# Scientific Research at

## The New York Botanical Garden

# Leading Benefactors for Scientific Research and Education

Altman Foundation
Edward P. Bass, Philecology Trust
Beneficia Foundation
Bristol-Myers Squibb Company and Bristol-Myers Squibb Foundation, Inc.
Ildiko and Gilbert Butler
The Louis Calder Foundation
Mr. and Mrs. Lewis B. Cullman
Cleveland H. Dodge Foundation, Inc.
The Everett Foundation Inc.
Gildea Foundation, Inc.
The Lillian Goldman Charitable Trust
Charles Hayden Foundation
William Randolph Hearst Foundation
The Heckscher Foundation for Children
Mrs. Andrew Heiskell
The William and Flora Hewlett Foundation
Mr. and Mrs. Thomas J. Hubbard and The Harriet Ford Dickenson Foundation
Institute of Museum and Library Services
JPMorgan Chase Foundation
Annette Kade Charitable Trust
The John D. and Catherine T. MacArthur Foundation
The Andrew W. Mellon Foundation
LuEsther T. Mertz Charitable Trust
MetLife Foundation
Dr. and Mrs. George M. Milne, Jr.
The Ambrose Monell Foundation
National Science Foundation
Mr. and Mrs. Wilson Nolen
The Overbrook Foundation
Pfizer Inc & The Pfizer Foundation
The Prospect Hill Foundation
V. Kann Rasmussen Foundation
Mr. and Mrs. John R. Robinson
Alfred P. Sloan Foundation
The Starr Foundation
Mr. and Mrs. William C. Steere, Jr.
The Tinker Foundation Incorporated
Verizon Foundation

J.P.Morgan Presenting Sponsor,
Global Biodiversity Programs

Front Cover

(Left to right, starting from the top row)
Dr. Scott Mori prepares an aroid specimen as part of a biodiversity survey on the Caribbean island of Saba.
Dr. Jacquelyn Kallunki, Associate Director and Curator of the Steere Herbarium, inspects a herbarium specimen.

(Second row)
Dr. Michael Balick interviews village elders on traditional uses of plants on the Micronesian island of Palau. Anna Nowogrodzki works in the Cullman Laboratory, home of the Lewis B. and Dorothy Cullman Program for Molecular Systematics and the Plant Genomics Program.

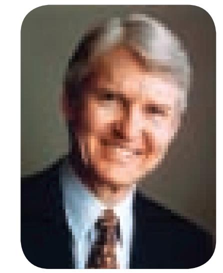
(Third row)
Graduate student Rachel Meyer tends plants in the research laboratory's growth chambers. Façade of the William and Lynda Steere Herbarium.

(Fourth row)
Façade of the Library building, seen through Tulip Tree Allée.
Dr. Robbin Moran examines ferns in Costa Rica.

# Table of Contents

# Preface

## "The New York Botanical Garden is an advocate for the plant kingdom..."



This excerpt from The New York Botanical Garden's mission statement drives our ambition to continually reach for new heights—in discovering, understanding, and preserving biodiversity. This is a critical objective in a world that is increasingly under environmental pressure, and whose future depends on momentous decisions based on rigorous scientific research.

One of the Botanical Garden's paramount goals is to lead in the documentation of every plant and fungal species on Earth. Despite growing habitat destruction and other environmental challenges, Garden scientists persevere in exploring new ground. Comprehensive identification of species and determination of plant relationships are important prerequisites for conservation efforts and sustainable management of plant resources used as foods, medicines, and fuels.

The Botanical Garden is one of the world's preeminent free-standing plant research organizations. The Garden conducts basic research in plant biology and studies all species of plants and fungi around the globe. Our scientists use sophisticated techniques such as molecular systematics, genomics research, and digital imaging. Never before has the need been greater to integrate the use of our unparalleled resources—in the field, laboratory, library, and herbarium—to maximize the impact of our work and maintain our position at the forefront of worldwide botanical research.

With its longstanding scientific mission and unmatched facilities, the Garden is uniquely positioned to address increasing environmental challenges. The herbarium collection, assembled by our scientist explorers over more than a century, is among the four largest in the world and the largest in the Western Hemisphere; the virtual herbarium database adds 45,000 new records each year; the library is the world's most important botanical and horticultural resource of its kind; our internationally renowned scientific staff work in a new state-of-the-art plant research laboratory and a pioneering center for molecular systematics, while running the largest botanical sciences graduate studies program at any botanical garden in the world.

The remarkable assets that the Garden brings to the scientific enterprise are documented in this book. It presents the physical and human resources that together comprise one of the top science, research, education, and scholarly centers in the world, distinguished in scope, depth, authority, and excellence. The Garden's greatest distinction, however, lies in the way its many assets are interwoven to form an entity greater than the sum of its parts. In this book, you will be able to see, through the eyes of the Garden's scientists, all of the ways we are working in concert to study and preserve the world's botanical heritage—and to help ensure the future of life on Earth.

Edward P. Bass and George M. Milne, Jr., Ph.D.
*Chairmen of the Botanical Science Committee*

# Introduction

In what has been described as the "century of biology," the approach to science at The New York Botanical Garden is evolving rapidly. During the last three decades, a wealth of new technologies has changed how botanists approach nearly every task they face. From the use of hand-held global positioning systems in the field, to the application of molecular data in the laboratory and the incorporation of rigorous statistical methods to analyze systematic data, these new methods have pushed botanical research to new frontiers.

With new sets of tools, such as Geographic Information Systems, and methods, such as DNA barcoding, we are answering questions that have long seemed to be intractable. The use of DNA sequences is allowing us to understand how plants are related and to build classifications that ref ect the evolutionary history of groups of organisms more accurately than has ever before been possible. As a result, we are building stable classifications of the plant, algal, and fungal kingdoms. The new molecular methods are allowing us to better understand how genes function and evolve, and the field of comparative genomics provides insight into the major events in plant evolution.

"We are racing against the clock to explore and inventory poorly known regions...while we continue to lose more than 50,000 square miles of forest each year."

As our research ability grows exponentially, we live in a world where our natural resources are being imperiled by rapid global change. Only a small percentage of natural habitats remain in most parts of the world, and these continue to be deforested or degraded and further threatened by invasive species, pollution, and climate change. These forests and other natural areas are important to us not only for the biodiversity they shelter and the full range of species upon which we rely for food, medicines, and other materials, but also for the ecosystem services that they provide, protecting watersheds, cycling oxygen and nutrients, and stabilizing climate. To ensure that Earth continues to be a comfortable place for us to live, it is essential to protect the full range of biological diversity, identifying those species at risk of extinction and developing the means to ensure their future survival.

One of the greatest impediments to protecting the full range of plant species is our incomplete knowledge of the world's plants. Many areas, particularly in the tropics, remain unexplored or understudied and perhaps a quarter of a possible 300,000 or more plant species remain unnamed. We are racing against the clock to explore and inventory poorly known regions, particularly in the tropics where diversity is greatest, while we continue to lose more than 50,000 square miles of forest each year, an area slightly greater than the state of Mississippi. With sufficient resources, it seems plausible that botanists could complete the first comprehensive inventory of all of the world's plant species within the next decade.

Against this background, the Science Program at The New York Botanical Garden is responding, using these new tools to address the most pressing questions. Research staff members are tackling amazing new scientific questions, inventing and developing new approaches to research, and connecting the results of research with the most pressing environmental and societal issues.

We concentrate our efforts in places in the world where the greatest needs intersect with our



unparalleled research resources and expertise. In the South Pacific, on the islands of Pohnpei and Kosrae in Micronesia and the Republic of Palau, an effort connecting research with conservation supports the Micronesia Challenge, an ambitious international effort to protect 20% of terrestrial habitats and 30% of near-shore marine resources by 2020. The program combines efforts to complete botanical inventories of these islands, which harbor a rich array of endemic plant species, and to identify the most important places for conservation. At the same time, indigenous knowledge about plants is integrated into conservation efforts that preserve both traditional medicinal practices and the botanical resources upon which they depend.

Most of the Garden's scientific expertise and collections' strength, however, is in the Western Hemisphere. The islands of the Caribbean are one such area. Most of the West Indies have been studied botanically one island or island group at a time, so our knowledge is uneven across the region. Having the largest collection of Caribbean plant specimens in the world allows us to understand these plants and harmonize the names used for them throughout the entire Caribbean. This is an important prerequisite to being able to advise on pressing conservation issues in a region where most of the islands have less than 20% of their original vegetation remaining.

The Amazon covers a vast region spread over nine countries and is home to a wealth of plant diversity, but, more importantly, the forests of Amazonia exert a tremendous inf uence on the climate of South America. About half of the rainfall in Amazonia is recycled by the plants, but the region continues to be deforested at a tremendous rate. Because of its size, the various parts of the Amazon have been explored and studied by different research groups, and now there is a need to synthesize this information for the entire region.

The narrow band of forests that once spanned nearly 4,000 kilometers along the coast of Brazil is, or was, among the highest in both species diversity and endemism of any in the world yet less than 7% remain, and many of the still-existing forest areas are completely unexplored botanically. This is certainly one of the places in the world where the largest number of plant species face a high risk of extinction in the near future unless research and conservation efforts are increased.

In our own backyard we are completing the f ora of the Intermountain Region and revising the f ora of the northeastern United States. Providing up-to-date accounts of the f oras of both regions informs efforts for conservation in both places.

For the scientists at The New York Botanical Garden, this is an era of great urgency and great excitement—urgency because the race to discover, document, and conserve the world's plants and fungi is so pressing, and excitement because of the depth and breadth of scientific questions that can be addressed now as never before thanks to the new and powerful research resources at our disposal. I hope in reading this book you will enjoy learning about the facilities, collections, programs, projects, and people comprising the Botanical Garden's scientific enterprise.

James S. Miller, Ph.D.
*Dean and Vice President for Science*
*Rupert Barneby Curator of Botanical Science*

# Research Facilities and Collections

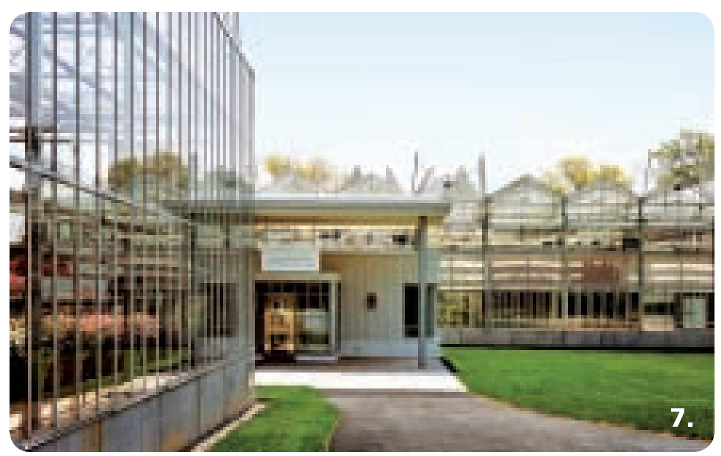

1.


5.

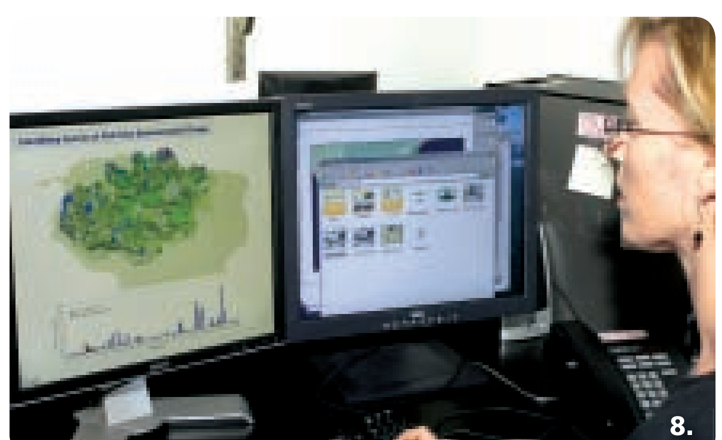

2.


6.


3.


7.


4.


8.



The 23-acre science campus in the northern section of the Botanical Garden is the headquarters of the Garden's scientific research. Its facilities include the Pfizer Plant Research Laboratory and the adjacent William and Lynda Steere Herbarium, which houses the Garden's research collection of plant specimens from all over the world. The Laboratory and Herbarium are key anchors of the science campus, along with the LuEsther T. Mertz Library, the most important botanical and horticultural library in the world. The Mertz Library includes the William D. Rondina and Giovanni Foroni LoFaro Gallery.

**1.** William and Lynda Steere Herbarium
The William and Lynda Steere Herbarium, among the four largest herbaria in the world and the largest in the Western Hemisphere, houses more than seven million specimens, representing all groups of plants and fungi from around the world, with exceptional strength in the flora of the Americas. Specimens have been collected from every continent and date from the 18th century to the present.

**2.** Digital Imaging Center
In the Digital Imaging Center, approximately 45,000 new images are created and added each year to the C.V. Starr Virtual Herbarium, a state-of-the-art database providing instant Internet access to information on more than 1 million plant specimens in the Steere Herbarium.

**3.** Lewis B. and Dorothy Cullman Conference Room
The Lewis B. and Dorothy Cullman Conference Room is an elegant yet functional area for visiting scholars and Garden scientists who are participating in international conferences and other events hosted by the Botanical Garden.

**4.** Arthur and Janet Ross Lecture Hall
The 400-seat capacity Arthur and Janet Ross Lecture Hall hosts conferences, lectures, and talks for professional and lay communities. Shown here is the audience listening to Edward O. Wilson, Ph.D., known for his pioneering work on evolution and sociobiology and a Distinguished Counsellor to the Garden's Board, introducing a sold-out symposium session on *Darwin: 21st-Century Perspectives* in May 2008.

**5.** Lewis B. and Dorothy Cullman Laboratory
This laboratory provides highly advanced scientific research facilities for molecular systematics and plant genomics, supporting the research of Garden scientists, graduate students, and visiting scholars.

**6.** LuEsther T. Mertz Library
The LuEsther T. Mertz Library is the most important botanical and horticultural library in the world, with holdings of more than one million items spanning ten centuries, encompassing 72 languages and one mile of archival materials.

**7.** Nolen Greenhouses for Living Collections
Encompassing nearly an acre under glass, the Nolen Greenhouses are the most sophisticated behind-the-scenes greenhouses at any botanical garden in the United States. The facility provides growing capacity and a staging area for hundreds of thousands of plants—from alpine to desert plants, aquatics to tropical rain forest trees, temperate perennials to annual bedding plants and bulbs, and orchids to ferns.

**8.** Geographic Information Systems Laboratory
The Garden's Geographic Information Systems Laboratory enables data-intensive analysis and identification of plant species at risk of extinction and of geographic regions with high concentrations of species of conservation concern.

# Pfizer Plant Research Laboratory

The Pfizer Plant Research Laboratory, designed by Polshek Partnership Architects, and opened in May 2006, provides highly advanced scientific research facilities for molecular systematics, plant genomics, and graduate studies. The light-filled, two-story, 28,000-square-foot facility houses the Lewis B. and Dorothy Cullman Program for Molecular Systematics, Genomics Program, and Graduate Studies Program. Large, beautiful laboratories outfitted with state-of-the-art equipment support chemical analysis, mycology, structural botany, molecular systematics, genomics, and graduate training.

The Pfizer Laboratory provides space for expanding programs in molecular systematics, plant genomics, natural products, and structural botany. Research activities include plant and fungal culture media and specimen preparation, slide storage, microscopic analysis, scanning electron microscopy, and DNA sequencing. Modern and spacious study suites accommodate the Botanical Garden's graduate students, providing a consolidated home base for the program. Elegant functional areas, including the Lewis B. and Dorothy Cullman Conference Room, facilitate scientific collaboration.

The Pfizer Laboratory not only offers Botanical Garden scientists and graduate students first-rate facilities in which to pursue their research, but also draws visiting scientists, post-doctoral researchers, and leading faculty to collaborate with the institution's scientists and to participate in conferences and other scientific events.

Dr. Fabián Michelangeli prepares samples in the Pfizer Plant Research Laboratory for a molecular systematics study of the plant family Melastomataceae, undertaken with funding from the National Science Foundation's Planetary Biodiversity Inventories program.

Genomics Lab Manager Anna Nowogrodzki prepares samples for DNA sequence analysis.

# Lewis B. and Dorothy Cullman Laboratory

An expansive, light-filled laboratory whose grand vista of outdoor forests and lakes complements equally grand explorations into the far reaches of plant molecular science, the Lewis B. and Dorothy Cullman Laboratory occupies most of the second f oor in the Pfizer Plant Research Laboratory. It contains 24 research stations in a f exible modular layout, and serves both molecular systematics studies and plant genomics.

The Cullman Laboratory is organized in a modern, open-format layout to optimize intellectual exchange among researchers, and is fully equipped for all standard forms of molecular analysis, including DNA and RNA extraction, high throughput polymerase chain reaction (PCR), *in situ* hybridization, tissue culture, cloning, and DNA sequence analysis. The Laboratory's sequencing facility includes a Beckman CEQ 8800 capillary DNA sequencer, two BioMec 3000 robotic liquid handlers, and a DTX 880 Multimode Detector.

Additional equipment in the Laboratory includes an autoclave, dishwasher, glassware oven, refrigerator, and freezers (-80°C and -20°C capacities); two Percival CU-36L5 tissue culture chambers; two NuAire LabGard 425 laminar f ow hoods; six thermal cyclers (9 blocks), including an Applied Biosystems 7300 real time thermal cycler and two machines with gradient capability; a QIAGEN TissueLyser for rapid DNA extraction from up to 192 samples simultaneously; a Syngene Multi Genius Bio Imaging system for gel viewing and recording; Barnstead water purifying systems; two Beckman Allegra 25R refrigerated bench-top centrifuges and a Sorvall f oor-model centrifuge; a Nanodrop 1000 and a Beckman DU-800 spectrophotometer; and standard equipment such as vacuum oven and pumps, incubators, hybridization ovens, orbital shaker, and various standard smaller pieces of equipment.

For microscopy, the Laboratory has a Zeiss Axiophot microscope equipped with phase-contrast and DIC optics, epif uorescence, automated photomicrography, and Spot digital video camera and image processing system. Several additional microscopes, both dissecting and compound, are also available, including Nikon digital imaging systems on both dissecting and compound scopes.

The Laboratory also houses a JEOL scanning electron microscope; a Leica TP-1020 automated tissue infiltration system; a Microm AP280 automated embedding system; a Zeiss automated microtome; two controlled-environment walk-in growth chambers; and two four-shelf light carts for plant growth experiments. DNA sequence analysis and molecular cloning software is available and shared by researchers, and for genome analysis, the Laboratory has acquired a powerful new computer with a high-speed dual Opteron Server.

As a result of constantly maintaining and updating equipment with the latest available technologies, the Lewis B. and Dorothy Cullman Laboratory is a premier site for cutting-edge research undertaken by the Botanical Garden's faculty, postdoctoral researchers, graduate students, and visiting scholars in the disciplines of plant molecular systematics and genomics.

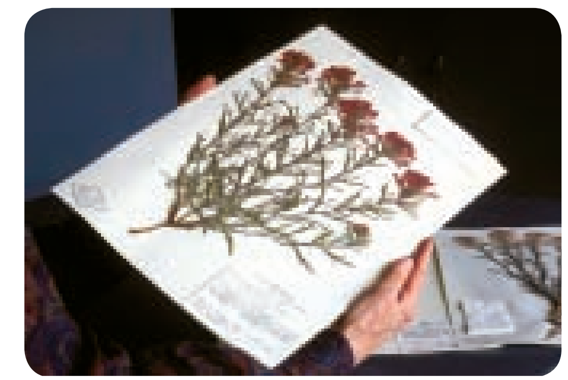
# William and Lynda Steere Herbarium

The William and Lynda Steere Herbarium, designed by Polshek Partnership Architects and opened in May 2002, is a National Systematics Research Resource Center containing more than 7,000,000 specimens. The largest in the Western Hemisphere, the Steere Herbarium is also among the four largest in the world. It holds significant collections of all groups of plants and fungi. Approximately 5,000,000 specimens are vascular plants, 1,000,000 are bryophytes (mosses and hepatics), 1,000,000 are fungi (including lichens) and 300,000 are algae. Although all areas of the world are represented, the emphasis of acquisitions has always been on the flora and mycota of the New World. Approximately 3,000,000 are from North America; 3,000,000 from Central America, the Caribbean, and South America; and the more than 1,000,000 remaining are from Africa, Asia, Europe, and the Pacific region.



Throughout its existence, the Botanical Garden's Herbarium has grown steadily, through collections made by staff members and collaborators, exchange, and accession of orphaned herbaria. Immediately upon the Garden's incorporation in 1895, Nathaniel L. Britton, the founding director, began acquiring specimens for the soon-to-be constructed herbarium. The initial acquisitions included the Columbia College herbarium and a selection of very fine private herbaria. As a result, The New York Botanical Garden Herbarium was an important resource on the day it opened in 1901. Particularly noteworthy among these original holdings was the Torrey Herbarium, perhaps the most comprehensive collection of American plant specimens at the time. John Torrey (1796–1873), the first internationally renowned American botanist, received plant specimens such as those collected on the exploring expeditions of John C. Frémont to the Oregon Territory and California (1842–1845) and the surveys for the Pacific Railroad routes (1853–1855). The private herbarium of Job Bicknell Ellis (1829–1905) was also among the original acquisitions. A New Jersey native, Ellis was the first to document the fungi that were responsible for diseases of crop and ornamental plants in the Western Hemisphere. His herbarium included over 4,000 species that were previously unknown to European scientists.

The Steere Herbarium continues to grow at a rate of 50,000 to 75,000 specimens per year, keeping pace with the acquisition rates in the early years of the institution's history. The sources of new accessions today are much the same as in the early years: staff expeditions; exchange programs with other herbaria; specimens sent to Garden scientists as a gift in return for identification; purchase; and donation. As a source of recent and historical specimens, the Herbarium provides essential services and support to plant science research projects throughout the world. Garden scientists and students consult the Herbarium for their current research projects, and an average of 150 visitors travel to New York each year to use the collection, spending on average 1,200 person-days per year. The Herbarium lends approximately 30,000 to 50,000 specimens annually to scientists at other institutions.



Top: Technician Cindy Hirsch mounts specimens in the Herbarium Specimen Preparation office, part of a renovation opened in the fall of 2004. In the past few decades, the collections have increased by an average of 50,000 to 75,000 specimens annually.

Virtually all major taxonomic revisions and inventories of plants and fungi of the Americas and parts of the Old World include examination of specimens deposited in the Steere Herbarium, making it one of the most frequently consulted in the world. In 2002 the collections were moved to a new 70,000-square-foot building with state-of-the-art environmental controls.

# LuEsther T. Mertz Library

Dedicated to access and service, the LuEsther T. Mertz Library is a key resource for an international community of scientists and students. Founded in 1899, the Mertz Library has evolved to be the largest, most comprehensive botanical library at any botanical garden in the world and is a treasury of knowledge about all aspects of plants and related topics.



For more than a century, the Mertz Library's collections have grown through the negotiation of hundreds of publication exchange agreements with other research institutions, adoption of botanical book collections from important academic and research libraries and private collections, and broad-scale purchases. Today the Library continues to expand its collections in the areas of systematics, floristics, genomics, economic botany, horticulture, and garden design through the acquisition of new books, journals, and a wide range of electronic media, including the digitization of its own collections. Exhibitions presented in the Library's William D. Rondina and Giovanni Foroni LoFaro Gallery allow us to share the collections more widely with the visiting public.

Supporting research and study in the fields of botanical science, horticulture, and landscape and garden design, the Mertz Library is noted for the importance, breadth, and accessibility of its holdings. The General Research Collection consists of over 550,000 volumes, including nearly 12,000 serial titles. The Library's Rare Book Collection of pre-Linnean manuscripts and printed books includes one-of-a-kind works dating back to 1190 AD. The Folio Collection has exceptional holdings of 18th- and 19th-century books featuring fine botanical plates from paintings and drawings by renowned artists. The Art and Illustration Collection contains more than 22,000 original works encompassing a broad range of media, including line drawings, watercolors, oil paintings, and sculpture, and the Archival Collections contain over a mile of original documents that record the history and development of botanical exploration and discovery in the United States and abroad. These outstanding holdings represent more than a century of commitment to botanical and environmental research.

The Library's skilled staff also plays a vital role in the research process, providing the highest quality collections and services to meet the needs of the Garden's diverse research, instructional, and outreach programs. These include the Garden's research faculty, botanists, and horticulturists, as well as scientific, scholarly, and artistic researchers worldwide, and the public at large. Because of the scientific, historical, horticultural, and architectural significance of its renowned collections, the Library has maintained an active conservation program for four decades, attending to the preservation needs of both the book and non-book special collections.

In 1998 the Library was named in honor of LuEsther T. Mertz in recognition of Mrs. Mertz's enduring commitment to the Garden and her love of books. Mrs. Mertz's relationship with the Garden began in the 1980s when she took an active interest in horticulture and science programs. Since her death in 1991, important contributions from the LuEsther T. Mertz Charitable Trust have helped advance the Garden's mission and secure its future.

Ten of the world's major natural history and botanical libraries are working together to digitize all of their jointly held published literature on biodiversity and make it available on the Internet.

Above left: Representatives of the Biodiversity Heritage Library project in a meeting in the Shelby White and Leon Levy Reading Room of the Mertz Library

Above right: The William D. Rondina and Giovanni Foroni LoFaro Gallery presents world-class public exhibitions of rare botanical prints and books of horticultural history, landscape design, and plant science.

# Living Collections

Living collections, both on the grounds and in the greenhouses, have always been an integral part of botanical science research at The New York Botanical Garden. These living collections have served a variety of purposes, supporting the study of botany in all its manifestations, ranging from plant structure to plant ecology to gene sequencing. Historically the living collections played a very important role in the development of plant genetics at the Garden and our understanding of the role of chromosomes and genes. Also, living collections, including the 50-acre, old-growth forest, have been fundamental to our understanding of the diseases that attack plants both in horticulture and habitat. The living collections on the grounds are now being monitored for phenology—that is, the timing of leaf flushes, onset of flowering, and fruit ripening throughout the year—in order to give us an understanding of the shifts in climate and its effect on agriculture and our local flora.



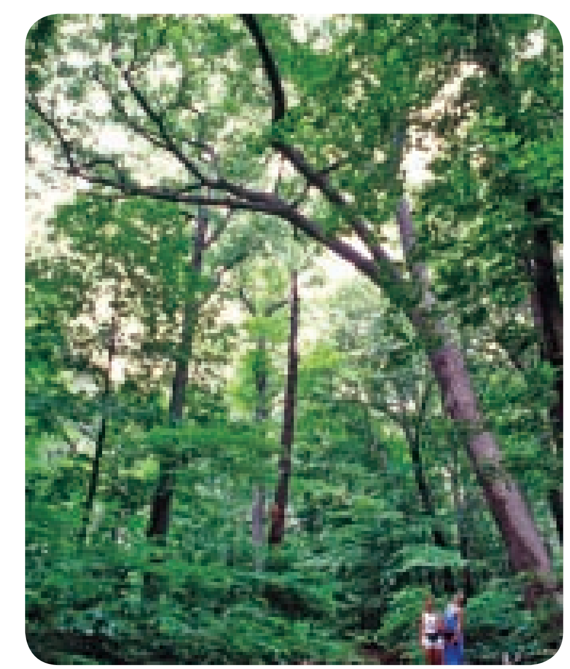
The living collections at The New York Botanical Garden (for example, in the Benenson Ornamental Conifers, Nolen Greenhouses for Living Collections, and others) are unique, differing in important ways from those found in university collections. This is because the Botanical Garden's broad field research program interests itself in the unusual, the rare, and the biologically interesting but hard to cultivate species. Just as researchers around the world use our Herbarium collections, they also study the unique holdings in our living collections. Moreover, our living collections range across the plant world, from algae to mosses to ferns to flowering plants and gymnosperms to fungi. This is a collection virtually unparalleled in the botanical research community.

As technology progresses within botanical science there is an ever broadening need and use for living collections as we try to unravel the history of plant evolution and diversification. Living collections are paramount to studying and elucidating changes in development and genes that gave rise to diversity. As a result, living plants are used to collect examples of the developmental stages in the life cycles of plants. These may represent various levels, ranging from the development of whole flowers to the development of flower parts, such as petals, to the development of the tissues we find within a petal, to the development of cell types and their chemical constituents.

As we move forward in DNA-sequencing technology, living collections have taken on a new role. In our research to reconstruct the tree of life, we now not only sequence the DNA of single genes, but also sequence whole genomes, as in the human genome project, but for plants. We sequence all of the DNA of chloroplasts as well as all of the DNA of the nucleus of the cell. These must be done with living plant material and the holdings in the living collections at the Garden are proving to be essential for supplying samples from rare and unusual species that are fundamental to our reconstruction of the history of life on Earth.

The New York Botanical Garden is committed to plant conservation. One way this is achieved is through the living collections, with their superb coverage of endangered species in some major plant groups such as orchids, cycads, conifers, and cacti. These *ex situ* collections provide plants for restoration to the wild and the study of their biology (e.g., pollination, seed germination, and seedling establishment). Employing the methods of molecular systematics, we are able to develop DNA barcoding for identification of plants lacking their normal identifying features, such as cone color, to prevent illegal collection, smuggling, and other commercial or illicit uses of parts of these endangered species. These methods also allow us to ascertain the genetic diversity within a species so that plant breeding can be done to maximize the genetic diversity of plants used for the restoration of the species in the wild.

Among the most important resources for plant science research at the Botanical Garden and around the world, these collections are fundamental to work in systematics, plant development, ecology, conservation, and the health of the planet as a whole. They are an essential component of the Garden's leading role in botanical research.



Botanical Garden scientists study and observe living specimens of plants throughout their life cycle, both indoors in the Nolen Greenhouses for Living Collections and the Enid A. Haupt Conservatory and outdoors across the Garden's 250 acres.

Far left: *Cerastoma silvicola,* part of the Garden's exceptional collection of tropical Ericaceae, a large and diverse plant family that also includes blueberries, rhododendrons, and heather.

Near left: The Garden's 50-acre native Forest, the largest extant uncut remnant of the forest that once covered New York City, is one of the most thoroughly studied forests in the region and a useful resource for further investigations.

# Research Programs and Projects



Since 1891, New York Botanical Garden scientists have undertaken field research at thousands of sites around the world, on a "mission of discovery" to document all species of living plants and fungi. Locations are as varied as the island of Saba in the Caribbean (far left), where Dr. Scott Mori prepares a philodendron leaf for collection as part of an island-wide biodiversity inventory, and Borjomi, Georgia (near left), where research botanist Daniel Atha collects seeds, herbarium specimens, and DNA samples of *Rhododendron caucasicum*.

# Institute of Systematic Botany: Contributing to the Global Inventory of Plants

If we are to protect Earth's plant resources and use them wisely, we must be able to identify them and understand their relationships, evolutionary histories, and geographic distributions. An adequate understanding of the f ora and vegetation of a place is a fundamental prerequisite for the conservation and sustainable use of the species that comprise other ecosystems.

Plant systematic research at The New York Botanical Garden ranges from the most inaccessible corners of the unexplored tropics to the meadows of New England. Discovery has always been both the primary mission and the primary motivation of systematics at the Garden. Curators in the Garden's Institute of Systematic Botany focus their field studies in five geographic areas: the Brazilian coastal forest, the Amazon Basin, the Caribbean, Micronesia, and North America, but field studies extend into dozens of countries. As recent examples, an expedition to Vietnam found 25 new species of palms, while fieldwork and review of herbarium collections from Madagascar uncovered 30 new species of the genus *Canarium*; the study of a tree plot in eastern Brazil found that 20% of the trees were new species. As a group, Botanical Garden systematists discover and name nearly fifty new species each year.

Each of the Garden's systematists specializes in one or a few plant families and the f ora of one or a few geographic areas, acquiring deep expertise over decades of focused research. Each maintains a network of long-term, usually international collaborations, and this positions Garden staff to inf uence conservation and resource management directly. The Garden also leaves an indelible mark on future public policy because our graduate studies program has trained so many of the world's top botanists, particularly from tropical America.

The core output of our systematists consists of scientific monographs and revisions, which decipher, describe, distinguish, and reveal the evolutionary relationships among species of particular groups of related plants. The principal tools for this work continue to be found at the William and Lynda Steere Herbarium and the LuEsther T. Mertz Library, both of which are the largest of their kind in the New World.

While today's systematist is still equipped with pruning shears, plant press, dissecting microscope, and often gear for climbing trees, his or her tool kit now also invariably includes the electron microscope, digital maps with multiple electronic layers, a complete anatomical laboratory, DNA sequencers, and powerful computers with a battery of software programs for analyzing massive data sets. Adding the Garden's Pfizer Plant Research Laboratory, Lewis B. and Dorothy Cullman Program for Molecular Systematics, and Geographic Information Systems Laboratory to the LuEsther T. Mertz Library, William and Lynda Steere Herbarium, and living collections, The New York Botanical Garden is one of the most complete facilities in the world for studying plant systematics.

The incorporation of molecular data allows the construction of classification systems that truly ref ect the evolutionary history of plants. The deep knowledge of plant groups that the Botanical Garden's researchers have acquired, combined with the Garden's unparalleled resources for comparative research in plant systematics, enables them to pose as well as answer critical questions that lead to a much better understanding of plant relationships, requirements, management, and conservation.

# Institute of Economic Botany: Studying the Relationship of Plants and People

In a time of rapid global change, humankind's ability to maintain secure and healthy lives in clean environments is increasingly uncertain. We now generally accept global climate change as one of the most serious threats to the environment and to human life. However, there are other agents of change that are equally powerful—economic forces, for example. According to the World Bank, around 1.4 billion people live in "extreme poverty" (i.e., on less than $1.25 a day), and some 2.7 billion more live in "moderate poverty" (on less than $2 a day). The social and political systems of our 6.6 billion neighbors on Earth are often unstable or in constant f ux. In addition, billions of people suffer needlessly from debilitating symptoms of disease because they lack access to proper health care and inexpensive medications.



Far left: Postdoctoral Researcher Dr. Ina Vandebroek collects a specimen of *Chrysophyllum cainito*, an edible fruit, in the Dominican Republic, as part of research on how plants are used for medicinal purposes in that country as well as by Dominican immigrants in New York City.

Near left: Drs. Michael Balick and Wayne Law collecting a specimen of a palm, *Pinangia insignis*, on the Micronesian island of Pohnpei. In 2005, Dr. Balick received a Guggenheim Fellowship to research and write a comprehensive manuscript on the ethnobotany of Pohnpei.

Research carried out by the staff of the Garden's Institute of Economic Botany (IEB) addresses all of these global issues. One mission of the IEB is to study the diversity of plants, as well as local plant knowledge and plant management practices. Through this work, we hope to help reduce destruction and degradation of natural ecosystems, thereby allowing environments and the communities that live within them to f ourish.

The IEB focuses its efforts on four central issues:

- **Food Security and Conservation of Crop Diversity:** working to understand the biological, social, and political processes that lead to the maintenance, conservation, and continued evolution of major crop plants such as rice and lesser known food species.
- **Sustainable Forest Management for Conservation and Economic Development:** working with local communities to promote the sustainable exploitation of wild populations of economically important plants. Ultimately this will promote community resource management as an effective strategy for conserving natural habitats, such as tropical forests.
- **Biodiversity and Human Health:** working with traditional healers to record information about the uses of medicinal plants for the provision of primary health care, and training today's health care professionals who treat patients using medicinal plants.
- **Conservation of Biodiversity and Cultural Knowledge:** working to record information on plant diversity, utilization, and traditional resource management, and partnering with local conservation agencies to use this knowledge to identify and protect key habitats.

The IEB is an incubator of new ideas—new options for environmental and societal resilience in the face of global change, and a place where these options can be tested for possible wider implementation by other organizations, such as agencies for international economic development and conservation. The models (or successful small-scale demonstration projects) developed in agro-biodiversity could enhance food security and the ability of people to cope with f uctuating agricultural conditions. The models developed in sustainable resource management, particularly of tropical forests, could provide essential strategies for carbon sequestration to protect our planet, along with incomes to help alleviate poverty in some areas. The models developed to transfer knowledge of plants from traditional medical practice into modern health care systems could result in the improved quality of life and health for millions of people. These IEB programs are interdisciplinary, collaborative, problem oriented, and policy relevant.


Natural products research begins in the field, which can be as close at hand as *botánicas* in New York City, documenting the use of medicinal plants by immigrants from the Dominican Republic and then sharing this cultural knowledge with healthcare professionals. The yellow flower shown is *Momordica charantia*, a plant used to treat diabetes and skin rash.

# Natural Products Research: Improving Human Health Through Plant Science

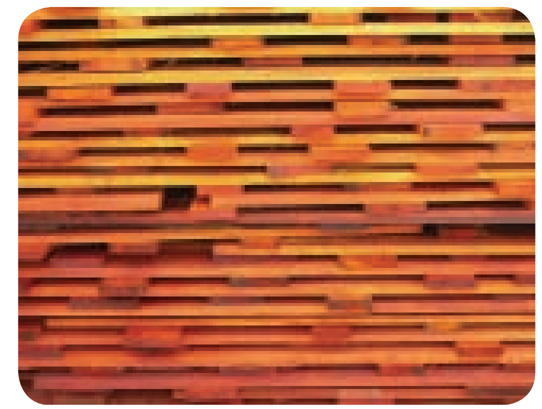
Almost a third of our prescription drugs contain an ingredient derived from a source in nature and many more have chemical structures that are similar to the plant-derived compounds from which they were originally discovered. Today we are also beginning to realize that many of the plants that we eat as foods have beneficial effects on our health beyond basic nutrition. Plants have always played an important role in human health care and this modern paradigm, which sees plants not only as sources of chemical compounds that can become drugs that combat illness, but also as dietary supplements that help prevent illness and promote health, provides a promising research frontier.

Garden scientists work in collaborative partnerships with government, corporate, and academic collaborators to survey the vast chemical diversity that exists in the natural world in an effort to discover new medicines, document and validate traditional knowledge in plants, and develop nutritional products that can improve our health. In a partnership with the United States National Cancer Institute that spans more than 20 years, Garden botanists collect and supply plants that are evaluated for anti-cancer activity against sixty different tumor cell lines. Collaborative work with companies like Merck and Pfizer has evaluated many thousands of plant samples, some of which have yielded promising lead compounds. A National Institutes of Health-funded project with the National Center for Natural Products Research at the University of Mississippi documents the use of medicinal plants by immigrants from the Dominican Republic living in New York City, preserves the traditional knowledge associated with these remedies, and surveys the plants for anti-inf ammatory properties.

Together these projects support extensive field exploration and plant collections, increase our understanding of the chemistry of plants, and have great potential to improve human health.

# Conservation: Preserving Our Natural Heritage

From the time Nathaniel L. Britton conducted the Garden's first field expedition to the Caribbean in the late 19th century, information from our research programs has helped inform us about patterns of plant diversity and distribution. Today, in a world of rapid global change that threatens perhaps a third of all plant species with extinction, information on plant diversity as well as patterns of distribution and abundance is critical for identifying those plant species that face the greatest risk of extinction and the geographic places that are most important for their protection.



With the William and Lynda Steere Herbarium's plant collections, information about the collections in the Garden's C.V. Starr Virtual Herbarium, and our Geographic Information Systems (GIS) Laboratory's capacity to analyze species distribution data, we have an unparalleled set of resources for informing the conservation process and identifying priority species and places for conservation. GIS analysis also allows us to study how a changing climate will affect the future availability of appropriate habitats and predict which species will expand or contract their ranges, thus identifying those that might be threatened by climate change.

Through a process developed by the Species Survival Commission, we can "Red List" species that are at risk of extinction and estimate that risk by designating them *Vulnerable*, *Endangered*, or *Critically Endangered* by analyzing their patterns of distribution. Each group that is analyzed serves as an example for identifying priority areas for conservation. This then allows us to rigorously evaluate how effective protected areas are in conserving plant diversity and to make policy recommendations about modifying reserve borders or establishing new protected areas.

In the field locations where we work, our scientists play a unique role in the conservation process. Not only have we gathered an unparalleled amount of collections data that helps us analyze priorities, but we have also established a complex network of personal connections with both international research partners and members of the local communities in areas where we work. In the Selva Maya of Mexico's Yucatan Peninsula, a program initiated by the Botanical Garden is under way to band trees and measure annual growth to help local foresters determine what is a sustainable yield of each of the species that are harvested. This helps foresters ensure that the natural capital of their forests is not depleted and it helps improve their economic situation by helping them obtain certification that the timber they produce is sustainably harvested. These local partnerships help us arrive at the conservation solution that is appropriate for each individual situation, involving local communities in the process.

The combination of our capacity to analyze a wealth of collection data coupled with the impact we can have through our extensive network of international partnerships, places us in a unique position in the conservation world.

Far left: On the Pacific island of Guam, the population genetics of an endangered cycad, *Cycas micronesia*, is being analyzed by Garden scientists in order to plan a conservation strategy.

Near left: In the Selva Maya, the second largest tropical forest in the New World after the Amazon and located in Mexico's Yucatan Peninsula, local foresters band trees and measure annual growth to help determine and manage sustainable yields of mahogany and other timber species. Dr. Charles Peters is advising the local foresters.

# Field Studies: The Amazon

In some places, the Amazon Basin seems endless; in others it seems to be coming to an end, and fast. Given its vast perimeter and the many habitats (from dry forests to dry or super-wet savannas, mountains, and rocky hills) transitional to Amazon forests, sometimes it is hard to know where it even begins.

The New York Botanical Garden's history of scientific work in Amazonia began in 1881, when Henry Hurd Rusby descended the Andes and arrived at Rurrenabaque, Bolivia. Now with 47 continuous years of collaborations in various parts of the Basin, Garden scientists continue to participate in the effort to decipher this great puzzle. They are also working to inf uence its future; at stake is the fate of millions of acres of forest and several million forest dwellers. The Amazon continues to be the primary focus of several of the Garden's scientists, and much of its research staff studies at least some aspect of that region.

Garden systematists in particular tackle some of the most diverse, ecologically important, and difficult families of plants in the Amazon and use them to develop models for revealing evolutionary mechanisms and biological patterns. Systematics is the gravitational center of all biodiversity studies, and all of them, whether they relate to management or conservation, depend heavily on rapid, accurate, and consistent identification. Identification is in a sense a by-product of good systematics, and Garden scientists have developed or advanced (or are in the process of creating) new identification tools, ranging from DNA barcoding to a manual for describing the architecture of leaves.



Botanical Garden scientists have worked in many parts of the vast Amazon basin for more than a century.

Far left: An aerial view of Rio Tarauacá shows the typical meandering, ever-changing courses of rivers in southwestern and western Amazon.

Center: In the western Brazilian state of Acre, Dr. Douglas Daly and local master woodsman Edilson Oliveira are working with local scientists and other residents to document biodiversity and to manage both timber and non-timber forest resources sustainably.

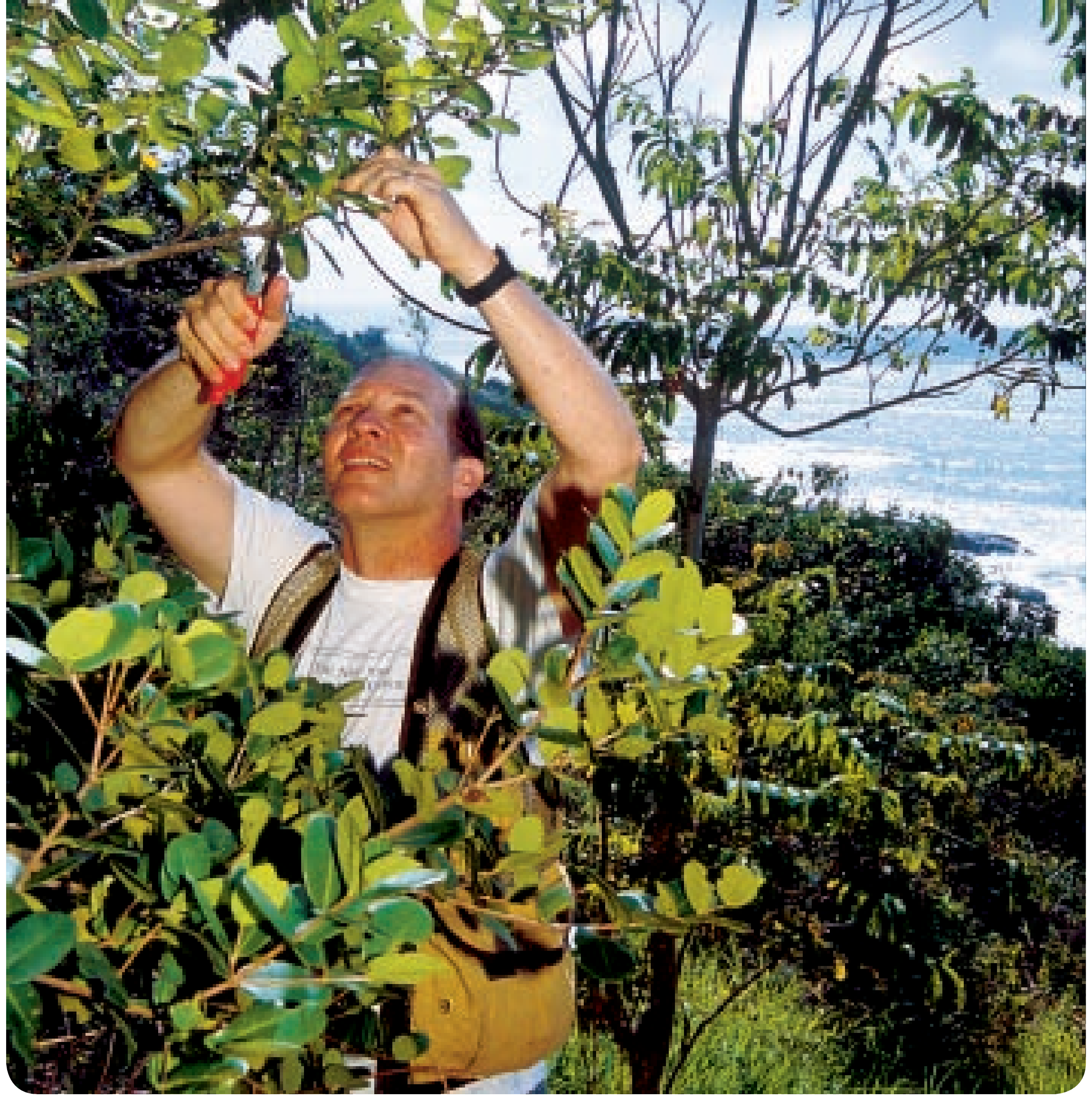
Near left: Rio Negro near the Brazilian/Venezuela border, is a very different habitat, a black water river poor in nutrients washed down from the Guayana Highlands to the north.

Unfortunately, given the scale of the area, the resources for botanical research in-country are few and far-f ung, and there is an increasingly urgent need to train and employ botanists throughout the region. Curators, botanists, and economic botanists at many Latin American institutions obtained their doctorates at the Botanical Garden. Close collaborations, like the ongoing 18-year-old program with the University of Acre in Brazil, also foster training at the technician, undergraduate, and master's levels. That same program is currently knitting into an integrated cooperative network all the herbaria in the three countries comprising Southwestern Amazonia.

In the area of forest management, the Garden's Institute of Economic Botany has been at the vanguard of studies demonstrating the importance of combining traditional resource management systems with solid, current ecological and economic information about a changing social landscape.

The Garden also houses the world's most comprehensive herbarium collection of the Amazon f ora, and, in collaboration with Brazil's Biodiversity Research Program, it now has a National Science Foundation grant to digitize, and form an electronic database of, images of its estimated 300,000 specimens from Brazilian Amazonia. The Garden's new Geographic Information Systems Laboratory has developed a map of Amazonia with over 400 habitats onto which distributions can be plotted to indicate if a given species is restricted to one or a few habitats.

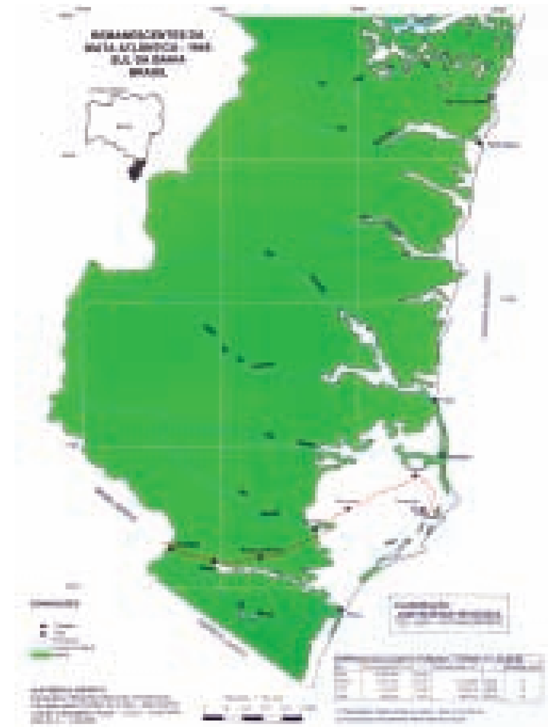
Botanical Garden scientists create and seize opportunities to contribute to public policy in Amazonia. These opportunities for policy input will only increase as the Garden strengthens its collaborations in Amazonia, and as it continues to enhance its agility and creativity with large sets of biodiversity data.

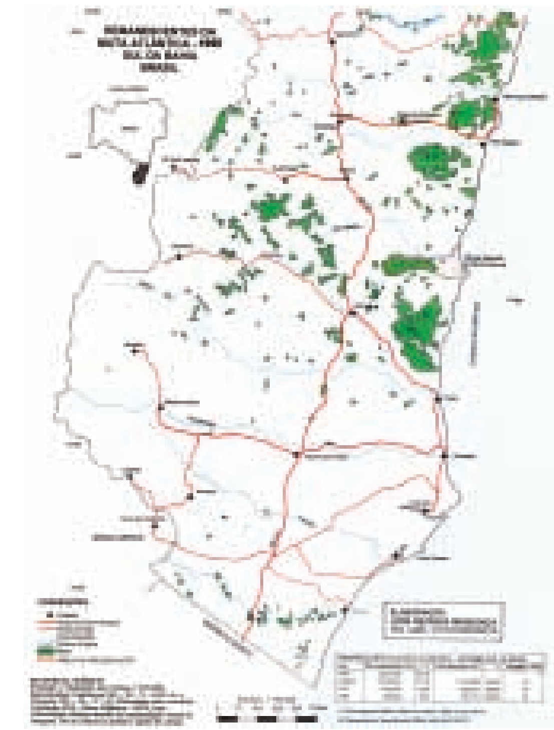


# Field Studies: Brazilian Coastal Forest

The Brazilian coastal forest is one of the world's biodiversity "hotspots"—highly threatened, biodiverse areas rich in species found nowhere else. This long, narrow strip of forest spans over 23° of latitude and over 4,000 kilometers along the coast of Brazil—a distance equivalent to that of Nova Scotia to Cuba. As a result, it comprises many different kinds of forest, each with its own f ora and conservation problems. Our program focuses on those of northeastern Brazil, principally those of southern Bahia, an area twice the size of Switzerland, where forests have been reduced to fragments occupying less than 7% of their original extent. Compared to the forests farther south, the northeastern coastal forests are more diverse, more endangered, and less understood.







Dr. Wayt Thomas reaches up to collect a specimen at the Pé da Serra beach in tha Mata Atlântica rain forest in Bahia, Brazil. Studies have shown forests in Bahia to have one of the highest levels of biodiversity of any forest in the world. The maps contrast the extent of forests in Bahia in 1945 and 1990, a dramatic story of deforestation and fragmentation in this highly threatened biodiversity hotspot.

The region is varied in its rainfall, topography, and geology. That diversity and the climatic stability of the region have resulted in a patchwork of distinct forest types throughout the landscape and an extremely diverse f ora. A single hectare (2.5 acres) may have more than 250 species of trees with trunks measuring over four inches in diameter. By comparison, all of temperate eastern North America is home to just 230 tree species. In addition, our research shows that over a quarter of the plant species found in the forests of southern Bahia only exist there. These endemic species, unique to each forest type, will become extinct if these forests are cleared. The coastal forests in the rest of the Northeast, in the small states of Sergipe, Alagoas, Pernambuco, Paraíba, and Rio Grande do Norte, are even more endangered than those of Bahia—and just as poorly known.

The Botanical Garden has had an active research and conservation program in northeastern Brazil since 1990. Our collaborations have led to complete botanical inventories of numerous forest sites, and the resultant data has been used to inform the conservation process and encourage environmentally responsible development in the area. For example, in the region south of Itacaré, Bahia, Garden-sponsored research showed that coastal forests there were among the most diverse in the world, and local policymakers used this information to help guide rational development there. At the time, an asphalt road was being planned to enable the development of Itacaré as a beach resort. Local collaborators were able to use our data to force construction of an environmentally friendly road, following the terrain's contours and avoiding, thus saving, large blocks of forest.

Farther south, the significance of our botanical inventory work led to the acquisition of land forming the largest state park in Bahia, Parque Estadual Serra do Conduru. The research from this project has guided purchases of intact forests as conservation areas, as in the case of the expansion of the Una Ecopark. Farther north, in the state of Alagoas, we collaborated with the Federal Rural University of Pernambuco, Federal University of Paraíba, and Institute of the Environment of Alagoas to survey the Murici forest, one of the world's most critical habitats for bird conservation.

# Field Studies: The Caribbean

Dr. Brian Boom (middle), Director of the Caribbean Biodiversity Program, examines plant specimens in the herbarium of the Jardín Botánico Nacional in Cuba.

A tree fern (bottom), *Cyathea arborea*, on the island of Saba in The Netherlands Antilles, site of an island-wide inventory of plants conducted by the Garden in partnership with local and regional conservation groups

Another biodiversity hotspot, the Caribbean is home to some 11,000 native species of seed plants, of which nearly 72% occur nowhere else. However, more than 500 years of colonization, conf ict, and economic development have taken a heavy toll on the Caribbean's biodiversity. While 75% of the Caribbean's pre-Columbian forest cover has been lost, fortunately there is growing environmental awareness in the region, with increasing numbers of places being set aside as protected natural areas.

The New York Botanical Garden has worked to document, study, and conserve plant and fungal diversity in the Caribbean for more than a century, amassing as a result the world's largest and most important collection of Caribbean plant and fungal specimens and associated scholarly literature. The Garden's current Caribbean program has a three-pronged mission to 1) document Caribbean plants and fungi: names, distributions, uses, habitats; 2) disseminate biodiversity information to scientists and the general public; and 3) inform policies for Caribbean conservation and sustainable development.

The Garden carries out this mission through a variety of projects, some of which span the entire Caribbean region and others that are island-specific. The central and most encompassing of these region-wide projects, involving biodiversity data synthesis and dissemination, is the Virtual Flora of the Caribbean. The results of this project, which will be available on the Garden's Web site through its Caribbean Biodiversity Portal as a dynamic electronic publication, will have electronic keys to identify species, as well as high resolution digital images of specimens from the William and Lynda Steere Herbarium, pictures of living plants and fungi, maps, links to DNA barcodes, and relevant published literature via links with the online catalog of the LuEsther T. Mertz Library.

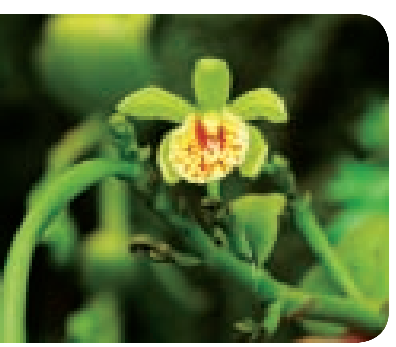
Another kind of project undertaken by the Garden in the Caribbean focuses on an assessment of threats facing the region's biodiversity. For example, in a current project, Habitat Specificity of Selected Endemic Cuban Plant Species, specimen localities are being mapped, and these maps are being analyzed in the Geographic Information Systems Laboratory of the Garden. Not only will the results have implications for conservation of some of Cuba's most threatened plant species, the data collection and analysis protocols developed will be applicable for use throughout the Caribbean region and beyond.

Yet another island-specific project that has region-wide implications is Plant Conservation and Sustainable Management in the Jaragua-Bahoruco-Enriquillo Biosphere Reserve, Dominican Republic, the main goal of which is to identify the best routes for corridors to connect the core areas of the Reserve in order to conserve threatened species. The project will result in a new cadre of biodiversity scientists and resource managers, a more biodiversity-literate local population within the Reserve, and a set of protocols that can be scaled-up throughout the Caribbean as a best-practices model for *in situ* biodiversity conservation.

When plant populations are too small for threatened species to be conserved in nature, an alternative strategy is to relocate them to a safe place, where conservation might be possible. This so-called *ex situ* conservation is the approach of a developing project in Puerto Rico, the activities of which are getting threatened species into cultivation, learning to propagate them, and attempting to reintroduce them into their native habitats. This project will serve as an *ex situ* model for rescuing endangered plant species throughout the Caribbean region.

The mountainous topography of the Caribbean's second largest island, Hispaniola, is the locale for several research and conservation initiatives of the Garden's Caribbean Biodiversity Program.

# Field Studies: Micronesia



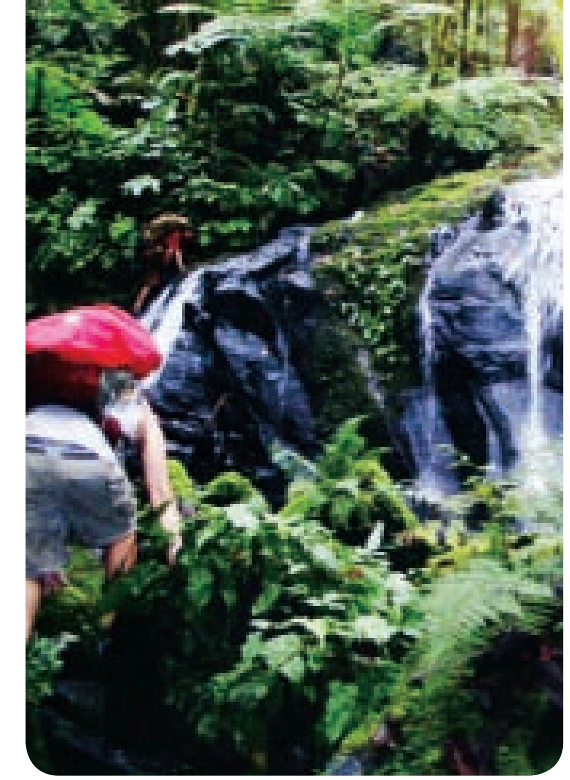
*Galeola ponapensis*, an orchid found only on the island of Pohnpei

Micronesia, in the western Pacific Ocean, is a region of vast biodiversity, with many unique plant species—76% of the plants native to these islands are found nowhere else on Earth, making this region the eighth most important biodiversity hotspot based on rates of plant endemism. This rarity is the result of the isolation of the individual islands, their diverse topography, and the fact that they are found very far from continents that would otherwise dominate their f oras. Micronesia contains over 2,000 individual islands spread throughout 3.5 million square miles of ocean, an area approximately the size of the continental United States, and is located about 2,500 miles southwest of Honolulu. The Garden's work in Micronesia involves the study of the botany and the traditional utilization and conservation of the f ora across an approximately 1,500-mile-long transect from the islands of Kosrae and Pohnpei in the east to the Republic of Palau in the west.



The local people who staff the three centers of botanical research in these island nations were all trained by the Botanical Garden. Teams of botanical scientists are exploring some of the most remote and least known parts of these islands to collect plants and fungi, producing biodiversity inventories and gathering information on how plants and fungi have been used traditionally for food, fiber, construction materials, medicine, and other purposes. Most recently, Garden scientists and collaborators have made expeditions to the Rock Islands of Palau and the high volcanic mountain forests of Pohnpei—both regions with poorly known f oras. They are documenting this information in papers, books, and databases. Through a new grant from the National Science Foundation, they are also working to evaluate the effects of agriculture on streams and rivers that f ow through the high mountain watersheds of Kosrae and Pohnpei—for example, by measuring the water chemistry, f ora, and fauna of these streams and seeing how these are affected by different ways of managing the forests.

There is also an ethnomedical training component of this project, designed to build an understanding of the relationship between public health and biodiversity. One feature of this is the preparation of primary health care manuals for each field site, where, working with local and international physicians, we evaluate plants for their potential use in treating common health conditions. Another is the on-site training (of U.S.-based physicians, medical students, and students in the medical sciences) in ethnomedicine and its potential application to clinical practice. Through the College of Micronesia



in the Federated States of Micronesia, Garden faculty members have developed an ethnobotany course, the first of its kind in the region; hundreds of students have participated in this class, designed to foster a better understanding of the importance of plants in island life.

The Botanical Garden's work in Micronesia comes at a particularly important time in the history of conservation efforts in this region. Since 2006, the Micronesia Challenge—a commitment by the leaders of Palau, the Marshall Islands, Federated States of Micronesia, Guam, and the Northern Mariana Islands to conserve at least 30% of the near-shore marine and 20% of the terrestrial resources across Micronesia by the year 2020—is one of the globe's most ambitious efforts to protect native habitats. Armed with the knowledge of plant diversity, particularly the locations of endemic and rare plant species, and an understanding of the ecology of the habitats where they are found, conservation planners can demarcate the most important terrestrial areas. Botanical Garden scientists are actively working with these planners to help identify and protect these critical habitats.

Far left: A canoe glides on the Lewi River in Pohnpei, an island habitat that fostered the development of many species found nowhere else on Earth. Botanical Garden scientists are working to document the plant biodiversity of the island, as well the uses and conservation status of the flora.

Near left: An expedition by Postdoctoral Research Associate Dr. Wayne Law and local team members involved climbing up a waterfall to monitor stream flow.

Far left: Garden scientists work in a variety of North American landscapes. Dr. Ken Karol studies freshwater green algae, thought to be the closest living relatives of all land plants, in locations such as lakes in Yosemite National Park.

Near left top: *Eschscholzia glyptosperma*, a poppy from the Intermountain Region of the western United States.

Near left botttom: Dr. Robert Naczi, Curator of North American Botany, inspects plants in the Garden's own Forest. Dr. Naczi is updating the Botanical Garden's classic "Gleason and Cronquist" *Manual* of the flora of the northeastern United States, an important reference work for botany and conservation studies in the region.

# Field Studies: North America

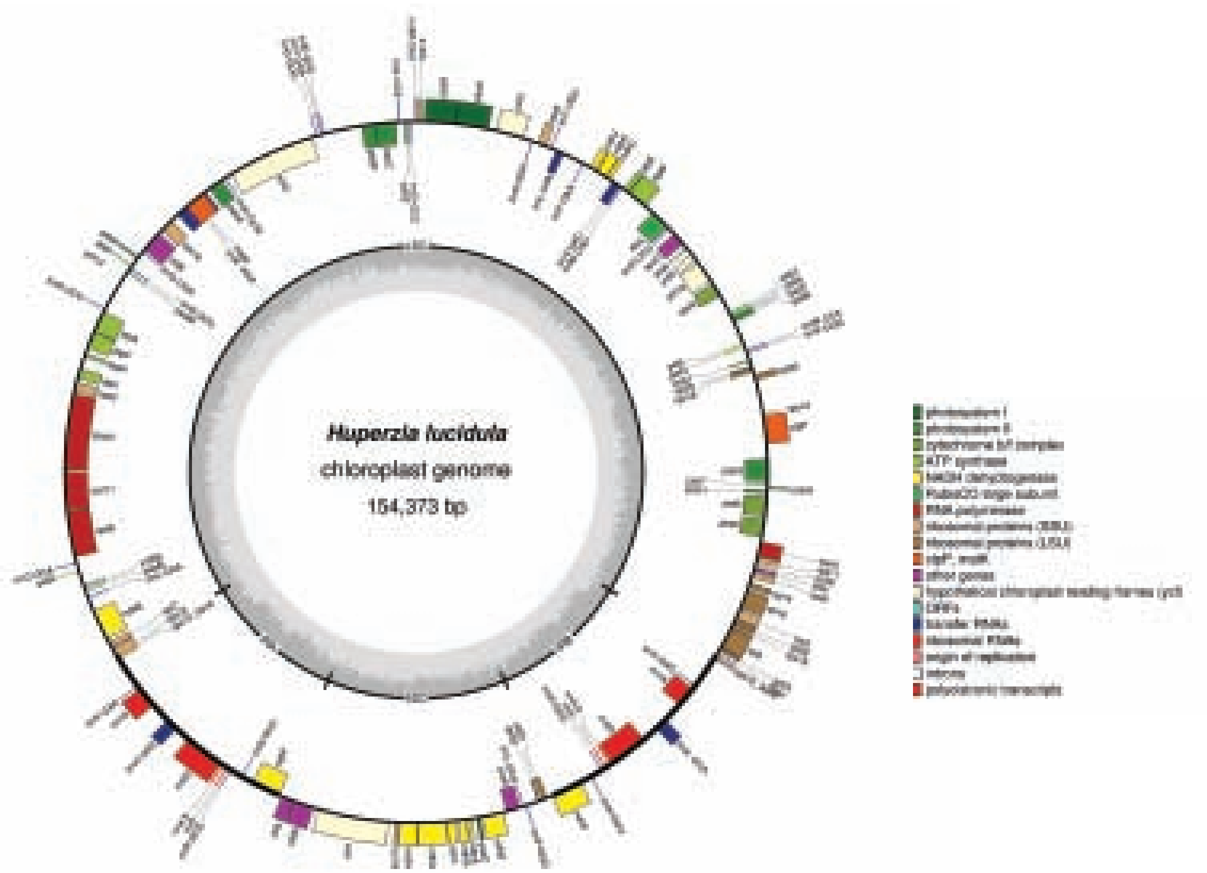
One of the major goals of The New York Botanical Garden's founding director, Nathaniel L. Britton, was to produce a manual that would enable anyone with a basic knowledge of botany to identify any plant growing wild in the northeastern United States and adjacent Canada. Since the first volume of Britton's *An Illustrated Flora of the Northern United States, Canada, and the British Possessions* was published in 1896, Botanical Garden curators have been involved in research and publication on the f ora of North America. The most recent incarnation of Britton's legacy is Dr. Noel Holmgren's 1998 book, *Illustrated Companion to Gleason and Cronquist's Manual: Illustrations of the Vascular Plants of Northeastern United States and Adjacent Canada*.

Since then, Garden curators have taken the lead in the study of the f ora of other parts of North America. For example, *Intermountain Flora* (published by The New York Botanical Garden Press) covers all of Utah and portions of Arizona, California, Idaho, Nevada, Oregon, and Wyoming. The first volume of this f ora was published in 1972, and the final volume is nearing completion.

A new curator for North American botany was recently hired to re-establish a program for research on the f ora of North America at the Garden. The initial step in building this program will be to produce a revision of Gleason and Cronquist's *Manual*. The *Manual* includes identification tools, descriptions of the morphology, habitat notes, and description of geographic ranges for about 4,350 species of vascular plants. This chunk of diversity amounts to about 25% of the total plant species for North America, a surprisingly high figure considering several centers of continental plant diversity are elsewhere. In addition, the *Manual* provides descriptions of about 200 plant families, 65% of the North American total.

The time is ripe for a new f ora of the Northeast. Through this project, the Garden will have the opportunity to build on its tradition of leadership in the study of the f ora of North America, while moving f oristics into the 21st century. This project will utilize and develop tools for the latest technologies, for example Internet publication and hand-held devices, which will enable users to take the electronic f ora with them into the field. The *Manual* will expand to include species described as new to science since the last revision, and the many invasive species that have become established in the *Manual* range in recent years.

"Gleason and Cronquist," as the *Manual* is familiarly known, has instant name recognition among botanists, especially in the Northeast. The market for the *Manual* is broad, since it is in use among college and university students, conservationists, environmental consultants, native plant gardeners, and members of the general public interested in plants. As well, the revised *Manual* will be a springboard to other projects on the f ora of North America. These projects will contribute to the Garden's mission by studying plants in the field and documenting them with collections. Through these projects, the Garden will continue to participate in the global inventory of plants and to publish tools for their identification.




# Laboratory Studies: Lewis B. and Dorothy Cullman Program for Molecular Systematics

The Lewis B. and Dorothy Cullman Program for Molecular Systematics, established in 1994 in partnership with the American Museum of Natural History, has been a major addition to laboratory-based research at The New York Botanical Garden, allowing our scientists to maintain their international leadership role in plant research. The methods of molecular biology have revolutionized the way we reconstruct the genealogies of plant families and orders. We can now sequence the DNA of one or more genes; each sequence can generate 1,000 or more pieces of information, which we may then analyze to produce family trees, i.e., genealogies. Obtaining this quantity of data has become quite routine and relatively fast, particularly when compared to the old method of generating data from chemistry or structure. Hypothetical family trees using DNA sequence data have become the benchmarks against which hypotheses are then tested with structural and chemical data, and vice versa.

Cullman Program scientists are now generating sequences of whole genomes of chloroplasts (the green bodies in plant cells responsible for photosynthesis and production of the oxygen we breathe) and whole plant cell genomes. In partnership with Cold Spring Harbor Laboratory, as part of a program to further develop and refine the sequencing process and the analysis of the data produced by it, we will complete whole plastid genomes of cereal grasses and gymnosperms. We have also completed a whole genome of a fern ally, *Selaginella apoda*, a result achieved by the interaction of molecular systematics, structural botany, and plant genomics at the Botanical Garden, which ref ects the uniqueness of laboratory research here.

Another important new research technique enabled by the Cullman Program is DNA barcoding, through the adaptation of a familiar technology developed for commercial use, to the purposes of scientific research. The black and white "barcode" label that is present on virtually all commercial products today was developed as the "universal product code system." This pattern of eleven varying width black lines on a white background, with ten possibilities at each position, allows for 100 billion alternative products to be uniquely identified and tracked. In the same manner, a short segment of DNA sequence composed of varying patterns of A,C,G,T nucleotides should be able to identify different species of organisms from one another, including the perhaps 400,000 known species of plants in the land f ora. It also makes possible the identification of plants and their parts when the traditional parts for identification are missing.

Barcoding is powerful in many other ways as well. For example, it works with fragments, so that it can identify a species from bits and pieces. When established, barcoding will quickly identify undesirable animal or plant material in processed foodstuffs and detect commercial products derived from regulated species. It also works for all stages and plant parts, so that it can identify a species in its many forms, from seed, to seedlings, to adults and f owers; it thus can help to identify invasive species before they become established. Barcoding also unmasks look-alikes, uncovering dangerous organisms masquerading as harmless ones and enabling a more accurate view of biodiversity. Barcoding links biological identification to advancing frontiers in DNA sequencing, miniaturization in electronics, and computerized information storage. Integrating those links will lead to portable desktop devices and ultimately to hand-held barcoders. Imagine the promise of a schoolchild with a barcoder in hand learning to read biodiversity in the wild, the power granted to a field ecologist surveying with a barcoder and global positioning system, or the security imparted by a port inspector with a barcoder linked to a central computer! These are just a few of the exciting ways that barcoding is revolutionizing plant science at the Garden and elsewhere.

Intern Alexandra Kassidis processes samples for study in the Lewis B. and Dorothy Cullman Laboratory. She worked with Botanical Garden scientists to extract DNA from plant tissue, amplify it with polymerase chain reactions, and separate DNA molecules by size through gel electrophoresis.

# Laboratory Studies: Plant Genomics

Initiated in 2000 as a natural extension of the highly successful Cullman Program for Molecular Systematics, The New York Botanical Garden's Plant Genomics Program has already established itself as an important program for studying the genomic basis of plant diversity. The mission of the Genomics Program is to establish the role of gene function in plant evolution: to understand how the genes of different species determine what they look like, how they function, and how they produce the fruits, seeds, fibers, medicines, and nutrients we rely on. As the only genomics program at a botanical garden, we are uniquely positioned to combine new genomic and molecular technologies with traditional techniques of systematics and morphology to elucidate the role that changes in gene function have played in the evolution of the diversity of plant life on Earth today.



Far left: Dr. Amy Litt, Director of Plant Genomics and Cullman Curator, tests the results of a genomics experiment.

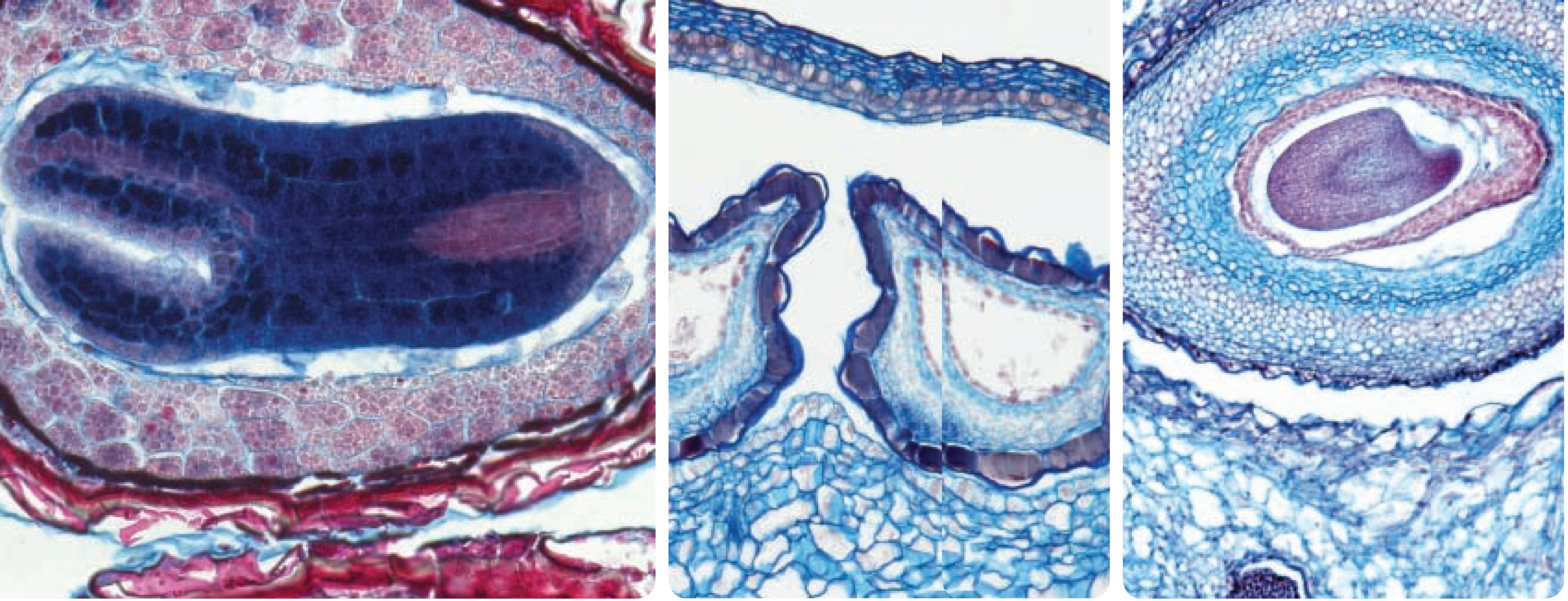
Near left: *Aristolochia fimbriata*, native to South America and a member of the Dutchman's Pipe family, is cultivated in the environmentally regulated growth chambers of the Pfizer Plant Research Laboratory so the Garden's genomicists can study the genes that control the formation of flowers.

The New York Botanical Garden's Plant Genomics Program is housed in the new, state-of-the-art Lewis B. and Dorothy Cullman Laboratory. This cutting-edge facility is equipped with new technologies that allow researchers to study aspects of the genomic basis of plant diversity that have previously been impossible to address. This and the other resources at the Garden, in particular the living collections, Steere Herbarium, and expertise of the Science and Horticulture staffs, create a research environment unequalled at any other institution. Taking advantage of the opportunity this provides, the staff and students of the Garden's genomics group have established a program recognized internationally for its unique ability to address some of the most important and long-standing questions in botany.

To maximize the potential of the unique research environment of New York City and the diverse resources of its high caliber local science research institutions, the Garden joined with New York University (NYU) and Cold Spring Harbor Laboratory (CSHL) to form the New York Plant Genomics Consortium. This collaborative relationship provides a framework for research projects that capitalize on the strengths and the distinct areas of expertise found at each institution. Currently consortium researchers are using the Garden's genomics and plant diversity expertise in conjunction with the DNA sequencing capability of CSHL and the computational facilities of NYU to identify genes that may have played a role in the origin of the seed. This evolutionary event not only allowed for the diversification of seed plants, such as the conifers or f owering plants, but also gave humans one of their most valuable sources of nutrition.

The staff of the Genomics Program is also committed to educating the next generation of plant genomicists, and participates in the joint graduate programs that the Garden has established with New York area universities. In addition, we provide research training for undergraduate and high school students during the academic year and during the summer. In carrying out their research projects under the supervision of our curators, postdoctoral researchers, and graduate students, these interns learn skills and knowledge that prepare them for a possible career in research, while at the same time generating data for publications and often getting university course credit.

Research in the Botanical Garden's Plant Genomics Program covers a diverse array of topics related to the roles genes play in plant structure, function, and evolution. These range from studying genomic responses to plant-produced neuroactive compounds, to the analysis of how gene activity affects f ower formation and f ower structure, to the genomic changes that accompany the domestication of crop plants. A major thrust of our research is aimed at studying the effects of climate change on plant genomes and we are currently developing genomic techniques for use in studies of plant conservation. The results of genomics research at the Garden are important for conserving the diversity of plant life in the face of a changing planet, as well as for agriculture, medicine, and a better understanding of the world around us.



Stained tissue sections of a nicotiana seed (far left), petunia capsule (middle), and tomato fruit (near left) enable scientists to study plant structure and development in the members of the nightshade family (Solanaceae).

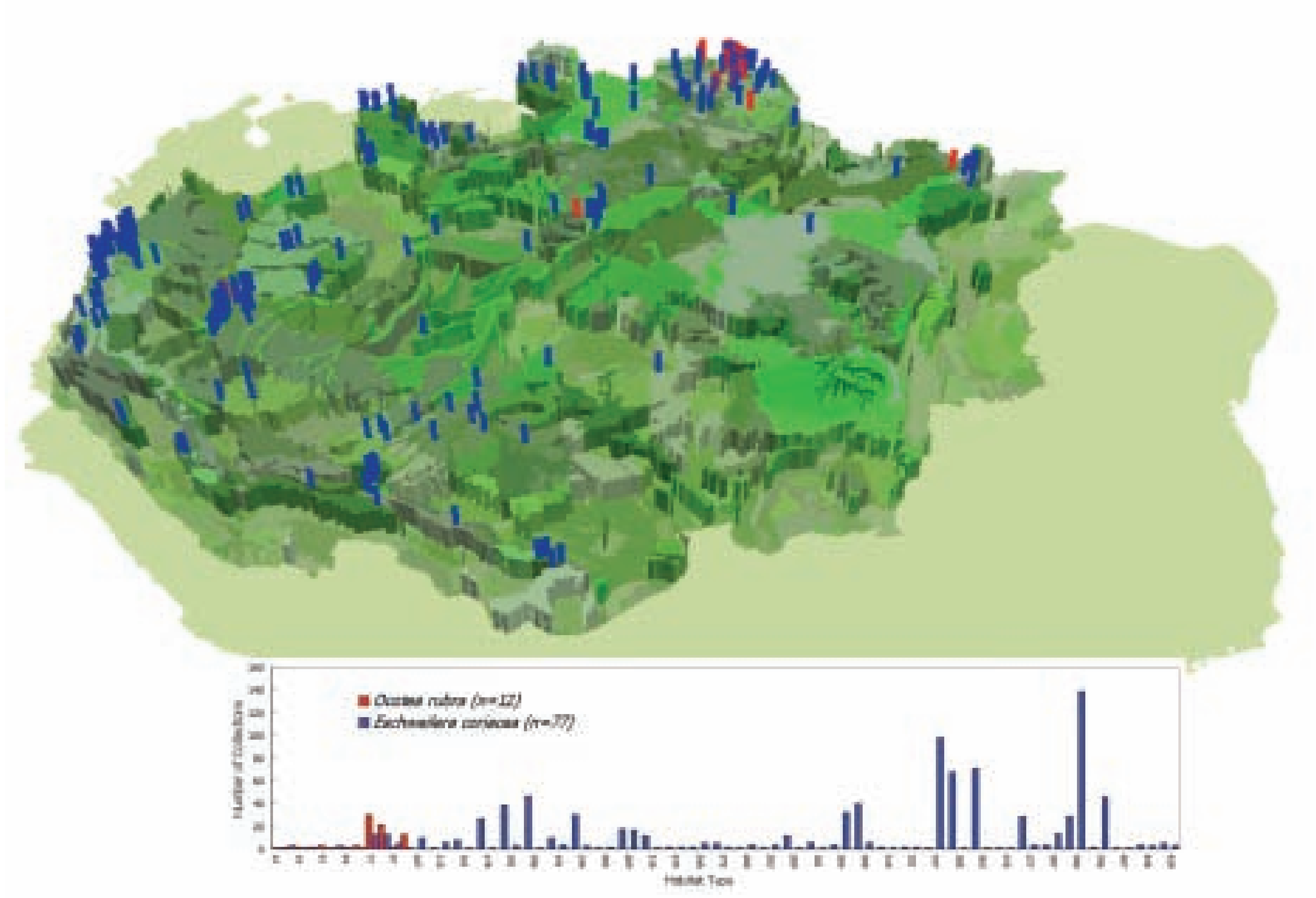
## Laboratory Studies: Structural Botany

Structural botany, which encompasses plant anatomy and morphology, is the study of how a plant is put together, from the form of the plant and its organs to the differentiation of its tissues and their cell types that make up a plant as we see it. As such, structural botany intersects with plant genomics, plant systematics, plant ecology, archeology, and climate change studies. The New York Botanical Garden is one of the very few institutions to have a modern, well-equipped, and internationally recognized laboratory and program in structural botany. Among its achievements is the production of a textbook in plant anatomy that is both highly regarded and widely used.

The basics of structural botany serve as the foundation for the study of the evolution of development in genomics. One has to establish the baseline of the specialization of cells, tissues, and organs in space and time before one can begin to assess what genes in the genome are responsible for the changes that lead to a mature structure. Basic plant structure, such as the types of cells in a tissue as compared across many species, is valuable for testing the results obtained from molecular systematics. Plant structure is related to function, and ecological plant anatomy allows us to explore the changes in development and final structure as they relate to ecological conditions, such as the leathery leaves with thick layers of wax to prevent water loss in desert plants or the large air spaces in lily pad leaves that allow them to f oat on the surface of the water to maximize exposure to the sun. In order to study plant structure, we need to take a plant apart and examine it with traditional light microscopes and now with the Scanning Electron Microscope as well.

The New York Botanical Garden is a leader in the study of plant structure and development because it has a unique combination of staff using genomic approaches as well as staff expertise in structural botany. Supporting this research is a Scanning Electron Microscope (SEM) facility along with a facility for modern light microscopy. The SEM provides a three-dimensional view of developing organs, which allows the researcher to follow changes in shape through time and space and can be used for external reference when the organ has been dissected or sliced in to thin tissue sections.

An important component of structural botany is wood anatomy, the study of the cell structure found in wood. This data is used in reconstructing plant family trees, identifying archeological materials (plant remains) and the ecological conditions that were present when the wood was formed, and in tree ring dating for determining historic climatic conditions, and shifts in temperate climates over time within a single tree's history. The Garden has a collection of wood slides and wood blocks that is valuable in undertaking such studies.

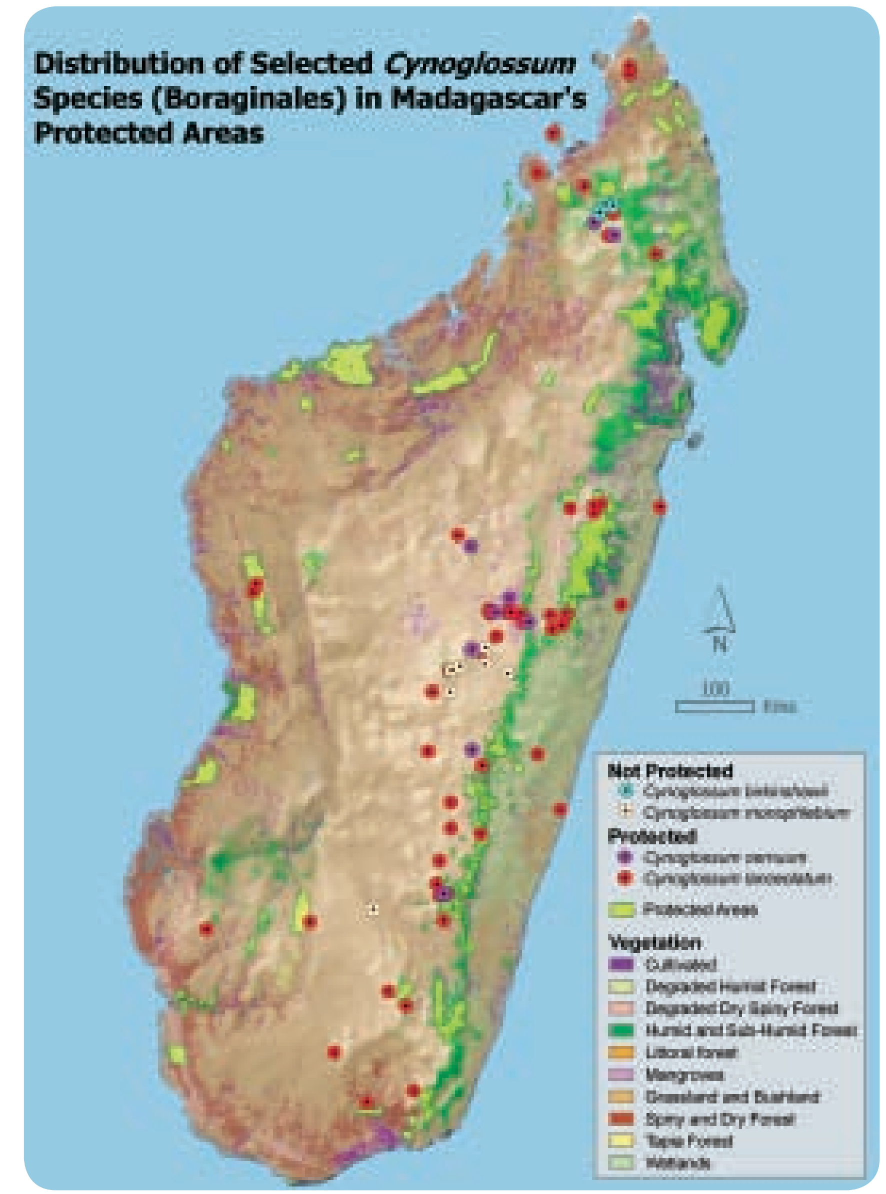



# Laboratory Studies: Geographic Information Systems

The state-of-the-art Geographic Information Systems (GIS) Laboratory was established to support the Garden's current botanical research and conservation programs. The primary goal of the GIS Laboratory is to utilize the wealth of herbarium specimen data available through the Steere Herbarium, in conjunction with a variety of spatial and geostatistical analyses to inform the preservation and management of plant resources.

A Geographic Information System is a computer-based tool for mapping and analyzing geographic information. GIS is used, first of all, to produce maps for fieldwork, presentations, and publications. It is also a suite of tools used to explore, manipulate, and visualize spatial information. The real power of a GIS is its ability to link spatial and descriptive data and to combine them in various ways to show relationships or to create geographic models.






The analytical power of GIS mapping technologies can be applied to plot distributions of specific species over large areas, and to combine that data with other parameters such as habitats.

Far left: The diagram shows different tree species and habitats across the Amazon. Geo-plotting helps identify species most at risk of extinction.

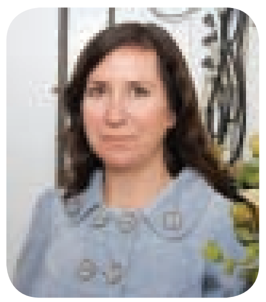
Near left: A GIS study in Madagascar demonstrates which endangered species occur in protected or non-protected areas.

The Garden's GIS Laboratory is applying this technology to a variety of spatial problems; applications range from mapping plant distributions and correlating these patterns with the distribution of habitats, to complex geospatial analyses prioritizing areas for research based on past collection efforts. In other geospatial analyses, the GIS Laboratory is adding to the dialogue concerning where new protected areas should be placed by assessing the effectiveness of protected area networks in preserving species at risk of extinction. Identification of those plants that fall within the categories of threatened and endangered is another objective, and a number of tools have been created to quantify spatial criteria for the Union for the Conservation of Nature and Natural Resources Red List (list of endangered species) assessments. Further work concerns the predictive modeling of species' distributions based on climatic preferences in order to measure changes in species' distributions in relation to changes in land cover, assess how distributions may shift over time due to climate change, and determine how these shifts might affect protection status.

# Faculty: Research Profiles

# Faculty

The research interests of the Garden's 32 Ph.D.-level faculty members are profiled here. These scientists are joined in their research projects by several dozen Garden graduate students, postdoctoral researchers, honorary curators and research associates, together with hundreds additional collaborators globally, resulting in one of the most extensive international networks for plant science research and training around the world.



### Barbara Ambrose, Ph.D.

There is an astounding array of land plant morphological diversity. I am interested in how this vast amount of morphological diversity is specified. To study this question, I use a group of proteins called the MADS-box family of transcription factors. These proteins are most well known for their role in building the flower. Different combinations of these proteins are able to make the floral organs: sepals, petals, stamens, and carpels. MADS-box proteins have been found throughout the land plants, particularly in mosses, lycophytes, ferns, and gymnosperms. However, it is not clear what role these proteins play in the development of these plants. I am using a combination of tools to study these proteins, including whole genome sequences from the moss *Physcomitrella patens*, the lycophyte *Selaginella moellendorffii*, and the flowering plant, *Arabidopsis thaliana.* Our functional studies have shown a role for some of these MADS-box proteins in pollen and seed development. Studies in mosses and lycophytes will help us understand the role these proteins have played in the development of land plants and provide insight into the generation of land plant morphological diversity.

### Michael Balick, Ph.D.

My research focuses on ethnobotany, the study of the relationship between plants, people, and culture, as well as seeks to understand the floristic diversity of selected tropical regions where our ethnobotanical studies are taking place. A significant part of this work involves the study of traditional ethnomedical systems—specifically, how people use plants for primary health care. At its core, ethnobotany is a multidisciplinary field, and thus our projects in Micronesia and Central America involve teams with specialists from many fields. Over the past decade our project, Biodiversity and Human Health in Micronesia, has involved fieldwork in Pohnpei, Kosrae, and Palau to document plant diversity and its uses, and explore strategies for improving primary health care based on studying local traditional medical systems. During the past three decades I have conducted scientific research in Bolivia, Brazil, Belize, China, Colombia, Costa Rica, Haiti, Honduras, India, Israel, Jamaica, Mexico, Federated States of Micronesia, Palau, Peru, Sri Lanka, Thailand, Trinidad, and Venezuela. In addition to international travel, my fieldwork also involves surveys of the botánicas of New York City, learning about the variety of herbal remedies.

### Brian Boom, Ph.D.

In my career, I have conducted research that is divided almost equally among systematic botany, economic botany, and neotropical forest inventories. I have published on several families of vascular plants (Theaceae, Rapateaceae, Gentianaceae, Isoetaceae, etc.), but most of my systematics research has centered on the Rubiaceae, the coffee family, including a revision of the genus *Isertia*; floristic accounts of the family at important biodiversity research sites in Amazonian Brazil (Biological Dynamics of Forest Fragments Project) and in central French Guiana (Saül); and descriptions of new species. I have led or participated in forest inventories of trees in Brazil, Ecuador, French Guiana, Bolivia, Guyana, Puerto Rico, and Venezuela. In conjunction with several of these forest inventories, I have conducted ethnobotanical studies in which I have quantified the use of plants by local indigenous people (e.g., the Chácobo of Amazonian Bolivia and the Panare of the Venezuelan Guayana). As director of the Garden's Caribbean Biodiversity Program, I am responsible for the creation, operation, and management of the institution's botanical research and conservation initiatives in the Caribbean, one of the world's biodiversity hotspots.



### Eric Brenner, Ph.D.

I am currently involved in three research projects at the Garden. In one, I am investigating the role of cycad-derived neuroactive compounds (believed to cause ALS-PDC, or Amyotrophic lateral sclerosis/Parkinsonism dementia complex) in Guam by exploring the affects of these neurotoxins on receptors in plants with structural similarity to those found in the nervous system of humans. Such studies may help us better understand the environmental causes of neurological disorders. My second research project centers on the conservation of these rare cycads of Guam (and Micronesia), which have become endangered from a recently invasive scale insect. The goal of this project is to genetically characterize individuals of these plants and target them for protection to maintain their diversity. In my third area of interest, I am studying the genomics of seed plant evolution. In particular, by using the most current sequencing and bioinformatic tools available to researchers, I would like to identify the genes in the oldest living seed plants—cycads, ginkgo, and gnetum—that were responsible for their evolution.

### William Buck, Ph.D.

Mosses are often overlooked, being of small stature, but they play major roles in the ecosystems they inhabit. I have studied mosses for more than 30 years, specializing in those groups that are mostly strongly branched and mat-forming (rather than weakly branched and tuft-forming) and whose spore capsules are formed laterally along the stems (rather than at the stem apex). These pleurocarpous mosses seem to be the most advanced group of mosses. Their evolution was strongly influenced by the appearance of angiospermous (having trees with seeds enclosed in a pod) forests, with many mosses evolving into epiphytic habitats. Throughout my career I have been interested in how different groups of mosses are related to one another. Initially, my evolutionary speculation was based primarily on examination of herbarium specimens. By studying mosses in their natural habitats in many parts of the world, I have learned much about how ecology is related to phylogeny (the history of organismal lineages as they change through time). More recently, I have added DNA sequencing data to my arsenal of tools for understanding moss relationships. Through the use of a wide array of techniques, I have come to understand the broad evolutionary patterns of pleurocarpous mosses and continue to study how various families of these mosses are related to one another.

### Lisa Campbell, Ph.D.

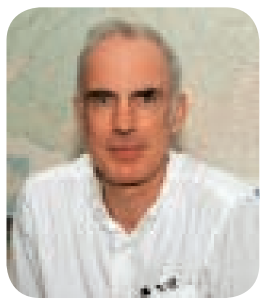
My research focuses on the biology and systematics of Xyridaceae (Yellow-eyed Grasses) and related families in the monocot order Poales, which also includes the grasses and sedges. These investigations include taxonomic revision, and anatomical, morphological, cytological, and reproductive biology studies, which are heavily reliant on field observations and collections. My research has centered on species occurring in the Guayana region of northern South America, a geologically ancient and unusual area, where many of the oldest Poales are endemic and have undergone great diversification. The structural diversity exhibited by these groups has enabled me to address questions that are fundamental to understanding their relationships and biology, and will aid in understanding plant diversity in general. A multi-national collaboration is developing a robust phylogeny that will provide a framework in which hypotheses of relationship, biogeographic history, and character evolution can be assessed. Most Xyridaceae are adapted to specific substrates, and many occur in ecologically fragile habitats that experience extreme exposure to the sun. Future investigation will address the utility of Xyridaceae as bioindicators of habitat health and whether policymakers can make use of data on their populations in developing management strategies.

### Douglas Daly, Ph.D.

I like to work in the area where systematics intersects with conservation, economic botany, and resource management. For me, the pure enjoyment of botany is in exploration, discovery, and especially solving puzzles, while ultimately the satisfaction comes from finding ways to apply botanical knowledge to steer our interactions with plant diversity. I study the Burseraceae, a family of tropical trees that is an important component of floras ranging from the parched Arabian peninsula to the pluvial forests of Pacific coastal Colombia. Many lineages in the family show bizarre geographical patterns, often with a few scattered relictual taxa but also one place where they have taken hold and diversified. One epicenter of Burseraceae diversity is the Amazon region, where it comprises one of the ten most important tree families. This is where I have focused most of my research, developing collaborations, fostering the growth of regional institutions, and studying the flora and plant resources, notably in southwestern Amazonia. Botanists are always seeking better tools for describing, identifying, and classifying plants, especially in diverse tropical forests, and leaves have been strangely overlooked. I have worked with six other botanists to produce a manual for describing leaf architecture.

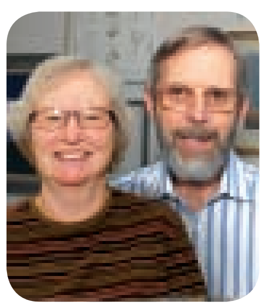
### Roy Halling, Ph.D.

My major research emphases have been on the classification, systematics, biogeography, and diversity of mushrooms. Mushrooms are important in terrestrial ecosystems as primary decomposers, litter binders, and nutrient recyclers. In addition, they form obligate root symbioses (mycorrhizae) with forest trees that maintain ecosystem health and integrity. This is natural and normal for 95% of all land plants and is undoubtedly responsible for the appearance of the global landscape. To better understand the diversity of these below-ground and essentially unknown fungi, I am exploring and cataloging fungal diversity; this requires fieldwork around the world, in northern and southern temperate zones as well as in the neo- and paleotropics. Continuing field efforts in these areas have added substantially to general investigations on tropical and temperate fungi. Critical laboratory analyses are coupled with this fieldwork. Via primary exploration in unexplored habitats, my researches are emphasizing inventories, classification, mycorrhizal relationships, and distribution of the Boletineae (porcini mushrooms). International collaboration with other specialists is under way on the systematics, biogeography, and phylogeny of Bolete mushrooms with particular emphasis in Australia and Southeast Asia.



### Andrew Henderson, Ph.D.

My research on the Palm family takes place in two different hemispheres and employs two different methodologies. In both cases, however, the goals are the same: to understand the diversity and distribution of species, make this information widely available, and further the cause of conservation. In the Neotropics I am using morphometric methods to revise the large and complex genus *Geonoma*, with about 100 species. Results of this work are made available on the Garden's Internet site as they become available. In the Eastern Hemisphere, I am involved in several projects. I have completed a treatment of the palms for the Flora of China, and am working on a treatment of the palms of Vietnam. My colleagues and I are studying ways to conserve and manage rattans, which are spiny palms whose long, flexible stems are the basis of the rattan furniture industry. I make the results of my research available to a wider audience by publishing field guides. *The Field Guide to the Palms of the Americas* was first published in 1995 and stayed in print for over 10 years, and my next project is the *Field Guide to the Palms of Southern Asia.*



### Noel Holmgren, Ph.D., and Patricia Holmgren, Ph.D.

We are actively working to complete the final volume of the fully illustrated, six-volume (eight-book) series, *Intermountain Flora*, the leading reference book on plant diversity in the Intermountain region of the western United States. This area comprises the dryland area between the Cascade-Sierra axis on the west and the Rocky Mountains on the east. The region contains many isolated mountain ranges, each with its own peculiar edaphic and climatic situation and many endemic and rare plants. Refusing to sacrifice quality for expediency, we prepare comprehensive descriptions, exhaustive bibliography, nomenclature, extended discussions, and detailed line drawings for each species, which makes this series nearly monographic in nature, in contrast to the more abbreviated treatments that are otherwise the norm for modern floras. *Intermountain Flora* is a widely used and essential resource for scientists, policymakers, land use managers, and others interested in the study and conservation of plant diversity and critical ecosystems and for wilderness protection in the American West.

### Jacquelyn Kallunki, Ph.D.

My research concerns the taxonomy of one group of genera (subtribe Galipeinae) of the Citrus family (Rutaceae). Although species of this group occur in lowland forests throughout tropical America, 34% occur in eastern Brazil, and 28% of these are endemic to the forests of that region. Based on specimens collected during only a few short trips in this region, a Brazilian colleague, José R. Pirani (Universidade de São Paulo), and I were able to describe 21 new species of a single genus (*Conchocarpus*). I am currently collaborating with Pirani in taxonomic treatments, with the goal of a subtribal treatment for *Flora Neotropica* and with Milton Groppo (Universidade de São Paulo-Riberão Preto) in molecular studies of the subtribe. My contribution to the latter is comparison of my morphological observations with Groppo's molecular analyses. Currently, I am working with Klaus Kubitzki on the treatment of the New World genera of Rutaceae for his *Families and Genera of Vascular Plants* and will continue to describe the new taxa recognized among collections from Eastern Brazil and elsewhere now residing in my office.

### Kenneth Karol, Ph.D.

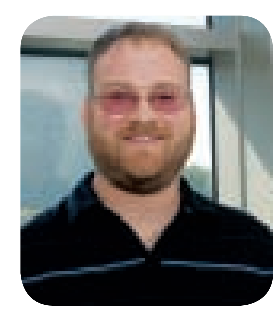
The evolutionary origin of land plants from their green algal ancestor was unquestionably a pivotal event in the history of life. This transition, and subsequent diversification, has radically transformed the biosphere, as plants now form the matrix in which all other terrestrial life exists. My primary research interests include understanding the transition of green algae to the land by gaining insight into the evolutionary history of the green algal family Characeae, the closest living relatives of land plants, an ancient lineage more than 430 million years old. The Characeae are found in fresh water lakes and streams throughout the world, and being the closest living relatives of land plants, the Characeae are an exciting group to study. I collaborate with an international group of scientists and together we use morphology, DNA gene sequence data, and complete chloroplast genome data to reconstruct the phylogenetic history of the Characeae and their land plant relatives. Our overall objective is to resolve the primary evolutionary history among green algae and land plants and to understand the genomic changes associated with that pattern. In the process we hope to produce a robust and stable classification system for this ancient and diverse lineage that can be used to study species diversity and target areas where conservation efforts should be focused.

### Lawrence Kelly, Ph.D.

My research focuses on evolution and classification in flowering plants, primarily in the sweetleaf family (Symplocaceae), and the kiwi family (*Saurauia*; Actinidiaceae). These are trees that grow in the high-elevation cloud forests of the neotropics and Asia. Both families are poorly understood taxonomically and in need of revision, as are many plants of the cloud forests. For *Symplocos* and *Saurauia*, I am working on taxonomic revisions for Mexico and Central America, and will soon begin working on the South American species of the genus in order to complete revisions of all New World species. I have discovered numerous undescribed species, and have also used molecular and morphological data to shed light on relationships, flower evolution, and biogeography in these genera. I am also involved in developing electronic keys for plant identification. These keys can be used on small, handheld computers, and therefore provide a valuable identification aid that can be used by scientists and nonscientists alike in remote field localities.

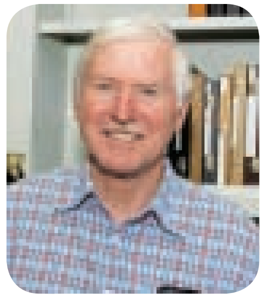
### Amy Litt, Ph.D.

I am interested in uncovering the genetic basis of plant diversity—how genes act differently in different species to produce the variety of plant forms we see around us. We are investigating this both by looking at how changes in specific "candidate" genes have caused evolutionary changes in plant structure, as well as by using gene discovery techniques to identify the genes responsible for the evolution of key innovations. Currently, we are studying how changes in one particular group of regulatory genes influenced flower evolution by examining the structure and function of these genes in flowering plant species selected from across the family tree. We are also identifying genes required to form an economically valuable fleshy fruit, by comparing gene activity during the development of dry capsules and fleshy berries in the tomato family. We are using a variety of newly developed genomic and molecular biology techniques, in combination with traditional systematic and morphological studies, to understand how changes in gene function during the course of plant evolution have produced the wide variety of plant structures and functions around us today.



### Damon Little, Ph.D.

My research is focused on Cupressaceae—the family of conifers that includes redwoods (*Metasequoia*, *Sequoia*, and *Sequoiadendron*), arborvitae (*Thuja*), junipers (*Juniperus*), and cypress (*Callitropsis* and *Cupressus*). The New World cypresses (*Callitropsis*) are generally restricted to relatively dry marginal habitats and thus have highly fragmented distribution patterns. These patterns, in combination with slight morphological variation, have led some to recognize almost every population as a distinct species. Nine cypresses are included in the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List. My research uses DNA data and a repeatable analysis of morphological characters to test the intuitive morphology-based species circumscriptions previously proposed and to produce a taxonomic monograph with companion electronic species pages for all cypress species. The large percentage of threatened species within *Callitropsis*, coupled with the extraordinarily controversial species boundaries, makes it critical to delimit biologically meaningful species. The DNA data that I am gathering will equip conservationists and policymakers with a high resolution map of genetic boundaries within the cypresses, allowing informed conservation and management decisions to be made.



## John Mickel, Ph.D.

Since the publication of the NYBG Press volume on the ferns of Mexico, I have been helping Mexican botanists with their studies of individual states or regions (Oaxaca, Veracruz, Guerrero, and the Yucatan Peninsula). Currently, I am working primarily on completion of my monograph of the primitive fern genus *Anemia*. It is a fascinating genus of 110 species that goes back over 130 million years in both macrofossils and spores. It is widespread in tropical America, much of it in Brazil, with twelve species in Africa and India, though in Cretaceous times it was worldwide. *Anemia* spores are the most distinct of all ferns with their parallel ridges, and Dr. Judy Garrison Hanks of Marymount Manhattan College and I are making a study of their variation with the aid of the scanning electron microscope. Horticulturally, I am helping in the development of fern gardens and brochures about them at several public sites, including the Rockefeller State Park Preserve (Pocantico Hills, N.Y.), Lyndhurst in the National Trust (Tarrytown, N.Y.), and Rocky Hills in the Westchester County Parks and Garden Conservancy (Mount Kisco, N.Y.). I also conduct tours of my home garden, which includes over 140 kinds of ferns, for garden clubs and other organizations.

## Fabián Michelangeli, Ph.D.

I am interested in understanding the processes responsible for the evolution of plant diversity in tropical ecosystems, and particularly the evolution of animal-plant interactions. To this end, I have focused most of my research on the large tropical family Melastomataceae, the glory bushes. This family is an ideal choice for a model system in the tropics because its species are locally abundant in all moist environments from sea level to above the tree line at the same time that they exhibit a high level of endemism and morphological variation. I use DNA sequences, and anatomical and morphological evidence to reconstruct the relationships of these plants, and then use this knowledge to study the evolution of ant-plant interactions, breeding systems, and pollination biology. This information is also used to understand the distribution patterns of large plant groups in the Andes, Amazon, and Caribbean basin. Additionally, along with collaborators throughout Latin America and the U.S., we are currently producing a comprehensive treatment that will be available through the Internet for a group of 1,800 species of Melastomataceae that are restricted to the New World tropics.

## James Miller, Ph.D.

My research and conservation studies combine my interests in tropical floristics, systematics of Boraginaceae, the use of systematics data in conservation, and the discovery of natural products derived from plants. I have collected plants and conducted botanical inventories throughout many parts of the New World tropics, Africa, and Madagascar. I also study the systematics of the tropical members of the Borage family. One of the outcomes of this work is the discovery that, with a robust classification and enumeration of all species, well-studied groups can inform conservation efforts by identifying places that are rich in endemic or endangered species. Without a strong taxonomy, conservation can be based on erroneous conclusions. We care about preserving the full range of biodiversity, because the genetic diversity found in plants is the basis for our food and many of our medicines. I have participated in numerous partnerships to collect and evaluate plants in efforts to discover novel chemicals that may lead to the development of new pharmaceutical, agricultural, or nutritional products.

## Robbin Moran, Ph.D.

I study ferns, especially those in Central and South America. My main interests are in fern evolution, geography, and classification. I have a grant from the U.S. National Science Foundation to study *Megalastrum* (Dryopteridaceae), a fern genus that grows primarily in the American tropics. With Dr. Judith Garrison Hanks of Marymount Manhattan College, I am studying fern spores using the scanning electron microscope. I also serve as Associate Editor for two scientific journals: *Brittonia*, the Garden's journal of systematic botany, and the *American Fern Journal*. Besides scientific research, I interpret ferns to the public, serving as President of the New York Fern Society, which meets at the Garden the first Saturday of every month. I also teach graduate courses about ferns and general plant systematics. I am currently supervising two graduate students from the City University of New York.

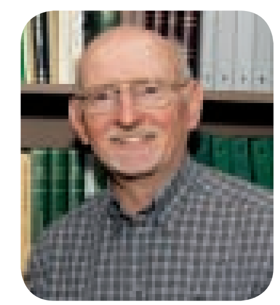


## Scott Mori, Ph.D.

My mission as a tropical botanist is to contribute to an understanding of neotropical plant diversity, educate others about neotropical plants, and provide scientific data in support of their conservation. I am accomplishing this mission by learning everything I can about the Brazil nut family and by studying all of the plants in selected geographic regions of the New World tropics (e.g., French Guiana, the island of Saba in the Netherlands Antilles, and the Osa Peninsula of Costa Rica). Recent advances in molecular biology and computer science have inspired me to utilize these technologies to address questions about the ecology and evolution of the plants I study. I am thankful that I have been able to work at The New York Botanical Garden, where all of the tools I need for my studies are available.

## Robert Naczi, Ph.D.

Much of my research is devoted to revisionary systematics of sedges, especially the genus *Carex* (Cyperaceae). *Carex*, with about 2,200 species, is the largest genus of flowering plants in North America and one of the world's largest genera. Few species of sedges have been subject to modern revisionary studies. Data from field, laboratory, and herbarium techniques permit me to describe new sedge species, reconstruct their phylogenies, and improve their classifications. I also study the systematics of the Western Hemisphere Pitcher Plants (Sarraceniaceae), a small family of carnivorous plants. Despite being inherently interesting, pitcher plants remain poorly understood. I am applying novel approaches to study their systematics. For example, symbiotic and host-specific mites and flies serve as flags for potential realignments in our present classification scheme of the Sarraceniaceae. Many threats to the future survival of pitcher plants exist. Habitat destruction, fire suppression, and poaching are the most serious menaces, and several species are critically imperiled. An improved understanding of the systematics of pitcher plants and of their associated insects will help ensure the long-term survival of these wonderful plants.



## Michael Nee, Ph.D.

Bolivia is about the size of California plus Texas but has about as many plant species as the United States and Canada. It is also one of the least explored countries in tropical America. I have been attempting to document Bolivian plants focusing on Amboro National Park, a very diverse area that ranges from Amazon rain forest to montane forests, cactus-dominated deserts in the dry interior valleys, and cloud forest above 10,000 feet. *The Flora de la Región del Parque Nacional Amboro* will include 3,000 species of flowering plants and ferns, with more being discovered and described with every expedition. At the same time I have been working with botanists from the National Herbarium in La Paz, Bolivia, and the Missouri Botanical Garden in St. Louis on a checklist of the ca. 12,000 flowering plants known from Bolivia. My interests also include Solanaceae (potato, tomato, eggplant) family and the Cucurbitaceae (squash, melon, cucumber) family. The origin of the squashes (genus *Cucurbita*) has been of special interest, and expeditions have been made to many countries of tropical America to research the diversity of cultivated forms, as well as their wild ancestors. I am also a member of a team supported by the National Science Foundation researching the genus *Solanum*, to provide a website treating all the species of *Solanum*.

## Christine Padoch, Ph.D.

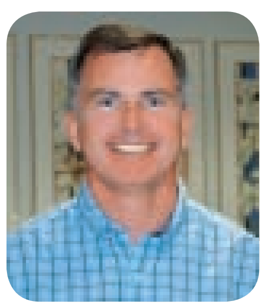
Over the last three decades, my research has focused on understanding, documenting, and promoting production patterns and technologies that satisfy human needs while maintaining high levels of plant biodiversity, among smallholder farmers in the humid tropics of Amazonia and southeast Asia. Among my current projects is a study in the Peruvian Amazon on the effects of migration and rapid urbanization on the state of floodplain forests as well as the promotion of sustainable forestry practices to ensure conservation of resources at the terrestrial-aquatic interface. At the other end of the Amazon Basin, I am studying the drivers of change in land use and land cover in the Amazon estuary. This research aims to advance understanding of the environmental and social effects of recent land use and land cover trends, as well as to support production practices and public policies that stem the destruction of the region's resources. Finally, I am continuing long-term research with Southeast Asian scientists to understand the processes that create, maintain, and destroy diversity in agricultural crops, especially in rice. This research has as its ultimate goal the promotion of practices and policies that enhance both food security and diversity.

### Paola Pedraza, Ph.D.

I conduct taxonomic, phylogenetic, and collections-oriented research that seeks to contribute to both the conservation and botanical knowledge of the tropical Andes, a region with among the highest levels of biodiversity and endemism, but which faces accelerated habitat loss. Through the study of the flora of the cloud forests and páramos (an alpine-like ecosystem exclusively found in the New World), I help to identify endangered species and conservation hotspots. I also study the blueberry family (Ericaceae), a prominent component of montane flora. I am currently working on floristic treatments for Peru, Bolivia, and Colombia, at the same time that I am revising important genera. My research also focuses on the evolution of the diverse tribe Vaccinieae, combining morphological, anatomical, and DNA sequence data. Vaccinieae is an exciting group to study: it is the food source of many animals from hummingbirds to mammals, about 94% of the neotropical species are endemic, and many of them are endangered. To address the threats that Ericaceae faces, I am experimenting with Geographic Information Systems (GIS) to integrate my phylogenetic research with spatial data and models of habitat change.

### Charles Peters, Ph.D.

My research focuses on the ecology, use, and management of tropical forest resources. This work is done in close collaboration with local community groups and is designed to solve problems of resource depletion, forest conservation, and rural livelihoods. I am currently working with several communities in the Selva Maya of Quintana Roo, Mexico, on forest certification issues; I have a project under way on the sustainable production of mescal from tropical dry forests in Guerrero, Mexico; and I have recently started to work on the conservation and sustainable use of rattan (Palmae) in northern Myanmar and central Vietnam. I have conducted long-term field research in the Peruvian Amazon; Papua, New Guinea; West Kalimantan, Indonesia; and Veracruz, Mexico, and have directed community forestry projects in Sri Lanka, India, Nepal, Brazil, Uganda, and Cameroon. I teach tropical ecology and ethnobotany at the Yale School of Forestry and Environmental Studies and at Columbia University. I am editor of the Garden's monograph series, *Advances in Economic Botany.*



### Gregory Plunkett, Ph.D.

My research focuses on the evolution and biogeography of tropical/Southern-Hemisphere angiosperms through field, morphological, and molecular studies, using two related families, Apiaceae and Araliaceae, as models. In Araliaceae, my efforts are concentrated on relationships among all genera but emphasize the two largest, the pantropical *Schefflera* and the paleotropical *Polyscias*. DNA evidence suggests that the *Polyscias* lineage includes six other genera with overlapping geographic ranges, and I have explored dispersal patterns among these plants across the Pacific and Indian Ocean basins. By contrast, *Schefflera* represents an artificial assemblage of five unrelated but geographically coherent groups. In Apiaceae, my efforts are concentrated on subfamily Hydrocotyloideae, which are most diverse in Patagonia, Australia-New Zealand, and southern Africa, a classic Gondwanan pattern of distribution. Phylogenetic studies suggest that the subfamily is artificial and that the complex geographic patterns cannot be explained simply by the break-up of Gondwanaland, but instead involve a mixture of vicariance and dispersal events.

### Dennis Stevenson, Ph.D.

My research program is a multifaceted and integrated approach to reconstructing the evolutionary history of the gymnosperms (i.e., cycads, ginkgo, conifers, and gnetophytes) and the monocotyledonous in flowering plants (e.g., lilies, orchids, palms, cereals, aroids, gingers, et al.). These projects involve the integration of data from the study of fossils, plant structure and development, plant chemistry, pollen, plant embryology, and molecular systematics from gene sequencing to the sequencing of whole genomes. I am interested not only in reconstructing the history of the tree of life, but also in the fundamental changes that have occurred and the genes that are responsible for those changes. In collaboration with the New York Plant Genomics Consortium, I am investigating those parts of the genome responsible for the evolution and development of the seed, the structure responsible for a major part of the world's food source. At the same time, I am involved in using the molecular data for developing DNA barcodes for plant identification when the traditional identifying features such as fruits and flowers are not present. This has important implications in controlling the traffic in endangered species where smuggled plants have had their traditional identifying features removed or have been ground to powders in the composition of dietary supplements.

### Barbara Thiers, Ph.D.

As director of the William and Lynda Steere Herbarium, I am responsible for overseeing the staff who manage the Garden's 7.3 million herbarium collections of algae, bryophytes, fungi, lichens and vascular plants. The largest in the Western Hemisphere, the Steere Herbarium is among the four largest in the world, and is one of the world's most actively used for biodiversity and evolutionary research on plants and fungi. I have been particularly interested in the application of information technology to herbarium management, and to increasing access to specimen-based data for the scientific community. I have also overseen the Garden's C.V. Starr Virtual Herbarium since its inception in 1995. The subject of my research is the Hepaticae. I am particularly interested in the systematics and morphology of the largest family of Hepaticae, the Lejeuneaceae. This family is primarily tropical in distribution, growing most frequently on the bark and living leaves of trees in tropical rainforests. I am currently completing a treatment of the family for the *Flora of North America* and the *Flora of Australia* project.

### Wayt Thomas, Ph.D.

My research centers on the plants of the American tropics. I am fascinated by the sedge family (Cyperaceae), especially the beaked-rushes (the genus *Rhynchospora*). I also study the Tree-of-Heaven family (Simaroubaceae and its segregate families, Picramniaceae and Surianaceae). In this research, I define species concepts, describe species and genera new to science, and use molecular techniques to understand the evolution of each group. I am also interested in the flora and vegetation of Atlantic coastal Brazil, especially the coastal forests of the state of Bahia. These forests constitute one of the most critically endangered rain forests in the world, with less than 5% of the original forests remaining but, paradoxically, we know too little about what grows there. My Brazilian collaborators and I focus our research on what species grow there, where each occurs, and which ones are rare. The results my colleagues and I produce are made available to local conservation organizations and have had a significant impact on local conservation. I also run the international Organization for Flora Neotropica, which promotes the preparation of systematic monographs of plants and fungi in the American tropics.

### Benjamin Torke, Ph.D.

My research integrates herbarium, laboratory, and field-based approaches and has two principle foci. The first is the systematics of the bean family, Leguminosae, one of the largest and most economically important of plant families. For this work, I study variation in DNA and morphology to determine evolutionary relationships, which in turn form the basis for classifications. Species that share a recent common ancestor possess similar attributes. As such, evolutionary classifications yield predictions about the presence of attributes among species, including economically and medicinally useful properties. The second focus is botanical inventory and plant species diversity in tropical rainforests, particularly in the Amazon basin of South America. About half of all species are found in tropical rain forests. Much of this biodiversity is poorly studied and is increasingly threatened by deforestation and climate change. By providing baseline data to conservation planners, primary biodiversity research is fundamental to stemming the impending extinction crisis in the tropics. My work in the Amazon involves documenting the species that are present in a given area and determining how they got there and became adapted to the local environment.

### Thomas Zanoni, Ph.D.

Currently, I am editor-in-chief of *Flora Neotropica Monographs*, published by The New York Botanical Garden Press. Before coming to the Garden, I worked for nearly 13 years at the Jardín Botánico Nacional, Santo Domingo, Dominican Republic, where my time was spent on intensive collection of the native and introduced plants of the Dominican Republic and Haiti, which share the island of Hispaniola. As a continuation of that work, I maintain an interest in the plants of Hispaniola and the other Caribbean Islands. I work with the botanists at the Jardín Botánico Nacional on plants from that island and also edit the *Flora of the Greater Antilles Newsletter*. I am also co-authoring two botanical biographies about Swedish botanists who collected in the Greater Antilles. The first is about Erik L. Ekman, who collected from 1914 to 1931 in Cuba and Hispaniola; this project began with Roger Lundin (who died in 2005) and continues with Bertil Nordenstam of the Swedish Museum of Natural History, Stockholm. The second book is about Olof Swartz, who collected in Jamaica, Cuba, and Haiti from 1784 to 1786; this work is also being done in coordination with Bertil Nordenstam. I also contribute to the *Index of American Botanical Literature* (published online by The New York Botanical Garden) and a bibliography of literature relating to the cultivars of woody plants.

*In addition there are several Postdoctoral Research Associates who work alongside the permanent faculty for one or more years on a variety of research projects. The current Postdoctoral Research Associates are listed in the Faculty Appendix.*

# Results Shared with the World

# C.V. Starr Virtual Herbarium

The C.V. Starr Virtual Herbarium is the electronic gateway to the collections of the William and Lynda Steere Herbarium. The goals of the Starr Virtual Herbarium are to make specimen data available electronically for use in biodiversity research projects; reduce shipping of actual specimens for projects where digital representations will suffice for study; and unite data elements (e.g., photographs, drawings, manuscripts, published works, microscopic preparations, gene sequences) derived from a specimen, with the catalog record for that specimen.



C.V. Starr Virtual Herbarium publications are of two main types:

- **Electronic catalogs**, which are contained in the Virtual Herbarium and organized into Illustrated or Annotated Catalogs of specific sets of collections in the Steere Herbarium.
- **Electronic publications**, which are authoritative assessments of given taxonomic groups of plants and fungi from selected geographic areas.

## Electronic Catalogs

Within the larger electronic catalog that is the whole Virtual Herbarium, valuable electronic catalogs of sets of collections in the Herbarium have already been developed. These are of two types: Illustrated Catalogs and Annotated Catalogs.

### Illustrated Catalogs

Illustrated Catalogs include data transcribed from herbarium specimens, at least some of which are accompanied by images of the specimens. Additionally, some specimen records have images of the living plant or fungus, or links to illustrations, publications, or other websites. Our online Illustrated Catalogs include:

- *Type Specimens– Vascular Plants*
- *Type Specimens – Algal Types*
- *Type Specimens – Bryophyte Types*
- *Type Specimens – Fungal Types*
- *American Bryophyte Catalog*
- *Ericaceae of Ecuador*
- *Ethnobotany and Floristics of Belize*
- *Flora and Mycota of Acre, Brazil*
- *Flora of Navassa Island*
- *Flora of The Caucasus Region*
- *Intermountain Flora*
- *Invasive Plant Species of the United States*
- *Kansas State University Mycological Herbarium*
- *Lichens of Eastern North America*
- *Macrofungi*
- *North American Gymnosperms*
- *Roger D. Goos Mycological Herbarium*
- Solanum *PBI*
- *Tulane University Mycological Herbarium*
- *Vascular Plant Species of Brazil*
- *West Indian Orchids*

### Annotated Catalogs

Annotated Catalogs contain transcribed specimen label data, specimen images, and other illustrations, as well as descriptions of taxa. A major one of these is the catalog *Flora Borinqueña*, including specimens of all groups from The New York Botanical Garden's century of plant collecting in Puerto Rico, with specimen images, as well as the text and illustrations from Nathaniel Britton's unpublished popular f ora of Puerto Rico (also called *Flora Borinqueña*). Additional material includes photographs of Puerto Rico from the Britton's field expeditions in the early 1900s, as well as Britton's field books, and scanned text from Britton's *Descriptive Flora of Puerto Rico*.


## Electronic Publications

More than catalogs, electronic publications are syntheses produced by Garden scientists and their collaborators and are scholarly publications akin to hard copy scientific publications. They typically contain both specimen-based and species- (i.e., name-) based aspects of organization such as digital records of all relevant herbarium specimens plus complete descriptions of each, individual species, among other aspects. Consisting of dynamic species pages, they are online, authoritative assessments of a given taxonomic group.

A model Electronic Publication contains:

- The accepted scientific name of the species, linked to publication details
- A PDF file of the protologue (the publication in which the name was published)
- An image of the type specimen on which the species name is based
- Synonyms for species names and synonym associated information (protologues, types, etc.)
- A species description that includes the morphological features of the species; common names for the species; a written description of the species' distribution; habitats in which the species grows; time of year the species f owers and fruits; information on pollination and seed dispersal; taxonomic notes including a statement of the diagnostic features for identification of the species; and a discussion of taxonomic problems, uses, and the meaning of the name of the species
- A distribution map showing known localities where the species is found
- Images, video, links, and any other electronic information relating to the species
- Links to specimens of the species in the Herbarium and other herbaria, and data associated with those specimens, including gene sequences and images



Electronic species pages, in combination with the digital management tool Lucid, will allow for fully illustrated multiple entry identification keys to all the species of a given taxonomic group—far superior to standard written keys. While not yet possible, a further goal of the electronic biodiversity center publications would be to allow customized, hard-copy publication on demand directly from such species pages. For example, someone traveling to Costa Rica would be able to download all of the information about that particular taxonomic group as it occurs in that particular geographic area—and print only that applicable information to take in the field.

### Electronic Publications Currently Online and Integrated with the Virtual Herbarium:

- *The Lecythidaceae Pages* – Drs. Scott Mori and Ghillean Prance
- *The Flowering Plants of the Osa Peninsula, Costa Rica* – Reinaldo Aguilar, Xavier Cornejo, Catherine Bainbridge, Melissa Tulig, and Dr. Scott Mori
- *French Guianan E-Flora Project* – Dr. Scott Mori, Melissa Tulig, Dr. Jean-Jacques de Granville, Sophie González, Véronique Guerin, Dr. Hervé Chevillotte, and Dr. Jérôme Chave
- *Plants and Lichens of Saba* – Dr. Scott Mori, Dr. William Buck, Carol Gracie, and Melissa Tulig

### Electronic Publications Currently Online but Not Yet Integrated with the Virtual Herbarium:

The following electronic publications were developed in the Garden's digitization programs before the ability to integrate such publications with the Virtual Herbarium. These electronic publications, currently available online through the Research Web sites of the indicated Garden scientist authors, could be converted to electronic publications as resources allow.

- *Atlantic Coastal Forests of Brazil* – Dr. Wayt Thomas
- Collybia *in Northeastern North America and Canada (Fungi)* – Dr. Roy Halling
- *Floristics and Economic Botany of Acre, Brazil* – Dr. Douglas Daly
- Geonoma *(Palmae)* – Dr. Andrew Henderson
- Lomariopsis *(Ferns)* – Dr. Robbin Moran
- *Macrofungi of Costa Rica* – Dr. Roy Halling
- *Neotropical Ericaceae* – Dr. James Luteyn
- *Surveys and Revisions in the Boletinae (Fungi)* – Dr. Roy Halling
- *Index to American Botanical Literature* – Dr. William Buck
- *Index Herbariorum* – Dr. Barbara Thiers

The following electronic publications, which were issued originally as traditional hard copy books by The New York Botanical Garden Press, have been digitized and are currently available online as e-books through the NYBG Press Web site. Additional NYBG Press titles will be converted to e-books in the future, as this is an ongoing activity. E-books could be converted to electronic publications as resources allow.

- *Manual of Vascular Plants of Northeastern United States and Adjacent Canada, Second Edition* – Drs. Henry Gleason and Arthur Cronquist
- *The Pteridophytes of Mexico* – Drs. John Mickel and Alan Smith
- *Cultural Uses of Plants: A Guide to Learning about Ethnobotany* – Gabriell Paye


# The New York Botanical Garden Press

Established in 1896, The New York Botanical Garden Press is one of the largest publishing programs of any independent botanical garden in the world. The mission of the Press is to advance knowledge about the classification, conservation, and uses of plants and fungi.

The Press supports conservation efforts, in particular, by disseminating emerging data and recommendations about the protection of sensitive habitats, original research about plants and fungi, studies of traditional and contemporary methods of resource management, and explorations of the rich relationship between plants and people around the world, including the past, present, and potential uses of plants.

The Press publishes books in four monograph series: *Flora Neotropica* (taxonomic treatments of plant groups or families growing in the Americas), *Memoirs of The New York Botanical Garden* (lengthy original research papers), *Advances in Economic Botany* (original book-length research papers, collections of papers, and symposia dealing with the use and management of plants), and *Contributions to The New York Botanical Garden* (classical works of botany that are rare, out-of-print, translations, or annotated bibliographies).

The Press co-publishes three quarterly journals—*Brittonia*, *The Botanical Review*, and *Economic Botany*—with Springer. The journals' high-quality research papers by scientists from around the world showcase the most current research in areas of botany ranging from genetics to classification, from evolution to ethnographic studies, and beyond.

The Press has also begun to publish books that are useful for amateur naturalists and professional botanists alike, often with a regional focus. For example, *Common Mushrooms of the Talamanca Mountains, Costa Rica* (Roy Halling and Greg Mueller, 2005) is a practical, full-color field guide, useful even in the northeastern U.S. due to the range of some fungi. *The Macrolichens of New England* (James W. Hinds and Patricia L. Hinds, 2008) and *The Liverworts of New England* (Mary Lincoln, 2008) are regional field guides that introduce novices to the art of finding and identifying liverworts and lichens that are visible to the naked eye. *Britton's Botanical Empire* (Peter Mickulas, 2007) paints a vivid picture of the personalities and politics involved in the founding and early life of The New York Botanical Garden.

The Press makes its journals and a growing number of books available electronically. Through the collaboration with Springer, individuals and institutions can purchase online access to current issues. Back issues of all journals and *Flora Neotropica* are available electronically through our partnership with JSTOR. Through nybgpress.org, individuals can also purchase access to electronic versions identical to the print versions. Two classic titles, Gleason and Cronquist's *Manual of Vascular Plants of Northeastern United States and Adjacent Canada* and Mickel and Smith's *Pteridophytes of Mexico* were the first publications available in electronic editions. Paye's *Cultural Uses of Plants* arrived online shortly thereafter and more are being added.

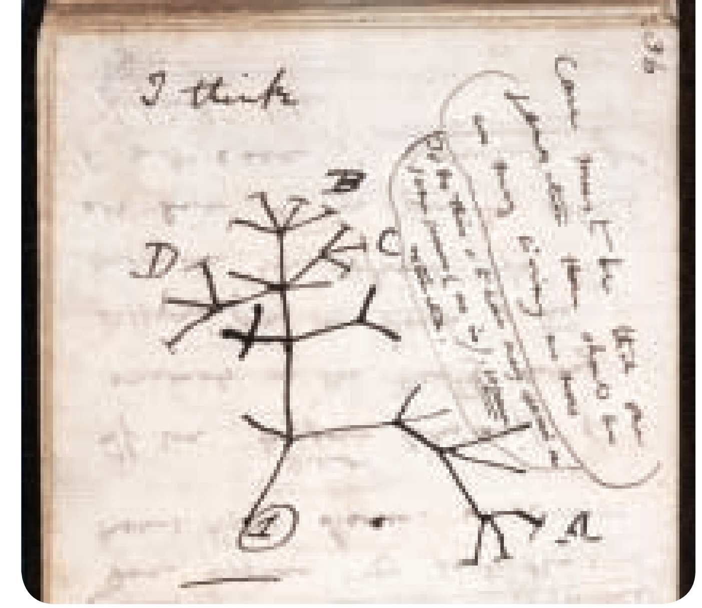
The Press now is capable of providing on-demand reprints of almost all of its out-of-print titles. A customer who orders an out-of-print title receives a printed and bound copy that resembles the original edition.

Communication is critical to the Garden's research mission, and research is not complete until the results are published. For this reason The New York Botanical Garden Press continues to expand book lists, reach new audiences, and diversify publication media.

# Science and Library Exhibitions

Visitor-oriented exhibitions highlighting the beauty, science, and uses of plants and fungi are an important part of the Botanical Garden's efforts to make the public aware of the scientific activity at the Garden. Renovations to the Library building created elegant galleries for exhibitions in the Nathaniel Lord Britton Science Rotunda and Elizabeth Knight Britton Science Gallery (opened October 2005) and in the William D. Rondina and Giovanni Foroni LoFaro Gallery (opened May 2002) of the LuEsther T. Mertz Library. The venues, designed by Polshek Partnership Architects, are important additions to the Botanical Garden's growing program of public exhibitions.






Far left: Cycad seeds and other cycad research artifacts, part of the Botanical Garden's *Plants and Fungi: Ten Current Research Stories* exhibition, illustrate the story of these living fossils, which were the dominant vegetation on Earth during the time of the dinosaurs. Dr. Dennis Stevenson, a leading expert on cycads, studies their primitive characteristics to better understand the biology and evolution of modern plants.

Near left: Charles Darwin's sketch of the "Tree of Life" was one of the rare prints and books on display in an exhibition in the LuEsther T. Mertz Library gallery, *Darwin's Garden: An Evolutionary Adventure.* Garden scientists' work today is still largely based on principles established by Charles Darwin.

### Britton Science Rotunda and Gallery

The opening of the Britton Science Rotunda and Gallery created a new formal entrance to the Botanical Garden's science collections, programs, and offices. The new spaces also made possible a new permanent exhibition, featuring unusual plant specimens, artifacts from explorations around the world, maps, research tools, a large-scale diagram of the Tree of Life, and audio/visual presentations. The exhibition, entitled *Plants and Fungi: Ten Current Research Stories,* includes herbarium specimens from the gigantic fruits of Brazil nuts to tiny lichens and mosses. It brings to life the many different research interests being explored by Botanical Garden scientists in the field, the laboratory, the library, and the herbarium.

Ten exhibit cases present research stories involving mushrooms, blueberries, lichens, mosses, cycads, rice, Brazil nuts, squashes, vanilla orchids, and ferns. They illustrate how scientists unravel the mysteries of nature, including the evolutionary history, ecological roles, and economic uses of plants and fungi.

### William D. Rondina and Giovanni Foroni LoFaro Gallery, LuEsther T. Mertz Library

The New York Botanical Garden presents two gallery exhibitions every year to share with the public some of the remarkable rare books, historic artifacts, archival documents, and artworks in the collections of the LuEsther T. Mertz Library. These exhibitions are mounted in the Library's Rondina and LoFaro Gallery.

Some exhibitions display the work of individual botanical artists—for example, stipple engravings of flowers by the French botanical artist Pierre-Joseph Redouté and watercolors by Margaret Mee, the indomitable 20th-century explorer of the Amazon. Other exhibitions have covered such topics as flowering bulbs, the history of glasshouse architecture, and European pleasure gardens. Several exhibitions have taken a geographic and cultural approach, illustrating, for example, 500 years of botanical exploration in the Caribbean and the rich horticultural traditions of Japan.

All the Gallery exhibitions vividly present ways that art has served science in recording and clarifying information, and how science, in turn, has inspired art. The interplay of art, science, and culture was never shown more clearly than in the Library's spring 2008 exhibition. As the cornerstone of the Botanical Garden's exhibition, *Darwin's Garden: An Evolutionary Adventure,* the Library presented a scholarly exhibition of beautiful botanical prints and Charles Darwin's original writings, field notebooks, and plant collections. These manuscripts, artifacts, and works of art revealed how Darwin came to be an evolutionary botanist and how his lifelong interest in plants contributed to his most fundamental contribution to science: a comprehensive view of life in his theory of evolution.


Far left: Dr. Michael Balick speaks to pharmacologists on medicinal uses of plants at a Natural Products Symposium in Puerto Rico, one component of an ongoing collaboration between the Botanical Garden and the University of Puerto Rico.

Near left: Presentations to the public at the Botanical Garden included behind-the-scene tours of the Garden's just-opened Pfizer Plant Research Laboratory, part of a larger weekend program of public lectures, films, interactive cafes with scientists, and guided tours in May 2006.

## Professional and Public Presentations

Botanical Garden scientists, recent graduates, and, on occasion, program supporters play leading roles at international research gatherings, presenting research results that establish the range, diversity, stature, and impact of the Garden's programs.

For example, in July at *Botany 2008*, a meeting of four of the leading botanical organizations in the United States and Canada held in Vancouver, Garden scientists, former graduate students, and program funders discussed the newest developments in plant science. A highlight was a symposium honoring the career of Dr. Dennis Stevenson, organized by Drs. Amy Litt and James Miller, and including superb presentations from collaborators, former students, and former postdoctoral researchers who have worked with Dr. Stevenson on subjects spanning morphology, anatomy, molecular systematics, and genomics.

At gatherings like this, and at The International Botanical Congress (IBC), a forum held once every six years for scientists to broaden their scientific horizons and to strengthen personal contacts with colleagues throughout the world, Garden scientists play leading roles. IBC serves as an effective showcase for the rich depth and diversity of The New York Botanical Garden's plant research. Garden scientists, graduate students, and former students organize and speak at symposia. They also lecture on a wide range of topics. Conference organizers typically invite numerous former Garden graduate students to give presentations, indicating the overall excellence of the Botanical Garden's graduate studies program and its growing inf uence on the future of plant science worldwide.

The New York Botanical Garden also hosts international scientific gatherings on site in the Arthur and Janet Ross Lecture Hall. Examples include meetings on monocots, pharamacology, and DNA barcoding of trees.

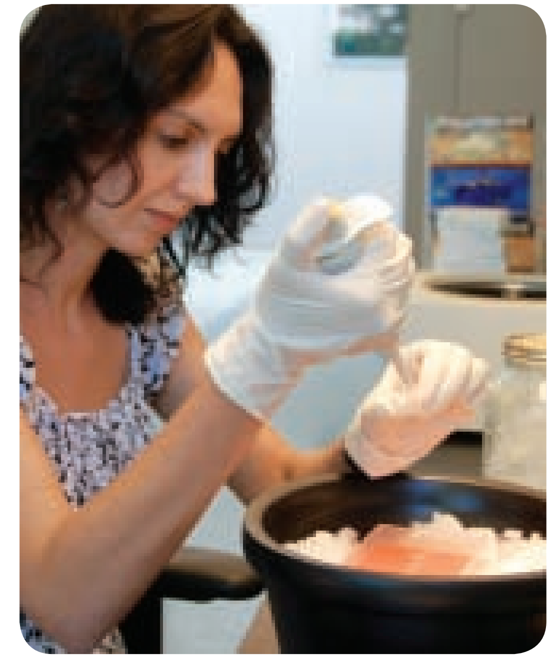
The Garden also offers presentations and seminars for the public, on topics ranging from an assessment of the work of Charles Darwin to the importance of the Brazilian tropical forests. Other educational offerings include behind-the-scenes tours of the Steere Herbarium and the Laboratories and Gallery Talks for Garden Members. The Garden's scientists and administrators give numerous interviews to the science media.

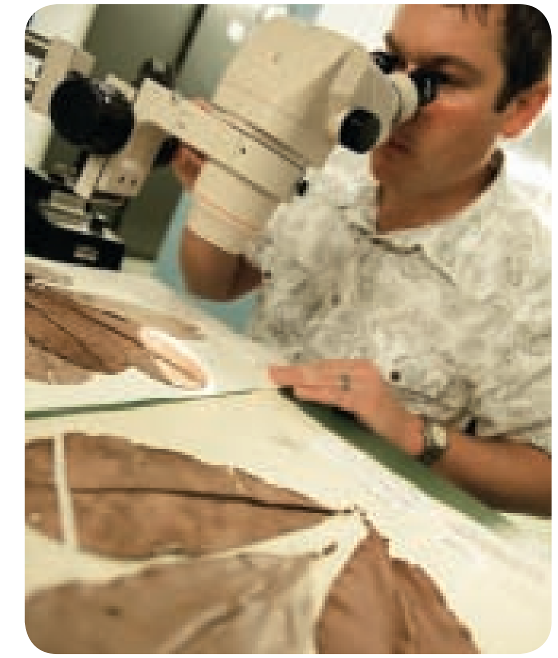
# Training, Science Education, and Collaboration: Resources for the Future

## Graduate Studies

The New York Botanical Garden is a preeminent center for biodiversity research, and a primary mission of the Garden, from its very outset, has been the education of the finest botanists possible. Since the inception of its Graduate Studies Program in 1896, more than 250 students have received advanced degrees through the Garden's joint programs with local universities. The Graduate Studies Program trains students to assume leadership positions at academic, research, and conservation organizations around the world. The strength of the program lies in its rare blend of classroom study, traditional fieldwork, and access to cutting-edge molecular technologies that have set the course for future biodiversity research.







The Graduate Studies Program includes approximately 40 students who are working toward the Ph.D. degree. It is operated in conjunction with the following six universities: The City University of New York, 1968–present; Columbia University, 1896–1975, 1996-present; Cornell University, 1992–present; Fordham University, 2008–present; New York University, 1993–present; Yale University, 1995–present

Students apply to and enroll at one of these universities and complete the degree requirements of the school, but have access to the staff, facilities, and research opportunities available at the Garden. The program is very f exible, and provides excellent opportunities for interdisciplinary study. In addition to the core courses in plant sciences, students may take courses in biology or other disciplines at other colleges, including City College, Hunter College, the CUNY Graduate Center, and Queens College. An agreement between all major universities in New York City entitles students to register for courses in virtually any school in the city. Independent tutorials can be arranged with staff at CUNY, Columbia, NYU, Cornell, Yale, The New York Botanical Garden, or the American Museum of Natural History.

The broad range of courses offered throughout the New York area, and the opportunity to interact with researchers in the natural and the social sciences, provide students with unique opportunities to develop skills in the various fields related to botany. Students here integrate data from many sources, including phytochemistry, molecular biology, genomics, bioinformatics, geographical information systems, ecological physiology, archaeology, anthropology, linguistics, economics, computer modeling, and nutrition.

The Botanical Garden's Graduate Studies Program is internationally acclaimed for its success in preparing tomorrow's biodiversity researchers, offering comprehensive training and broad-based practical experience. Responding to the accelerating rate of habitat destruction in the tropics, the Botanical Garden has placed a priority on tropical research and the training of more botanists, not only from the U.S., but from other countries as well.

The program serves a diverse student body, and Garden graduates have come from Asia, Africa, Europe, and Latin America. After graduating, most foreign students return to their home countries to hold positions in government agencies, research centers, universities, and botanical gardens, where they have a direct impact on conservation, education, and biodiversity research. In this way, the Garden makes a major contribution to the development of sound environmental policies in many nations struggling with the often conf icting goals of economic development and conservation.

Advanced students in plant science are attracted to the Botanical Garden's Graduate Studies Program by the opportunity to work closely with leading research scientists in the field, the herbarium, and the laboratory.

Far left: Doctoral student Alejandra Vasco collects ferns in the high mountains of Piedras Blancas in Venezuela.

Center: Doctoral student Natalia Pabón-Mora carefully pipettes a plant extraction for analysis in the research lab.

Near left: Doctoral student Seth Ganzhorn inspects herbarium specimens at the Garden.

## Internship Programs

Analyzing DNA to determine the wild ancestors of the domesticated eggplant or geo-referencing the endemic plants of Micronesia are not the first activities that come to mind for a summer internship in New York City. Yet those are exactly the sorts of things that more than two-dozen dynamic young people do every summer, working as summer interns in the Botanical Garden's Laboratories and Herbarium. They include both college and high school students, many from the New York City area, others from as far away as Colombia, Brazil, and Puerto Rico. They work closely with curators, graduate students, and research associates, getting hands-on exposure to plant research and collections management. They learn not only techniques and procedures, but how to think critically in a scientific context.



The Botanical Garden has a thriving program of internships for both college and high school students, offering them hands-on experience in plant research in the laboratory and herbarium. Many interns are residents of New York City; others come from as far as Brazil and Puerto Rico. Recent interns included Kobi Shevin (far left) and Alexandra Kassidis and Jennifer Fasman (near left).

A few recent examples illustrate the variety of intern assignments:

- A Vassar College undergraduate tested DNA sequences for a recently discovered hybrid cypress on the U.S. West Coast, comparing them to sequences for each of the two presumptive progenitor species to establish definitive parentage. These trees are of economic importance for their durable and rot-resistant wood as well as for their attractive foliage.
- Two New York University students analyzed genetic differences among populations of rare cycads on several Pacific islands around Guam. This analysis of genetic variation will inform management plans to help preserve a species under attack by an invasive scale parasite.
- A Barnard student extracted DNA from tree leaf and root samples of local trees in the northeastern U.S., to create a database that will enable identification of tree species based just on root tissue.
- Two undergraduate students from the University of Puerto Rico at Mayagüez worked on digitizing the Botanical Garden's rich collection of herbarium specimens from Puerto Rico. As part of the Starr Virtual Herbarium's *Flora Borinqueña* project, they transcribed data, added digital photographs, and determined geographical coordinates. The Institute of Museum and Library Services funded their internships.
- Three high school students worked in the Geographical Information Systems (GIS) Laboratory, analyzing distributions of endemic species in Cuba and in the Federated States of Micronesia. They worked from specimen data in the Garden's Starr Virtual Herbarium to categorize species by family, genus, collection date, and other particulars. They then determined the latitude and longitude for those missing a geographic reference. The resulting distribution data will inform conservation efforts.

# Children's Programs

The New York Botanical Garden's science training offerings are by no means limited to those for graduate, undergraduate, and high school students. At the Botanical Garden, students, pre-kindergarten through eighth grade, and their teachers are served through a variety of facilities and by a diversity of programs.

## Facilities and Student Programs

- The **Everett Children's Adventure Garden** is a unique 12-acre outdoor/indoor museum where children discover plant science through fun, hands-on, and engaging educational programs. Interactive exhibits convey different plant science concepts. Playful elements such as topiaries and mazes capture children's imaginations and create an atmosphere of exploration and fun.
- The **Enid A. Haupt Conservatory**, a New York City Landmark, is an acre under glass featuring four distinct climatic regions: Lowland and Upland Tropical Rain Forests and Deserts of the Americas and Africa. The galleries feature misty rain forests and deserts, aquatic plants, and outdoor pools. The Haupt Conservatory is also home to **GreenSchool**, which offers hands-on, inquiry-based lessons in a classroom setting, followed by excursions to other destinations in the Conservatory, the 50-acre Forest, or on the Garden grounds.



- The **Ruth Rea Howell Family Garden**, a 1.5-acre garden made up of playful topiaries, a pond teaming with life, a f ourishing meadow, and individual garden plots, is where students learn about plants and the natural world through fun, hands-on gardening. Created and maintained by children, it is a place where they can dig, plant, weed, and compost.
- The **Garden grounds** comprise 250 acres featuring 50 gardens and living plant collections, and a 50-acre **Forest**, a remnant of the uncut forest that once covered New York City. The **Mitsubishi Wild Wetland Trail**, designed especially for children, highlights life in a wetland marsh. In all seasons these destinations provide excellent settings for science education.

## Teacher Training

- Children's Education at the Botanical Garden provides innovative, hands-on professional development opportunities for science educators. A major goal is to provide teachers with the techniques and tools so that their students can perform authentic science.
- Current programs for teachers include **Professional Development Workshops**, in which teachers learn how to use the Garden as an extension of their classrooms, **Professional Development Seminars**, in which teachers get assistance in designing a specific program for their classes, and **Summer Institutes**, week-long immersion in ecology and botanical science led by scientists and educators during which teachers learn how to make science fun, through field-tested, hands-on, inquiry based activities.
- The Garden is an active participant in a New York City-wide initiative in science teacher training called **Urban Advantage**, an unprecedented partnership among the City's science-rich cultural institutions and the New York City Department of Education. This partnership has led to a model science education program that connects NYC public schools, middle-school teachers, and students with the excitement of scientific discovery and hands-on learning.

# Continuing Education

For adults, The New York Botanical Garden's extensive Continuing Education department, with Certificate Programs in seven disciplines (Botany, Botanical Art and Illustration, Horticulture, Floral Design, Gardening, Horticultural Therapy, and Landscape Design), offers more than 30 courses in plant science, with levels from novice to advanced, a half dozen of which are approved by the Board of Regents of the University of the State of New York as equivalent to college-level instruction. The **Botany Certificate Program** allows adult students to select one of three areas of concentration: Field Botany, Plant Systematics, or Ethnobotany.

The New York Botanical Garden's Continuing Education Botany program offers a strong foundation in all aspects of plant science: growth and development, evolution, and the role of plants in ecosystems and society. The program benefits anyone interested in broadening their understanding of the "green" world around them, gardeners seeking to improve their plant identification skills, and students aspiring to develop a base of knowledge for further academic study. The program ref ects the Garden's strengths in botanical science and its dedication to a greater understanding of plants and their role in a sustainable, global environment.

# Collaborations and Partnerships

New York Botanical Garden scientists have been conducting research around the world for more than a century; the resulting relationships and partnerships have made the Garden a nexus in the international research and conservation community. Garden scientists have strong and multi-faceted collaborations with other research organizations, scientists, governmental and non-governmental institutions. Here are a few examples:

## The New York Plant Genomics Consortium

The Botanical Garden's Lewis B. and Dorothy Cullman Program for Molecular Systematics is a founding member of the New York Plant Genomics Consortium, along with New York University, Cold Spring Harbor Laboratory, and the American Museum of Natural History. The consortium was formed in 2000 to pool individual abilities and resources from four of New York's top science institutions, combining their individual strengths and wide variety of approaches to evolutionary biology. The New York Botanical Garden provides expertise in plant diversity and an unparalleled number of species of plants. The consortium builds upon technology that was developed to study model organisms such as the mouse, the fruit f y, and *Arabidopsis,* applying it to understanding the evolution and biodiversity of plants and fungi.

## TreeBOL (Barcode of Life): Global DNA Barcoding of Trees

On May 1 and 2, 2008, the Botanical Garden launched TreeBOL, a 24-month campaign to DNA barcode the trees of the world, at an international symposium held at the Garden attended by 44 scientists from 18 countries and 6 continents. TreeBOL participants are divided into regional working groups; the Garden manages the coordination through Web pages, blogs, and workshops. The project will culminate at the Garden in 2010 at an international symposium on plant DNA barcoding. TreeBOL will provide an invaluable scientific resource for research, conservation, and sustainable management of the trees of the world.

## Latin American Plants Initiative

The Latin American Plants Initiative (LAPI) is a collaborative project to database and digitize all herbarium "type" specimens of plants for Latin America. The organizers are The New York Botanical Garden, the Missouri Botanical Garden, and the Royal Botanic Gardens, Kew. Along with Aluka, a not-for-profit initiative to build an online digital library of resources from and about Africa, the collaborators will make accessible online data and images produced by more than 100 international participating institutions. The Garden is coordinating, facilitating, and supporting digitization projects at all the participating institutions; serving as a training center for staff of selected institutions; and digitizing and databasing specimens in the Garden's Steere Herbarium, which is particularly strong in the f ora of the Americas.

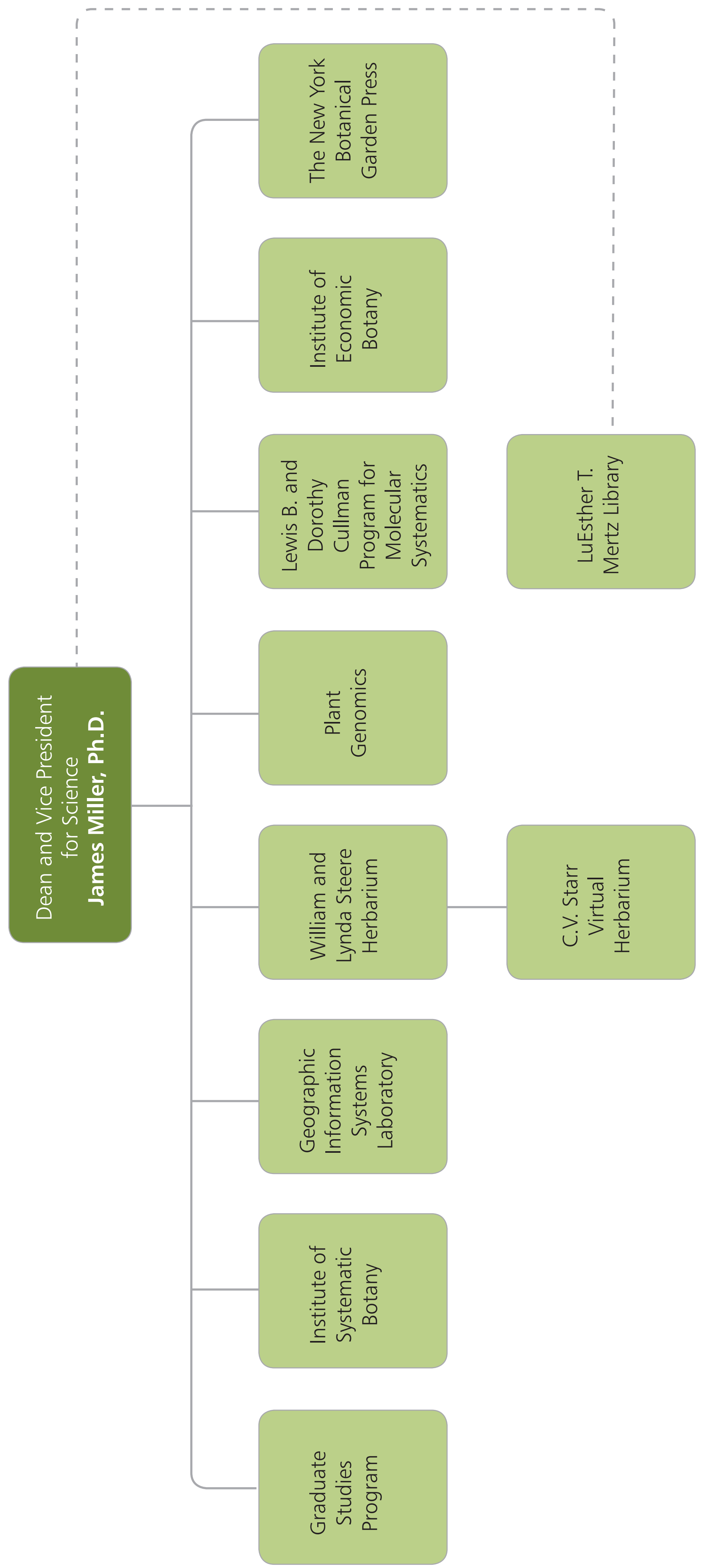
## Local partnerships

Wherever Garden scientists work, they build partnerships to further botanical exploration, foster sustainable use, work with local communities to manage natural resources, and train local scientists and natural resource managers. In Guerrero, Mexico, for example, Dr. Charles Peters is collaborating with the Grupo de Estudios Ambientales and the local association of mescal harvesters. Together, they are designing a community management program to manage wild populations of agave to ensure sustainable production of mescal. Efforts such as these develop research and conservation capacity where it is most desperately needed.

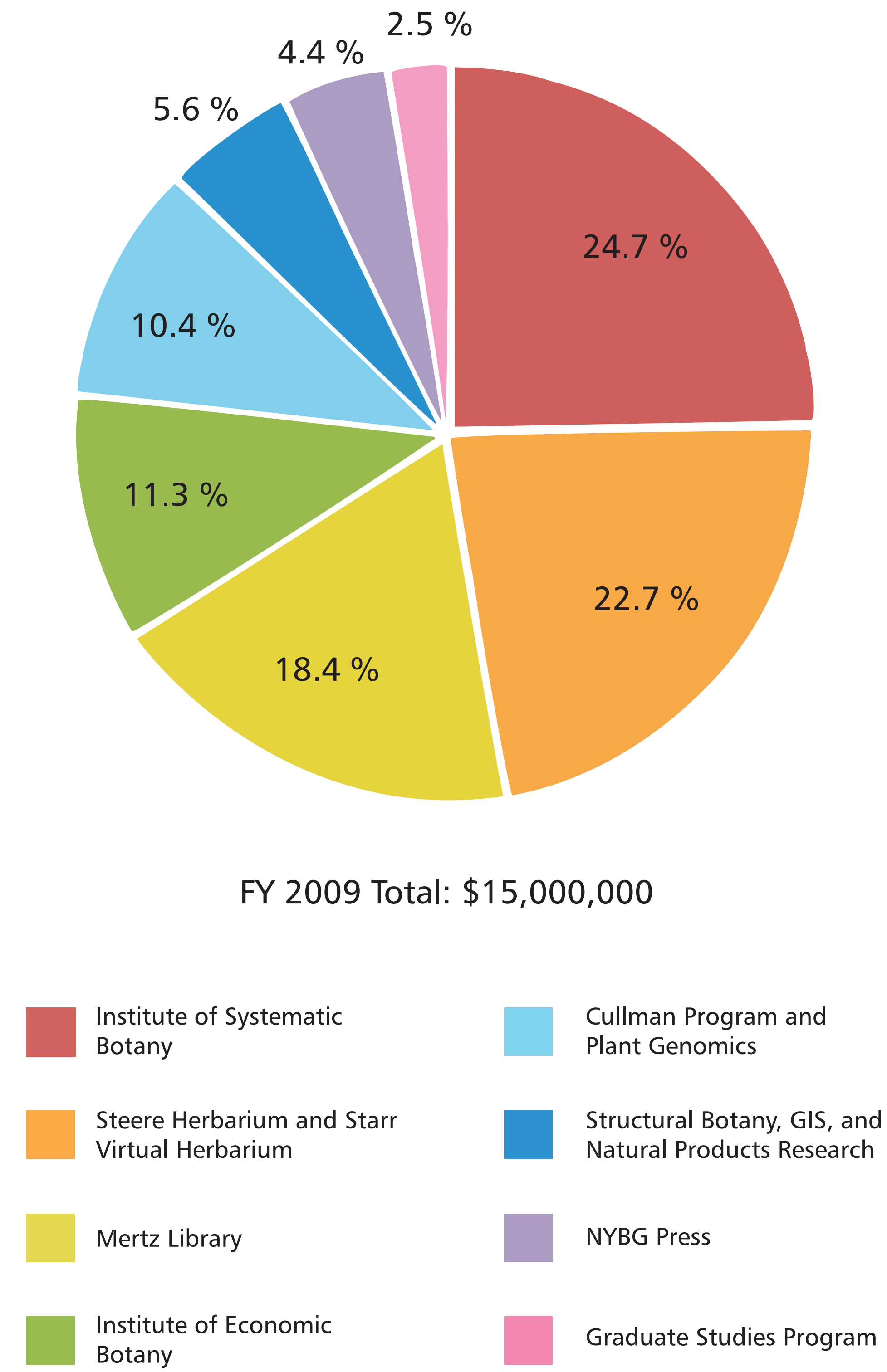
At the N. Ketskhoveli Institute of Botany in Tbilisi, Georgia, research botanist Daniel Atha conducts a workshop for Garden collaborators from the Georgian and Armenian national herbaria on specimen preparation and preservation.

# Appendices

# Organizational Chart




# Annual Expense Budget



# The New York Botanical Garden Faculty

## Science Faculty

James Miller, Ph.D., Dean and Vice President for Science; Rupert Barneby Curator of Botanical Science

## Institute of Systematic Botany

Douglas Daly, Ph.D., Director; B.A. Krukoff Curator of Amazonian Botany

Brian Boom, Ph.D., Curator

William Buck, Ph.D., Mary Flagler Cary Curator

Roy Halling, Ph.D., Curator

Andrew Henderson, Ph.D., Curator

Noel Holmgren, Ph.D., Curator Emeritus

Patricia Holmgren, Ph.D., Curator Emerita

Fabián Michelangeli, Ph.D., Assistant Curator

John Mickel, Ph.D., Curator Emeritus

Robbin Moran, Ph.D., Mary Flagler Cary Curator

Scott Mori, Ph.D., Nathaniel Lord Britton Curator

Robert Naczi, Ph.D., Curator

Michael Nee, Ph.D., Curator

Paola Pedraza, Ph.D., Assistant Curator

Wayt Thomas, Ph.D., Elizabeth G. Britton Curator

Benjamin Torke, Ph.D., Assistant Curator

## Institute of Economic Botany

Michael Balick, Ph.D., Vice President for Botanical Science; Director, Institute of Economic Botany and Philecology Curator

Christine Padoch, Ph.D., Matthew Calbraith Perry Curator of Economic Botany

Charles Peters, Ph.D., Kate E. Tode Curator of Botany

## Lewis B. and Dorothy Cullman Program for Molecular Systematics

Gregory Plunkett, Ph.D., Director; Cullman Curator

Kenneth Karol, Ph.D., Assistant Curator

Damon Little, Ph.D., Cullman Curator

## Plant Genomics

Amy Litt, Ph.D., Director; Cullman Curator

Barbara Ambrose, Ph.D., Cullman Curator

Eric Brenner, Ph.D., Assistant Curator

## Pfizer Plant Research Laboratory

Dennis Stevenson, Ph.D., Vice President for Botanical Science; Director, Pfizer Plant Research Laboratory and Pfizer Curator of Botany

Lisa Campbell, Ph.D., Administrative Curator

## William and Lynda Steere Herbarium

Barbara Thiers, Ph.D., Director

Jacquelyn Kallunki, Ph.D., Associate Director and Curator

Thomas Zanoni, Ph.D., Senior Collections Manager

## Graduate Studies Program

Lawrence Kelly, Ph.D., Director

## Postdoctoral Research Associates

Angélica Cibrián-Jaramillo, Ph.D., Plant Genomics

Thomas Couvreur, Ph.D., Institute of Systematic Botany

John Hall, Ph.D., Lewis B. and Dorothy Cullman Program for Molecular Systematics

Wayne Law, Ph.D., Institute of Economic Botany

Abeer Mohamed, Ph.D., Plant Genomics

Holly Porter-Morgan, Ph.D., Geographic Information Systems Laboratory

Michael Sundue, Ph.D., Institute of Systematic Botany

Marcela Thadeo, Ph.D., Lewis B. and Dorothy Cullman Laboratory

Ina Vandebroek, Ph.D., Institute of Economic Botany



# Honorary Curators and Research Fellows

Thomas Andres; The Cucurbit Network News

Mark Ashton, Ph.D.; Yale University

Amy Berkov, Ph.D.; The City College of New York, CUNY

Graeme Berlin, Ph.D.; Yale University

Robert Bye, Ph.D.; Universidad Nacional Autónoma de México

Gloria Coruzzi, Ph.D.; New York University

Paul Cox, Ph.D.; Institute for Ethnomedicine, Wyoming

William Crepet, Ph.D.; Cornell University

Jerrold Davis, Ph.D.; Cornell University

Wade Davis, Ph.D.; National Geographic Society

Michael Donoghue, Ph.D; Yale University

Paul Fine, Ph.D.; University of California, Berkeley

Steven Franks, Ph.D.; Fordham University

Judith Garrison Hanks, Ph.D.; Marymount Manhattan College

Carol Gracie; The New York Botanical Garden

Elysa Hammond; Clif Bar & Co

Richard Harris, Ph.D.; The New York Botanical Garden

Flor Henderson, Ph.D.; Hostos Community College, CUNY

Noel Holmgren, Ph.D.; The New York Botanical Garden

Patricia Holmgren, Ph.D.; The New York Botanical Garden

Vivian Irish, Ph.D.; Yale University

Edward Kennelly, Ph.D.; Lehman College, CUNY

Steven King, Ph.D.; Napo Pharmaceuticals, Inc.

Paulo Labiak, Ph.D.; Universidade Federal do Paraná, Brazil

Roberta Lee, M.D.; Beth Israel Medical Center

James David Lewis, Ph.D.; Fordham University

Tatyana Lobova, Ph.D.; Old Dominion University

David Lorance, Ph.D.; National Tropical Botanical Garden, Hawaii

James Luteyn, Ph.D.; The New York Botanical Garden

Cameron McNeil, Ph.D.; Queens College, CUNY

John Mickel, Ph.D.; The New York Botanical Garden

J.D. Miller, Ph.D.; Fordham University

John Mitchell; The New York Botanical Garden

Shahid Naeem, Ph.D.; Columbia University

Kevin Nixon, Ph.D.; Cornell University

Cameron O'Neil, Ph.D., Fordham University

Andreana Ososki, Ph.D.; Humboldt State University

Susan Pell, Ph.D.; Brooklyn Botanic Garden

Thomas Philbrick, Ph.D., Western Connecticut State University

Claudio Pinheiro, Ph.D.; Universidade Federal do Maranhão, Brazil

José Pirani, Ph.D.; Universidade de São Paulo, Brazil

Jefferson Prado, Ph.D.; Instituto de Botânica, Brazil

Professor Sir Ghillean Prance, FRS, VMH

Joseph Rachlin, Ph.D.; Lehman College, CUNY

Diane Ragone, Ph.D., National Tropical Botanical Garden, Hawaii

James Reveal, Ph.D., Cornell University

Martin Ricker, Ph.D.; Universidad Nacional Autónoma de México

Guy Robinson, Ph.D.; Fordham University

Marcos Silveira, Ph.D.; Universidade Federal do Acre, Brazil

Lena Struwe, Ph.D.; Rutgers University

John Wehr, Ph.D.; Fordham University

Andrew Weil, M.D.; University of Arizona College of Medicine

Elli Wurtzel, Ph.D.; Lehman College, CUNY

# Selected Research Grants, 2009–2015

Below is a sampling of the numerous current and recent grants received by The New York Botanical Garden in support of research activities and facilities. These grants, which are obtained from a diversity of private and governmental sources, are a testimony to the vigor and robustness of the Garden's scientific programs.

### Barbara Ambrose, Ph.D.
- Lewis B. and Dorothy Cullman: Grants in Support of the Research of Dr. Barbara Ambrose, Cullman Curator

### Michael Balick, Ph.D.
- National Science Foundation: A Biodiversity Survey of Pohnpei and Kosrae Islands, Federated States of Micronesia; Understanding the Impact of Anthropogenic Disturbance on Plant, Fungal, and Stream Biodiversity
- National Center for Complementary and Alternative Medicine: Dominican Traditional Medicine for Urban Community Health
- The Jacob and Valeria Langeloth Foundation: Dominican Ethnomedicine and Culturally Effective Health Care in New York City
- V. Kann Rasmussen Foundation: Biodiversity and Human Health in Micronesia
- MetLife Foundation: Ethnobotanical and Ethnomedical Studies in Micronesia: Implications for Healthy Aging
- San-Mar Laboratories: Institute of Economic Botany and the Micronesia Project
- U.S. Department of Agriculture: Enhancing plant science education in the Bronx: training the next generation of botanists to protect US natural resources. (Edward Kennelly, PI, Michael Balick and Charles Peters, Co-PIs)
- National Geographic Society: A Botanical Inventory and Assessment of Plant Biodiversity on Kosrae Island

### Brian Boom, Ph.D.
- The John D. and Catherine T. MacArthur Foundation: Plant Conservation and Sustainable Management in the Jaragua-Bahoruco-Enriquillo Biosphere Reserve, Dominican Republic
- Christopher Reynolds Foundation: Plant Biodiversity and Conservation in Cuba
- Critical Ecosystem Partnership Fund: Ecosystem Profile for the Caribbean Hotspot: Conservation Outcome Definition for Plants

### Eric Brenner, Ph.D.
- U.S. Department of Agriculture: Genetic Structure of the Cycas Population in the Mariana Islands and Nearby Islands: Conservation, Evolution, and Gene Flow (with Tommy Marler, Project Director)

### William Buck, Ph.D.
- National Science Foundation: Phylogeny of the Daltoniaceae. (with Jon Shaw of Duke University)

### Douglas Daly, Ph.D.
- Beneficia Foundation: Three projects: Development of the Flora of Acre, Brazil; Science-Based Forest Certification in Amazonia; and Deciphering Endemic Lineages of Forest Trees in Southeast Asia
- Leo Model Foundation: A Pilot Project to Test New Standards and Protocols for Forest Certification

### Susan Fraser
- The New York State Library: Discretionary Program for the Preservation of Library Research Materials to fund the manufacture of preservation enclosures for rare botanical folios
- The Institute of Museum and Library Services: Enhancing Access to 120 Years of Scholarship on the Plants and Fungi of the Americas via the *Index to American Botanical Literature (IABL)*
- The National Endowment for the Humanities (NEH): *Darwin's Garden: An Evolutionary Adventure*
- Beneficia Foundation: Library Acquisitions
- Mary Livingston Grigg and Mary Griggs Burke Foundation: *Plants of Japan in Illustrated Books and Prints* and *The Chrysanthemum in Japanese Art*
- New York Council for the Humanities: *Darwin's Garden: An Evolutionary Adventure*
- Indian Point Foundation: Library Exhibition Program
- The Andrew W. Mellon Foundation: Digitizing Latin American Plant Research Collections of the LuEsther T. Mertz Library

### Roy Halling, Ph.D.
- National Geographic Society: Macrofungi of Fraser Island, Australia

### Andrew Henderson, Ph.D.
- National Geographic Society: Systematics and sustainable use of rattans in Vietnam (Charles Peters, Co-PI)
- The John D. and Catherine T. MacArthur Foundation: Conservation and Management of Rattan in the Central Truong Son Mountains of Vietnam (Charles Peters, Co-PI)

### Noel Holmgren, Ph.D., and Patricia Holmgren, Ph.D.
- The William and Flora Hewlett Foundation: Support for *Intermountain Flora* vol. 2A
- The New-Land Foundation: Support for *Intermountain Flora* vol. 2A

### Jacquelyn Kallunki, Ph.D.
- National Science Foundation: Catalogue of Vascular Plant Specimens from Brazil, Part 2: Central and Northeastern States

### Lawrence Kelly, Ph.D.
- Annette Kade Charitable Trust: Franco-American Fellowship in Plant Systematics
- The Prospect Hill Foundation: Support for the Director of the Graduate Studies Program

### Amy Litt, Ph.D.
- Lewis B. and Dorothy Cullman: Grants in Support of the Research of Dr. Amy Litt, Director of Plant Genomics and Cullman Curator
- The Ambrose Monell Foundation, Wallace Genetic Foundation, and Charles and Mildred Schnurmacher Foundation: Plant Genomics Program



### Damon Little, Ph.D.
- Lewis B. and Dorothy Cullman: Grants in Support of the Research of Dr. Damon Little, Cullman Curator, Lewis B. and Dorothy Cullman Program for Molecular Systematics

### Fabián Michelangeli, Ph.D.
- National Science Foundation: A phylogenetic analysis of Miconieae (Melastomataceae) Based on Morphological Characters and DNA Sequence Data From all Three Genomes. Collaborative proposal with W. Judd (Univ. of Florida) and R. Goldenberg (Univ. Federal de Parana) as Co-PIs
- National Science Foundation: Planetary Biodiversity Inventories: A complete Web-based monograph of the tribe Miconieae (Melastomataceae)

### James Miller, Ph.D.
- JPMorgan Chase and The JP Morgan Chase Foundation: Global Biodiversity Programs
- National Cancer Institute: Contract for Bulk Plant Sample Collections in Micronesia and the Caribbean
- Alfred P. Sloan Foundation: Tree-BOL: a Collaborative Effort to Establish Global Priorities for Plant DNA Barcoding

### Robbin Moran, Ph.D.
- National Science Foundation: Monographic Revision and Phylogeny of the Fern Genus *Megalastrum* (Dryopteridaceae)

### Scott Mori, Ph.D.
- National Geographic Society: Documentation of endangered species of the Brazil nut family in the Amazon and in the coastal forests of eastern Brazil
- National Science Foundation: Seed dispersal by bats in a Neotropical Rain Forest

### Michael Nee, Ph.D.
- National Science Foundation: Planetary Biodiversity Inventories: *Solanum*: A Worldwide Treatment (Lynn Bohs, University of Utah, P.I.; Sandra Knapp, Natural History Museum, London, Michael Nee, The New York Botanical Garden, and David Spooner, University of Wisconsin, Co-PIs)
- The Lillian Goldman Charitable Trust: Search for Wild Ancestors of Squashes in the Andes: Phase II

### Christine Padoch, Ph.D.
- Tinker Foundation: Sustainable Forestry for an Urbanizing Amazonia: Phase 2.
- McKnight Foundation: Collaborative Crop Research Program Grant: Agrodiversity for *in situ* Conservation of Local Rice Germplasm in and near its Center of Diversity
- National Science Foundation: HSD Program Global Markets, Regional Landscapes, Household Decisions: Modeling the History of Transformation of the Amazon Estuary

### Charles Peters, Ph.D.
- Blue Moon Fund: Building Capacity to Develop and Manage Myanmar's Protected Areas (with Wildlife Conservation Society)
- Overbrook Foundation: Two projects: Building Bridges for Sustainable Forestry in the Selva Maya, Mexico, and Community Management of Maguey Papalote (*Agave cupreata*) in Guerrero, Mexico
- National Science Foundation: DDEP: International: Biodiversity and Management of Tea Production Systems in Yunnan, China

### Gregory Plunkett, Ph.D.
- Lewis B. and Dorothy Cullman: Grants in Support of the Research of Dr. Gregory Plunkett, Director and Cullman Curator, Lewis B. and Dorothy Cullman Program for Molecular Systematics

### Dennis Stevenson, Ph.D.
- National Science Foundation: Genomics of Comparative Seed Evolution
- National Science Foundation: Collaborative Research: From *Acorus* to *Zingiber* - Assembling the Phylogeny of the Monocots
- National Science Foundation: Collaborative Research: Gymnosperms on the Tree of Life: Resolving the Phylogeny of Seed Plants
- Lewis B. and Dorothy Cullman: Grants in Support of the Lewis B. and Dorothy Cullman Laboratory at The New York Botanical Garden

### Barbara Thiers, Ph.D.
- The Starr Foundation: C.V. Starr Virtual Herbarium
- The Andrew W. Mellon Foundation: Latin American Plants Initiative
- The Institute of Museum and Library Services: Completion of the *Flora Borinqueña* Digital Herbarium and Library Project
- National Science Foundation: Collaborative Digitization of New York Botanical Garden Herbarium Specimens from Amazonian Brazil. (W. Thomas, Co-PI)

### Wayt Thomas, Ph.D.
- Beneficia Foundation: Botanical Knowledge for Conservation: The Northeast and Southern Bahia, Brazil

# Selected Faculty Publications

**Ambrose, B. A.,** S. Espinosa-Matías, S. Vázquez-Santana, F. Vergara-Silva, E. Martínez, J. Márquez-Guzmán and E. Alvarez-Buylla. 2006. Comparative developmental series of the Mexican triurids support an euanthial interpretation for the unusual reproductive axes of *Lacandonia schismatica* (Triuridaceae). *American Journal of Botany* 93: 15-35.

**Brenner E. D.,** R. Stahlberg, S. Mancuso, J. Vivanco, F. Baluska, and E. Van Volkenburgh. 2006. Plant neurobiology: an integrated view of plant signaling. *Trends in Plant Science* 11(8): 413-419.

**Buck, W. R.** 2007. The history of pleurocarp classification: two steps forward, one step back. *In:* A. E. Newton and R. S. Tangney (eds.), *Pleurocarpous Mosses: Systematics and Evolution. Systematics Association Special Volume Series* 71: 1-18.

**Campbell, L. M.** and **D. W. Stevenson.** 2007. Inflorescence architecture and floral morphology of *Aratitiyopea lopezii* (Xyridaceae). *Aliso* 23: 227–233.

**Campbell, L. M.** 2007. Xyridaceae. *In*: R. Duno, G. Aymard, and O. Huber (eds.) *Catálogo Anotado y Ilustrado de las Plantas Vasculares de los Llanos de Venezuela.* FUDENA, Fundación Empresas Polar, y Fundación Instituto Botánica, Caracas.

Casanova, M. T. and **K. G. Karol.** 2008. Monoecious *Nitella* species (Characeae, Charophyta) from southeastern mainland Australia including *Nitella paludigena* sp. nov. *Australian Systematic Botany* 21: 201-216.

Chandler, G.T., **G.M. Plunkett,** Pinney, S.M., L. Cayzer, and C. Gemmill. 2007. Molecular and morphological agreement in Pittosporaceae: phylogenetic analysis using nuclear ITS and plastid *trnL-trnF* sequence data. *Australian Systematic Botany* 20: 390-401.

**Cibrián, A,** T. Marler, **E. D. Brenner.** 2008. Development of EST-microsatellites from the cycad Cycas *rumphii*, and their use in the recently endangered *Cycas micronesica. Conservation Genetics* 9(4): 1051-1054.

Cutler, D. F., T. Botha, and **D. W. Stevenson.** 2008. *Plant Anatomy: An Applied Approach.* 302 pages, plus a CD. Blackwell Publishing, Oxford.

Dahlem, G. A. and **R. F. C. Naczi.** 2006. Flesh flies (Diptera: Sarcophagidae) associated with North American pitcher plants (Sarraceniaceae), with descriptions of three new species. *Annals of the Entomological Society of America* 99: 218–240.

**Daly, D. C.** 2007. A new section of *Protium* Burm. f. from the Neotropics. Studies in neotropical Burseraceae XIV. *Brittonia* 59: 1-24.

Davis, J. I., G. Petersen, O. Seberg, **D. W. Stevenson,** C. R. Hardy, M. P. Simmons, **F. A. Michelangeli,** D. H. Goldman, L. M. Campbell, C. D. Specht, and J. I. Cohen. 2006. Are mitochondrial genes useful for the analysis of monocot relationships? *Taxon* 55: 857-870.

Douglas, A., **D. W. Stevenson,** and **D. P. Little.** 2007. Ovule development in *Ginkgo biloba* L., with emphasis on the collar and nucellus. *International Journal of Plant Sciences* 168(9):1207–1236.

Duplessis, M. R., **K. G. Karol,** E. T. Adman, L. Y. S. Choi, M. A. Jacobs and R. A. Cattolico. 2007. Chloroplast His-to-Asp signal transduction: a potential mechanism for plastid gene regulation in *Heterosigma akashiwo* (Raphidophyceae). *BMC Evolutionary Biology* 7: 70.

Feinstein, J., **S. A. Mori** and A. Berkov. 2007. Saproflorivory: a diverse insect community in fallen flowers of Lecythidaceae in French Guiana. *Biotropica* 39(4): 549-554.

Feinstein, J., K. L. Purzycki, **S. A. Mori,** V. Hequet and A. Berkov. 2008. Neotropical soldier flies in French Guiana: do bat-pollinated flowers attract saprophiles. *Journal of the Torrey Botanical Society* 135(2): 200-2007.

Ford, B. A., M. Iranpour, **R. F. C. Naczi,** J. R. Starr, and C. A. Jerome. 2006. Phylogeny of *Carex* subgenus *Vignea* (Cyperaceae) based on non-coding nrDNA sequence data. *Systematic Botany* 31: 70–82.

Ford, B. A., **R. F. C. Naczi,** H. Ghazvini, and M. Iranpour. 2006. Amplified fragment length polymorphism analysis reveals three distinct taxa in *Carex digitalis* sect. *Careyanae* (Cyperaceae). *Canadian Journal of Botany* 84: 1444–1452.

Fritsch, P. W., **Kelly, L. M.,** Y. Wang, F. Almeda, and R. Kriebel. 2008. Revised infrafamilial classification of Symplocaceae based on phylogenetic data from DNA sequences and morphology. *Taxon* 57: 1-31.

Goldenberg, R., D. S. Penneys, F. Almeda, W. S. Judd and **F.A. Michelangeli.** 2008. Phylogeny of *Miconia* (Melastomataceae): initial insights into broad patterns of diversification in a megadiverse neotropical genus. *International Journal of Plant Sciences* 169: 963-979.

Goffinet, B., **W. R. Buck,** F. Massardo and R. Rozzi. 2006. *Miniature Forests of Cape Horn/Los Bosques en Miniatura del Cabo de Hornos.* Editorial Fantástico Sur, Punta Arenas, Chile. 254 pages.

Gottschling, M. and **J. S. Miller.** 2006. Clarification of the taxonomic position of *Auxemma, Patagonula,* and *Saccellium* (Cordiaceae, Boraginales). *Systematic Botany* 31:361-367.

Groppo, Jr., M., J. R. Pirani, M. L. Salatino, S. Blanco and **J. Kallunki.** 2008. Phylogeny of Rutaceae based on two non-coding regions from cpDNA. *American Journal of Botany* 95: 985-1005.

Hall, G. S. and **D. P. Little.** 2007. Relative quantification of virus population size in mixed genotype infections using sequencing chromatograms. *The Journal of Virological Methods* 146 (1–2): 22–28.

**Hall, J. D., K. G. Karol,** R. M. McCourt and C. F. Delwiche. 2008. Phylogeny of the conjugating green algae based on chloroplast and mitochondrial nucleotide sequence data. *Journal of Phycology* 44: 467-477.

**Halling, R. E.,** T. W. Osmundson, M. A. Neves 2006. *Austroboletus mutabilis* sp. nov. from northern Queensland. *Muelleria* 24: 31-36.

**Halling, R. E.,** T. J. Baroni, M. Binder. 2007. A new genus of Boletaceae from eastern North America. *Mycologia* 99: 310-316.

**Halling, R.E.,** T. W. Osmundson, M. A. Neves. 2008. Pacific boletes: Implications for biogeographic relationships. *Mycological Research.* 112: 437-447.

Hausner, G., R. Olsen, I. Johnson, D. Simon, E.R. Sanders, **K. G. Karol,** R. M. McCourt and S. Zimmerly. 2006. Origin and evolution of the chloroplast *trnK (matK)* intron: a model for evolution of group II intron RNA structures. *Molecular Biology and Evolution* 23: 380-391.

**Henderson, A.** 2006. Traditional morphometrics in plant systematics and its role in palm systematics. *Botanical Journal of the Linnaean Society* 151: 103-111.

**Henderson, A.,** Guo Lixiu, and A. Barfod. 2007. A new, dioecious, dimorphic species of *Licuala* (Palmae) from Hainan, China. Systematic Botany 32: 718-721.

**Henderson, A.,** F. Borchsenius, and H. Balslev. 2008. New species of *Geonoma* (Palmae) from Ecuador. *Brittonia* 60: 190-201.

**Henderson, A.,** Ninh Khac Ban and Nguyen Quoc Dung. 2008. New species of *Licuala* (Palmae) from Vietnam. *Palms* 52: 141-154.

Henderson, F. and **D. W. Stevenson.** 2006. A phylogenenetic study of the Arecaceae based on seedling morphological and anatomical data. *Aliso* 251-264.

Hermsen, E., E. Taylor, T. Taylor, and **D. W. Stevenson.** 2006. Cataphylls of the middle Triassic cycad Antarcticycas schopfii and new insights into cycad evolution. *American Journal of Botany* 93: 724–738.

Hileman, L.C., J. Sundstrom, **A. Litt,** M. Chen, T. Shumba, and V. F. Irish. 2006. Molecular and phylogenetic analyses of the MADS-box gene family in tomato. *Molecular Biology and Evolution* 23: 2245-2258.

Hill, K. D., **D. W. Stevenson,** and R. Osborne. 2007. The World List of Cycads [La Lista Mundial de Cíadas]. *Memoirs of The New York Botanical Garden* 97: 454-483.

**Holmgren, N. H.** 2007. Penstemons of the Intermountain West. *Rock Garden Quarterly*. 65: 96-105.

**Holmgren, N. H.** and R. Wingfield. 2007. Scrophulariaceae. *In*: Duno de Stefano, R., G. Aymard, and O. Huber. *Catálogo Anotado e Ilustrado de la Flora Vascular de los Llanos de Venezuela.* FUDENA—Fundación Empresas Polar—FIBV, Caracas, Venezuela. Pages 667-671.

**Holmgren, P. K.** and **N. H. Holmgren.** 2006. Additions to *Index Herbariorum* (Herbaria), Edition 8-Seventeenth Series. *Taxon* 55: 812-813.

Huang, Y.-Y., **S. A. Mori** and G. T. Prance. 2008. A phylogeny of *Cariniana* (Lecythidaceae) based on morphological and anatomical data. *Brittonia* 60(1): 69-81.

Jarvis, D. I., **C. Padoch** and H. D. Cooper (eds.). 2007. *Managing Biodiversity in Agricultural Ecosystems.* Columbia University Press: New York.

Jiang, B., F. Kronenberg, **M. J. Balick,** and E. J. Kennelly. 2006. Analysis of formononetin from black cohosh (*Cimicifuga racemosa). Phytomedicine* 13:477-486.

**Karol, K. G.** and M. T. Casanova. 2007. Klebsormidiales, Coleochaetales and other early diverging lineages of the Charophyta, *In: Algae of Australia: Introduction,* pp. 356-362. McCarthy, P.M. & A.E. Orchard (eds.). Australian Biological Resources Study, Canberra; CSIRO Publishing, Melbourne.

**Kelly, L. M.** and F. Almeda. 2006. *Symplocos pachycarpa* (Symplocaceae), a new species from southern Mexico. *Brittonia* 58: 318-321.

**Litt, A.** 2007. An evaluation of A function: evidence from the APETALA1 and APETALA2 gene lineages. *International Journal of Plant Sciences* 168(1): 73-91.

**Little, D. P.** 2006. Evolution and circumscription of the true cypresses (Cupressaceae: *Cupressus). Systematic Botany* 31 (3): 461–480.

**Little, D. P., R. C. Moran, E. D. Brenner,** and **D. W. Stevenson.** 2007. Nuclear genome size in *Selaginella. Genome* 50 (4): 351–356.

**Little, D. P. and D. W. Stevenson.** 2007. A comparison of algorithms for identification of specimens using DNA barcodes: examples from gymnosperms. *Cladistics* 23 (1): 1-21.

Liu, M., **G. M. Plunkett,** P.P. Lowry II, B.-E. van Wyk, and P.M. Tilney. 2006. The taxonomic value of fruit wing types in the order Apiales. *American Journal of Botany* 93: 1357-1368.

López, M. G., A. P. Prata and **W. W. Thomas.** 2007. New synonymy and new distributional records in *Bulbostylis* (Cyperaceae) from South America. *Brittonia* 59: 88-96.

Lücking, R., **W. R. Buck** and E. Rivas Plata. 2007. The lichen family Gomphillaceae (Ostropales) in eastern North America, with notes on hyphophore development in *Gomphillus and Gyalideopsis. Bryologist* 110(4): 622-672.

Luteyn, J. L. and **P. Pedraza-Peñalosa.** 2005. Claves para las familias. *In:* P. Sklenar, J. L. Luteyn, C. Ulloa, P. M. Jørgensen and M. O. Dillon, *Flora Genérica de los Páramos: Guía Ilustrada de las Plantas Vasculares.* The New York Botanical Garden Press.

May, K., M. Bryant, X. Zhang, **B. A. Ambrose** and B. Scott. 2008. Patterns of expression of a lolitrem biosynthetic gene in the *Epichloë festucae* – perennial ryegrass symbiosis. *Molecular Plant-Microbe Interactions.* 21: 189-197.

Martin, C. V., **D. Little,** R. Goldenberg and **F. A. Michelangeli.** 2008. A phylogenetic evaluation of *Leandra* (Miconieae, Melastomataceae): a polyphyletic genus where the seeds tell the story, not the petals. *Cladistics* 24: 317-327.

McGhee, W., J. Craig, R. deGroot, **J. S. Miller,** and K. Bowers. 2007. Making restoration work: non-monetary mechanisms. Pages 294-302, In: J. Aronson, S. J. Milton and J. N. Blignaut (eds.), R*estoring Natural Capital: Science, Business, and Practice.* Island Press. 384 pages.

**Michelangeli, F. A.** 2006. Two new species of myrmecophytic *Tococa* (Melastomataceae) with unusually large floral bracts. *Brittonia* 58 (2): 151-155.

**Michelangeli, F. A.,** W. S. Judd, D. S. Penneys, J. D. Skean, Jr., E. R. Bécquer, R. Goldenberg and C. V. Martin. 2008. Multiple events of dispersal and radiation of the tribe Miconieae (Melastomataceae) in the Caribbean. *Botanical Review* 74: 53-77.

**Miller, J. S.,** and W. L. Applequist. 2006. Research grade botanicals: issues in dietary supplement research. *Acta Horticulturae* 720: 49–58.

**Miller, J. S.** and M. Gottschling. 2007. Generic Classification in the Cordiaceae (Boraginales): Resurrection of the genus *Varronia* P. Br. *Taxon* 56: 163-169.

**Miller, J. S.** 2007. Chapter 5: Impact of the Convention on Biological Diversity: The lessons of ten years of experience with models for equitable sharing of benefits. Pages 58-70, *In:* C. McManis (ed.) *Biodiversity & the Law: Intellectual Property, Biotechnology and Traditional Knowledge.* Earthscan. 484 pages.

Mitchell, J. D., **D. C. Daly,** S. Pell, and A. Randrianasolo. 2006. *Poupartiopsis* gen. nov. and its context in Anacardiaceae classification. *Systematic Botany* 31: 337-348.

**Moran, R. C.,** J. Garrison Hanks, and G. Rouhan. 2007. Spore morphology in relation to phylogeny in the fern genus *Elaphoglossum* (Dryopteridaceae). *International Journal of Plant Sciences* 168(6): 905-929.

**Moran, R. C.,** J. Prado, P. Labiak, J. Garrison Hanks and E. Schuettpelz. 2008. A "new" species of tree fern from southeastern Brazil: *Cyathea myriotricha* (Cyatheaceae). *Brittonia* 60(2): 1-10.

**Moran, R. C.** 2008. Biogeography of ferns and lycophytes. Pages 369-396, *In:* C. Haufler and T. A. Ranker (eds.), *The Biology and Evolution of Ferns and Lycophytes.* Cambridge University Press. 500 pages.

**Mori, S. A.,** C.-H. Tsou, C.C. Wu, B. Cronholm and A. A. Anderberg. 2007. Evolution of Lecythidaceae: information from combined *ndhF* and *trnL-F* sequence data. *American Journal of Botany* 94(3): 289-301.

Mueller, G. M., J. P. Schmit, P. R. Leacock, B. Buyck, J. Cifuentes, D. E. Desjardin, **R. E. Halling,** K. Hjortstam, T. Itturriaga, K.-H. Larsson, D. J. Lodge, T. W. May, D. Minter, M. Rajchenberg, S. A. Redhead, L. Ryvarden, J. M. Trappe, R. Watling, Q-X. Wu. 2007. Global diversity and distribution of macrofungi. *Biodiversity & Conservation* 16: 37-48.

**Naczi, R. F. C.** 2006. *Scandix procumbens* L. lectotypification and epitypification, *In:* C. E. Jarvis, J. Reduron, M. A. Spencer, and S. Cafferty (eds.), Typification of Linnaean plant names in Apiaceae. *Taxon* 55: 207–216.

**Nee, M.** 2005. Solanaceae, *In:* P. Sklená et al. (eds.), Flora Genérica de los Páramos, Guía Ilustrada de las Plantas Vasculares. *Memoirs of The New York Botanical Garden* 92: 431–437.

**Nee, M.,** L. Bohs and S. Knapp. 2006. New species of *Solanum* and *Capsicum* (Solanaceae) from Bolivia, with clarification of nomenclature in some Bolivian *Solanum. Brittonia* 58: 322–356.

**Nee, M.**, 2007. Geography of Solanaceae in Bolivia. *In:* D. Spooner et al. (eds.), Solanaceae VI: Genomics Meets Biodiversity. Proceedings of the Sixth International Solanaceae Conference. *Acta Horticulturae* 745: 43–55.

**Nee, M.,** 2008. *Flora de la Región del Parque Nacional Amboró, Bolivia. III. Dilleniidae.* Fundación Amigos de la Naturaleza, Santa Cruz de la Sierra, Bolivia.

Nelson, L., R. Shih, **M. J. Balick,** 2007. *Handbook of Poisonous and Injurious Plants, Second Edition.* Springer and The New York Botanical Garden (co-publishers), New York. 340 pages.

Osmundson, T. W., **R. E. Halling,** H. C. den Bakker. 2007. Morphological and molecular evidence supporting an arbutoid mycorrhizal relationship in the Costa Rican páramo. *Mycorrhiza* 17: 217-222.

**Padoch, C.,** K. Coffey, O. Mertz, S. J. Leisz, J. Fox, R. L. Wadley. 2007. The demise of swidden in southeast Asia: local realities and regional ambiguities. *Geografisk Tidsskrift: Danish Journal of Geography* 107(1): 29-41.

**Pedraza-Peñalosa, P.,** R. Valencia, J. Santiana, R. Montúfar and A. Tye. 2007. Ericaceae, *In:* S. León-Yánez, N. Pitman, R. Valencia, L. Endara, C. Ulloa., H. Navarrete. *Libro rojo de las plantas endémicas del Ecuador 2007.* Publicaciones del Herbario QCA, Pontificia Universidad Católica del Ecuador, Quito.

**Pedraza-Peñalosa, P.** 2008. Three New Species of *Disterigma* (Ericaceae: Vaccinieae) from western Colombia, with comments on morphological terminology. *Brittonia* 60(1): 1-10.

**Peters, C. M., A. Henderson,** U. Myint Maung, U Saw Lwin, U Tin Maung Ohn, U Kyaw Lwin, and U Tun Shaung. 2007. The rattan trade of northern Myanmar: Species, supplies, and sustainability. *Economic Botany* 61(1):3-13.

Pirani, J. R. and **J. A. Kallunki.** 2007. Two new species of *Galipea* (Rutaceae, Galipeae) from Bolivia, Ecuador, and Peru. *Brittonia* 59: 343-349.

Pires, J., I. Maureira, T. Givnish, K. Sytsma, O. Seberg, G. Petersen, J. Davis, **D. W. Stevenson,** P. Rudall, M. Fay, and M. Chase. 2006. Phylogeny, genome size, and chromosome evolution of Asparagales. *Aliso* 287-304.

Posey, D. A. and **M. J. Balick** (eds.). 2006. *Human Impacts on Amazonia: The Role of Traditional Ecological Knowledge in Conservation and Development.* Columbia University Press, New York. 368 pages.

Putzel, L., **C. Padoch** and M. Pinedo-Vasquez. 2008. The Chinese timber market and the logging of the Peruvian Amazon. *Conservation Biology* 22(6)

Reid, J.D., **G.M. Plunkett,** and G.A. Peters. 2006. Phylogenetic relationships in the heterosporous fern genus *Azolla* (Azollaceae) based on DNA sequence data from three non-coding regions. *International Journal of Plant Sciences* 167: 529-538.

Ricker, M, G. Gutiérrez-García, and **D. C. Daly.** 2007. Modeling long-term tree growth curves in tropical forests in a warming climate. *Canadian Journal of Forest Research* 37: 977-989.

Rouhan, G., J. Garrison-Hanks, D. McClelland and **R. C. Moran.** 2007. Preliminary phylogenetic analysis of the fern genus *Lomariopsis* (Lomariopsidaceae). *Brittonia* 59(2): 115-128.

Rozzi, R., J. J. Armesto, B. Goffinet, **W. R. Buck,** F. Massardo, J. Silander, M. T. K. Arroyo, S. Russell, C. B. Anderson, L. A. Cavieres and J. B. Callicott. 2008. Changing lenses to assess biodiversity: patterns of species richness in sub-Antarctic plants and implications for global conservation. *Frontiers in Ecology and the Environment* 6(3): 131-137.

Rudall, P. J., D. D. Sokoloff, M. V. Remizowa, J. G. Conran, J. I. Davis, T. D. Macfarlane, and **D. W. Stevenson.** 2007. Morphology of Hydatellaceae, an anomalous aquatic family recently recognized as an early-divergent angiosperm lineage. *American Journal of Botany* 94(7): 1073–1092.

Sass, C., **D. P. Little, D. W. Stevenson,** and C. D. Specht. 2007. DNA Barcoding in the Cycadales: testing the potential of proposed barcoding markers for species identification of cycads. *Public Library of Science ONE* 2 (11): e1154.

Sears, R., **C. Padoch** and M. Pinedo-Vasquez. 2007. Amazon forestry transformed: Integrating knowledge for smallholder timber management in eastern Brazil. *Human Ecology* 35(6): 697-707.

Shevock, J. R., R. Ochyra and **W. R. Buck.** 2006. Observations on the ecology and distribution of *Hydrocryphaea wardii,* a southeast Asian monospecific genus, reported new for China from Yunnan Province. *Journal of Hattori Botanical Laboratory* 100: 407-418.

Specht, C. and **D. W. Stevenson.** 2006. A new phylogeny-based generic classification of Costaceae (Zingiberales). *Taxon* 55: 153-163.

Simpson, D. A., A. M. Muasya, M. Alves, J. J. Bruhl, S. Dhooge, M. W. Chase, C. A. Furness, K. Ghamkhar, P. Goetghebeur, T. R. Hodkinson, A. D. Marchant, R. Nieuwborg, A. A. Reznicek, E. H. Roalson, E. Smets, J. R. Starr, **W. W. Thomas,** K. L. Wilson and X. Zhang. 2007 [2008]. Phylogeny of Cyperaceae based on DNA sequence data - a new *rbcL* analysis. *In:* J. T. Columbus, E. A. Friar, J. M. Porter, L. M. Prince, and M.G. Simpson (eds.), Monocots, Comparative Biology and Evolution (Poales). *Aliso* 23:72-83.

**Thomas, W. W.** (ed.). 2008. The Atlantic Coastal Forest of Northeastern Brazil. *Memoirs of the New York Botanical Garden* 100: 1-586.

Thomson, J., **J. T. Mickel** and K. Mehltreter. 2008. Taxonomic status and relationships of bracken ferns *(Pteridium:* Dennstaedtiaceae*)* of Laurasian affinity in Central and North America. *Botanical Journal of the Linnaean Society* 157: 1-17.

**Torke, B. M.** and B. A. Schaal. 2008. Molecular phylogenetics of the species-rich neotropical genus *Swartzia* (Leguminosae-Papilionoideae) and related genera of the swartzioid clade. *American Journal of Botany* 95: 215–228.

**Torke, B. M.** 2007. Three new species of *Swartzia* (Leguminosae-Papilionoideae) from northern South America. *Botanical Journal of the Linnaean Society* 153: 343–355.

**Torke, B. M.** 2007. New combinations and species-level synonyms in *Swartzia* (Fabaceae: Papilionoideae). *Novon* 17: 110–119.

Tsou, Chih-Hua and **S. A. Mori.** 2007. Floral organogenesis and floral evolution of the Lecythidoideae (Lecythidaceae). *American Journal of Botany* 94(5): 716-736.

**Vandebroek, I., M. J. Balick,** J. Yukes, L. Duran, F. Kronenberg, C. Wade, A. L. Ososki, L. Cushman, R. Lantigua, M. Mejía and L. Robineau. 2007. Use of medicinal plants by Dominican immigrants in New York City for the treatment of common health conditions. A comparative analysis with literature data from the Dominican Republic, pages 39-63 *In:* A. Pieroni and **I. Vandebroek,** eds., *Traveling Cultures and Plants: The Ethnobiology and Ethnopharmacy of Human Migrations.* Berghahn Books, New York. 256 pages.

Watkins, J. E., Jr., C. Cardelús, R. K. Colwell and **R. C. Moran.** 2006. Species richness and distribution of ferns along an elevational gradient in Costa Rica. *American Journal of Botany* 93(1): 73-83.

# The New York Botanical Garden Board



# Botanical Science Committee



# Library Visiting Committee

# Photography Credits

Front cover (left to right, starting at upper left): Carol Gracie, NYBG staff, Wayne Law, NYBG staff, Amy Litt, Robert Benson, Robert Benson, Adrian Hepworth

Page 2: Adrian Hepworth

Page 3: Courtesy of Edward P. Bass, Courtesy of Draper Laboratory

Page 4: NYBG staff

Page 8: (left to right, starting at upper left): NYBG staff, NYBG staff, Raimund Koch, Jason Green, NYBG staff, Robert Benson, Jason Green, NYBG staff

Page 10: Jeff Goldberg-ESTO

Page 11: NYBG staff

Page 12: NYBG staff

Page 14: Robert Benson

Page 15: Raimund Koch, NYBG staff

Page 16: Robert Benson

Page 17: NYBG staff, Robert Benson

Page 18: Christine Douglas

Page 19: NYBG staff

Page 22: Carol Gracie

Page 23: Sarah Carter

Page 24: Courtesy of Ina Vandebroek

Page 25: Courtesy of Wayne Law

Page 26: Ina Vandebroek

Page 27: Ina Vandebroek

Page 28: Eric Brenner

Page 29: Charles Peters

Page 30: Douglas Daly, Clênia Pessôa

Page 31: Douglas Daly

Page 32: Rogerio Reis

Page 33: Maps from Mendonça et al., 1994

Page 34 : Ina Vandebroek, Wayt Thomas, Carol Gracie

Page 36: Michael Balick, Wayne Law

Page 37: Wayne Law

Page 38: Kenneth Karol

Page 39: Noel Holmgren, NYBG staff

Page 40: Courtesy of Kenneth Karol

Page 41: Amy Litt

Page 42: NYBG staff

Page 43: Natalia Pabón-Mora

Page 44: Natalia Pabón-Mora

Page 46: Diagram by Hannah Stevens

Page 47: Diagram by Holly Porter-Morgan

Pages 50-57: NYBG staff, except for Gregory Plunkett's portrait, page 56, Courtesy of Gregory Plunkett

Page 60: NYBG staff

Page 62: NYBG staff

Page 64: NYBG staff

Page 66: Robert Benson

Page 67: By permission of the Syndics of Cambridge University Library

Page 68: Courtesy of the Universidad de Puerto Rico

Page 69: NYBG staff

Page 72: Edwin Ramos

Page 73: Amy Litt, NYBG staff

Page 74: Amy Litt

Page 75: Amy Litt

Page 76: NYBG staff

Page 77: NYBG staff

Page 78: NYBG staff

Page 79: NYBG staff

Page 80: Sarah Carter



# Production Credits

Editors: Sally Armstrong Leone, Anne Skillion

Principal Writers: Brian Boom, Karl Lauby, James Miller, George Shakespear

Designer: Creative Services Department of The New York Botanical Garden

--------------------------

THE NEW YORK BOTANICAL GARDEN

Bronx River Parkway and Fordham Road
Bronx, New York 10458-5126
718.817.8700 • nybg.org