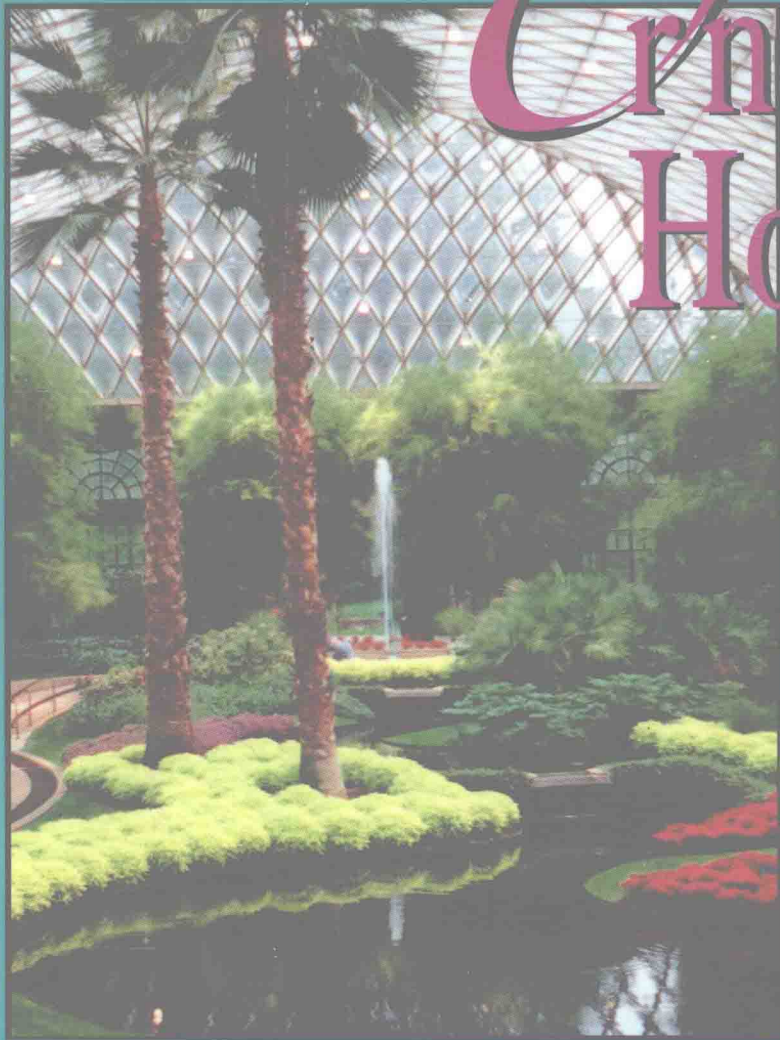


2nd Edition



Ornamental Horticulture

SCIENCE,
OPERATIONS,
& MANAGEMENT

Jack E. Ingels

ORNAMENTAL HORTICULTURE: SCIENCE, OPERATIONS & MANAGEMENT

2nd edition

JACK E. INGELS

State University of New York
College of Agriculture and Technology

Cobleskill, New York

NOTICE TO THE READER

Publisher does not warrant or guarantee any of the products described herein or perform any independent analysis in connection with any of the product information contained herein. Publisher does not assume, and expressly disclaims, any obligation to obtain and include information other than that provided to it by the manufacturer.

The reader is expressly warned to consider and adopt all safety precautions that might be indicated by the activities herein and to avoid all potential hazards. By following the instructions contained herein, the reader willingly assumes all risks in connection with such instructions.

The publisher makes no representations or warranties of any kind, including but not limited to, the warranties of fitness for particular purpose or merchantability, nor are any such representations implied with respect to the material set forth herein, and the publisher takes no responsibility with respect to such material. The publisher shall not be liable for any special, consequential, or exemplary damages resulting, in whole or in part, from the readers' use of, or reliance upon, this material.

Cover photo courtesy of Jack Ingels

Cover Design: Judy Orozco and Wendy Troeger

For information, address Delmar Publishers Inc.

3 Columbia Circle, Box 15-015

Albany, New York 12212

Delmar Staff

Publisher: Tim O'Leary

Associate Editor: Cathy L. Carter

Production Editor: Wendy Troeger

COPYRIGHT © 1994

BY DELMAR PUBLISHERS INC.

The trademark ITP is used under license.

All rights reserved. No part of this work covered by the copyright hereon may be reproduced or used in any form or by any means—graphic, electronic, or mechanical, including photocopying, recording, taping, or information storage and retrieval systems—without written permission of the publisher.

Printed in the United States of America
published simultaneously in Canada
by Nelson Canada,
a division of The Thomson Corporation

5 6 7 8 9 10 XXX 00 99 98

Library of Congress Cataloging-in-Publication Data

Ingels, Jack E.

Ornamental horticulture : science, operations &
management / Jack E. Ingels.

p. cm.

Includes bibliographical references (p. 525) and index.

ISBN 0-8273-6364-8 (text)

1. Ornamental horticulture. I. Title.

SB404.9.I54 1994

635.9—dc20

93-28344

CIP

Preface

Ornamental horticulture is a multifaceted industry which offers challenging employment opportunities. Those who have a basic understanding of plant science, its applications to practical growing situations, the crafts of horticulture, and business practices as applied in horticulture will find themselves better prepared to accept the challenges of the industry.

ORNAMENTAL HORTICULTURE: SCIENCE, OPERATIONS & MANAGEMENT was written because the author saw an educational need not being served by texts previously available to students. The texts either presented the science of horticulture at too high a level and in too much depth, or provided merely an overview of the industry techniques without giving the necessary scientific basis of those techniques. As a result, these texts fail to provide the necessary blend of theory and practical application that makes the subject more meaningful to the beginning student. ORNAMENTAL HORTICULTURE: SCIENCE, OPERATIONS & MANAGEMENT fulfills this need for the beginning student who has no prior academic training or work experience in the industry. It is the author's intent to write a truly comprehensive text that would inspire the beginning ornamental horticulturist with an initial enthusiasm for the subject and sustain it throughout the program.

SCOPE OF THE TEXT

Unlike other texts that emphasize one aspect of the subject more than others, this text offers a balanced study of ornamental horticulture as an applied sci-

ence, a craft, a profession, and a business. Section I consists of six chapters devoted to the science of ornamental horticulture. Plant structure and the mechanisms by which plants survive (photosynthesis, respiration, and transpiration) are described. This information is essential to an understanding of how the manipulation of the environment will affect plant growth and response. The role of soil (both natural and that made by horticulturists) in plant growth and nutrition is thoroughly explained. The basic binomial plant classification system is described. Methods of controlling plant growth through the use of natural and synthetic growth regulators are also explained. The very important area of plant reproduction, both sexual and asexual, is described in detail. The discussion includes the most common methods of propagating plants and their application in the professions of ornamental horticulture. The plant science section concludes with a discussion of common plant pests/diseases, including common symptoms of injured plants, principles of pest control, types of pesticides and their safe use, and the concept of biological controls. A color section is also provided in the text and gives full color examples of common plant pests/diseases.

Once the student has a basic understanding of plant physiology and how plants interact with their environment, the author discusses the application of plants in the various segments of ornamental horticulture. In Section II, the author presents the principles of floral design and describes the experiences

and skills needed by a floral designer; discusses the status of the interior foliage plant industry, the problems unique to the interior use of plants, and the cultural requirements; presents the principles of landscape design with checklists and numerous examples; describes the procedures involved in the installation of trees, shrubs, groundcovers, vines, bedding plants, and bulbs and their cultural requirements; covers the maintenance of landscape plantings, including watering, fertilizing, mulching, pruning, winterizing and weed, insect, and disease control; presents basic principles of using vines in the landscape, espalier pruning, topiary pruning, and bonsai; discusses turfgrasses to meet the needs of differing environmental conditions and uses, presents common methods of turf installation, and outlines a maintenance program for professional lawn care; and concludes with a discussion of propagation techniques, including tissue and organ culture.

Section III discusses the major professions of ornamental horticulture: the floriculture industry, the nursery industry, and the landscape industry, as well as specialized, nontraditional career opportunities. Each chapter describes the unique characteristics of the industry segment, including any specialized educational requirements for workers. The author also points out that interest, training, and skills in ornamental horticulture can be adapted to an assortment of career fields.

Section IV concentrates on the business and production techniques of ornamental horticulture. The chapter on growing structures covers the types of structures used, systems utilized to grow plants, and the physical layout of plant production areas. This is followed by a discussion of specific growing techniques used for greenhouse production. The author then distinguishes between the different types of nurseries and provides typical production techniques for each. The final chapters of the section concentrate on business management techniques. As a business, ornamental horticulture is governed by the same forces to which every business must respond if it is to be successful. Too many other texts over-

look or ignore the fact that ornamental horticulture is a consumer-driven industry requiring skillful business management methods. This text is the first to offer equal coverage of this aspect of the profession.

STRUCTURE OF THE TEXT

The structure of **ORNAMENTAL HORTICULTURE: SCIENCE, OPERATIONS & MANAGEMENT** is designed to support and enhance the learning process. Each chapter opens with clearly stated learning objectives. These objectives are accomplished by means of the well-organized text material and the most extensive collection of photographs and drawings of any textbook written on this subject. Student mastery of the learning objectives is measured at the end of each chapter in the achievement review. The answers to the achievement reviews are provided in an Instructor's Guide. Wherever possible, the information has been summarized in tables for ready reference. All terms are defined upon first use in the text and again in a comprehensive glossary at the end of the text. Two appendices are included, following the glossary, for the student's reference. One appendix is a list of professional and trade organizations for horticulture and related areas, while the other is a list of selected readings for the study of ornamental horticulture.

ABOUT THE AUTHOR

Jack E. Ingels holds a Board of Trustees' Distinguished Teaching Professorship at the State University of New York's College of Agriculture and Technology at Cobleskill. His undergraduate schooling was at Purdue University and his graduate schooling was at Rutgers University. His fields of specialization include ornamental horticulture, landscape design, plant physiology, and plant pathology. He is an experienced university teacher with a diverse practical background in industry as well. He is also the author of *Landscaping: Principles and Practices*, one of the most successful texts in Delmar's agriculture series.

Acknowledgments

The following individuals devoted their time and considerable professional experience to reviewing the manuscript. Their critical insights were a valuable component in ensuring the integrity of this text.

Richard Austin
Olympia Technical Community College
Olympia, WA 98502

Charlie P. Giedeman
Belleville Area College
Belleville, IL 62221

John J. Ball, Ph.D.
University of Minnesota Technical College
Waseca, MN 56093

Susan Wilson
University of Tennessee
Knoxville, TN 37901

John M. Centko
Valencia Community College
Orlando, FL 32802

James W. Boodley, Ph.D.
Development Horticulturist
Smithers-Oasis Company
Kent, OH 44240

Cathy Haas
Hartnell College
Salinas, CA 93901

The author wishes to thank the following individuals, organizations, and companies for providing illustrations or technical information for this textbook.

Sharlotte Albert
James and Linda Angell, Floral Designers
Arnold Arboretum of Harvard University
Mark Barry
Beverly Becher
Beckman Industrial Corporation, Cedar Grove
Division
A. T. Bianco Landscaping and Nursery
Big John Tree Transplanter Manufacturing
Brooklyn Botanic Garden

J. A. Buck, General Electric Lamp Marketing
Department
Carefree Garden Products
ChemLawn Corporation
Chevron Chemical Company
Council of Linnean Society of London
Design Imaging Group
Stephen DiCerbo, Illustrator
Economy Label Sales Company
John Farfaglia

Frank Ferraro, Jr.
Terry Forsyth
James Glavin, Landscape Architect
Albert Glowacki Landscape, Inc.
Cari Goetcheus, Illustrator
Carol Holliday
Michael Horaz, Bonsaist
Rodney Jackson, Photographer
Thomas Kenly, Landscape Designer
Lake County Nursery Exchange
Lord and Burnham, Division of Burnham
Corporation
J. J. Mauget Company
Monrovia Nursery Company
Michael Montario
Emily Morgan
Sheryl Morzella
National Garden Bureau, Inc.
Jean Oppenheim
Stanley Pendrak

Greg Perez
Kelly Pottenburgh
Scott Raas, Landscape Designer
Olga Ressler
Mark Scelza
Schaefer Nursery
Peter Snopsky
Solar Sunstill, Inc.
Speedling Florist
Linda Stacey
Jere Tatich, Landscape Architect
3M Agrichemicals Corporation
Timothy Toland, Illustrator
Kathy Tripp
United States Department of Agriculture
Richard Vedder
Weather-Matic Corporation, Division Telsco
Industries
Ray Wyatt
Robert Yates, Landscape Designer

Foreword:

A Brief History of

Ornamental Horticulture

It is easier to define and distinguish the crops and crafts of ornamental horticulture from the rest of horticulture than to separate the historical antecedents of ornamental horticulture from those of pomology, forestry, and vegetable production. Several factors account for the difficulty of assigning specific dates to the horticultural time line for ornamentals. Foremost among these factors is the changing way people have used and regarded many of the plants of horticulture over time. Today's flowering specimen trees were commonly more prized for their fruit in centuries past. Even their importance as food suffered inconsistencies. For example, peaches were once as important for hog feed as for peach brandy. Today, certain cultivated varieties of peaches may be used for the landscape value of their flowers, with their fruit regarded as little more than a maintenance nuisance. Olive trees have undergone a similar change of purpose in landscape use.

The development of ornamental horticulture has accompanied the evolution of a worldwide system of agriculture, but it has not paralleled that development. Agriculture reaches back to primitive cultures and to the cultivation of edible plants, which began when the reliable availability of wild game waned.

The biblical Garden of Eden is not possible to date,

but its influence in ornamental horticulture has been great. Several Western cultures have set the Garden of Eden as an ideal standard to strive toward in the development of their gardens. Eastern cultures have similar romanticized ideals of the garden as a spiritual paradise, and those ideals have frequently influenced the design of their earthly landscapes.

Aside from the religion-based garden influences, there are documented records of gardens as far back as the ancient Egyptians and Sumerians, over 5,000 years ago. Irrigation made arid lands productive, and the selective production of preferred plants began. Although food provision was undoubtedly the major purpose of these ancient gardens, the Egyptians were among the earliest civilizations to cultivate plants for their aesthetic values. Their interest in plants as sources of spices, fragrant oils, and fibers eventually progressed to the development of formal gardens around the homes of the affluent. For centuries the Egyptians refined their techniques of horticulture production. Their pictorial and written documentation of the plants important to them throughout their thirty-five centuries of cultural dominance comprise a great legacy that will keep scientists and historians busy for years.

As human society evolved and advances were made

in agricultural technology, those civilizations that were attentive to the stewardship of their land tended to last longer than those such as ancient Greece, which flourished brilliantly but briefly on the calendar of Mankind. After the Egyptians it was not until the era of the ancient Romans, about 2,500 years ago, that ornamental horticulture was again recognized as having value in the lives of people. The Romans were the photocopy society of history, borrowing extensively from the agricultural and horticultural knowledge of Egypt and Greece. However, to their credit, they refined and improved the techniques and proved themselves to be much better stewards of their land than the Greeks, whose culture they supplanted. It was the Romans who introduced grafting and budding as common propagative techniques.

Ancient Rome exemplified what many would regard as a regrettable accompaniment to the appreciation and advancement of ornamental horticulture. As a result of its total cultural dominance of the known world, its unchallenged military might, its enslavement of weaker societies, and its supreme self-assurance, Rome's wealthy citizens were free to practice civility at the highest levels. They built gracious villas at the center of large farms. Directly adjoining the villas were large gardens that extended the spaciousness of the indoors to the outside. Those villa gardens were usually walled to permit greater control of the growing environment and the development of the owners' fantasies. Formal patterns, water features, sculpture, flower plantings, pruned shrubbery, and carefully planned paving patterns created outdoor rooms whose primary purposes were visual enjoyment and leisure time pleasure.

Had Rome not fallen, it is interesting to wonder how the history of ornamental horticulture would be written today; but decline and fall it did. With the demise of Rome, Western civilization plunged into the Dark Ages. Surviving only fragmentally in the small protected gardens of monasteries scattered across Europe, ornamental horticulture did not return to favor until the Renaissance, which began in Italy in the sixteenth century.

The gardens of the Italians of that century were joyous rediscoveries of their rich Roman ancestry, whose ruins were literally strewn at their feet. Once again confident of their power to exercise control

over their environment, Italians of the sixteenth century built large formal gardens that were as remarkable for their engineering as for their aesthetics. The technology of the time allowed the Italians to transform their steep hillsides into broad terraces for pleasurable human activity. Lavish water displays resulted from the redirection of rivers and streams into and out of the gardens. With the sculpture of heathen Rome still abundant, former marbleized deities assumed new roles as novel ornaments in the gardens of Christian Italy.

In the seventeenth century, France continued the tradition of lavish formal garden development on a scale even larger and grander than that of the Italians. As the lead player on the stage of Western civilization, France, during the reigns of the Louises, affirmed again that gardens and ornamental horticulture paralleled the growth of military prowess, power, and wealth more than the improvement of agricultural technology. While many less fortunate citizens of France were barely subsisting, the great formal garden master André LeNotre was creating living works of art at Versailles and other sites throughout France. His apprentices spread throughout Europe, attempting to bring the gardens of every other country into compliance with the formal, Baroque tradition of France. While the French gardens were seemingly simple—symmetrical balance, walk intersections marked by a fountain or piece of sculpture, plants sheared into sculptural shapes (topiary), and a design most intricate and complex near the building, becoming less intense as it advanced toward the surrounding countryside—few were able to match the genius of LeNotre. Also, not every garden site could duplicate the vast flatness of France, where the gardens could cover hundreds of square miles and create the desired impression of limitless luxury and extravagance.

England, in the eighteenth century, brazenly rejected the belief that landscapes must be formalized and display the heavy hand of Man in order to qualify as a garden. With a court life less formal than that of the French and a more free-willed aristocracy, England was receptive to the influences of men like William Kent, Lancelot "Capability" Brown, and Humphrey Repton, who believed formality to be anti-Nature. The English Naturalism style gained such popularity throughout the British Isles that centuries-old formal

gardens were swept away, to be replaced with grassy landscapes whose groupings of trees, carefully shaped lakes, serpentine streams, distant views of grazing sheep, fabricated grottoes, and manufactured ruins atop distant hillsides fit their designers' ideas of how a romantic Eden-like paradise landscape should appear. Nowhere was a straight, formal line, sheared plant, or splashing fountain to be seen. Yet these naturalistic gardens were just as contrived as their formal Continental predecessors. Observing these gardens today, many wonder what was so special about them. They are so parklike and so evocative of a drive through the open countryside, it is easy to forget that at the time of their development they were as extraordinary as was the horseless carriage at the start of the Industrial Revolution.

The other great contribution of the English in the history of ornamental horticulture was their role as plant collectors. Their fondness for plants is almost genetic. As they moved back and forth across the civilized and not-so-civilized world, English explorers took and/or collected plants with them. In addition, they wrote about the plants they collected and even preserved pressed samples of them, much to the benefit of later botanists and taxonomists. They established great botanic gardens for the propagation, study, and public display of their plant bounty collected from the far reaches of the empire. Also, though the English did not invent greenhouses, the orangeries of the aristocracy planted the benefits of indoor plant production into our historic consciousness.

Concurrent with the evolution of ornamental horticulture in Europe, but separated both geographically and attitudinally, were the gardens of Asia. First the Chinese, then the Koreans, and later the Japanese used plants within and surrounding their homes in ways that most Westerners can never fully comprehend. Closely tied to their Buddhist and Shinto faiths, oriental Asians perceived themselves as being a part of the natural world, not separate from and dominant over it. In their cities, crowded even centuries ago as they are today, gardens were small by comparison to Europe's. The gardens were walled and within their confines the Orientals developed gardens that ranged from lush and green (the Buddhist paradise gardens) to stark and minimal (the Zen

gardens). Plants were pruned and trained to represent their larger counterparts outside the walls. In more abstract uses, plants represented mountains, clouds, islands, and other nonplant elements of the natural world. The intent was to represent the larger, not-so-perfect, natural world in scaled-down, perfect form. Shinto gardeners frequently believed that certain unusual plants possessed spirits or the souls of departed friends or relatives or important persons. As such those plants were regarded with special reverence. Unlike the formal gardens of Europe, which were intended as a grand stage for the display and glorification of the human players, with plants subjugated to a minor role, the gardens of the Orient were designed to feature plants and other elements of the natural world in a way that provoked an intellectual thoughtfulness by the visitors. In many cases, a walk through an oriental garden was a psychodrama intended to remind even the most aristocratic Asians of their natural place in the world.

If any one thing stands out as a landmark along the historic progression of ornamental horticulture, it is the discovery of the New World. The Americas were a rich repository of plants, already being cultivated for both food and ornamental purposes by Indian cultures, long before the invasion by European explorers began. Once underway, the exploration and settlement of the New World promoted large-scale transplantation of foreign plant species and plant products between Europe and the Americas.

As the various nations of Europe sought to stake their territorial claims in the New World, numerous colonies were established in the lands that years later would become the United States. The seventeenth century saw the Spanish, the Dutch, and the English heavily committed to the colonization of the coastal areas of North America. While indigo, tobacco, timber, rice, and other economic crops were of far greater importance to the settlers, they still found room in their lives to value and grow ornamentals too. The New England Puritans established cottage gardens to produce flowering plants that scented their houses, spiced their cooking, and decorated their celebrations. The Dutch discovered and sent back to Holland the bulbs that would later establish their international preeminence as bulb purveyors to the world.

For much of the next century, even as the early

colonists were replaced by sons and daughters who sought and eventually seized their independence from their European homelands, American gardens and uses of ornamental plants were copies of Old World ideas. Twentieth-century tourists visiting historic Williamsburg, Virginia, see eighteenth-century formal gardens everywhere. Savannah, Georgia, is a picturesque city built to a European ideal of public squares at the center of residential clusters.

The great estates of George Washington's Mount Vernon and Thomas Jefferson's Monticello were profoundly influential in America's perception of ornamental horticulture, due largely to the godlike esteem that both men enjoyed from their contemporary countrymen and the admiring millions who have followed. Both estates were a combination of farm and English naturalistic garden. Spectacularly sited, Mount Vernon and Monticello represented their owners' responsible stewardship of their lands and their willingness to try new agricultural techniques. While neither estate made lavish uses of flowers, their shade tree plantings and expansive lawn areas were reminiscent of the designs of Kent and Brown in England.

As the post-Revolution nation grew stronger economically, the favorable climate and tobacco/cotton economy of the Southeast fostered a lifestyle and garden culture that were aristocratic and formalized. Bowling greens, Elizabethan flower gardens, and serpentine walks lined with graceful shade trees typified the gardens of early America in the South. It is tempting to seek similarities between the self-confident, slave labor centered, plantation lifestyle of the pre-Civil War southern United States and that of the Ancient Romans, wherein both societies found time to cultivate their appreciation of ornamental plants under similar circumstances.

As the nation pressed its boundaries westward through the visionary efforts of Jefferson, Lewis and Clark, and others, the vegetation of the prairies and the fertile soil of the American Midwest were added to the American treasure chest of resources. Far away, at the western edge of the continent, Spanish settlers were building missions throughout the land that would become California. Mission plantings were generally typified by orchard groves, vine-

yards, kitchen gardens, and small flower plantings. As the Spanish Mexican influence took root in southwestern North America, it laid the foundation for a garden design legacy that reaches back to the fourteenth century, yet is still viable today. The Moorish gardens, which were prevalent in southern Spain in that early time, were typically walled and paved and closely related to the buildings they adjoined. They often used water features for their psychological cooling effect, and the term *Spanish Patio* came to define a distinctive type of outdoor area development. Six centuries later, that garden style is still popular, particularly around the adobe and mission-like architecture of California, New Mexico, and Arizona.

The history of ornamental horticulture in America is as difficult to chart on a time line as is its history worldwide. Perceptions of the role of plants change over time. Exploration and discovery of new species continue. Nevertheless, certain individuals, places, and events are worthy of note, even at the risk of omitting others of comparable merit.

- Dutch settlers brought bowling greens to America. These set the precedent for our village greens, city parks, and athletic fields.
- Botanic gardens, featuring all types of horticultural plants, were first established in Colonial America in the eighteenth century and facilitated the exchange of plant species between the country and the city and between the Old World and the New. One of the earliest and most famous botanic gardens was that of John Bertram of Pennsylvania, established in 1728.
- Greenhouses were also being built in America, originally as orangeries for citrus fruits, prior to the Revolution. In appearance and construction materials used, they were far cruder and darker structures than those of today.
- Nurseries, although not unknown elsewhere in the country, were most important in western New York, around Rochester. Both fruit trees and ornamentals were grown and shipped to all parts of the nation and the world. For at least half of the nineteenth century, Rochester reigned as the center of nursery production in America.

- Commercial seed houses and the mail order seed businesses began in the mid-1800s, further diversifying the regional floras of America.
- Jacob Bigelow, a Boston physician and botanist, took responsibility for the development of the Mount Auburn Cemetery in Massachusetts about 1817. It was done in the naturalistic style of eighteenth-century England and set a new national standard for burial grounds. So widespread was the enthusiasm for naturalistic cemeteries and their inclusion of a wide variety of trees and shrubs that the best ones became comparable to botanic gardens. These cemetery grounds also whetted the American appetite for more numerous and more naturalistic city parks.
- Frederick Law Olmstead, regarded as the Father of Landscape Architecture in America, drew upon the designs of the English naturalists to win the competition for the design of New York City's Central Park, the first great city park in America. He and his partner, Calvert Vaux, built city parks throughout the eastern United States and firmly established the democratic concept of public landscaping for all citizens, not just the wealthy and powerful.
- Late in the nineteenth century, the lawnmower was technically improved to the point that lawns could be kept trimmed in a manner similar to today. Prior to that, scythes and/or grazing animals were the means of controlling turf height.
- Pierre du Pont, of the Pennsylvania du Ponts, established what is arguably America's premier horticultural display garden over a forty-five year period, beginning in 1906. Now open to the public in Kennett Square, Pennsylvania, Longwood Gardens is an Americanized eclectic interpretation of sixteenth-century Italian Renaissance, seventeenth-century French Baroque, and eighteenth-century English Naturalism.

Ornamental horticulture in the United States is not as much a state of being as it is a state of becoming. As America's ethnic heritage expands from a majority of Euro-Americans to include more Asian-Americans, African-Americans, Hispanic-Americans, and other immigrant groups, it is predictable that the uses and appreciation of ornamental plants will continue to evolve. That is probably as it should be. One can only wonder how this Foreword will be written when the third edition is published.



Contents

SECTION I

THE SCIENCE
OF ORNAMENTAL
HORTICULTURE

Key Tables and Figures	xi
Preface	xiii
Acknowledgments	xv
Foreword: A Brief History of Ornamental Horticulture	xvii
1 The Green Plant	2
<i>The Value of Plants in Our Lives</i>	2
<i>Classifying Plants</i>	3
<i>Parts of a Plant</i>	4
<i>The Structure of Plant Parts</i>	8
<i>Juvenility and Maturity in Plants</i>	12
<i>Major Plant Processes</i>	12
<i>What Plants Need for Growth</i>	13
<i>Summary</i>	17
2 The Soil	21
<i>What is Soil?</i>	21
<i>Why Soils Differ</i>	22
<i>Soil Separates and Soil Texture</i>	23
<i>Soil Nutrients</i>	25
<i>Soil Structure and Organic Material</i>	26
<i>Soil Acidity and Alkalinity</i>	28
<i>Cation Exchange</i>	30
<i>Fertilizers</i>	31
<i>Summary</i>	34
3 Describing and Identifying Plants	38
<i>Plant Taxonomy</i>	38
<i>Horticultural Descriptions of Plants</i>	40
<i>How Plants are Identified</i>	42

<i>Visual Descriptions of Plants</i>	43
<i>The Assimilation of Terminology</i>	47
<i>Summary</i>	48

4 Plant Growth Regulators 56

<i>Growth Regulators Defined</i>	56
<i>Types of Growth Regulators</i>	56
<i>Commercial Growth Regulators</i>	61
<i>Summary</i>	63

5 Plant Reproduction 66

<i>Plant Reproduction Defined</i>	66
<i>Sexual and Asexual Reproduction</i>	66
<i>How Plants are Propagated</i>	68
<i>Plant Improvement</i>	73
<i>The Contribution of Gregor Mendel</i>	74
<i>Summary</i>	77

6 Plant Pests and Their Control 82

<i>Plant Injuries and Their Causes</i>	82
<i>Insects</i>	83
<i>Plant Diseases</i>	88
<i>Symptoms of Injured Plants</i>	96
<i>Weeds</i>	98
<i>The Control of Plant Pests</i>	99
<i>Pesticides</i>	103
<i>Integrated Pest Management</i>	108
<i>Summary</i>	109

SECTION II

THE CRAFTS OF ORNAMENTAL HORTICULTURE

7 Floral Design 118

<i>The Value of Flowers</i>	118
<i>Floral Design—Art or Craft?</i>	119
<i>Materials Needed to Arrange Flowers</i>	119
<i>Containers for Floral Arrangements</i>	121
<i>Care of Cut Flowers</i>	122
<i>Forms of Arrangement Materials</i>	123
<i>Principles of Floral Design</i>	124
<i>Patterns of Arrangements</i>	127
<i>Using Color to Advantage</i>	128
<i>Wiring Flowers for Design</i>	131
<i>Making Bows and Puffs</i>	131
<i>Assembling the Arrangements</i>	135
<i>Summary</i>	144

8	The Interior Use of Plants	149
	<i>Background and Status Update</i>	149
	<i>Uniqueness of Interior Plantscapes</i>	150
	<i>Light and Interior Plantings</i>	150
	<i>The Growing Medium</i>	159
	<i>Watering and Drainage</i>	161
	<i>Other Concerns</i>	163
	<i>The Interdisciplinary Team</i>	165
	<i>The Future</i>	166
	<i>Summary</i>	166
9	Landscape Design	169
	<i>The Need for Gardens</i>	169
	<i>Landscaping Today</i>	171
	<i>The Outdoor Room</i>	171
	<i>The Principles of Design</i>	176
	<i>Selecting Plants for Landscapes</i>	180
	<i>Designing Plantings for Landscapes</i>	196
	<i>Enrichment Items</i>	198
	<i>Selecting Construction Materials</i>	201
	<i>Materials and Methods</i>	205
	<i>Creating a Residential Plan</i>	215
	<i>Summary</i>	218
10	Installing Landscape Plants	224
	<i>The Importance of Proper Installation</i>	224
	<i>The Necessary Tools</i>	224
	<i>The Soil for Installation</i>	227
	<i>Root Forms of Landscape Plants</i>	227
	<i>The Time to Transplant</i>	228
	<i>Methods of Installation</i>	228
	<i>Mulching</i>	233
	<i>Using Antitranspirants</i>	234
	<i>Problems of Arid Regions</i>	235
	<i>Summary</i>	238
11	Maintaining Landscape Plants	242
	<i>Sustained Care of Plantings</i>	242
	<i>Pest Control</i>	247
	<i>Pruning Trees and Shrubs</i>	247
	<i>Flower Plantings</i>	255
	<i>Winterizing the Landscape</i>	260
	<i>Summary</i>	264

12	Special Training Techniques for Plants	268
	<i>Selecting and Using Vines in the Landscape</i>	268
	<i>Installing and Training Vines</i>	269
	<i>Espaliers</i>	271
	<i>Installing and Training Espaliers</i>	272
	<i>Topiary Pruning</i>	273
	<i>Bonsai Development</i>	275
	<i>Summary</i>	281
13	Turf: Selection, Establishment, and Maintenance	284
	<i>The Many Uses of Turfgrass</i>	284
	<i>Comparison of Turfgrasses</i>	285
	<i>Purchasing Grass Seed</i>	287
	<i>Mixtures Versus Single-species Blends</i>	289
	<i>Methods of Installation</i>	294
	<i>Proper Lawn Construction</i>	296
	<i>Calibrating a Spreader</i>	300
	<i>Maintaining an Established Lawn</i>	300
	<i>Summary</i>	308
14	Techniques of Plant Propagation	310
	<i>Science and Craft</i>	310
	<i>The Media for Propagation</i>	310
	<i>The Structures for Propagation</i>	311
	<i>Propagation by Seeds</i>	312
	<i>Propagation by Plugs</i>	315
	<i>Propagation by Cuttings</i>	316
	<i>Propagation by Grafting</i>	319
	<i>Propagation by Budding</i>	325
	<i>Propagation by Layering</i>	332
	<i>Propagation by Tissue and Organ Culturing</i>	335
	<i>Summary</i>	339
	SECTION III	
	THE PROFESSIONS	
	OF ORNAMENTAL	
	HORTICULTURE	
15	The Floriculture Industry	345
	<i>Careers in Ornamental Horticulture</i>	345
	<i>The Professions of Floriculture</i>	346
	<i>Summary</i>	350
16	The Nursery Industry	354
	<i>The Scope of the Business</i>	354
	<i>Different Types of Nurseries</i>	355
	<i>The Link Between the Nursery and Landscape Industries</i>	359
	<i>Summary</i>	359