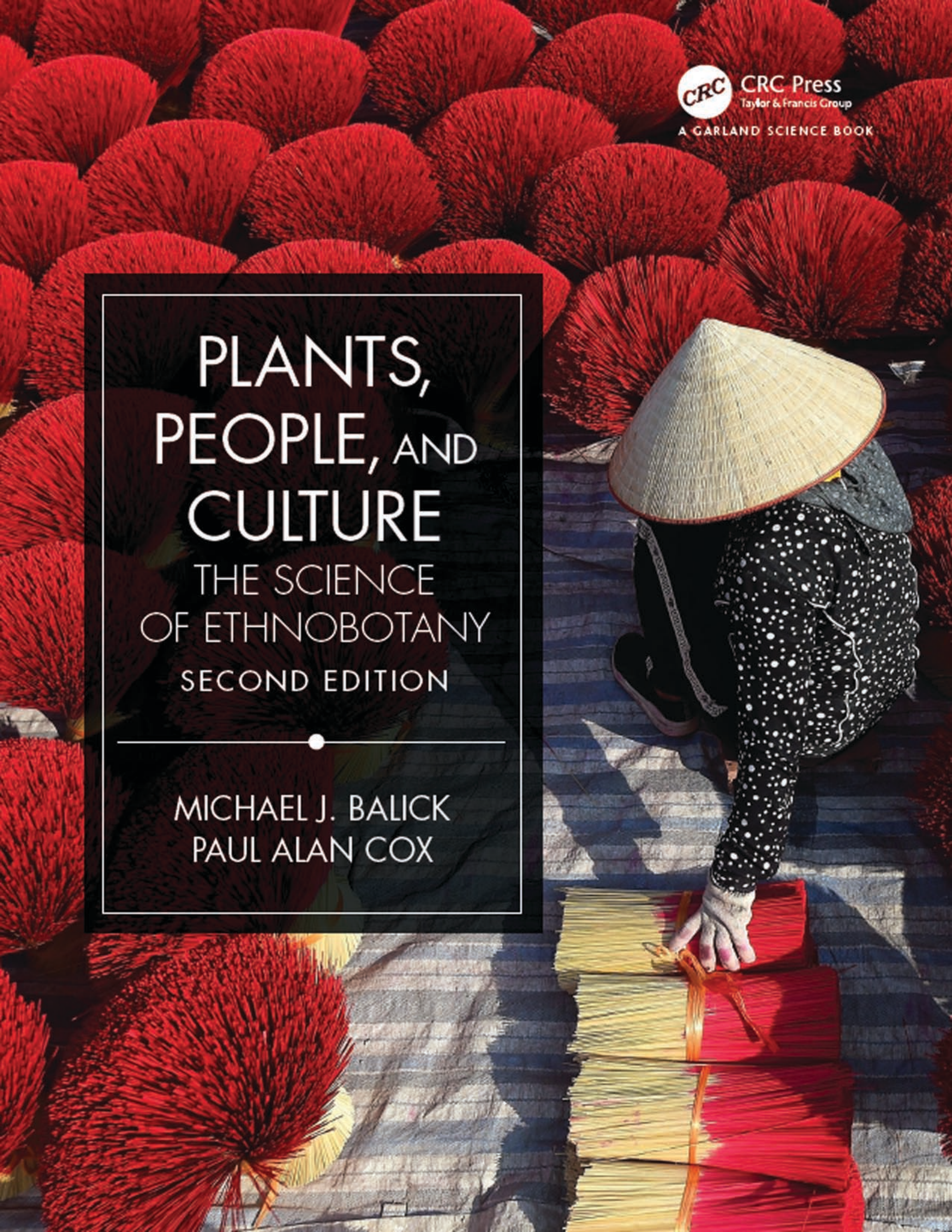

CRC Press
Taylor & Francis Group
A GARLAND SCIENCE BOOK

PLANTS, PEOPLE, AND CULTURE

THE SCIENCE OF ETHNOBOTANY

SECOND EDITION

MICHAEL J. BALICK
PAUL ALAN COX

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Cover: On the outskirts of Hanoi, Vietnam, in Quang Phu Cau,village, incense sticks crafted from bamboo are coated with red powder. As noted by the Vietnamese government, "Incense is considered as a sacred bridge between the visible life of human beings and the spiritual world of heaven, earth and gods." These incense sticks were prepared for Tet, the lunar new year, for people to show respect while visiting Buddhist temples and family members (photo by NHAC NGUYEN/AFP via Getty Images).

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PREFACE

In this book, we assert that the very course of human culture has been deeply influenced by plants, particularly plants that have been used by indigenous peoples around the world. Although most schoolchildren learn, for example, that Columbus ventured out in search of a new route to the Spice Islands, few of us realize the tremendous geopolitical influence of the demand for spices in the rise and decline of the great cities of Europe. Many pharmacists know that plants once played an important role in healing, but few are aware that potent anesthetics and glaucoma treatments were derived from studies of arrow poisons and ordeal poisons, respectively. Whether it be the construction of vast sailing boats used to transport hundreds of Polynesians to new islands, the role agricultural surpluses and scarcities played in the stratification of early societies in the Americas, or the formulation of potent hallucinogenic snuffs used to transport Amazonian shamans to the other world, plants have largely guided the trajectory of human culture.

The study of the interactions between plants and people, including the influence of plants on human culture, is the focus of the interdisciplinary field of ethnobotany. The interests of ethnobotanists range from the functioning of indigenous healing systems to the imbibing of plants in rituals, from the cultural consequences of the extinction of a vine used to construct fish traps to the health consequences of a change in diet, from the class implications of forms of dress to the cultural role of body paint and adornments. As scientists have become aware of the rich variety of questions that ethnobotany addresses, the field has been undergoing a resurgence. Now equipped with new scientific tools from molecular and computational biology, chemistry, chemical engineering, medical anthropology, and others, modern ethnobotanists are asking a dazzling array of new questions while shedding insight on older questions. Using the latest molecular techniques, for example, some ethnobotanists are empirically testing theories of plant origin, while others study the plants used by indigenous peoples in healing for clues to biochemical function in the hope of developing better pharmaceuticals and therapies for the entire world.

We write from the perspective of scientists who have spent a large part of our careers living in remote villages interviewing healers, weavers, shipwrights, and other indigenous experts in the use of plants. Over the last four decades, both of us have undertaken extensive fieldwork in the tropics, with Michael Balick focusing on Central and South America, Micronesia, and Melanesia and Paul Cox concentrating on Polynesia, Indonesia, the Solomon Islands, Fiji, Australia, Japan, Sri Lanka, East Africa, Scandinavia, the Arabian Gulf, and the Colorado Plateau. Although much fine ethnobotanical work is being done elsewhere, we have focused most on the areas we know best, as will become particularly apparent in the last chapter, where we discuss indigenous strategies for conservation.

To standardize the scientific names of plants in this volume, we have consulted two important references: species names with the International Plant Names Index (based on *Index Kewensis*) and generic names with D.J. Mabberley's *The Plant Book*. For the classification of plant families, we have generally followed Mabberley and the Angiosperm Phylogeny website. Family designations are shown in the text in brackets when a taxon is mentioned for the first time. Plant names do change through time, so it is best to check against recent sources. Titles and spellings of pre-Linnean works have been checked against the *Catalogue of the Library of the British Museum of Natural History*.

The first edition of *Plants, People and Culture: The Science of Ethnobotany* was published as part of the Scientific American Library. Invited to write that volume by Professor Richard Evans Schultes, we saw it as a chance to convey to a general audience some of the profound insights ethnobotany offers into the human condition, as well as a chance to discuss some of the exciting new advances in this discipline. This book, the second edition, has been rewritten and expanded so it can also be used as a textbook for university students. We have included new information on contemporary discoveries and ideas that have been put forward since the publication of the first edition but do not claim to have written an encyclopedia of ethnobotany or even a thorough survey of current work in the field. Although we have tried to briefly review some of the historical figures in ethnobotany, there are many advances by contemporary scientists that, because of space limitations, we have not here covered. Indeed, the *Scientific American* format did not allow for footnotes; rather, it required us to write a series of essays without references so the book would be accessible to lay readers and students. Our goal has been to educate and inspire—and to share the joy and occasional adventure—inherent in living and studying with indigenous peoples. Perhaps a few younger readers will choose to pursue careers in ethnobotany. Certainly, for us, this career path has been rewarding, most notably for the chance to work in a field filled with purpose and impact, introducing us to novel insights into the human condition. This has been possible because of the commitment of those who have preceded us, our teachers and colleagues, to whom we owe a tremendous intellectual debt. Because of limitations of space and focus, we could not mention all of these individuals in this book. However, we encourage those who find the topic as fascinating as we do to acquaint themselves with the broader community of ethnobotanists by browsing the pages of *Economic Botany*, the *Journal of Ethnopharmacology*, the *Journal of Ethnobiology*, or any of a number of anthropological, botanical, and chemical journals that cover the topic of people and plants. Through such efforts, readers will be introduced to a rich and diverse community of ethnobotanists whose scholarly achievements clearly eclipse our own efforts.

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We thank those institutions that have supported our work for so many years. In particular, Paul Cox wishes to acknowledge Harvard University; the Miller Institute for Basic Research in Science at the University of California, Berkeley; the Danforth Foundation; the University of Melbourne; Brigham Young University; the Institute for Polynesian Studies; the National Cancer Institute; the National Institutes of Health; the National Science Foundation; the National Tropical Botanical Garden; the Schering Research Institute; The University of Umeå; the University of Uppsala; the Swedish Agricultural University; the Royal Swedish Academy of Agriculture and Forestry; the Linnean Society of London; and the Brain Chemistry Labs for their generous support of ethnobotanical research. Michael Balick wishes to thank the National Cancer Institute, the U.S. Agency for International Development, National Center for Complementary and Integrative Health, The National

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Finally, we wish particularly to thank those indigenous people who for years have so unselfishly taught us about plants, people, and remaining both human and humane in a complex world. We dedicate this book to our friend and former classmate, the late Calvin R. Sperling, plant explorer extraordinaire.

PEOPLE AND PLANTS

1

Within sight of Mount Everest, between the Ganges River and the foothills of the Himalayas, grows a small climbing shrub with pinkish-white flowers, smooth leaves, and milky sap. Called in Hindi *chota-chand*, the shrub is rarely disturbed by the local people unless someone is bitten by a snake. The plant is then unearthed and a decoction of its long root given to the victim. A local legend claims that in ancient times, mongooses were observed to feed on the plant before engaging in combat with cobras. Copying the reputed activity of the mongoose, local people found that the shrub could serve as a potent antidote for snakebite.

Eighteenth-century botanists named the shrub *Rauvolfia serpentina* [Apocynaceae]. *Rauvolfia*, the name of the genus, honors the sixteenth-century explorer and botanist Leonard Rauwolf who introduced coffee to Europe; *serpentina*, the name of the species, describes the snakelike appearance of its root. Apocynaceae is the name of the family of plants that includes *Rauvolfia serpentina*.

In the eighteenth century, a specimen of this plant was sent to the herbarium, a museum-like repository of dried plants in Leyden, Holland, but *Rauvolfia serpentina* was then ignored by scientists, as most medicinal plants have been: fewer than ½ of 1% of all flowering plant species in the world have ever been exhaustively studied for their potential pharmacological activity.

But the plant was not forgotten by the local people, and its use spread to nearby cultures. In Bihar province, it was rumored that when a demented man had eaten slices of the root, he was cured of his madness. The people of Bihar began to use the plant to treat insanity, epilepsy, and insomnia, calling the shrub *pagal-ka-dawa*, "insanity cure." They also found that a single dose of powdered roots could put a child into a deep sleep that lasted all night. Slowly the use of *Rauvolfia serpentina* to treat anxiety, insomnia, and madness spread throughout India.

In 1931, Indian chemists isolated a variety of molecules from the plant but found them to be relatively inactive. Their interest was renewed, however, by a report published in the *Indian Medical Record* that *Rauvolfia* powder not only had a hypnotic effect but also dramatically lowered blood pressure. Like many scientific reports published in developing countries, this discovery was unfortunately ignored by Western scientists. Then, in 1949, Emil Schlittler, a chemist at CIBA (Chemische Industrie Basel) Pharmaceuticals in Basel, Switzerland, read a clinical study of *Rauvolfia* by R. J. Vakil in the *British Heart Journal*. Schlittler, with his colleague Hans Schwarz, extracted from *Rauvolfia* roots an alkaloid, a nitrogen-containing physiologically active organic compound that they named reserpine. They demonstrated that a remarkably low oral dose of reserpine, 0.1 milligram per kilogram body weight, lowered blood pressure. In clinical tests, reserpine lowered one patient's blood pressure from 300/150 to 160/100. American investigators confirmed these dramatic findings. "It has a type of sedative action that we have not observed before," a Boston team reported to the New England Cardiovascular Society.

Figure 1.1 Diego Rivera depicted ancient Aztec healers and some of the medicinal plants they used in this detail from his mural, History of Medicine, found in the Hospital de la Raza, Mexico City.

"Unlike barbiturates or other standard sedatives, it does not produce grogginess, stupor, or lack of coordination."

CIBA soon introduced reserpine to medicine under the trade name Serpasil. Up to that time, all known compounds that lowered blood pressure did so by dilating blood vessels. Reserpine, however, had a direct effect on the hypothalamus of the brain, opening up an entirely new mode of pharmacological action. In 1954, the New York Academy of Sciences sponsored a symposium devoted to the pharmaceutical importance of *Rauvolfia*. Reserpine became the first major drug to treat one of the most serious illnesses of the Western world: hypertension. More recently it has been prescribed in combination with other antihypertensive drugs, such as hydralazine hydrochloride.

How are we to characterize the discovery of reserpine? Does discovery of this important drug rest on "solid" science, such as structural chemistry and pharmacology, or is it attributable to folklore and legend? Laboratory scientists may hail the invention of reserpine as serendipitous, but one fact is inescapable: a plant used by indigenous peoples eventually became the source of one of the world's most important pharmaceuticals.

There appears to be a wide gulf between folk knowledge and modern science, a gulf based on empirical verification. Science is the acquisition of knowledge based on careful observation and experimental tests of theory. Indigenous traditions are sometimes derided as steeped in superstition. Nevertheless, every time a Shipibo hunter fires a poison dart at an animal or a Tahitian healer administers a medicinal plant to a sick child, the efficacy of the indigenous tradition is empirically tested. Indigenous traditions and modern science are epistemologically closer to each other than Westerners might assume. The contexts of trials performed by Western scientists and by Shipibo hunters or Tahitian healers are obviously very different, but the empirical basis of both is clear: indigenous peoples use what works. The field of study that analyzes the results of indigenous manipulations of plant materials together with the cultural context in which the plants are used is called ethnobotany.

In broad terms, ethnobotany is the study of the relationship between plants and people. The two major parts of ethnobotany are encapsulated in the word itself: "ethno," the study of people, and "botany," the study of plants. Arrayed between these two points labeled "ethno" and "botany" lies a spectrum of interests ranging from archeological investigations of ancient civilizations to the bioengineering of new crops. However, the field is limited on both sides. On the botanical side of the field, few ethnobotanical studies are concerned with plants that have no connection to people. On the ethno side, most studies are concerned with the ways indigenous peoples use and view plants. And those uses and those views can provide deep insights into the human condition.

Much of ethnobotany deals with intellectual goals similar to those of cultural anthropology: to understand how other peoples view the world and their relation to it. The way people incorporate plants into their cultural traditions, religions, and even cosmologies reveals much about the people themselves. Some products of ethnobotanical research, such as the drug reserpine, transcend mere anthropological interest and are of profound medical importance to the West. People use plants in so many different ways that there are few arenas of human endeavor in which plants do not play an important role. Indeed, plants have determined the very course of civilization. In the thirteenth century, Marco Polo described an island "producing pepper, nutmegs, spikenard, galingale, cubebs, and all the precious spices that can be

Figure 1.2 ***Rauvolfia serpentina*, the snake-root plant traditionally used as a sedative in the Ayurvedic system of medicine in India.**

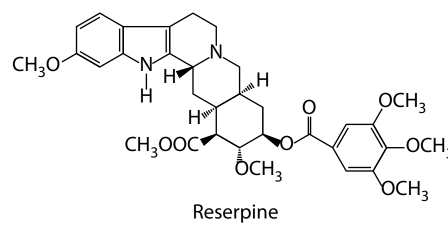

Figure 1.3 The alkaloid reserpine, a chemical derived from *Rauvolfia serpentina*, was an early, very significant drug for treating high blood pressure.

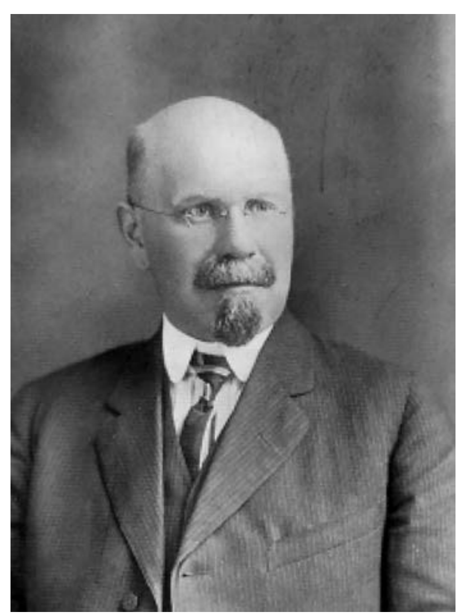

Figure 1.4 The American botanist John W. Harshberger coined the term "ethnobotany" in 1895 to describe studies of "plants used by primitive and aboriginal people." His 1896 publication, *The Purposes of Ethno-Botany*, is generally accepted as a starting point for the field as an academic discipline.

Figure 1.5 Samoan healer Pela Lilo applies an herbal remedy to a sick villager.

found in the world." This report spurred a search for the Spice Islands, which inadvertently resulted in Europeans' discovery of America and culminated in Magellan's circumnavigation of the globe. Since the Renaissance, patterns of international trade in rubber, opium, and quinine have altered the fates of entire nations.

Even the plague of drug abuse that afflicts the world today can be considered an ethnobotanical problem, since it involves illicit traffic in substances—heroin, cocaine, hashish—that are derived from plants that indigenous peoples have used for centuries. In the economic sphere, few industrial societies can ignore the pivotal role of agriculture and forestry; indeed, much of the regulatory structure of the European Union governs trade in crops and other plants. A plethora of environmental crises—climate change, loss of biodiversity, tropical deforestation—are, at their core, issues involving plants. Ethnobotanical research may shed light on some of these issues and may even point to possible solutions. Although we hope to make a convincing case for the importance of plants in the development of civilization, we will focus most of our attention on ethnobotanical studies of indigenous peoples.

The term "indigenous peoples" refers to peoples who follow traditional, nonindustrial lifestyles in areas that their ancestors have occupied for generations. Thus the European settlers of Australia or North America are not considered "indigenous," while the Australian Aborigines and Native Americans are. Given the pivotal role of plants in directing the trajectory of modern societies and the ubiquity of industrialized cultures today, why should ethnobotanists focus so much attention on indigenous peoples?

There are several reasons for this interest. First, the relationships between plants and people are often clearer in indigenous societies than in our own, since the link between production and consumption is more direct. Within a single village, an ethnobotanist can study how people forage for wild plants or sow crops; how they use plants to construct houses, baskets, boats, or clothing; how they produce and prepare foods; and the role plants play in myth and lore. In these cultures, such information resides within individuals, families, or villages. In industrialized societies, however, economic patterns of production and consumption are so complex that most individuals have little understanding of the botanical origins of or processing technology used to provide the plant materials they use every day. Such information does not reside within extended families or even entire towns.

Take such a simple and ubiquitous object as a pencil. Not only has the libertarian philosopher Leonard Read failed to find any single individual in America who could accurately describe how to make a pencil, he discovered

Figure 1.6 Bush doctor Peter Tucker (right) from Windsor Forest, Portland, Jamaica, and ethnobotanist Ina Vandebroek (left) sitting next to chainy root (*Smilax canellifolia* [Smilacaceae]) that they just dug up. This plant is one of up to a hundred ingredients in Jamaican root tonics, popular fermented beverages made with the bark and roots of primarily wild plant species prepared and consumed as a tonic to build the body and increase stamina.

the companies that manufacture specific components of pencils are ignorant of how other components are produced and how they are fitted together to form an entire pencil. Such compartmentalization of knowledge is rare in indigenous cultures: though individual villagers may lack esoteric knowledge of a plant, they can usually refer an investigator to a local expert—a shaman, shipwright, or weaver—who has the requisite understanding.

Second, indigenous cultures sometimes represent living analogues of previous stages of Western civilizations. Thus archaeologists can explore hypotheses concerning the hunter-gatherer phase of the earliest Europeans by studying the lifestyles of modern hunter-gatherers. They can scrutinize the precursors of modern agriculture by studying the pre-agricultural strategies of indigenous cultures such as that of the Torres Straits Islands, south of New Guinea. The problem, of course, is that we can never be sure how close (or distant) such analogies are. At least, however, they can generate useful discussion and help us reject unworkable hypotheses.

Third, indigenous cultures retain much knowledge concerning plants that modern peoples have largely lost. Indigenous peoples have maintained knowledge of plant medicines, textiles, and plant cultivation strategies out of necessity. Some knowledge, such as ethnotaxonomic systems (biological classification schemes used by indigenous peoples) or legends and myths concerning plant origins, are of interest because of the insight they shed on the cultures themselves. Other types of knowledge can be of more immediate benefit to Western peoples. Indigenous knowledge systems, for example, can guide the development of new crop varieties or medicines.

Fourth, indigenous peoples are stewards of some of the most sensitive ecosystems on this planet. Indigenous knowledge systems, developed over centuries of residence in such habitats, can inform current approaches to the conservation of natural resources.

Finally, in today's global economy, indigenous peoples are vulnerable to rapid economic and cultural change that can cause loss of the collective cultural memory. It is this memory that allows them to live as a community, a social unit that provides nurture, norms, protection and other benefits essential to maintaining identity. Without an intact cultural identity, and the practices embedded within it, indigenous peoples have fewer options in their ability to maintain secure and healthy lives. Understanding of traditional ways, including uses and management of plant resources, can point to strategies for ameliorating negative consequences of that change.

Given this twin focus on plants and indigenous peoples, a contemporary ethnobotanist tends to be a combination anthropologist, archaeologist, botanist, chemist, nutritionist, psychologist, ecologist, explorer, folklorist, pharmacologist, and diplomat. Only through an interdisciplinary approach can we hope to understand the close connection between plants and human societies.

1.1 PLANTS AS THE MATERIAL BASIS FOR HUMAN CULTURE

One may ask why plants rather than animals have traditionally been the focus of such investigations. Why does ethnobotany command far more academic interest than its sister discipline of ethnozoology?

The material culture of nearly every people on this planet is based more on plants than on animals. From the Vikings of Scandinavia with their large wooden sailing vessels to the Maoris of New Zealand with their intricately carved meetinghouses, from the Shipibo of the Amazon rain forest with their 3-meter-long blowguns to the Navajo of the North American desert with the dyes that color their patterned rugs, the peoples of the earth have long depended on plants for food, clothing, shelter, transportation, medicine, and ritual. Why should plants rather than animals play such a crucial role in the development of human cultures?

Part of the reason is found in the profound ecological disparity between plants and animals: plants are able to transform atmospheric carbon dioxide and minute quantities of inorganic nutrients into life itself. As a result, plants outweigh all the elephants, lions, squirrels, and every other form of animal life by a factor of at least ten. Plants are also vast factories of chemical diversity. However, the crucial difference is that plants produce, while animals consume.

All animals, including people, depend on consumption not only for their lives but also for the way they live. It is the food animals eat, be it herb, fowl, fish, or other flesh, that largely determines their position in the ecological community. In this ecological sense, animals are indeed what they eat and are defined in the web of life by what they consume. With the exception of a few microorganisms that contain chlorophyll and a few coral reef organisms that harbor symbiotic cyanobacteria, no animal can live and grow without consuming something else. If we exclude carnivorous plants such as the Venus flytrap and plants that live as parasites on a host, such as the mistletoes, we can distinguish plants not by what they consume but by what they produce.

But what about soil and nutrients? Is earth itself the food of plants? In 1648, the Flemish plant physiologist Johannes Baptista van Helmont elegantly tested this conjecture. Van Helmont planted a 5-pound willow in 200 pounds of soil. After five years he removed the willow, dried it, and found that it weighed 169 pounds 3 ounces. Reweighing the soil after it had dried, he found that it now weighed 199 pounds 14 ounces. In other words, 164 pounds 3 ounces of willow was produced by only 2 ounces of soil. How could this be? Did the plant create its bulk from thin air?

The answer, of course, is yes. During photosynthesis, plants are able to recombine the carbon atoms from carbon dioxide into the six-carbon rings we know as hexose sugars. Other elements used in the light and dark reactions of

Figure 1.7 In many parts of the Pacific, *Pandanus tectorius* [Pandanaceae] is used to weave baskets, mats, walls for houses, boat sails, and gifts for exchange.

photosynthesis are important, but they are required only in minuscule quantities. The hexose sugars produced by photosynthesis are linked to make long-chain polymers such as starch and cellulose. When cellulose is combined with plant resins, it forms one of the most important building materials ever discovered: wood. The photosynthetic pathway leading from carbon dioxide to wood means that even the massive rain forests of the Amazon have ultimately been produced from thin air. The sequestration of carbon dioxide is one of the great services that plants perform for the world.

The carbon dioxide in the atmosphere is nearly inexhaustible. Thus, plants compete with one another not for this gas but for a position in the plant canopy that will enable them to capture the sunlight that powers the photosynthetic process. Since they must maintain both their leaves in the sun and their roots in the soil, no terrestrial plants are mobile. Their immobility coupled with their tremendous production of cellulose makes plants a far more efficient and reliable source of building materials and food than animals. Carpenters need not chase their trees through the forest. Pity the culture that would require wildebeest bone or tiger skin for housing material or clothing or that demands the gall bladder of an endangered bear for medicine. In times of abundance such materials might be found, but in times of scarcity, plants are far more accessible. As omnivores, we can eat meat, and, indeed, most cultures revel in the hunter's exploits or the fisherman's success. Yet all cultures, except for a few confined to tundra regions of the Arctic and pastoral peoples such as the Masai of Kenya, depend on plants for the bulk of their diet. Even peoples that follow their herds across the landscape depend on plants for forage for their animals.

People rely on plants for much more than food and shelter. The estimated 400,000 species of flowering plants differ not only in form but also in hidden biochemistry. No animals, including human beings in white laboratory coats, have ever been able to produce more than a fraction of the dazzling array of molecules routinely assembled by plants. Even today we can synthesize only a fraction of these natural plant chemicals. Since all plants require the same staples—carbon dioxide and sunlight—the biochemical diversity of plants probably has little to do with the machinery of photosynthesis. Among all plant species, only a handful of photosynthetic pigments have been discovered. Why, then, should plants produce exotic chemicals ranging from opiates that deaden our nervous systems to sweetening agents that enhance our diets?

The answer again lies in the immobility of plants. Unlike animals, plants cannot move about to carry out reproductive activities or escape enemies. Plants must either rely on the uncertain forces of wind and water to move their pollen and seeds or alternatively entice animals to perform these services for them. In this sense, then, the flower of the orchid and the fruit of the mango tree represent contracts between plants and animals. The orchid provides sweet nectar and occasionally sex pheromones or a trysting place for insects that transport pollen. The mango provides needed nourishment to the flying fox that carries its massive seed.

Not all plant-animal interactions, however, are benign. The animal mouth, be it insect mandible or mammalian jaw, represents a potent threat to a carbohydrate-rich, water-filled organism that cannot flee a potential predator or parasite. Plants have therefore become specialists in animal biochemistry of necessity. Their chemicals function not only to reward animal pollinators and carriers of their seeds but also to repel, maim, or poison those animals that attempt to destroy them. The chemical agents that plants employ against animals have profound implications for medicine: we depend on these chemicals for 25% of our prescription drugs and for nearly all of our recreational chemical substances, including the caffeine in coffee, the nicotine in tobacco, the theophylline in tea, the theobromine in chocolate, and a virtual cornucopia of other psychoactive substances throughout the world.

This triad of immobility, carbohydrate production, and diverse biochemistry makes plants far more useful to human beings than animals can ever be. Indigenous peoples throughout the world have become expert at using the plant resources around them.

Figure 1.8 Antonio Cuc, a *yerbatero* or herb gatherer in San Antonio Village, Belize, chops roots from *Chiococca alba* for use that day by a traditional healer. *Chiococca alba* [Rubiaceae], known locally as skunkroot, is a powerful plant with many uses in the region.

1.2 PLANTS AND PEOPLE IN ANCIENT TIMES

Thatch for huts, timbers for boats, fibers for cordage and textiles and dyes to color them, and a plethora of medicinal plants all appear at early stages of human prehistory. Yet these uses pale in comparison with the use of plants for food. Agriculture is a relatively recent development in human history, arising independently in several parts of the world during the last 10,000 years. In valleys nestled in the Swiss Alps, groups of people lived in fishing communities on the edges of large lakes. Perhaps seeds from plants used for thatch or food fell onto piles of waste and flourished in the nutrient-rich environment. The ease of gathering these plants led people to repeat deliberately what began as an accidental process. The ancestors of the Polynesians in Indomalaysia and Taiwan developed a different form of agriculture by tending trees and tuberous plants that furnished edible nuts and rhizomes. Soon they discovered how to propagate these plants from cuttings, possibly by observing that the leafy tops of the tubers grew after they had been discarded.

Cultivation of the grains that supported Western civilization also developed within the last 10,000 years. In what is now Iraq, remains of grinding stones from 8000 B.C. and seeds of wheat and barley from 6700 B.C. have been found. Mesoamerican agriculture also developed in the last 10,000 years: gourds and squash from 6000 B.C. have been found in Mexico; maize, one of the most

Figure 1.9 An open-air market on Tanna Island, Vanuatu, where shoppers can find plants used for foods, beverages, fibers, and medicines. Markets are fascinating places to carry out ethnobotanical investigations, and vendors are often quite knowledgeable about the origins and uses of their wares.

productive plants in the world, developed even later. Yet the ancient use of such plants can be traced through more than archaeological conjecture: many societies have left graphical or written representations of their interactions with plants.

For centuries people created durable representations of plants, etching them in stone or molding them in clay. Such images not only provide modern ethnobotanists with clues concerning plant origins but function as tangible indicators of the importance these peoples attached to plants. Early beliefs about plants, such as the association of the creation of the first man and woman with a garden, were transmitted not only orally but also in written form. Such records often combine the religious and the pragmatic. An Assyrian bas-relief sculpture at the palace of Nimrod at Assur-Nassur-Aphi, for example, portrays winged gods pollinating date palms, evidence of early knowledge of plant reproduction. The sculpture also suggests, however, that the Assyrians

Figure 1.10 This rendering depicts the bas-relief at the ancient Palace of Nimrod, on the east bank of the Tigris River, portraying a winged god pollinating date palms.

viewed the process of pollination as part of the realm of religious experience. In the fifth century B.C., Herodotus recorded the Babylonians' knowledge of crop pollination with no religious overtones. Later, Aristotle, in the third century B.C., began philosophical consideration of plants. His student Theophrastus, who inherited Aristotle's library, wrote extensively about plants and recorded many observations made by a fellow student, Alexander the Great. The ninth book of his *Enquiry into Plants* contains a good deal of information about medicinal plants, although Theophrastus ridiculed the superstitions associated with the way the plants were gathered. Further efforts to codify mythical and folk medicine led Dioscorides, a Greek physician of the first century, to write a compendium called *De Materia Medica*, which not only describes 500 medicinal plants but illustrates many of them. *De Materia Medica* was accepted as authoritative until the early Renaissance. Such early compilations of folk wisdom concerning medicinal plants were not confined to the West; traditionally dated as before 2000 B.C., the Chinese emperor Shen Nung compiled the *Pen Tsao*, which is perhaps the earliest known herbal.

1.3 HERBALS AND MEDICINAL PLANTS

In the early Renaissance, there was an explosion of interest in herbals, most of which were based on the work of Dioscorides, with incremental improvements made from the authors' own knowledge. The first herbal written in the Anglo-Saxon world was an eleventh-century codex known as the *Herbarium of Apuleius Platonicus*. The earliest printed English herbal was an anonymous quarto of 1525, printed by Richard Banckes: "Her beynneth a newe matter, the whiche sheweth and treateth of y virtues and proprytes of herbes, the whiche is called a Herball."

A year later, a translation of a French herbal was published by Peter Treversi, and in 1538, William Turner published *Libellus de re Herbaria Novus*. In 1551, Henry F. Lyte (author of the hymn "Abide with Me") published a translation of Rembert Dodoens' herbal *Stirpium Historiae Pemptades Sex*, which had achieved renown on the continent because of its encyclopedic scope and superb plates of flowers. But the most popular of all sixteenth-century herbals was that of John Gerard, published in 1597. It is one of the few books to remain in print for over 400 years and is one of the most important books on plants ever published in the English language.

Gerard was born in Nantwich, Cheshire, in 1545. At the age of 16, he began a seven-year apprenticeship to a London surgeon, Alexander Mason. In those years, medicine was considered a branch of botany. Gerard traveled briefly as ship's surgeon in the Baltic but showed far more interest in plants than in life at sea. In 1577, he was appointed superintendent of the gardens of Lord Burleigh at the Strand in London, and later he was appointed curator of the Physic Garden of the College of Physicians of London. George Baker, surgeon to Queen Elizabeth, reported that Gerard's own garden was filled with

> all manners of strange trees, herbes, rootes, plants, flowers, and other such rare things, that it would make a man woonder, how one of his degree, not having the purse of a number, could ever accomplish the same. I protest upon my conscience, I do not think for the knowledge of plants that he is inferior to any.

In 1596, Gerard published a catalogue of the plants in his garden. The work he published the next year, *The Herball, or Generall Historie of Plantes*, rapidly became one of the most quoted botanical works ever published. Gerard's *Herball*, with 1392 pages and 2200 woodcut images by the artist Mattiolli of medicinal plants, was greeted with tremendous enthusiasm by medical practitioners, who prescribed from it.

Twentieth-century authors have accused Gerard of plagiarism because much of his herbal appears to be taken from the earlier work by Dodoens. This charge is disingenuous, however, for herbals are by definition compilations of

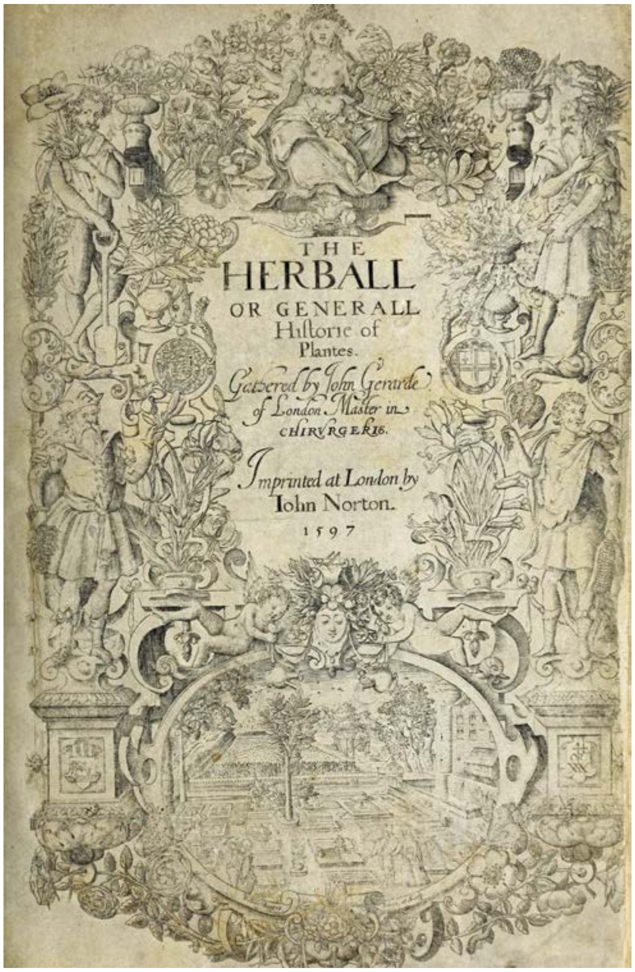

Figure 1.11 The frontispiece of Gerard's *Herball*. First published in 1597, this compilation of information on medicinal plants was extensively referred to by physicians in search of herbal remedies.

knowledge accumulated through the ages. Dodoens himself borrowed very heavily from both Pliny and Dioscorides, who in turn borrowed from the *rhizotomi*, Greek root gatherers, whose business was "preparing and selling of roots and herbs that were of repute in medicine."

It was precisely this collection of accumulated folk knowledge that made John Gerard's *Herball* so valuable. Renaissance doctors carefully searched its pages for descriptions of plant medicines. Take, for example, the entry on page 646 for the foxglove plant, *Digitalis purpurea* [Plantaginaceae]:

> Foxe gloue boiled in water or wine, and drunken, doth cut and consume the thicke toughness of grosse and slimie flegme and naughtie humours; it openeth also the stopping of the liver, spleene and milt and of other inward parts.

1.4 WILLIAM WITHERING AND CARDIAC DRUGS

Gerard's claim for the effects of foxglove on internal organs was not examined until 1775, nearly 200 years later. After a decade of investigation, William Withering published in 1785 *An Account of the Foxglove and Some of Its Medical Uses*. Withering quoted Gerard's account of the "virtues" of foxglove and proposed that the plant could yield an important medicine for dropsy, an ailment characterized by swelling of the limbs and torso, which we now know is due to inadequate pumping action of the heart.

There is certainly little in Withering's upbringing to suggest that he would one day produce one of the first modern studies in ethnobotany by interviewing a folk healer and carefully investigating the pharmacological activity of the plants she used. Like many modern premedical students, Withering was not enamored of the necessity of learning botany. In a letter to his parents, Withering described his botany professor at Edinburgh, John Hope, as quite dull:

> The Botanical Professor gives annually a gold medal to such of his pupils as are most industrious in that branch of science. An incitement of this kind is often productive of the greatest emulation in young minds, though, I confess, it will hardly have charm enough to banish the disagreeable ideas I have formed of the study of botany.

Figure 1.12 English folk healers prescribed the foxglove plant, *Digitalis purpurea* [Plantaginaceae], to treat dropsy, a condition caused by inadequate pumping action of the heart.

Withering's botanical interest lay dormant until 1775, when he was smitten with Helen Cookes, an aspiring artist who liked to paint flowers. Young Withering, eager to please, collected plants for her to sketch. During this romantic interlude, the plants captured Withering's imagination. Although he continued his practice of medicine, he later published several texts on botany and was elected a Fellow of the Linnean Society, a premier botanical institution in London. Thus trained in both medicine and botany, Withering was well prepared to make the most important ethnobotanical discovery of his age:

> In the year 1775, my opinion was asked concerning a family receipt [recipe] for the cure of the dropsy. I was told that it had long been kept a secret by an old woman in Shropshire, who had sometimes made cures after the more regular practitioners had failed.... This medicine was composed of twenty or more different herbs, but it was not very difficult for one conversant in these subjects, to perceive, that the active herb could be no other than Foxglove.

The retention of fluid that swelled the dropsy patient's body was clearly alleviated by the administration of foxglove, but the connection between dropsy and inadequate pumping action of the heart was not properly understood in Withering's day. In a brilliant insight, Withering observed that foxglove "has a power over the motion of the heart, to a degree yet unobserved in any other medicine." Withering foresaw that "this power may be converted

Figure 1.13 A portrait of William Withering, the English physician and botanist who, while investigating the folk use of plant mixtures to treat dropsy, discovered that these mixtures shared the common element foxglove, the plant that he holds in his hand.

to salutary ends." He began prescribing foxglove for cases of dropsy, "but I gave it in doses very much too large."

Part of his problem was standardizing the dosage from ground leaves:

> These I had found to vary much as to dose, at different seasons of the year; but I expected, if gathered always in one condition, viz, when it was flowering late, and carefully dried, that the dose might be ascertained as exactly as that of any other medicine; nor have I been disappointed in this expectation.

Withering soon began to prescribe infusions of the leaves (which he made by steeping the leaves in water) and, later, ground leaf powder. By any standard, foxglove as administered by Withering was an astonishingly successful treatment for dropsy. When J.K. Aronson at Oxford reanalyzed data from the cases Withering carefully recorded, he found a success rate of between 65% and 80%.

Powdered foxglove leaf is still prescribed in tablet or capsule form to treat congestive heart failure. The Latin name of the foxglove genus, *Digitalis*, has been affixed to this crude drug as well as to the cardiac glycosides isolated from foxglove in the early twentieth century. Cardiac glycosides are steroidal compounds (naturally occurring compounds with a characteristic 17-carbon skeleton bonded into four fused rings) with attached sugars, and they are so named because of their powerful action on the heart. These drugs are useful because they increase the force of heart contractions and allow the heart more time to rest between contractions. More than 30 cardiac glycosides have been isolated from dried foxglove leaves, including digitoxin and digoxin. Neither of these drugs has ever been commercially synthesized; both are still extracted from the dried foxglove leaves. Each year over 1500 kilograms of pure digoxin and 200 kilograms of digitoxin are prescribed to hundreds of thousands of heart patients throughout the world.

Although the development of new pharmaceuticals has added to the repertoire of heart medicines, digitalis still saves many lives each year. Digitalis remains the drug of choice in the treatment of acute atrial fibrillation, a life-threatening condition characterized by unsynchronized contractions of the heart that reduce its pumping action. In perhaps the earliest demonstration of the power of the ethnobotanical approach to drug discovery, William Withering's willingness to consult "an old woman in Shropshire" eventually resulted in a drug of tremendous importance.

Withering's ethnobotanical study of a single plant, *Digitalis*, resulted in an important advance in medicine by reporting his investigation of the knowledge of folk healers in his own culture. His contemporary, the Swedish botanist Carl Linnaeus, made no new drug discoveries but significantly advanced ethnobotany by studying the uses of plants in the indigenous Sami culture of

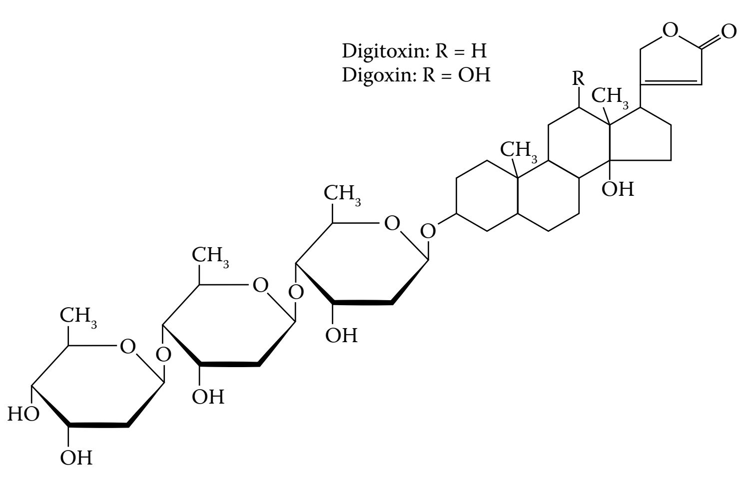

Figure 1.14 Digoxin and digitoxin, two important heart medications still extracted from the foxglove plant, are classified as cardiac glycosides. "Cardiac" refers to their action on the heart, while "glycosides" refers to the linked sugar molecules shown at the lower left of the structure.