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The botanical garden – An unexploited source of information

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We honor today the Jardin botanique de Genève, on the occasion of the 150th anniversary of its founding. We cannot pay honor to this garden alone without considering the men who have directed it, the members of its staff who have served and contributed in many different roles, and the people of Genève who from the beginning have supported it, and especially have valued it.

To any student of plants the name of the garden and the conservatoire of botany in Genève and the family name of its first two directors, de Candolle, are intimately associated. For most students the two letters "DC." after a plant name are as familiar as the "L." in botanical literature which stands for Linnaeus. The symbols of reference to what Frans Stafleu has called "The Great Prodromus" (the 17 volumes of the "Prodromus systematis naturalis regni vegetabilis") and to its successor the "Monographie Phanerogamarum" (in 9 volumes) are symbols which we all know refer to important and historic contributions to botanical knowledge. Eventually the younger student comes to appreciate that there were three men of plant science with the name of de Candolle. Two of them served as directors of the Jardin botanique and in fact formed a unique combination of father and son as joint directors of the garden for a period of nearly a decade. The other continued the fame of the family name through similar contributions in taxonomy and floristics, in the morphology and phylogeny of wild and cultivated plants. Although I single out but a few individuals by name from the history of the Jardin botanique, I do so with the knowledge that theirs were early contributions to which I seek to add with my own research. Theirs were specimens now protected and preserved in the present herbarium which I seek to study knowing confidently that others too will be able to consult these valued records in later years. I consult regularly the work of Jean Müller of Aargau (Argovie) on the *Euphorbiaceae;* that of John Briquet on the *Labiatae* and *Umbelliferae;* that of B. P. G. Hochreutiner in the *Malvaceae* and that of Charles Baehni in his monographs of the *Sapotaceae* or the *Solanaceae.* These men who have guided the development of this garden have also made their own contributions in a lasting way to the field of systematic botany.

We have become familiar with the story of Augustin-Pyramus de Candolle who was the founder and the first director of this garden. He was born in Geneva in 1778 and spent his early professional life in France, in Paris and later in

Montpellier. His catalogue of the plants in the botanical garden at Montpellier published in 1813 shows his critical interest in the accuracy of nomenclature and the completeness of description of plants under cultivation. This work is consulted frequently today for the comparative observations he made in an attempt to have the correct name on every plant.

In 1817 A.-P. de Candolle returned to Geneva to accept a chair in natural history established for him by the government. Biographers seem to differ in their reports of this event, one relating that de Candolle was asked to develop a botanic garden while another reports that de Candolle requested land for the purpose. In any case the site of the first garden had been a place of execution in the political turbulence of 1794 and had since that time been regarded as a contaminated spot where no one dared set foot. De Candolle asked for and received public support of the new garden by participation in its activities, by making an inventory of the plants which grew there and by financial backing through gifts and bequests. De Candolle was a public figure nationally and internationally, and he used his position to call attention to the value of botanical gardens and to the study of cultivated plants. Few directors of gardens have ever done so with equal success. De Candolle visited many private gardens and estates. He admired them, wrote about them, obtained from them plant materials for his own research and for the developing Jardin botanique. In turn he was equally generous in his program for the distribution of plant materials from the Jardin botanique. Two years after its founding he published an extensive list of the fruit trees and vines in the Jardin botanique which he said had two purposes–to propagate in the canton of Geneva the most remarkable species of fruits, and to aid the amateur as well as the professional fruit grower in knowing the correct names of the varieties most admired. As most generous policy, de Candolle stated that propagating material was to be distributed to those people who evidenced a desire to have it. In the garden new varieties could be introduced and tested for their adaptability to the climate and for their edibility.

There is further evidence of the concern of de Candolle for the participation of the public in the development of the new garden. He published a series of ten reports on rare and new plants which had flowered in the Jardin botanique de Genève, the first for the years 1819-1821. These reports he indicated were published on the invitation of the Society of physics and natural history to the directors of the new Jardin botanique and the Musée académique as well as the older observatory. The directors were invited to record in the memoirs of the society the new or little-known deeds and objects which had been observed. De Candolle suggested that his observations, which would not merit individual publication, would collectively contribute to the completion of the knowledge of plant products. Although de Candolle apologized for the fact that a director must first pay more attention to the general foundation and establishment of the organization and only secondarily to the component plants, his actions showed he did otherwise. His reports were often illustrated and he recorded the fact that the plants which grew in the garden were for the most part being drawn by the artists of the city and by amateurs according to an agreed formula. The assembled drawings, the ladies being responsible for the greatest number of them, from a public collection from which he could extract for publication those which were species or novelties not yet represented in botanical literature.

In the reports published in 1831 de Candolle mentioned in the preface that he was offering to the Society a notice of some remarkable plants cultivated in the botanic garden. "I have been guided in their choice," he said, "partly by their novelty and rarity and partly, also, because of their bearing on the theory of botany". He proceeded in this report to elaborate on his ideas of plant morphology and the homology of parts. De Candolle used the garden and its plants for his research as did his direct descendants and many of his successors. For this reason the cultivated plants preserved both in the "Prodromus Herbarium" and in the general herbarium in Geneva carry a special importance for certain studies, often exceeding that of the usual herbarium specimen. I will refer again to this in the work of his son Alphonse and his grandson Casimir.

In 1833 in the fifth notice on rare plants, Augustin-Pyramus de Candolle announced that his son Alphonse had been named honorary professor of botany and joint director of the garden. He said that "the one and the other of us, thus called to occupy ourselves with the plants cultivated in this establishment, will continue jointly this series of notices destined to make them known. Each of us will put down the observations which he has been able to make on the species with which he is occupied."

I will not refer in detail to the many valuable contributions of A.-P. de Candolle during the period he was director of the Jardin botanique. Certainly the editorship of the "Prodromus" alone should have kept both father and son fully engaged. I am interested in fact that A.-P. de Candolle's concern was with the internal structure and the development of the vascular body. From this investigation he formed the basis of a portion of his system of classification. His interest in the structure of the plant was also communicated to his son and probably was most elaborated in the work of his grandson, Casimir.

The work of Alphonse de Candolle on economic plants, which culminated in the publication "The origin of cultivated plants", involved observations on the anatomical structure of plants grown in the Jardin botanique. Casimir de Candolle was well aware of the value of the vascular bundle patterns in the stem and the leaf, especially so in the complicated structural patterns found in the stems of species of *Piper* and *Peperomia*. Casimir de Candolle's many papers, including those on the comparative anatomy of leaves, the theory of the leaf, and the nature of the epiphyllous inflorescence, all were studies which often involved techniques and observations similar to those his grandfather had used on possibly the same plants within the garden or the herbarium.

It is in the work of the three generations of de Candolle—Augustin-Pyramus, Alphonse, and Casimir, that I find examples of the kinds of botanical information that represent the almost unique contribution possible from a botanical garden. These men used the resources of the Jardin botanique for practical as well as theoretical work; for local problems or for the investigations of distant floras. Fortunately they documented their studies, and did so in a way that casts shame on much current botanical research. Their garden and its plants were used in ways rarely exploited today. Let me consider some of these areas of potential research so evident in modern compendia which can still be exploited to further and complete our knowledge of plants and plant materials.

This international symposium has been exploring the many functions of a botanical garden. We have acknowledged that no two gardens are exactly alike due to variations in their geographic location, their resources, the interests of their

controlling boards or their own staff members. Perhaps I should speak primarily about gardens in my own country, yet international comparisons are of value and can be profitable to both parties.

Through all gardens today runs a general theme—the display of plants and the education of visitors. Any scientific value beyond that seems to be a variable, dependent in part on the director or the trustees.

There can be no denial of the value of the botanic garden merely for the rest and tranquillity afforded to the visitor. Yet this tiny area of natural environment may be under constant demand for replacement by commercial development. The opportunity to walk softly on a turf and in peace; to sit in the sun or the shade, oblivious to tensions of modern life; to feel coolness from the wind or to smell the sweetness of flowers in the breeze are reasons why some people visit gardens and value them. American visitors may wonder why some of these values are forbidden when one is not permitted to walk across the grass even to examine a plant in bloom. Other visitors admire the rules and regulations which control or forbid the blare of radios or the litter of picnics. By contrast, our visitors from Europe to American gardens are appalled at the commercial aspects, the activities of fishing or baseball or football or even the use of an arboretum hill for illicit skiing. Such activities in American gardens are not the wishes of the directors who are responsible for the growth and care of the plants, but often they cannot be controlled either by law or by public opinion. Personal enjoyment is indeed a role for a botanic garden, but the nature of the individual enjoyment may vary as will as its acceptability.

The role of education in the botanic garden is equally well established. American gardens in particular have had diverse methods of origin and therefore use. Some gardens began and continue as adjuncts of educational institutions, as pharmaceutical gardens for colleges of medicine, as systematic collections for departments of botany or even combined zoological and botanical gardens for departments of biology. Other gardens are completely the function of a government agency ranging from those of small towns to large cities, to county, state or even federal association. Many of our excellent gardens started as private estates of wealthy individuals and are either open to the public on limited access terms or are now established as separate foundations.

For the greatest number of people the educational value of a botanic garden is no doubt in the identification of a plant, therefore related to the frequency of the label and the accuracy of identification of specimens. Although most visitors seek only the name of the specimen they examine, many others want more information and can get it themselves from more complete labels. From the director's point of view, long and informative labels are expensive to create, difficult to maintain, and perhaps more subject to errors. I can contrast a public garden I visited several weeks ago where all plants in it bore only code numbers with the system we use at the Arnold Arboretum. Our labels carry a scientific name, a family name, a common name when a practical one exists, an indication of the native range of the plant or its distribution, the source of the particular specimens, the method by which it was propagated, the date it was planted on the grounds and a serial number of accession. From such a label we find the average visitor can learn some botany, plant geography, even horticulture. The age of the particular plant can be used to infer its speed of growth and perhaps an interpretation of its form. Such labels reduce but do not eliminate completely the questions of interested visitors and they do serve as a method of self-instruction within the garden.

A second advantage inherent in a wall-labeled garden is the ease of cataloging for content and location the species that are under cultivation. Perhaps most disturbing today is our general inability, on a national as well as an international basis, to know exactly what plant species are under cultivation and where. Certainly the fullest use of plant tissues will not be made until we do have a worldwide inventory. Relatively few gardens today publish listings of the plants represented within their collections even if they have such a list. This is only in part due to the cost of publication. There is often the more practical reason of reducing the demands upon a limited staff to fill repeated requests for plant parts. If my two observations seem inimicable or in conflict, they are. We know from experience that a colleague would rather cut the branches from our labeled specimen of a common tree than search the woods near his home for the same species, which he might not recognize if he saw it. We have experienced the request for several hundred apical buds for a morphological study when we have but one specimen of that rare species. Another request was for many pounds of bark or roots for chemical analysis. The letter ended, "we will appreciate your prompt cooperation" but made no mention of payment for labor or postage.

We recognize that time and trouble are required even to determine if a request can be filled or to explain why not. Yet in this age when new scientific techniques develop so rapidly and scientific progress is so important for the welfare of man in an ever growing population it seems morally and scientifically wrong to be without an inventory of our potentially useful plant materials. Chemists and pharmacologists have found biologically active compounds capable of experimentally reducing a tumor in genera of three families previously unsuspected of having such chemical compounds. Herbarium records will tell us where related species have been collected and expeditions could be made to procure material. However would it not be quicker and simpler to check first the material in all of our greenhouses and our gardens ? I am not even considering the tremendous commercial value to nurserymen and horticulturists to know of sources of new clones for breeding or for propagation. Most of us who answer questions of the general public of "where can I buy such a plant" would be pleased to have opportunity to refer the question to a central source. We would save time and money in the process.

There are several attempts under way involving different kinds of plant materials to record what is available and where it is located. A program of international cooperation sponsored in part by the FAO will use computer techniques for storage and recovery of data on plant germ plasm of commercial varieties of rice and other cereal crops. Recently the American Horticultural Society has established a Plant Records Center which hopes to develop a similar coordinated inventory-source program for plants under cultivation in botanic gardens. The possibilities of the program were described at the International Horticultural Congress in Maryland in 1966 and endorsed with enthusiasm by the International Association of Botanical Gardens and the American Association of Botanical Gardens and Arboreta. The latter organization, through the generosity of some of its members established a fund for several initial studies. Now a grant from the Longwood Foundation will permit the Plant Records Center, directed by Mr. Robert MacDonald of the Tyler Arboretum (P.O. Box 216, Lima, Pennsylvania, U.S.A. 19060), to apply these experimental techniques to the collections of the Longwood Gardens. A living out-of-door collection of plants, extensive greenhouse plant collections, materials commonly offered in index seminum, herbarium vouchers, library books

and pamphlets, cytological records, compatibility information and so on will be coded for electronic data processing and retrieval. If this initial project is successful, the American Horticultural Society proposes to seek the cooperation of botanical gardens, horticultural societies, even commercial sources in the United States and abroad, to make an international directory of plant materials under cultivation. The kinds of information that can be recorded, processed or analyzed, rearranged and recovered by modern computer techniques is almost unlimited and varies from strictly practical to highly theoretical. The limitations are obvious now: people to do the work, time to do it, and money. Although massive projects have been accomplished before, modern computers offer more value for time invested than any type of information storage previously used. Clearly the need for this information filing and retrieving system is growing and the cost may soon become insignificant in terms of the values to be gained.

Anticipate, if you will, the day not too far ahead when each garden staff, including yours, may be called upon to indicate their willingness to participate in an international program of locating plant material. Think again of the quality of your own records. Do you know what you have growing, where it is, and in what condition ? Are you sure of its identification ? Do you know its source or how it can be propagated ?

We are certainly aware of some of the problems within the relatively young gardens of North America. At the Arnold Arboretum we maintain a separate herbarium of specimens of plants under cultivation for teaching and for research. These sheets number 133,000 but are primarily of woody plants and mostly from eastern North America and western Europe. Monocotyledons are poorly represented, as are herbaceous plants. We have been considering the need to publish a new edition of Rehder's "Manual of cultivated trees and shrubs". We wanted information on cultivated plants within the United States, so we sent a questionnaire to a member of the department of botany or biology of major colleges in every state in the Union. We asked if there was a local flora or a listing of the plants growing under cultivation on the campus or adjacent areas. We asked if specimens of cultivated plants were preserved in a local herbarium and if specimens were available for distribution. Less than 10% of the replies indicated any local lists of plants under cultivation. Even fewer indicated that reports were supported by herbarium vouchers and only 9 schools so far have expressed an interest in the exchange of specimens of cultivated plants.

The herbarium specimens is the voucher of an accurate identification as well as the verification of the maturity and hardiness of the species in a given area. We did not send a similar questionnaire to botanical gardens. In compiling the "Directory of botanical gardens of North America" and later the "International directory of botanical gardens", we found that few gardens publish complete listings of their holdings, although over half do distribute an index seminum. The majority of those without lists may keep looseleaf files or card catalogues. Very, very few botanical gardens maintain herbaria, even collections of voucher specimens, of the plants they grow within their collections. The hardiness of cultivated plants within the United States is reported in manuals, popular books or commercial nursery catalogues in terms of hardiness zones. Some authors have resorted to using the commercial nursery catalogues as an indication of the area where a particular species may be hardy. They assume, of course, that the nursery is literally growing the plant and has not had it shipped in for the sale or subcontracted the purchase.

They assume, too, that all listings are of plants correctly identified. How very different are the standards of accuracy involved in our writings on native plants and on cultivated plants. Truthfully, much work remains to be done before information of sources of plant materials in botanical gardens is ready to be placed in a computer.

There are also unexploited resources in the purely scientific information to be obtained from specimens in various botanical gardens. As systematic botanists we give lip-service to the idea that any part of the plant body involving many different stages in its life cycle can give information of value in description, classification or phylogenetic considerations of the plant. If we seek knowledge on the vascular structure of the sporophyte body we turn to the work of C. R. Metcalfe and his collaborators working out of the Jodrell Laboratory at Kew. Here at a botanic garden, largely unassociated with a university, there is progress in the painstaking accumulation of facts on plant structure which are compiled and published as the "Anatomy of the Dicotyledons" and the several volumes which will be the "Anatomy of Monocotyledons". Even this excellent work has areas where knowledge is not complete. In my own work on the nature of the node and the petiole, I recognize the contribution of my predecessors, know what I have accomplished, and realize fully well how many gaps remain. For years anatomists considered there were three types of nodal structure until Bailey and Marsden reported "A fourth type of nodal anatomy in dicotyledons". In fact 20 would probably be a more realistic number of useful descriptive types to be employed in comparative morphological studies.

The work of C. D. Darlington and his associates in the compilation of published records of the chromosome number in wild and cultivated plants is a standard reference. More recently an editorial team of the IOPB has published lists of additional chromosome counts in issues of "Taxon". Still another list is available as published by the University of North Carolina. There is no easy way to file this information by family or genus, alphabetically or systematically, but a computer could sort out lists with ease. I checked to determine if the chromosome count was published for 10 random selections of plants from three botanical gardens I have visited in the past month. I found less than half of them recorded. This may be due to my inability to locate the published record, to the lack of any attempt at a count, or to technical difficulties. We know from the experience of cytologists who have worked at the Arnold Arboretum that the mature trees from which we have no recorded chromosome counts are also those species in which it is difficult to make appropriate fixation due to size of cells, nuclei or chromosomes, or to the presence of confusing chemical substances within the tissues.

John Hutchinson reports in the second volume of "Genera plantarum" that fruits and seeds are unknown for two plants which I know flower and fruit regularly in cultivation in tropical American botanical gardens. Gwenda Davis in her excellent compendium titled "Systematic embryology of the Angiosperms" reports, for example, that the families *Didiereaceae, Eucryphiaceae, Hernandiaceae, Julianaceae, Nandinaceae* and *Picrodendraceae* are "embryologically unknown" while "the embryogeny has not been traced in detail" in any member of the *Araliaceae, Cabombaceae, Cochlospermaceae* or *Crossosomataceae,* to cite only four families. All of these families are under cultivation in American botanical gardens. These are some of the unexploited resources of botanical gardens. No blame is to be placed on the author of the book for not investigating a plant under cultiv-

ation, and certainly the director of the garden cannot be held responsible for knowing what facts are missing regarding his particular plants. However consider how close to reality is Augustin-Pyramus de Candolle's desire to have all of the information possible on all plants. With the aid of the computer we will have the ability to sort out the data. The projected "Flora of North America", to be sponsored by the American Institute of Biological Sciences, proposes using electronic data processing and recovery. The source of their information will be botanists and botanical gardens. Modern machines may organize the information but a botanist is also required to make the observations.

Recently I wrote to a botanical institution requesting some historical information from old and apparently rarely used records. I received an apology in reply to my request, stating that that section of their library and therefore their history was not available because an electron microscope had been placed in front of the shelves of books I wanted them to consult. Here is one case where modern technology literally blocked tha path of my research program.

While modern methods and instruments may be necessary for some information, there remains data to be gathered more simply and efficiently by different techniques. The razor blade and free-hand section will show many things that are overlooked with the electron microscope. There is room and need for both methods. There is data of value within the history of our field and within our own collections that has scarcely been touched. I have been investigating quite recently the introduction of native plants of the West Indies into cultivation in various parts of the world and the changes that have occurred subsequently in the species. Part of this work can be done only from the printed or written page. The records of the voyages of Cook or Houstoun or Céré offer much information. From the records of Philip Miller at the Chelsea physic garden or those of the Pamplemousse garden on Mauritius or of Jacquin at Schoenbrunn in Austria, I find a bit more data of value. The herbarium specimens prepared by the Duchess of Beaufort and stored in the Sloane Herbarium may document other steps in this story. A knowledge of the nurseries which grew the plants and the cultivars they recognize tell of the variation. The modern specimen of a plant growing under cultivation or as a noxious weed permits the final chapter to be written.

In our more recent collections at the Arnold Arboretum we have the photographs of plants Ernest Wilson saw in his travels in China in this century. Herbarium specimens and often fruits and seeds were collected from the same plants. The seeds were grown and now two or three generations of descendants may be available for comparison with each other and with the original photograph and herbarium specimen. The changes are documented with herbarium specimens. How much of the genealogy of other cultivated plants remain unstudied within collections of older gardens where single clones have been propagated for literally hundreds of years !

Within the last few years our herbarium collections have been methodically searched for alkaloids and glucosides by simple tests of leaf tissue. Other workers have faithfully copied data from herbarium labels regarding the native uses of the specimens to aid pharmacological studies. Pollen has been taken from anthers as vouchers for palynological studies and twigs have been used for anatomical investigations and so on. I need not give you additional examples of the reference value of your living collections, your herbarium material or your library. I need only point out that we have acquired only a small fraction, certainly not half, of the

information which can be gathered from our materials. The values and resources of the botanical garden are still to be exploited and even greater uses lie ahead. This potential of utilization, of benefit for manking is the reason why living collections will be maintained as well as the herbaria, libraries and laboratories associated them. This is the heritage we have from men like Augustin-Pyramus de Candolle and in treasures like the Jardin botanique de Genève.

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