr. Sydney H. Vines, F.R.S., F.L.S.
Curator	Mr. William Baker

Queensland - Botanic Gardens:

Brisbane

Colonial Botanist	Mr. F. M. Bailey, F.L.S.
Head Gardener	—
Overseer	Mr. J. Cameron

Acclimatization Society's Gardens

Secretary and Manager	Mr. Wm. Soutter.

Rockhampton

Superintendent	Mr. J. S. Edgar

St. Lucia - Botanical Station:

Curator	Mr. John Gray

South Australia - Botanic Gardens:

Adelaide	
Director	Dr. Schomburgk, Ph.D.
Port Darwin	
Curator	Mr. Maurice Holtze

Straits Settlements - Gardens and Forest Department:

Singapore	
Director	Mr. H. N. Ridley, M.A., F.L.S.
Head Gardener	Mr. Walter Fox
Penang	
Assistant Superintendent	Mr. C. Curtis
Malacca	
Assistant Superintendent	Mr. R. Derry

Tasmania - Botanical Gardens:

Hobart Town	
Superintendent	Mr. F. Abbott

Trinidad - Royal Botanical Gardens:

Superintendent	Mr. John H. Hart, F.L.S.
Assistant	Mr. W. E. Broadway

Victoria

Government Botanist	Baron Sir F. von Mueller, F.R.S., K.C.M.G.
Melbourne - Botanical Gardens	
Director	Mr. W. R. Guilfoyle, F.L.S.

Bibliography

- Adams, Robert Mc.
 1974 Anthropological Perspectives in Ancient Trade. *Current Anthropology* 15:239-258.
- Allen, G.C. and Audrey Donnithorne
 1962 *Western Enterprise in Indonesia and Malaya*. London: Allen and Unwin.
- Allison, A.C. and B.S. Blumberg
 1965 *Polymorphism in Man*. Boston: Little-Brown.
- Anderson, Frank
 1975 Flawless Eye, Faultless Hand: The Botanical Artistry of Walter Hood Fitch. *Garden Journal* 25:98-103.
- Angel, Lawrence
 1966 Porotic Hyperstosis, Anemias, Malaras, and Marshes in the Prehistoric Eastern Mediterranean. *Science* 153:760-763.
- Appleman, Philip (ed.)
 1970 *Darwin*. New York: Norton.
- Ayensu, Edward S.
 1974 Beautiful Gardens in the Biosphere. *Natural History* 83:837-845.
- Baikie, Robert
 1857 *The Neilgherries, including an account of their topography, climate, soil, and production; and of the effects of the climate on the European constitution*. Madras.
- Baker, H.G.
 1970 *Plants and Civilization*. Belmont, California: Wadsworth.
- Beales, Derek
 1969 *From Castlereagh to Gladstone: 1815-1885*. New York: Norton.
- Bean, William J.
 1908 *The Royal Botanic Gardens, Kew: Historical and Descriptive*. London: Cassell.
- Bennett, William and Joel Gurin
 1977 Science that Frightens Scientists: The Great Debate over DNA. *Atlantic Monthly* 239:43-62.

- Berreman, Gerald D.
 1969 Academic Colonialism: Not So Innocent Abroad. The Nation, November 10. (Reprinted in To See Ourselves: Anthropology and Modern Social Issues. Thomas Weaver, Ed. Glenview, Ill.: Scott, Foresman, 1973, pp. 152-156.)
- Bidie, George
 1897 Cinchona Cultivation in India. In Miscellaneous Government Reports, Cinchona 1890-7. pp. 28-47.
- Biswas, J. (ed.)
 1961 Cinchona Cultivation in India--Its Past, Present, and Future. Journal of the Asiatic Society 3,2:63-80.
- Bohannon, Paul
 1964 Africa and Africans. Garden City: Natural History Press.
- Bower, Faubion
 1913 Sir Joseph Dalton Hooker. In Makers of British Botany. F. W. Oliver (ed.) London: Cassell.
- Boxer, C.R.
 1969 Four Centuries of Portuguese Expansion: 1415-1825. Chicago: University of Chicago Press.
- Braudel, Fernand
 1972 The Mediterranean and the Mediterranean World in the Age of Philip II, Vol. I. New York: Harper and Row.
- Brecks, James Wilkinson
 1873 An Account of the Primitive Tribes and Monuments of the Nilagiris. Great Britain: India Office.
- Britan, Gerald and Bette S. Denich
 1976 Environment and Choice in Rapid Social Change. American Ethnologist 3,1:55-72.
- Burn, W.L.
 The Age of Equipoise: A Study of the Mid-Victorian Generation. New York: Norton.
- Cady, John F.
 1964 Southeast Asia: Its Historical Development. New York: McGraw-Hill.
- Cameron, H.C.
 1952 Sir Joseph Banks, K.B., P.R.S.: The Autocrat of the Philosophers. London: The Batchworth Press.

- Chagnon, N.
 1968 Yanomamo: The Fierce People. New York: Holt, Rinehart & Winston.
- Cipolla, Carlo M.
 1965 Guns and Sails in the Early Phase of European Expansion. London: Collins.
- 1976 Before the Industrial Revolution: European Society and Economy, 1000-1700. New York: Norton.
- Collier, Richard
 1968 The River that God Forgot: The Dramatic Story of the the Rise and Fall of the Despotical Amazon Rubber Barons. New York: Dutton.
- Crane, Diana
 1972 Invisible Colleges: Diffusion of Knowledge in Scientific Communities. Chicago: University of Chicago Press.
- Cronquist, Arthur
 1968 The Evolution and Classification of Flowering Plants. Boston: Houghton-Mifflin.
- Crosby, Alfred W., Jr.
 1972 The Columbian Exchange: Biological and Cultural Consequences of 1492. Westport, Conn.: Greenwood Press.
- Curtin, Philip D.
 1961 The White Man's Grave: Image and Reality, 1780-1850. Journal of British Studies, University of London Institute of Commonwealth Studies #14,1:95-110.
- 1964 Image of Africa. Madison: University of Wisconsin.
- 1968 Epidemiology and the Slave Trade. Political Science Quarterly 83,2:190-216.
- Darwin, Charles
 1845 The Voyage of the "Beagle." Reprinted 1968. London: Heron Books.
- Davidson, Basil
 1961 The African Slave Trade: Pre-Colonial History 1450-1850. Boston: Little-Brown.
- De Beer, Gavin
 1965 Charles Darwin: A Scientific Biography. Garden City: Natural History Press.
- Deerr, Noel
 1949 History of Sugar. 2 vols. London: Chapman and Hall.

- Dock, George
1931 Medical Use of Cinchona. In Proceedings of the 300th Anniversary of the Use of Cinchona. St. Louis, Mo.
- Dumont, René
1965 Lands Alive. New York: Merlin
- Dunn, Frederick
1965 On the Antiquity of Malaria in the Western Hemisphere. Human Biology 37:383-393.
- Dunn, Richard S.
1973 Sugar and Slaves: The Rise of the Planter Class in the English West Indies, 1624-1713. New York: Norton.
- Duran-Reynals, Marie-L.
1946 The Fever-Bark Tree: The Pageant of Quinine. Garden City: Doubleday.
- Dutt, Romesh C.
1950 The Economic History of India. London: Routledge and Kegan Paul.
- Fairbank, John K., Edwin O. Reischauer, and A.M. Craig
1973 East Asia: Tradition and Transformation. Boston: Houghton-Mifflin.
- Fay, Peter Ward
1975 The Opium War, 1840-42. Chapel Hill: University of North Carolina.
- Firth, Raymond
1951 Elements of Social Organization. London: Watts.
- Flannery, Kent
1969 The Ecology of Early Food Production in Mesopotamia. In Environment and Cultural Behavior. A.P. Vayda (ed.) Garden City: Natural History Press, pp. 283-307.
- Fosberg, F.R.
1945 Principal Economic Plants of South America. In Plants and Plant Science in Latin America. Frans Verdoon (ed.) Waltham, Mass.: Chronica Botanica.
1946 Gifts of the Americas: Quinine. Agriculture in the Americas 6:91.
- Frank, André Gunder
1969 Latin America: Underdevelopment or Revolution. New York and London: Monthly Review Press.

- Gage, A.T.
 1938 History of the Linnean Society of London. London: Linnean Society.
- Gager, C. Stuart
 1938 Botanic Gardens of the World. Brooklyn Botanic Garden Record 27:151-406.
- Gay, Peter
 1966 The Enlightenment: An Interpretation. New York: Knopf.
 1969 The Enlightenment. volume 2.
- Geertz, Clifford
 1970 Agricultural Involution: The Processes of Ecological Change in Indonesia. Berkeley: Univ. of California.
- Giles, Eugene
 1962 Favisim, Sex-Linkage, and the Indo-European Kinship System. Southwestern Journal of Anthropology 18:286-290.
- Goldstene, Paul N.
 1977 The Collapse of Liberal Empire: Science and Revolution in the Twentieth Century. New Haven: Yale University.
- Goodrich, L. Carrington
 1969 A Short History of the Chinese People. New York: Harper.
- Gould, Stephen Jay
 1976 Darwin and the Captain. Natural History 85:32-34.
- Graham, Richard
 1968 Britain and the Onset of Modernization in Brazil, 1850-1914. Cambridge: Cambridge University Press.
 1969 Sepoys and Imperialist Techniques of British Power Nineteenth Century Brazil. Inter-American Economic Affairs 23:23-37.
- Griffin, Keith
 1969 Underdevelopment in Spanish America. Cambridge, Mass.: MIT Press.
 1974 The International Transmission of Inequality. World Development 2:3-15.
- Grigg, D.B.
 1974 The Agricultural Systems of the World: An Evolutionary Approach. London: Cambridge University Press.

- Grigg, Henry B.
1880 A Manual of the Nilagiri District in the Madras Presidency.
Madras: Government Press.
- Gross, Daniel R.
1970 Sisal and Social Structure in Northeastern Brazil. Ph.D.
Dissertation, Columbia University, New York.

1971 The Great Sisal Scheme. Natural History 88:48-55.
- Gross, Daniel R. and Barbara Underwood
1971 Technological Change and Caloric Costs: Sisal Agriculture
in Northeastern Brazil. American Anthropologist 73:725-
740.
- Guttsman, W.L.
1963 The British Political Elite. London: MacGibbon and Kee.
- Hamilton, Henry
1948 England: A History of the Homeland. New York: Norton.
- Hardenburg, W.E.
1912 The Putumayo, The Devil's Paradise. London: T.F. Unwin.
- Harris, Marvin
1972 Portugal's Contribution to the Underdevelopment of Africa
and Brazil. In Protest and Resistance in Angola and
Brazil. R. Chilcote (ed.) Berkeley: University of
California Press.

1975 Culture, People, Nature. New York: Thomas Y. Crowell.
- Heiser, Charles B., Jr.
1973 Seed to Civilization: The Story of Man's Food. San Fran-
cisco: Freeman.
- Henderson, W.O.
1975 The Rise of German Industrial Power, 1834-1914. Berkeley:
University of California Press.
- Ho, Ping-ti
1955 The Introduction of American Food Plants into China.
American Anthropologist 57:191-201.

1959 Studies on the Population of China, 1368-1953. Cambridge,
Mass.: Harvard University Press.
- Hobsbawm, Eric J.
1968 Industry and Empire: An Economic History of Britain since
1750. London: Weidenfeld and Nicholson.

- Hooker, Joseph Dalton
 1902 A Sketch of the Life and Labours of Sir William Jackson Hooker. *Annals of Botany* 16:9-220.
- Hooker, William Dawson
 1839 Inaugural Dissertation upon the Cinchonas, their history, uses, and effects. Glasgow: Glasgow University Press.
- Horowitz, Irving L.
 1967 The Rise and Fall of Project Camelot: Studies in the Relationship between Social Science and Practical Politics. Cambridge, Mass.: MIT Press.
- Hopkins, A.G.
 An Economic History of West Africa. London: Longmans.
- Hutchins, Francis G.
 1967 The Illusion of Permanence: British Imperialism in India. Princeton: Princeton University Press.
- Huxley, Leonard
 1901 The Life and Letters of Thomas Henry Huxley. New York: D. Appleton.
 1918 The Life and Letters of Sir Joseph Dalton Hooker. New York: D. Appleton.
- Instituto do Açúcar e do Alcool.
 1972 Brasil/Açúcar. Recife, Brazil.
- Irwin, Howard S.
 1974 Energy and Living Systems. *New York Botanical Newsletter* 9,4:1.
- Jain, Ravindra K.
 1970 South Indians on the Plantation Frontier in Malaya. New Haven: Yale University Press.
- Jennings, Francis
 1976 The Invasion of America: Indians, Colonialism, and the Cant of Conquest. New York: Norton.
- Kew Bulletin of Miscellaneous Information
 1887 Fibre Plants 3:1-8.
 1889 Bahamas Hemp 27:57-59.
 1889 List of the Staffs of the Royal Gardens 29:122-126.
 1891 Historical Account of Kew Gardens to 1841 60:279-327.
 1892 Sisal Hemp 62:21-40; 65:141-143; 71:272-277.

- 1894 Sisal Hemp 90:189-190.
- 1906 Para Rubber. Additional Series 7:241-242.
- 1908 Sisal Hemp 7:300-302.
- 1931 The Introduction of Cinchona to India 3:113-117.
- 1934 Early Introduction of Sisal to East Africa 3:137.
- 1941 Centenary of the Royal Botanic Garden 3:201-209.
- Kew, A Guide to the Royal Botanic Gardens.
1970 London: Her Majesty's Stationery Office.
- King, Ronald
1976 The World of Kew. London: Macmillan.
- Klein, Richard
1976 The 'Fever Bark' Tree. Natural History 85:10-19.
- Kumar, Dharma
1965 Land and Caste in South India. Cambridge: Cambridge University Press.
- Labrecque, Marie F.
1975 Production et Agriculture dans la Région Nordest du Yucatan. Master's Thesis, Université Laval, Quebec.
- Lane, Frederick C.
1973 Venice: A Maritime Republic. Baltimore: Johns Hopkins.
- 1976 Economic Growth in Wallerstein's Social Systems. Comparative Studies in Society and History 18:517-532.
- Langer, William
1975 American Foods and Europe's Population Growth, 1750-1850. Journal of Social History, Winter:51-66.
- Lathrap, Donald
1970 The Upper Amazon. New York: Praeger.
- Levenson, Joseph
1967 European Expansion and the Counter-Example of Asia. New York: Prentice-Hall.
- Linton, Ralph
1964 The Study of Man. New York: Appleton-Century-Croft.
- Lipp, Frank J.
1976 A Heritage Destroyed: The Lost Gardens of Ancient Mexico. Garden Journal 26:184-188.

- Ludowyk, E.F.C.
1967 A Short History of Ceylon. New York: Praeger.
- Markham, Clements R.
1862 Travels in Peru and India while Superintending the Collection of Chinchona Plants and Seeds in South America, and their Introduction into India. London: John Murray.
- 1880 Peruvian Park: A Popular Account of the Introduction of Chinchona Cultivation into British India. London: John Murray.
- Marshall, William E.
1873 A Phrenologist among the Todas. London: Longmans, Green.
- Masefield, G.B.
1967 Crops and Livestock. In The Economy of Expanding Europe in the Sixteenth and Seventeenth Centuries, E.E. Rich and C.H. Wilson (eds.) Cambridge: Cambridge University Press.
- McKeown, Thomas
1976 The Modern Rise of Population. New York: Academic Press.
- McLeod, Roy
1974 The Ayrton Incident: A Commentary on the Relations of Science and Government in England, 1870-73. In Science and Values, A Thackray and E. Mendelsohn (eds.). New York: Humanities Press.
- McNeill, William
1974 The Shape of European History. New York: Oxford.
- 1976 Plagues and Peoples. Garden City: Doubleday.
- Merton, Robert
1973 The Sociology of Science. Chicago: University of Chicago Press.
- Mintz, Sidney W.
1960 Worker in the Cane: A Puerto-Rican Life History. New Haven: Yale.
- 1974a The Caribbean Region. Daedalus 102:45-71.
- 1974b Caribbean Transformations. Chicago: Aldine.
- Miscellaneous Government Reports, Cinchona, Madras, 1860-97.
Madras: Higginbottom.
- Moon, Penderel
1944 Strangers in India. London: Faber and Faber.

- Moreland, W.H.
1962 India at the Death of Akbar. Delhi: Atma Ram & Sons.
- Moreland, W.H. and A.T. Chatterjee
1957 A Short History of India. New York: McKay.
- Moore, Barrington, Jr.
1966 Social Origins of Dictatorship and Democracy. Boston: Beacon Press.
- Mukherjee, Ramkrishna
1974 The Rise and Fall of the East India Company. New York: Monthly Review Press.
- Mumford, Lewis
1934 Technics and Civilization. New York: Harcourt, Brace.
- Murphy, Robert
1960 Headhunters' Heritage: Social and Economic Change among the Mundurucu Indians. Berkeley: University of California Press.
- Murphy, Yolanda and Robert Murphy
1970 Women of the Forest. New York: Columbia University Press.
- Newby, Howard
1975 The Deferential Dialectic. Comparative Studies in Society and History 17:139-164.
- O'Brien, Patricia J.
1972 The Sweet Potato: Its Origin and Distribution. American Anthropologist 74:342-365.
- Oliver, F.W.
1913 Makers of British Botany. Cambridge: Cambridge University Press.
- Owen, John B.
1976 The Eighteenth Century, 1714-1815. New York: Norton.
- Palmer, Robert R.
1950. History of the Modern World. New York: Knopf.
- Parliamentary Blue Book, Cinchona, Madras, 1852-63; 1860-97.
- Parry, J.H.
1974 The Discovery of the Sea. New York: Dial.
- Porter, Arthur
1963 Creoleedom: A Study of the Development of Freetown Society. London: Oxford University Press.

- Reed, Nelson
 1964 *The Caste War of Yucatan*. Stanford: Stanford University Press.
- Reynolds, Robert
 1961 *Europe Emerges: Transition toward an Industrial World-Wide Society, 600-1750*. Madison: University of Wisconsin Press.
- Ribeiro, Darcy
 1967 *Indigenous Cultures and Languages of Brazil*. In *Indians of Brazil in the Twentieth Century*. ICR Studies #2, Institute of Cross-Cultural Research, 79-165.
- Rice, C. Duncan.
 1975 *The Rise and Fall of Black Slavery*. New York: Harper & Row.
- Rich, E.E. and C.H. Wilson (eds.)
 1967 *The Economy of Expanding Europe in the Sixteenth and Seventeenth Centuries*. Vol. IV, *The Cambridge Economic History of Europe*. Cambridge: Cambridge University Press.
- Rivers, W.H.R.
 1906 *The Todas*. London: Macmillan.
- Royle, J. Forbes
 1834 *On the Cultivation of Tea in the Northern Provinces of India*. London: J.L. Cox & Son.
- Sauer, Carl O.
 1941 *Settlement of the Humid East*. USDA Yearbook.
 1969 *Conditions of Pioneer Life in the Upper Illinois Valley (1916)*. Reprinted in *Land and Life*. Berkeley: University of California Press.
- Schoenermarck, Heinzdeiter von
 1974 *Nathaniel Bagshaw Ward: How a Sphinx Moth Altered the Ecology of the Earth*. *Garden Journal* 24:148-154.
- Schwarz, Walter
 1968 *Nigeria*. New York: Praeger.
- Seng, Philip Loh Fook
 1969 *The Malay States, 1877-95*. New York: Oxford.
- Small, John K.
 1921 *Historic Trails, by Land and Water*. *Journal of the New York Botanical Garden* 22:193-222.

Sokolov, Raymond

1975 Potatoes are Cheaper. . . . Natural History 84:78-81.

1977 Strange Fruits. Natural History 86:84-87.

Spruce, Richard

1908 Notes of a Botanist on the Amazon and Andes, edited and condensed by Alfred Russel Wallace. London: Macmillan.

Ruse, Michael

1976 Review of Darwin on Man: A Psychological Study of Scientific Creativity, by Howard Gruber. Journal of Interdisciplinary History 7:351-354.

Stebbing, E.P.

1924 The Forests of India. London: The Bodley Head.

Stephens, John L.

1949 Incidents of Travel in Central America, Chiapas, and Yucatan. 2 vols. New Brunswick: Rutgers University Press. First published 1841.

1963 Incidents of Travel in Yucatan. 2 vols. New York: Dover. First published 1843.

Steward, Julian H. (ed.)

1948 The Tropical Forest Tribes. In Handbook of South American Indians. BAE 143. Washington, D.C.: Smithsonian Institution. Volume 3.

Summerson, John

1971 Victorian Architecture in England. New York: Norton.

Thackray, Arnold

1974 Natural Knowledge in Cultural Context: the Manchester Model. American Historical Review 79:672-709.

Thiselton-Dyer, W.T.

1891 Historical Account of Kew to 1841. Kew Bulletin 60: 279-327.

Thompson, Edward and G.T. Garrett

1966 Rise and Fulfillment of British Rule in India. Allahabad: Central Book Depot.

Thurston, Edgar

1909 Castes and Tribes of South India. Vol. 1 and Vol. 4. Madras: Government Press.

Tinker, Hugh

1974 A New System of Slavery: The Export of Indian Labour Overseas, 1830-1920. London: Oxford University Press.

- Turberville, A. S.
 1957 *English Men and Manners in the Eighteenth Century*. New York: Oxford.
- Turrill, W.B.
 1959 *The Royal Botanic Gardens at Kew: Past and Present*. London: Herbert Jenkins.
- Vayda, Andrew P. and Roy Rappaport
 1968 *Ecology, Cultural and Non-Cultural*. In *Introduction to Cultural Anthropology*. J. Clifton (ed.). Boston: Houghton-Mifflin.
- Wallerstein, Immanuel
 1947a *The Modern World System: Capitalistic Agriculture and the Origins of the European World Economy in the Sixteenth Century*. New York: Academic Press.
 1947b *The Rise and Future Demise of the World Capitalist System: Concepts for Comparative Analysis*. *Comparative Studies in Society and History* 16:387-415.
- Weisenfeld, Stephen L.
 1967 *Sickle-Cell Trait in Human Biological and Cultural Evolution*. *Science* 157:1134-1140.
- Whiffen, Thomas
 1915 *The North-West Amazon: Notes of Some Months Spent Among Cannibal Tribes*. London: Constable.
- Wickham, Henry
 1872 *Rough Notes of a Journey through the Wilderness from Trinidad to Para, Brazil*. London: W.H.J. Carter.
 1908 *On the Plantation, Cultivation, and Curing of Para Indian Rubber*. London: Kegan Paul.
- Wilkie, Mary E.
 1977 *Colonials, Marginals, and Immigrants: Contributions to a Theory of Ethnic Stratification*. *Comparative Studies in Society and History* 19:67-95.
- Wilson, Ernest
 1929 *China, Mother of Gardens*. Boston: The Stratford Co.
- Winks, Robin W.
 1976 *On Decolonization and Informal Empire*. *American Historical Review* 81:540-556.
- Wolf, Eric and Joseph G. Jorgensen
 1970 *Anthropology on the Warpath in Thailand*. New York: *Review of Books*, November 19, pp. 26-35.

Wolf, Howard and Ralph Wolf

1936 Rubber, A Story of Glory and Greed. New York: Covici Friede.

Wolff, Richard D.

1974 The Economics of Colonialism: Britain and Kenya, 1870-1930. New Haven: Yale University Press.

Young, G.M.

1964 Victorian England: Portrait of an Age. New York: Oxford.

Zeitlin, Irving

1972 Capitalism and Imperialism. Chicago: Markham.

Ziman, John

1976 The Force of Knowledge: The Scientific Dimension of Society. Cambridge: Cambridge University Press.