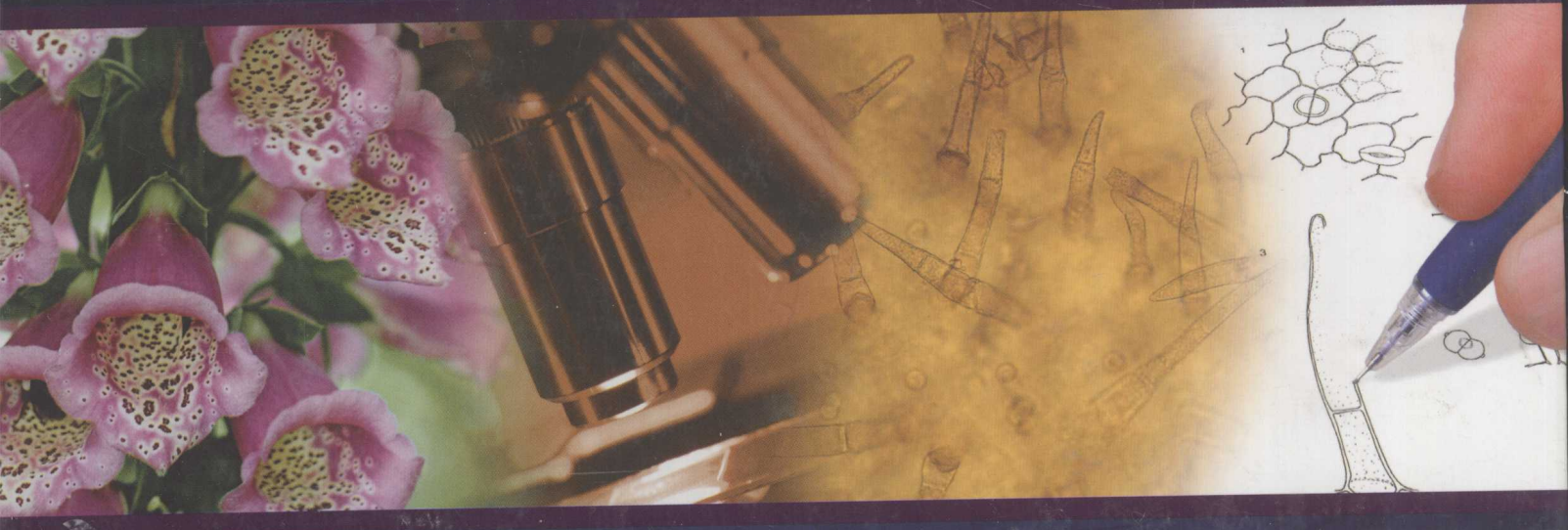
Edited by
Roy Upton
Alison Graff
Georgina Jolliffe
Reinhard Länger
Elizabeth Williamson

Microscopic Characterizations
Reinhard Länger
Elizabeth Williamson

Research Associate
Diana Swisher

American Herbal Pharmacopoeia®

BOTANICAL PHARMACOGNOSY



MICROSCOPIC CHARACTERIZATION OF BOTANICAL MEDICINES

AHP

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American Herbal Pharmacopoeia®

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Editors

Roy Upton, RH, DAyu
American Herbal Pharmacopoeia, Scotts Valley, CA

Alison Graff, PhD
American Herbal Pharmacopoeia, Scotts Valley, CA

Georgina Jolliffe, Pharm PhD, CChem, MRSC
Professor Emeritus, University of London, London, UK

Professor Dr. Reinhard Länger
AGES PharmMed, Vienna, Austria

Elizabeth Williamson, BSc, PhD, MRPharmS, FLS
University of Reading, Reading, UK

Microscopic Characterizations

Professor Dr. Reinhard Länger
AGES PharmMed, Vienna, Austria

Elizabeth Williamson, BSc, PhD, MRPharmS, FLS
University of Reading, Reading, UK

Research Associate

Diana Swisher, MA
American Herbal Pharmacopoeia, Scotts Valley, CA

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Coming together is a beginning. Keeping together is progress. Working together is success.

Henry Ford (1863–1947)

This text is dedicated to Paul Coates and Joseph Betz of the Office of Dietary Supplements (ODS), National Institutes of Health (NIH). They recognized the value of this work in helping to promote botanical microscopy as a quality assurance tool, provided funding, and expressed unrivaled patience in its completion. The text is also dedicated to

Professor Dr. Johannes Jurenitsch and Professor Dr. Wolfgang Kubelka of the Institute for Pharmacognosy, University of Vienna, Austria, who generously provided the technical resources and allowed Professor Dr. Reinhard Länger to develop all of the microscopic characterizations included in this work. This text would not have been possible without their vision, dedication to classical botanical pharmacognosy, and their generosity; and to

Professor Dr. Reinhard Länger, whose unrivaled skill and dedication to botanical microscopy has and will help to keep this important discipline alive for future generations.

FIGURE 1 Professor Dr. Wolfgang Kubelka (left), Prof. Dr. Reinhard Länger (center), Roy Upton (right). University of Vienna Botanical Excursion, Southern Tyrols, Italy (2000).

I do not need to expound at length the pleasure and delight that the knowledge of plants brings, since there is no one who does not know that there is nothing in life more pleasant and delightful than to wander through the woods, and over mountains and meadows, garlanded and adorned these varied, exquisite blossoms and herbs, and to gaze at them with keen eyes. This pleasure and delight is increased not a little if an understanding of their usefulness and powers is added. For there is as much pleasure and enjoyment in learning as in looking.

Leonhart Fuchs, 1542, De Historia Stirpium commentary insignes

FIGURE 2 Yarrow (*Achillea millefolium*); the signature plant of the University of Vienna. (From Woodville, W. *Medical Botany*. 1810.)

Georgina Jolliffe, BPharm, PhD, CChem, MRSC 1923–2010

To give pleasure to a single heart by a single act is better than a thousand heads bowing in prayer.

— **Mahatma Gandhi**

Dr. Georgina Jolliffe with her husband Dr. Geoffrey Jolliffe on Geoffrey's 80th birthday (2008).

Dr. Georgina Jolliffe, who served as a technical editor for this text, passed away before she could enjoy the fruits of her labor. According to her husband Geoffrey, Georgina worked on this text for the "sheer love of it." Georgina was fondly remembered by many students, friends, and family members as a kind and gentle soul whose academic excellence and achievements were equally matched by her personal kindness and generosity.

Dr. Jolliffe worked with AHP for a period of almost four years reviewing every aspect of the introductory chapters and providing detailed commentary on the more than 140 microscopic characterizations contained in the Atlas portion of the text. It is perhaps fitting that her last work will have been in the development of the first English-language botanical medicine text to unite classic illustrations of microscopic structures with modern microphotographs of the same structures and tissues. This work will help keep alive

one of her passions—botanical microscopy—at a time when worldwide it has been on a steady decline, and is once more on the rise. Georgina's academic excellence coupled with her practical experience was a great contribution to the text, and we are grateful that *Microscopic Characterization of Botanical Medicines* is a part of her legacy as she is now a part of the legacy of the American Herbal Pharmacopoeia.

Foreword

American Herbal Pharmacopoeia: Botanical Pharmacognosy — Microscopic Characterization of Botanical Medicines provides an excellent historical treatment of botanical nomenclature, a review of the science of taxonomy, and strong arguments for the need, necessity, and ability to identify and standardize crude drug material. Scattered throughout the first ten chapters are numerous, excellent photomicrographs and line drawings of the microscopic features of whole and powdered drugs and photographs of whole crude materials. It is through this mechanism that the botanical nomenclature associated with plant analysis is primarily illustrated. The historical value and methodologies of this tome set the stage for the primary practical value of this book, i.e., that it provides detailed descriptions and microscopic elements of more than 135 species of widely used botanical dietary supplements and major pharmaceutical species. All of the descriptions of the included species are clearly and accurately described and the line drawings representing various microscopic features and photomicrographs are of high quality.

As one of four graduate students at the Massachusetts College of Pharmacy, it was an honor and privilege to know the now-deceased Heber W. Youngken, Sr., who taught us the elements described in this book in a course titled "Technical Microscopy." This book would have further extended my knowledge of crude drug identification if it was available at the time that I was a graduate student. I have always found that Roy Upton, the major driver for this work, has a long history of producing botanical monographs and his work and passion for botanicals has been clear, thorough, and accurate, which is exemplified in this textbook of botanical microscopy. It will soon become the major authority on the microscopic identification of crude botanical ingredients.

Norman R. Farnsworth, Ph.D., dr. hc (mult.)
UIC Distinguished Professor
Research Professor of Pharmacognosy
University of Illinois at Chicago

Foreword

Progress of science depends on progress in methodology.

The validity of the quotation above has been proven repeatedly during the last few decades, particularly by the development of chromatographic methods in plant sciences and pharmacognosy, from Tswett's simple column chromatography, to PC, TLC, GC, and HPLC, combined with MS and NMR. By means of these methods, new insights into the variety of secondary plant metabolites, almost inconceivable before, were obtained. Additionally, methods like DNA-analysis, aimed at the exploration of various –omics, nowadays seem to solve many problems.

However, a big mistake sometimes made by enthusiastic younger (or even more experienced) researchers is to proclaim the newest technologies as the "best," and to declare older methodologies as "classical" or "old-fashioned," and therefore no longer useful and valid. Only if a new method brings better solutions to an analytical problem should it replace its predecessors. This, for example, holds true for the replacement of paper-chromatography by modern chromatographic techniques—but it is definitely not valid for microscopy!

In the 1970s, I was a postdoc with Jack L. Beal and Raymond W. Doskotch at Ohio State University, where microscopy was no longer among the required courses for pharmacy students. This was very embarrassing for me! As a student of pharmacy at the University of Vienna I had fallen in love with the microscopy of herbal drugs. Not only did the microscope reveal an amazingly different world for me, it was also of enormous practical value. I was able to identify an unknown powder of a dried leaf, seed, or root, or even mixtures of plant materials, within a few minutes, a skill admired by botanists who could not imagine how this was possible. I came to understand why there was a disregard for microscopy in the US pharmacy curriculum when I visited US drug stores. In contrast to my home country of Austria, at that time there were almost no herbal drugs to be found among all the synthetic medications. Thus, of course, there was no need for pharmacy students and pharmacists to study and master microscopic analysis of herbal drugs.

Meanwhile, the wheel has turned almost completely around! Worldwide there is a dramatic increase in popularity and acceptance of herbal medicines, and the classical tools of the "traditional" pharmacognosist, in particular microscopy, are urgently needed for the assessment and quality control of plant products, be it crude herbal drugs, registered herbal medicinal products, over-the-counter herbal products, or health foods, all of which are used by large segments of the population for self-medication. While in the second half of the last century herbal medicines increasingly disappeared from pharmacopoeias, this trend is reversing as we enter the 21st century. Modern pharmacopoeias (e.g., the European Pharmacopoeia) offer new monographs on herbal drugs, including

their microscopic characterization, and the medicinal effects of new plants continue to be discovered. In contrast, there is a dramatic decline in the number of analysts capable of utilizing the advantages of microscopy!

Thus, when I first heard about the development of a text describing microscopic techniques and their application to herbal drug analysis, from the herb-enthusiastic director of the American Herbal Pharmacopoeia (AHP), Roy Upton, I was very excited about the project and immediately offered the collaboration of the Institute of Pharmacognosy, University of Vienna. In Vienna, the use of the microscope for pharmacognostical analysis is based on a longstanding tradition. Many notable pharmacognosists have worked here. Most notable among these are: Johann Adam Schmidt (1759-1809), the originator of the terms "pharmacognosis" and "pharmacodynamics," Carl Damian Schroff (1802-1887), Joseph Moeller (1848-1924), and August Emil Vogl (1833-1909). Vogl was the founder of microscopic investigation of foods and, when presented with the Hanbury medal, was described as the "Father of pharmacognosy." Vogl himself performed more than 50,000 microscopical examinations. Having studied pharmacognosy within this tradition, one of the authors of this work, Reinhard Länger, with his skill and dedication to botany and pharmacognosy, has helped to keep alive this vital discipline. Since there was no relevant modern text available in English, he enthusiastically agreed to contribute his microscopy skills both to the development of AHP monographs and to this text.

From simple practical instructions on how to conduct a microscopic analysis, particularly useful for beginners, to the selected 140 specific monographs of plant drugs on the market, there is an abundance of newly prepared photos and illustrations, altogether allowing an ideal access to the method itself and to solutions of specific problems arising with the identification of herbal drugs and their adulterations. Indeed, the book represents the passion and vitalism of traditional herbalists, combined with the scientific knowledge of academic pharmacognosists. In developing this text, the AHP and its director, Roy Upton, are helping to revitalize botanical microscopy as a unique, valuable, rapid, and cost-effective assessment tool.

Microscopy undoubtedly will, and rightfully should, be recognized for the important role it continues to play in the authentication and assessment of medicinal plants. Hopefully, AHP's microscopy text will encourage many people involved in practical plant drug analysis to once more make greater use of the microscope, and help experienced analysts solve their botanical authentication problems. It was a great pleasure and honor to collaborate with the AHP in bringing this work to fruition!

Professor Dr. Wolfgang Kubelka
Professor Emeritus
University of Vienna

Preface

The ox is slow but the earth is patient.

Ancient Chinese proverb

Almost 10 years in the making, the impetus for this text arose from a newfound and blossoming respect for the nearly departed but reemerging field of classical botanical pharmacognosy that has come to be embodied in the work of the American Herbal Pharmacopoeia® (AHP). Botanical pharmacognosy represents a focus on the botanical aspects of pharmacognosy whereby the plant and its growing habitat, harvesting, and processing conditions—rather than just the chemistry—are of central importance in ensuring the plant's medicinal efficacy. This is distinctly differentiated from modern pharmacognosy as it is typically represented in the West today.

In the former paradigm of classical botanical pharmacognosy, it is the quality of the plant, the environment in which it grew, and its myriad compounds and actions that are of utmost importance and most appropriate in the development of traditional herbal medicines that people worldwide rely upon in self-healing and traditional healing systems. In stark opposition, in modern pharmacognosy, it is the almost exclusive emphasis on the isolation of chemical compounds and specificity of an action that is centrally important for modern drug discovery and development, predominantly for commercial purposes. However, worldwide interest in traditional herbal medicines is reemerging precisely because modern drugs, whether synthetic or derived from nature, are failing to serve the health care needs of the people.

This text was developed because of the need for botanical quality assessment, which is the reason that a distinction between classical botanical and modern pharmacognosy is made. AHP's specific emphasis on botanical microscopy grew out of the fact that microscopic characterization was a cornerstone of the classical botanically descriptive discipline of nineteenth and early twentieth century pharmacognosy. So central was microscopy to pharmacognosy that Professor Norman Farnsworth, professor emeritus of the University of Illinois, Chicago, referred to microscopy as "pharmacy's unique contribution to science."

However, botanical microscopy is a dying art in North America and Europe, though it is alive and well in other, mostly developing nations. Our work in developing microscopic characterizations for AHP monographs as a fundamental identity test has underscored for us the value and importance of microscopy as a quality assessment tool. Thus, we embarked upon this project as our way of helping to preserve and reenergize this scientific discipline.

The practical genesis of this text came from discussions within the Standards Committee of the American Herbal Products Association (AHPA) on microscopy as an important analytical tool. There were suggestions to take some of our old out-of-print microscopy texts and put them into circulation once again. Concern was raised that a

number of the early microscopic characterizations were not developed from authentic specimens and were not representative of materials in trade, and that characterizations of many of the botanicals in use today were not available. Thus, it was determined that the most appropriate course of action was to begin the process of developing microscopic characterizations anew.

The technical genesis of this work evolved from original microscopy characterizations developed in the 1980s for the British Herbal Pharmacopoeia by Dr. Elizabeth Williamson, professor of pharmacy and director of practice at the School of Pharmacy, University of Reading, and formerly of the University of London School of Pharmacy. At the time, there were few texts in the modern English-language literature on microscopy, and many of the botanical ingredients used in modern herbal medicine were not included. Many of the texts also focused on powders and illustrations only and did not include cross-sections of relatively whole botanicals and photomicrograph images. Often, what was once available was out of print.

AHP was then introduced to Professor Dr. Reinhard Länger, currently of the Austrian Agency for Health and Food Safety (AGES), the Austrian equivalent of the Food and Drug Administration, and former lecturer in pharmacognosy at the Institute of Pharmacognosy of the University of Vienna. Dr. Williamson and Professor Länger are two of the leading experts on botanical microscopy in the West. AHP set out to gather botanically authenticated samples to replicate, confirm, and add to Dr. Williamson's earlier work, creating cross-sectional descriptions, illustrations, and photomicrographs. We gave particular emphasis to ensuring that characterizations were representative of the species and also gave emphasis to the differentiation between authentic plant specimens and potentially adulterating species. These two works were cross-referenced against each other as well as other works of botanical microscopy to ensure accuracy, consistency, and completeness. The culmination of this endeavor is the collection of microscopic characterizations presented in this text.

As interest in traditional herbal medicines grows, so does the need for the tools of classical botanical pharmacognosy. Alexander Tschirch (1856–1939), a noted pioneer in the early development of pharmacognosy and professor of pharmacognosy at the University of Bern, Switzerland, described pharmacognosy as a discipline that predated any of the branches of pharmacy. Tschirch described herbalists as the first pharmacognosists by virtue of their detailed examination and codification of medicinal plant knowledge. Thus, it is perhaps fitting that it is an *herbal pharmacopoeia* that gives emphasis to this wonderful art and science once again.

If any insult is visited upon pharmacognosists of today due to this text's overwhelming and highly biased emphasis on the botanical versus chemical or molecular aspects of modern pharmacognosy, the fault lies only with me and I offer my sincere apologies. This is our attempt to help in the revitalization of the *botanical* aspects of pharmacognosy and once again highlight the value of botanical microscopy as an important quality assurance tool, hopefully helping to bring this discipline full circle.

Roy Upton
Herbalist
Executive Director
Editor
American Herbal Pharmacopoeia®

Acknowledgments

Volunteers do not necessarily have the time; they just have the heart.

Elizabeth Andrew, author, ***On the Threshold: Home, Hardwood, and Holiness***

This work was a labor of many hands. Numerous individuals and organizations generously provided botanical samples, voucher specimens, editorial comments, and other forms of support and guidance to help make this the most comprehensive English-language work of botanical microscopy in the modern botanical pharmacognosy literature. On behalf of the authors, editors, and board of directors of AHP, we extend our sincerest thanks to those who have helped make this work one of the most seminal texts in the modern botanical microscopy literature and to return botanical microscopy to its rightful place as a valuable quality assessment tool.

Pavel Axentiev, MS
American Herbal Pharmacopoeia
Scotts Valley, California

Denise Blume, PhD
Natural Products Inc.
Boone, North Carolina

Angie Brackhahn
Trout Lake Farms
Trout Lake, Washington

John Cardellina, PhD
Reeves Group
Walkersville, Maryland

Lynette Casper, BS
Planetary Herbals
Scotts Valley, California

Rupa Das
Botanicals International
Long Beach, California

Prashanti De Jager
Organic India
Lucknow, India

Andy Ellis
Spring Wind Herbs
Berkeley, California

Ed Fletcher
Strategic Sourcing
Boone, North Carolina

Julia Gross, pharmacist
PhytoLab
Vestenbergsgreuth, Germany

Nancy Hensold, PhD
Field Museum, University of Chicago
Chicago, Illinois

Katie Huggins
Traditional Medicinals
Sebastopol, California

Vaishali Joshi, PhD
National Center for Natural Product Research
University of Mississippi
University, Mississippi

Joe-Ann McCoy, PhD
United States Department of Agriculture
North Central Regional Plant Introduction Station
Iowa State University
Ames, Iowa

Allison McCutcheon, PhD
Canadian Herb Society
British Columbia, Canada

Pulok K. Mukherjee, MPharm, PhD, FIC, FRSC
School of Natural Product Studies
Department of Pharmaceutical Technology
Jadavpur University
Kolkata, India

Vikram Naharwar, PhD
Amsar Natural Products
Indore, Madhya Pradesh, India

Belinda Pardue
Botanical Supply Inc.
Boone, North Carolina

Darlene Pickell
Botanicals International
Long Beach, California

Sebastian Pole
Pukka Herbs, Ltd
Bristol, United Kingdom

Qi Baochan, PhD
Liaoning Provincial Institute for Control of Food and Drug
Shenyang, China

Eike Reich, PhD
Camag
Muttenz, Switzerland

Klaus Reif, PhD
PhytoLab
Vestenbergsgreuth, Germany

Otto Sticher, PhD
Institute of Pharmaceutical Sciences
Eidgenössische Technische Hochschule
Zurich, Switzerland

Elan Sudberg, BA
Alkemists Pharmaceuticals
Costa Mesa, California

Sandy Sudberg, MT, ASCP
Alkemists Pharmaceuticals
Costa Mesa, California

Sidney Sudberg, DC, RH, LAc
Alkemists Pharmaceuticals
Costa Mesa, California

Michael and Martha Volchok
Blessed Herbs
Oakham, Massachusetts

Mark Wheeler
Pacific Botanicals
Grants Pass, Oregon

Eric Wong
Chromap Institute of Science and Medicine International Ltd.
Hong Kong, China

Xie Peishan, PhD
Guangzhou Institute for Drug Control
Chromap Institute of Science and Medicine International Ltd.
Guangzhou, China

Yang Chongren, PhD
Kunming Institute of Botany
Kunming, China

Zhao Zhongzhen, PhD
School of Chinese Medicine
Hong Kong Baptist University
Hong Kong, China

About the Editors, Authors, and Associates

Many hands make light work.

John Heywood (1497–1580), English playwright and poet

Editor

Roy Upton, herbalist, has been working and practicing professionally as an herbalist since 1981. Trained in ayurvedic, Chinese, Caribbean, and Western herbal medicine traditions, Roy is the founder, executive director, and editor of the American Herbal Pharmacopoeia; is cofounder, past president, and current vice president of the American Herbalists Guild (AHG); and serves on the General Chapters Committee of the United States Pharmacopeia (USP) and botanical expert advisory committees of AOAC International, the American Botanical Council, and NSF International. Roy is visiting faculty for Tai Sophia (Laurel, Maryland) and lecturer for the Complementary and Alternative Medicine Program at the University of California School of Pharmacy (Los Angeles, California). Roy is also the staff herbalist for the California-based herbal supplements company Planetary Herbals and is a member of the Standards Committee of the American Herbal Products Association.

Technical Editors

Alison Graff, PhD, works as a biologist for the state of California and does private consulting in the field of rare plant conservation. From 2000 to 2006, she worked as monograph development coordinator and associate editor at AHP. Dr. Graff received her doctorate in plant ecology from Washington University and the Missouri Botanical Garden and has taught plant systematics and plant anatomy at the University of California. She worked tirelessly on facilitating the detailed editing and cross-referencing of all the microscopy descriptions, providing important contributions to a number of chapters and bringing this text to completion.

Georgina Jolliffe, BPharm, PhD, CChem, MRSC, was senior lecturer in pharmacognosy at Chelsea College (now King's College), University of London. Her interests focused on analytical work involving microscopy and chemical analysis. Her particular interest in chromatographic techniques and microscopic analysis also led to the teaching of