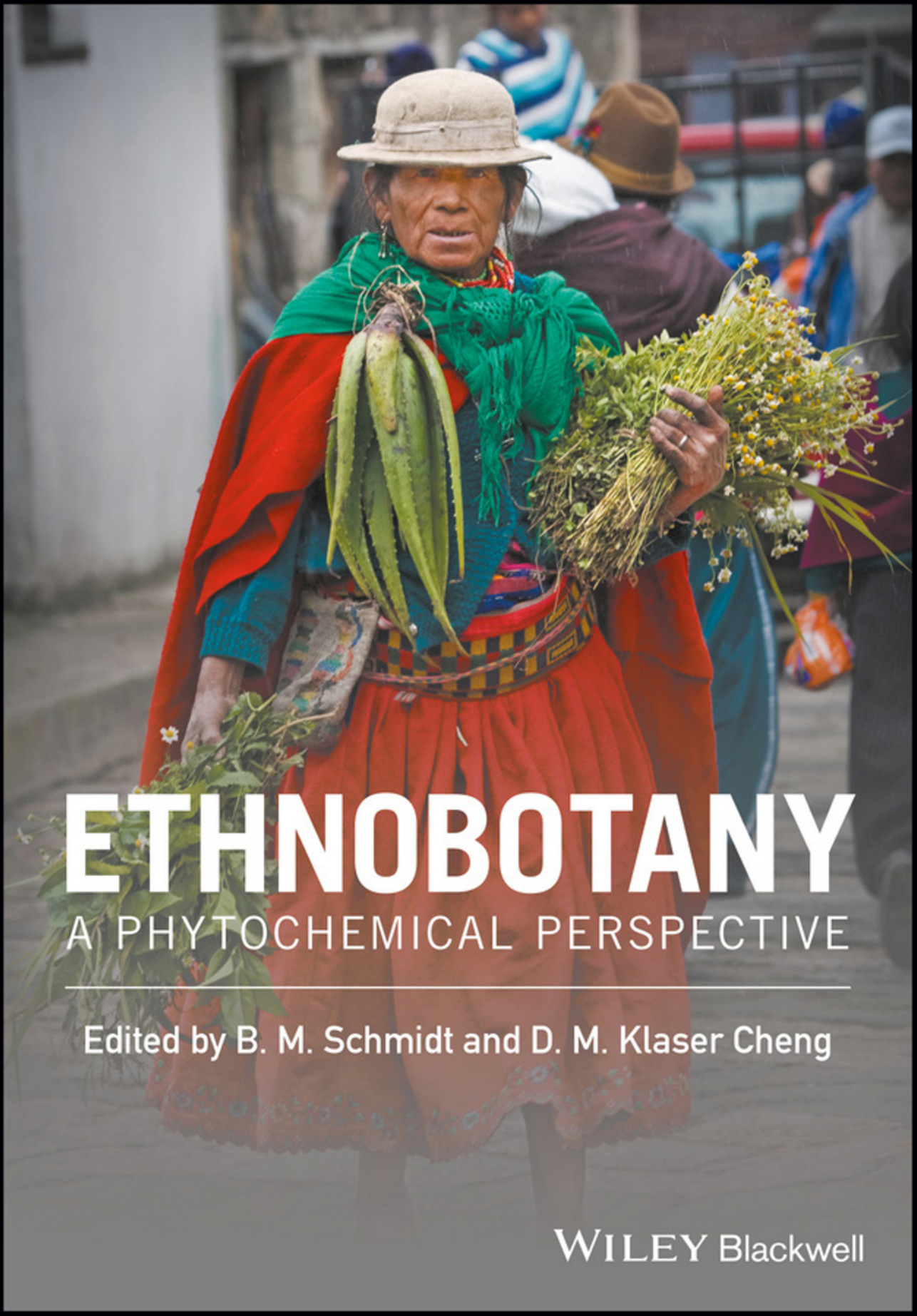

ETHNOBOTANY

A PHYTOCHEMICAL PERSPECTIVE

Edited by B. M. Schmidt and D. M. Klaser Cheng

WILEY Blackwell

Ethnobotany

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Foreword

Science, especially with the rise of the *-omics* technologies, has made amazing strides to decipher and elucidate the capacity of plants to synthesize and accumulate natural products that are uniquely capable of interfacing with human therapeutic targets to prevent or treat chronic human diseases. However, these revelations made in the modern scientific community would hardly come as a surprise to many indigenous communities, who have relied on well-known, highly potent medicinal plants for centuries. Modern science has only recently allowed us to characterize the phytochemical structures that provide anti-inflammatory or chemopreventive relief to humans, or to discern their mechanisms of action, but the traditional ecological knowledge of native communities has both channeled the search for phytoactive compounds and guided tests for safety and efficacy based on long history of human use. This book illustrates how traditional ethnobotany enriches the scientific discovery process, and in turn, how science validates and reinforces the wisdom of the elders.

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Preface

The Purpose of This Book

Both lead authors/editors and all contributing authors work in the fields of ethnobotany and/or phytochemistry. We wrote this book to help bridge the gap between the two fields of study and to bring about new collaborations and discoveries. A range of applications from around the world is presented, illustrating many areas of relevance and importance to phytochemical research. In industry, there is an ongoing initiative to discover new molecules from nature with a specific usefulness, be it nutritional, cosmetic, pharmaceutical, dyes, and so on. But there are not many reference books that describe the traditional use of a plant and also explain the chemistry at work "behind the scenes." Existing ethnobotany textbooks and reference books tend to focus on the anthropological side of ethnobotany, often ignoring phytochemistry altogether. They offer information on how a plant was used, but fall short of describing why a plant produces the observed effects. There are many edited reference books available that contain only case studies, with each contributing author following their own format. Occasionally the case studies stray far from the topic at hand or provide little background information. There are a few quality ethnobotany reference books on the market with a focus on phytochemistry, but the case studies need to be updated. This book features relevant, modern case studies in a uniform format that will be easy for the reader to follow. It also contains basic information on ethnobotany and phytochemistry, as tools to understand the information presented in the case studies and published ethnobotany research articles in general.

Target Audience

This book is intended as a reference book for an upper-level undergraduate- or graduate-level ethnobotany or phytochemistry course. Basic organic chemistry knowledge will be required to fully understand the phytochemistry. However, the book is still useful for readers without a chemistry background who are interested in ethnobotany. Industry scientists may use this book to gain a basic understanding of ethnobotany and phytochemistry and to become familiar with recent research for their position in the pharmaceutical, personal care, food, nutrition, or raw materials industry.

Inclusions and Exclusions

One of the most difficult tasks when writing a book is deciding where to draw the boundaries. What information will be included and what will be excluded? This book focuses on examples of ethnobotany where phytochemistry plays a role in the observed effects or activities. Therefore, aspects of ethnobotany that cannot easily be explained by science (such as supernatural or religious uses) and aspects that have only limited connections to phytochemistry (such as art and building materials) are not covered in depth. Unfortunately, fungi, microalgae, and other "lower plants" are not covered, although there are case studies on macroalgae and duckweed. There are thousands of cultural groups that all deserve mention for their ethnobotanical ingenuity, but there are not enough pages in this book to mention everyone. Readers may notice that this book does not include many long lists of bioactivities described for a specific plant. It seems that, even when studying the use of one plant by one cultural group, the list of uses is extensive, in some cases ranging from snakebite treatment to liver tonic with 20 other remedies in between. The task of deciding which activities to include usually came down to how often the plant and activity in question were mentioned in respected publications (journal articles, pharmacopoeias, historical texts, etc.). Please use the provided references for additional in-depth information, as this book provides just the tip of the iceberg on many topics.

The first section of the book contains a mini-course on botany and phytochemistry written by the lead authors. It should provide the reader with tools to understand the case studies and other related literature. The largest section in the ethnobotany chapter is "Taxonomy" (page 21). Families are arranged using the Angiosperm Phylogeny Group (APG) III phylogenetic classification system. The chapter describes hundreds of ethnobotanical plants, why they are important, their primary uses and/or activities, and active phytochemicals. Understanding taxonomy is essential if you want to make new phytochemical discoveries. You may notice that plants in the same family and closely related families tend to produce similar phytochemicals. So, for example, if you were searching for new isoquinolone alkaloids, you would be wise to investigate plants from families where they are known to occur such as Berberidaceae, Euphorbiaceae, or Ranunculaceae. We made every attempt to include the class of molecule with chemical names, to aid in further research.

Some may consider the case studies in Part II the most interesting part of the book. Most of the case studies were written by contributing authors in their field of expertise. The lead authors wrote the regional introductions and a few of the case studies as well. Many of the cases are cutting-edge research at the time of publication. Others tell in-depth stories of plants that had a huge impact on society.

Words of Caution

Scientific literature quickly becomes out of date and this textbook is no exception. What may have been state of the art or common knowledge at the time of publication may give way to new ways of thinking. Taxonomy is one important example. Plant names and classifications change quickly. Please take care to check the currently

accepted names using a respected database, such as The Plant List by Royal Botanic Gardens Kew and Missouri Botanical Garden. Another problem area is plant centers of diversity/origin. Many scientists still use Russian botanist Nikolai Vavilov's 1940 work, The theory of origins of cultivated plants after Darwin as a reference. But new discoveries in archaeology, paleobotany, and molecular genetics have proved a number of Vavilov's assumptions incorrect. Along the same lines, the authors have carefully attempted to provide accurate information regarding historical use of plants. Quite frequently, date agreement is a problem. Occasionally, a reference claimed that an ancient culture used a plant species plant that was not native to the region and was not introduced until hundreds to thousands of years later. This problem typically occurs when an author is either not familiar with botany or when there has been disagreement as to a plant's origins.

The final lesson for anyone reading this book comes from a quote attributed to Albert Einstein: "The more I learn, the more I realize how much I don't know." Both ethnobotany and phytochemistry are immense fields of study with so much more to be discovered. We hope readers will go away somewhat dissatisfied, with a desire to learn more about a particular plant or culture.

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Part I

Introduction to Ethnobotany and Phytochemistry

1

Ethnobotany

B. M. Schmidt

Key Terms and Concepts

Ethnobotany is the scientific study of the relationship between plants and people. It includes traditional and modern knowledge of plants used for medicine, food, fibers, building materials, art, cosmetics, dyes, agrochemicals, fuel, religion, rituals, and magic. A broader definition also includes how people classify, identify, and relate to plants along with reciprocal interactions of plants and people. In many ways, ethnobotany is a product of European curiosity with the New World and other native peoples encountered during their exploration voyages starting in the fifteenth century. Before the American botanist John Harshberger coined the term "ethnobotany" in 1896, "aboriginal botany" was used to describe European interest in the way aboriginal people used plants for medicine, food, textiles, and so on. Many European exploration missions were undertaken with the sole purpose of exploring natural and cultural wonders (see Captain Cook's breadfruit voyages, Chapter 1, the section titled "Moraceae: Mulberry Family"), often followed by colonial or imperialist expeditions. Early explorers, missionaries, clergy, physicians, traditional healers, historians, botanists, anthropologists, and phytochemists have all contributed to the field of ethnobotany. **Botany** is the study of plants (Kingdom Plantae) including physiology, morphology, genetics, ecology, distribution, taxonomy, and economic importance. Sometimes fungi (Kingdom Fungi) are included in botany, but for the purposes of this book, they will not be covered.

Ethnobiology is a multidisciplinary field that studies the relationships of people and their environment, which includes plants and animals. Ethnobotany could be considered a specialized branch of ethnobiology. There are several specialized branches of ethnobotany that focus on one particular aspect of the field. **Ethnomedicine** focuses on traditional medicine including diagnostic and healing practices along with herbal medicines. **Ethnopharmacology** is the study of the uses, modes of action, and biological effects of plant-based medicines, stimulants, or psychoactive herbs. **Economic botany** is closely related to ethnobotany. The main distinction is that economic botany focuses on applied economic, agricultural, or commercial aspects of human uses of plants, but does not deeply explore traditional cultures, the "ethno" side of ethnobotany. Economic botany studies often have the goal of developing new plant-derived products, which

Ethnobotany: A Phytochemical Perspective, First Edition. Edited by B. M. Schmidt and D. M. Klaser Cheng.

may or may nor be based on traditional uses, while ethnobotany studies may simply document facts about plant use when there is no prospect of commercial gain.

Ethnobotanists use a variety of tools for their scientific investigations including historical texts, surveys, interviews, and field observations of human–plant interaction. They typically collaborate with indigenous people or local scientists to make an inventory of local natural resources, identifying which plants are useful and in what way. **Biocultural diversity** is the total variety exhibited by the world's natural and cultural systems. It includes both the **biodiversity index** (the diversity of plants, animals, habitats, and ecosystems), and the **cultural diversity index** (diversity of human cultures and languages). Biodiversity is measured by dividing the number of distinct species in an area by the total number of individuals in the area. Cultural diversity can be calculated by dividing the number of distinct languages, religions, and ethnic groups in an area by the number of total individuals in the area. Hot spots of biocultural diversity include Central Africa, Malesia, and the Amazon Basin.

Phytochemistry is the study of plant natural products. Natural products include both primary metabolites (e.g., amino acids, carbohydrates, and fats) and secondary metabolites (e.g., alkaloids, carotenoids, and polyphenols). Phytochemistry also encompasses plant biosynthetic pathways and metabolism, plant genetics, plant physiology, chemical ecology, and plant ecology. It can be considered either a branch of chemistry or botany, depending on whether the scientist and/or research program focuses more on the plant or the chemicals.

Historically, there has been a significant gap between the fields of ethnobotany and phytochemistry. Ethnobotanists are often great anthropologists, with rich knowledge of traditional cultures, texts, and historical context. They provide valuable plant inventories in vulnerable areas and are particularly interested in the cultural role of plants. But when it comes to phytochemistry, the fundamental nature of how a plant works as a biologic (drug, stimulant, etc.), what properties make it a good building material or fiber, or why one natural dye requires a mordant and another does not, they frequently provide superficial answers. Therefore, their publications or presentations will often stop short of describing the chemistry behind the traditional use. Phytochemists, on the other hand, have a thorough grasp of the chemical nature of plants, from the biosynthetic pathways to the effects of the environment on the production of secondary metabolites, to the metabolism of phytochemicals in the human body. Often, they have a background in botany, with a picture of how plants are related and function on the basis of their common chemistries. But they lack training in anthropology or linguistics, with limited awareness of the historical and cultural context of plants. Collaboration between these two groups of scientists is essential to present the whole story of how valuable plants are to our society. More and more, university programs are preparing ethnobotanists and phytochemists with tools from both disciplines. Together, with the common goal of preserving biocultural diversity and promoting social well-being, we can make the best use of our natural resources.

Ethnobotany throughout History

Humans have been using plants since before recorded history. Our earliest relatives gathered plants to use as food, medicine, fibers, and building materials, passing on their knowledge through oral traditions. Agriculture, the practice of producing crops and

raising livestock, came about independently in different regions of the world 10,000–15,000 years ago. Botanical knowledge was a great advantage in ancient civilizations, as it conferred a greater chance of survival. Many ancient scholars took a keen interest in botany, publishing herbals that contained botanical information, as well as plants' usefulness. With this information, a person could identify a plant in the wild or in a garden and also know how to use it.

Ethnobotany as a science did not come about until more modern times. While people historically had a close connection to plants and many scholars studied botany, few studied the botanical knowledge of a social group until the twentieth century. The following are a few of the influential botanical scholars and texts that helped disperse ethnobotanical knowledge throughout the ages.

Early Botanical Figures and Texts (Antiquity–500 CE)

Egypt, Greece, and Rome

The mortuary temple of **Queen Hatshepsut** of Egypt (c. 1508–1458 BCE) at Deir el-Bahri depicts a trade expedition to the region of Punt. This is one of the earliest documentations of botanical trade. Her ships returned with myrrh trees, among other treasures. Scholars believe she died of bone cancer, which may have been caused by inadvertently using a carcinogenic skin salve composed of palm oil, nutmeg apple oil, and creosote. Creosote contains benzo(a)pyrene, which is highly carcinogenic. Her story provides a glimpse into the extent of botanical knowledge over 3500 years ago.

Around the same time (c. 1500 BCE), the Egyptian **Papyrus Ebers** (Figure 1.1) was written. It is considered the oldest book of botanical knowledge, a collection of old folk medicine that was likely copied from books that were hundreds of years older. The papyrus was found in a tomb along with another medical text, the Edwin Smith Papyrus.

Figure 1.1 Papyrus Ebers, column 38. © 2009, Einsamer Schütze.

Numerous herbal remedies are listed, such as *Acanthus*, aloe, balsam, barley, beans, caraway, cedar, castor oil, coriander, dates, figs, garlic, grapes, indigo, juniper, linseed, myrrh, onions, palm, pomegranate, poppy, saffron, turpentine, watermelon, wheat, willow, and zizyphus lotus.

Hippocrates (c. 460–350 BCE) was a Greek physician, often called the Father of Western Medicine. The *Hippocratic Collection*, a compilation of treatises containing medical remedies and most notably the Hippocratic Oath, was attributed to Hippocrates in ancient times. However, scholars now believe the *Hippocratic Collection* was actually written by several authors, perhaps medical scholars from different schools.

Theophrastus (c. 372–287 BCE) was the student of Aristotle and is known as the Father of Botany. After Aristotle's death, he inherited Aristotle's library and garden. Two of his most notable works are *Peri phytôn historia* also known by the Latin title, *De historia plantarum*, "Inquiry into Plants" (ten books) and *Peri phytôn aitiôn*, "The Causes of Plants" (eight books). Theophrastus described roughly 500 plant species, classifying them into four groups: herbs, undershrubs, shrubs, and trees. He noted many anatomical differences and separated flowering from non-flowering plants. Many of the names he gave to plants are still used today.

Pliny the Elder's publication of *Historia Naturalis* (c. 77–79 CE) built upon Theophrastus's work, but *De Materia Medica* (c. 70 CE) by the Roman physician **Pedanios Dioscorides** (c. 40–90 CE) (Figure 1.2) became the authoritative text on botany and medicinal plants for the next 1500 years. Dioscorides traveled as a surgeon with the Roman army, which allowed him to study the features of many medicinal plants. He advocated observing plants in their natural environment, during all stages of growth. *Materia Medica* describes 600 species of medicinal plants, including 100 not described by Theophrastus. These plants include opium and *Mandragora* (mandrake root) as surgical anesthetics, willow for pain relief, and henna for shampoo. Numerous drugs, spices, oils, cosmetics, and beverages still in use today were mentioned in *Materia Medica*. Dioscorides' work became the foundation for modern botany. He formed the connection between plants and medicine, which eventually gave rise to ethnobotany. *De Materia Medica* was widely copied and translated into Arabic and Latin through the Middle Ages.

Claudius Galen (c. 129–199), a Greek physician who brought about "Galenic medicine," is another notable figure of this time period. He wrote *De Alimentorum Facultatibus*, "On the Properties of Foodstuffs," a physiological treatise rather than a *materia medica*. He described a wide range of plants for food and medicine, for all classes of citizens. Some of his works were translated into Arabic and influenced Islamic medicine.

China

Chinese botanical legends date back farther than Queen Hatshepsut, but lack the same documentation. Chinese **Emperor Shen Nong** (Figure 1.3) was a legendary ruler of China. Although he may or may not have been a true historical figure, he is considered the founder of Chinese Herbal Medicine. Legend says that he wrote *Pen Ts'ao Ching*, "Great Herbal," in 2700 BCE. Modern researchers believe it was actually a compilation of oral traditions, written around 200–300 CE. The original text is no longer in existence, but it was said to be a catalog of 365 medicines from plants, minerals, and animals that formed the foundation of Chinese medicine. Emperor Shen Nong is credited with

Figure 1.2 Portrait of Dioscorides receiving a mandrake root in an early sixth-century copy of *De Materia Medica*.

the discovery of tea when a tea leaf accidentally landed in his pot of boiling water. He taught his people to plow the land and cultivate grains. Legend says that his love for plants lead to his demise, as he was poisoned by a toxic plant.

The oldest known traditional Chinese medicine text, *Huangdi Neijing*, "Yellow Emperor's Cannon" (c. 300–100 BCE), predates Dioscorides' *De Materia Medica*. Two influential herbalists emerged during the Han Dynasty (c. 202 BCE–220 CE), Zhang Zhongjing and Hua Tuo. **Zhang Zhongjing** (c. 150 CE–219 CE) was a physician, the Hippocrates of China and the Father of Medical Prescriptions. His text *Shang Han Lun*, "Treatise on Cold Damage Disorders," contains remedies still used in Chinese medicine today. It is one of four books students of Chinese medicine are required to study. Zhang Zhongjing advocated treatment according to symptoms, using a combination of acupuncture and herbs. **Hua Tuo** (c. 140–208 CE) was a physician best known for introducing the use of wine and hemp (Ma Fei San) for surgical anesthesia. There is speculation among scholars that Ma Fei San may have actually contained more potent anesthetics such as opium or other powerful alkaloids from *Datura, Aconitum*, or *Mandragora* species.

Figure 1.3 Shennong, one of the mythical emperors of China, Indian ink on silk by Xu Jetian.

India

Ayurveda, Indian naturalistic medicine, came about sometime during the sixth century BCE. The Saṃhitâs or "collections" are the main source of recorded knowledge for Ayurveda. The chronology remains unclear, but three primary Sanskrit texts were written c. 100 BCE–600 CE: the Charaka Samhita (c. 100 BCE–100 CE), Suśrutha Saṃhitâ (c. 300–400 CE), and Bheda Samhita (c. 600 CE). Excerpts from the Bheda Samhita are found in the medical portions of the Bower Manuscript (c. 400–600 CE), a birch bark document discovered by British intelligence officer Hamilton Bower in 1890. It also remains unclear if **Charaka**, **Suśrutha**, and **Bheda** were historical figures or divine beings, but they were likely not the authors of the manuscripts that bear their names.

The Middle Ages (500–1500 CE)

Europe and the Arabo-Islamic World

Little progress was made in European botany during the Middle Ages, as manuscripts were destroyed during wars and the fall of the Roman Empire. But it was during this time period that Islamic botany began to thrive. Islam was widespread, and there was extensive travel throughout northern Africa, India, and the Middle East. Abû Ḥanîfa Dînawarî or "**Al-Dinawari**" (c. 828–896) is considered the founder of Arabic botany for

his publication *Kitab al-nabat*, "Book of Plants." The first section of the book contains an alphabetical list of plants, mostly from the Arabian Peninsula. The second section contains monographs of plants and their uses. Al-Dinawari's "Book of Plants" became the authority on Arabic plant names. **Ibn Juljul** (c. 944–1009) built upon the work of Dioscorides, publishing a supplement titled *Maqalah* containing 60 plants not mentioned by Dioscorides. Ibn Sina "**Avicenna**" (c. 981–1037) was considered the father of early modern medicine. His *Qanun (Canon) of Medicine* (1025 CE) (Figure 1.4) is an encyclopedia of medicine based in part on Galen's work from the first century. Book two is a *materia medica* that describes, among other things, plant-based drug treatments for disease. Book five is a formulary of compounded drugs.

Al-Ghafiqi was born near Córdoba, Spain (c. 1100–1165) during the Muslim rule of the Iberian Peninsula. He was an influential physician and medical author, publishing *Kitab al-jami' fi 'l-adwiya al-mufrada*, "Book of Simples," and a *Materia Medica* manual. "Book of Simples" included plants not mentioned in any Greek text or Middle Eastern publications. His *Materia Medica* is considered one of the best from the Middle Ages. **Al-Idrisi** (c. 1100–1166) was born in Morocco, lived and studied in Spain, and traveled extensively throughout the region. He knew many languages and botanical names. In his *Jami' on Materia Medica*, he names botanical drugs in Spanish, Arabic, Berber, Hebrew, Latin, Greek, and Sanskrit. **Ibn al-Suri** (c. 1177–1242) was another physician botanist that traveled extensively. Accompanied by an artist, he documented plants throughout the region, especially in the Lebanon range. His *Materia Medica* contained paintings of plants at different stages in their life cycles and as they looked dried on a pharmacist's shelf. It was the first Arabic book illustrated in color. **Ibn al-Baytar** (c. 1197–1248) was an outstanding Islamic herbalist of the Middle Ages. Born in Malaga Spain, he studied in Seville and published several notable books including *Al-Mughni fi al-Adwiyah*, "The Sufficient"; *Al-Kitab 'l-jami' fi 'l-aghdiya wa-'l-adwiyah al-mufradah*, "The Comprehensive Book of Foods and Simple Remedies"; and a *Materia Medica*. He concentrated on "simples," one-ingredient drugs and remedies. "The Comprehensive Book of Foods and Simple Remedies" contained 3,000 simples listed in alphabetic order. As its title suggests, it was the most comprehensive encyclopedia of simples in the Middle Ages.

There are few (non-Islamic) European botanists worth mentioning from the Middle Ages. **Hildegard of Bingen** (1098–1179) was a German nun who wrote medical texts including *Physica*, based on her experiences in the monastery herb garden. **Matthaeus Platearius** (?–1161), an Italian physician from the medical school in Salerno, wrote *Liber de Simplici Medicina* or "Book of Simple Medicines." This book of simples was an influential guide to herbal medicine throughout the Middle Ages and was used as a prototype for modern pharmacopeias. German scientist and theologian **Albertus Magnus** (c. 1205–1280) was known as Albert the Great and Doctor Universalis. His work *De Vegetabilis et Plantis* contains a detailed descriptions of plant morphology and physiology, distinguishing dicots from monocots. English scholar **Bartholomaeus Anglicus** (c. 1203–1272) wrote the encyclopedia *De Proprietatibus Rerum*, "On the Properties of Things." The encyclopedia contained a section on natural sciences with descriptions of plants and their uses.

China

The Chinese empire also made advances throughout the Middle Ages. **Sun Simiao** (c. 581–682), the King of Medicine, wrote two famous books, *Bei Ji Qian Jin Yao Fang*, "Essential Recipes Worth a Thousand Gold for Any Emergency," and *Qian jin Yi fang*,

Figure 1.4 *Kitâb al-Qânûn fî al-ṭibb* (The Canon on Medicine) by ibn Sînâ.

"A Supplement to Recipes Worth a Thousand Gold." The first book focused on women and children's health and listed over 4500 medical formulas. It was later regarded as the first encyclopedia of clinical practice. The supplement added a further 800 ingredients. He is also well known for his interest in identification and preparation of medicinal herbs. He stressed the importance of collecting genuine plants during the appropriate season:

> Without knowing where the medicines are from, and whether or not they are genuine and fresh, they cannot cure five or six patients out of ten … If you do not know the proper seasons when they should be placed in the shade or in the sun to dry, the result will be that you know their names but do not obtain their intended effects. If you gather them at an improper time, they will be good for nothing just like rotten wood, and you will have made a futile effort.