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BOTANIZING

A GUIDE TO FIELD-COLLECTING AND HERBARIUM WORK

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BY

WILLIAM WHITMAN BAILEY, A.M.
Professor of Botany in Brown University

PROVIDENCE, R.I.
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TO THE MEMORY OF

JACOB WHITMAN BAILEY

LATE PROFESSOR OF CHEMISTRY, MINERALOGY, AND GEOLOGY

IN THE U.S. MILITARY ACADEMY AT WEST POINT, N.Y.

This Book is Affectionately Dedicated

BY

HIS SON

PREFACE

In the preparation of this work I have consulted Verlot's very useful "Guide du Botaniste Herborisant"; Crèpin's "Guide du Botaniste en Belgique"; Penhallow's "Botanical Collector's Guide"; Knowlton's "Directions for Collecting Recent and Fossil Plants"; and numerous articles which have from time to time appeared in "The Bulletin of the Torrey Botanical Club"; "The Botanical Gazette"; "The American Naturalist"; "Nature"; and other periodicals.

My former work, "The Botanical Collector's Handbook," published in 1881, met with a flattering reception. The present volume, while embracing all the matters contained in the earlier work, is entirely rewritten, much enlarged, and, I hope, improved. Its preparation has engaged my attention for several years. I should have often felt like abandoning the project, had it not been for the encouragement and active aid of my fellow-botanists.

Various remarkable vicissitudes have attended the publication of the book. Among these figure, besides "the law's delay," sickness, flood, and fire. When on the ninth of February last Maxcy Hall, of Brown

University, was on fire, the manuscript of this book was stored in the herbarium in the basement of that building. The writer had several bad half hours watching the flames, but, after all, the book was at that time saved. It had to meet with another trial in the fire at the printing establishment in Boston. There a portion of the manuscript was irreparably lost, and much of the remainder blackened and mutilated. It was only by the efficient aid of Mr. J. Franklin Collins, who also prepared all the illustrations, that I was enabled to almost immediately return the copy.

My thanks are especially due to Prof. B. L. Robinson, of Harvard University, for herbarium suggestions; to Mr. M. L. Fernald, also of the Gray Herbarium, for field notes; to Mr. Frank S. Collins, of Malden, Mass., for the instructive paper on algæ; to Mr. Haven Metcalf, my assistant, for remarks on lichens and fungi; to Mrs. N. L. Britton, of New York, and Prof. C. R. Barnes, of Chicago, for moss notes; and to Mr. Walter Deane, of Cambridge, Mass., for interesting hints and suggestions for field and closet. Mr. J. Franklin Collins, besides the work acknowledged above, at every stage of advance freely offered the aid of his long and valuable experience. Fertile in resource, and quick to seize upon the good features of any scheme, he has, by his assiduity, rendered my task, otherwise a burden, a distinct joy. I have no words sufficiently strong to express to him my deep obligation. We have often botanized together, thus practically putting to the test of field experience our thought in the seclusion of the study.

In again resuming this old-time labor, after so many years of intermission, I am saddened to think of the

inroads made by death upon the circle of friends who formerly lent me their assistance. Our beloved master, Asa Gray, while not directly contributing to my work, gave me the encouragement of earnest counsel, of unequalled criticism, and emphatic final approval. With him have passed from us Dr. Sereno Watson, my colleague on the Fortieth Parallel Survey; Prof. Edward Tuckerman, the expert on lichens; Mr. Thomas P. James, and Prof. Leo Lesquereux, who contributed the mosses; Rev. Francis Wolle, the student of fresh-water algæ; Charles Wright, the incomparable collector; Dr. George Thurber, the genial and learned; and Mr. George Hunt, the Nestor of Rhode Island botanists. No jaunt in the woods in these later days seems complete without my old friend Mr. Hunt. All of these were actively interested, and most of them directly contributed to my work.

The pleasant welcome that met my former little volume encourages me to hope that this book may justify its existence; that it may prove of service alike to the amateur and the professional. Its virtues are those of its distinguished contributors; its faults are entirely my own.

WILLIAM WHITMAN BAILEY.

BROWN UNIVERSITY, PROVIDENCE, R.I.
May 9, 1899.

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BOTANIZING

CHAPTER I

INTRODUCTORY

"O Botany, delightfullest of all sciences, there is no end to thy gratification!" — COLLINSON TO BARTRAM.

The Claims of Botany to Consideration. —The questions are often asked, "What is the purpose of Botany? Why should students pursue it? Why do botanists amass a lot of plants in a herbarium, or fruits, fabrics, or drugs in a museum? Why are botanical gardens established?"

Botanists are usually quiet people, unobtrusive, and pursuing their researches in private. They are little given to trumpet-blowing or the noising of their own achievements. Generally good-tempered men, and absorbed in occupations which to them seem important, they are for a moment staggered when questions of utility are suddenly presented to them. Almost every botanist has an occasional experience of this sort of vexation.

The questions often proceed, not from the illiterate, but from those educated in other fields of usefulness.

To these the claims of the science have, perhaps, never been properly presented. We must meet them kindly and fairly, insisting, however, that much scientific work, purely in the nature of research, and showing no immediate results, is still legitimate. No one can tell just when a scientific truth will bear fruit. Some of the early chemical work of Pasteur, for instance, had no direct reference to economic applications, but it has led to the most astonishing utilities. By its means the grape-vine scourge in France has been mitigated and an immense revenue restored to the state; the diseases of cattle and poultry have been assuaged; the silk-worm restored to health; and, lastly, hydrophobia checked in its terrible career.

We might, indeed, mention here the relations of Botany to the whole science of bacteriology, of antiseptic surgery, and antitoxine treatment as in diphtheria and similar diseases.

Often one's querists are honest seekers after truth. They really desire to learn what we are about. We should meet their questions calmly, fairly, patiently; seeking to put ourselves in their position, and to apprehend the ground of their thought.

We should now proceed to answer some of the questions more commonly asked. The science of Botany is one that in a preëminent degree trains the observing and reasoning faculties. It leads to close inspection, to accurate comparison, to terse and forcible forms of expression, to the habit of correct delineation. In its inception it requires inexpensive apparatus. A hand-lens, or, better, a simple dissecting microscope, with a thin-bladed knife and a couple of dissecting needles, is the necessary outfit. To be sure, in more

advanced stages of progress more costly instruments and even chemical and physical apparatus are employed.

Here I am led to speak of the relations of Botany to many kindred sciences. It is in close touch with Geology, which tells us of the ancient life of the globe, of a life indeed which antedated the coming of man; with Chemistry, which treats of the constitution of air, water, soil, and the very life of plants; with Geography, which tells of vegetable distribution over the earth, the origin and determination of migrations, and the causes of permanence or diminution; with Entomology, for insects are either handmaidens to help or active enemies to destroy plants; with Meteorology, showing the effects of climate and seasons; with Medicine, in pointing out plants useful to the physician in the mitigation or cure of disease.

As life, too, is always more attractive than death, we claim that our science is above and beyond many of the sister sciences in interest. Here we have life in its initial stages, leading from simple unicellular organizations up to the most complete forms of plant or animal.

Interesting as is the other branch of biological study, namely, Zoölogy, the botanist must often feel thankful that the question of pain cannot by any possibility arise in his pursuits. No law, religious or restrictive, stands ready to close our laboratories. We can point to our analyses as pure and painless.

Again, materials lie abundantly about us at all seasons and in every climate. Winter yields us her lichens and mosses on rocks and trees; her algæ in salt or fresh water; her mushrooms and toadstools

in meadows and woods; her smaller fungi as blights and moulds on leaves, etc. Spring and summer overwhelm us with abundant floral treasures, and autumn offers us her harvest of fruit. Let the traveller proceed to the utmost north, and still he will find plants. The dry Sahara presents its oases verdant with palms and grasses; the steppes of Asia or the barren heights of Arizona bristle with cacti; the Alpine summits of the Andes or the Himalaya bloom with brilliant flowers.

The depth of the ocean has a life of its own in diatoms and foraminifers; its lovely surfaces often, as in the Sargasso sea, present a wild tangle of huge marine growths. Nothing here "doth fade but doth suffer a sea change into something rich and strange."

Even in the chinks of his dungeon it may happen that the prisoner finds the weed that speaks of freedom and redemption:

"Nature never did forsake the heart that loved her."

As has been said, the elementary facts of Botany require mostly careful observation. From these, however, the student rises by gradual steps to complex conceptions, profound generalizations, philosophic discussions, which will require his most mature thought. Advanced Botany is now a very serious study, requiring in the student a knowledge of at least three modern languages, and an equipment in Greek and Latin. Besides he should have a ready knowledge of Chemistry and Physics and an aptitude in handling tools. Then, too, a certain inventive faculty is always a great advantage.

By the study of Botany one acquires the use of a

technical language unsurpassed in accuracy and flexibility by any employed in the whole range of science. It is the outgrowth of a long series of years, and the result of the thought of many philosophers.

While this language is itself so precise, one must remember that it is used to describe objects which, from their nature, do not admit of mathematical precision in their description. No two leaves on the same plant, for instance, are alike; we have to combine terms. The text-books contain a number of figures illustrating types. There are infinite variations from these forms, making a constant demand upon one's armory of words. The practice required in selecting the best terms or best combination of terms in which to record one's observations is, of itself, of inestimable value.

It is, perhaps, unnecessary to emphasize the æsthetic aspects of the subject. There are few persons whose sense of beauty is so dull that they do not admire a stately tree, a symmetrical fern, or a perfect and odorous flower. The poetry of all languages is adorned with flowers. The sacred writings of all nations glow with its figures. The palaces of princes and the hovels of the peasant alike evince the admiration of mankind for plants. A scientific knowledge increases and develops this love of the beautiful. Close acquaintance does not breed contempt, but inspires awe.

If one examines the most stately and ornate of human structures he will find flaws. Visit our finest cathedrals and churches, and in some odd corner we shall find something to offend. The builder has said, "Here is a corner that no one will see, or it will be

seen rarely. What use to finish here?" Nature has no such unseemly recesses. Nothing is so minute as to lack the most exquisite finish. The microscopic diatoms at the bottom of the sea require our highest lenses to resolve them, and yet are traced with delicate curves, and lines, and ornaments, which are the marvel and envy of all human designers.

Nor should we forget, in eulogizing the science, to speak of the friendships formed in its pursuit. These are among the most intimate of life. Sympathetic ties exist between those who have never met and may never meet on earth. They may indeed be separated by wide oceans or continental distances. Often these friendships give rise to heroic virtues. We have only to mention the familiar story of the simultaneous publication of the theory of natural selection by Charles Darwin and A. R. Wallace, and the beautiful and chivalrous relation, free from doubt or envy, that ever prevailed between them.

Botany introduces in the easiest way the use of the microscope, and this instrument is to-day to the botanist what the balance has long been to the chemist, and the telescope to the astronomer. Hovering all about us, in air or water, or even in our very food, are a myriad minute forms of vegetable life, many of them potent causes of disease. Against them the botanist urges ceaseless war, and his weapon is the microscope. Facility in its use adds much to one's equipment for medicine and other sciences. It affords as well, to himself and friends, an endless source of innocent pleasure. But what of the practical uses of the science? Let us consider some of these.

To a horticulturist some knowledge of Botany is of

great value. By its means he learns to adapt plants of one region to another. He ascertains the effects of climatal conditions, and how far the natural range of a species may be extended. He studies its life history.

Says a botanical writer, "By the help of this knowledge the inhabitant of a northern temperate climate is not only enabled to increase the quality of the vegetable productions indigenous around him, but also to enjoy at his own home many desirable fruits and flowers naturally confined to tropical regions." — Asa Gray, "Elements of Botany," 1836.

Again, one learns what plants are troublesome as weeds, or noxious to man or animals, and hence to be eradicated. The science teaches one not to waste his time on unprofitable plants, but to extend and improve the beneficial. It indicates families which are apt to contain useful plants, as Leguminosæ (pulse family), Solanaceæ (nightshade family), Rubiaceæ (madder family), Gramineæ (grass family), Palmaceæ (palm family), etc., and hence when and where to look for them.

It is generally considered that a knowledge of Botany is useful to the physician. Surely he should have some knowledge of the characters of the natural orders and genera "so that even if placed in a land with the vegetation of which he is wholly unacquainted he may decide with confidence as to the species in which certain medicinal virtues are or are not found; what plants are wholly inert, what kinds may be expected to produce esculent fruit, and what should be looked upon with suspicion or sedulously avoided." — Asa Gray, "Elements of Botany," 1836.

As an instance of the beneficent influence of the science the records of the Royal Gardens at Kew may be cited. Under the directorship of Sir William Hooker, and later of his son, Sir J. D. Hooker, and at present under that of Prof. W. T. Thistleton-Dyer, it has accomplished wonders for the education and delight of countless throngs of visitors. But its work does not cease with this objective teaching; it constantly enriches the many colonies of Great Britain. One of the annual reports of this truly Royal Garden contains a complete reply to any carping criticism of Botany.

Here is, no doubt, the largest herbarium in the world; here botanists, gardeners, and explorers are trained; here are conducted experiments of most varied and useful character. By means of Kew, coffee, cinchona, cotton, and many other important products have been extended to different countries. All the colonial as well as many foreign gardens are in touch with Kew. Every new plant is there examined, every supposed drug or fabric tested as to its value. Improvements of cultivation are suggested, means of protection instituted. Kew is now conceded to be one of the most practical, best paying, of all Britain's national institutions; it is honored alike at home and abroad.

Who can fitly estimate the amount annually saved to the farmer by the researches of botanists and entomologists? The student of fungi alone becomes a benefactor, for mould, blight, and mildew, as well as many of our own diseases, arise from the prevalence of active spores. We should then, in all ways, encourage those who with microscope and chemicals wage upon these pests an unrelenting war.

But let us consider a little more closely the uses of a herbarium and of a botanic garden.

In regard to the former it is to be said that much of the systematist's work is of necessity upon dried plants. These he soaks in warm water, which in a measure restores the contours and softens the tissues so they can be examined. A botanist could not by any chance visit all countries, nor even every part of his own, but in the herbarium he can have all or a large part of the plants of any given region exposed in their natural sequence, or what science at the time considers such. Plants even of one family or genus are not all simultaneously in flower or fruit, but in the herbarium all parts can be thus viewed. The natural affinities and geographical and altitudinal distribution can be learned in no other way, though closet work must needs supplement more direct field observation.

Again, the herbarium is a cyclopædia of ultimate appeal. To it the student in doubt may appeal as to an authority. At least he will ascertain what the best investigators have thought. Hence a fine public herbarium is something to be amassed and cherished.

A botanic garden is almost equally important. Therein plants should be arranged as nearly as possible by their natural affinities, well and clearly labelled so that all may learn them. Many horticultural experiments can here be tried. Moreover, the garden should, like that of Kew, be a centre of dissemination both of knowledge and useful products. It should at all times be open to the public and hence become a park of most delightful and varied usefulness.

CHAPTER II

EQUIPMENT

"If you catch quite a beginner and want to give him a taste of Botany, tell him to make a perfect list of some little field or wood." — CHARLES DARWIN TO SIR J. D. HOOKER.

In preparing for a jaunt in field or forest, in swamp or mountain, the experienced collector carefully attends to his outfit.

Clothing. — His clothes need not of necessity be old, but they must be comfortable and serviceable. All superfluous finery must be left at home. There may be persons here and there who, under all circumstances, preserve the *ensemble* of the shops or fashion-plates. The average botanist takes care that his clothes fit, that his shoes do not pinch, and that the fabric of his garments shall withstand the grasp of briars, come out well from impromptu baths, and allow him to climb, wade, run, or accommodate himself to any human vicissitude. The garments, too, should be cavernous with pockets.

It has been said that the shoes should not pinch. Equally important is it to have them long and broad enough. Inexpressible agony may be caused by neglecting this precaution, especially on a mountain excursion.

Often it is desirable to carry with one a pair of long rubber boots for wading in swamps and shallow

ponds. These are apt to be too heavy and heating to be worn except for the special occasion.

One should always have a pair of stout leather gloves for handling prickly or thorny plants such as cacti, green briars, blackberries, thistles, and nettles; as well as poisonous plants like *Rhus venenata* and *toxicodendron*.

Another useful implement for collecting such plants is a pair of pruning shears.

The character of the clothing worn will depend much upon individual taste and upon the length and character of the excursion. The season and climate will largely determine it. One cannot lay down precise rules for anything so largely influenced by idiosyncracy, caprice, or experience.

Many persons prefer a suit of corduroy; others thick woollen. It is for many reasons desirable to wear a flannel undershirt, to prevent sudden alternations of heat and cold, and to absorb perspiration. A rubber coat of some kind is almost indispensable in case of rain. Indeed, a complete rubber suit is good, for a coat alone simply directs the water upon one's knees. Woollen and rubber blankets are always taken on long excursions involving days or weeks. They pack readily on the outside of a knapsack. The rubber blanket is sometimes of sudden avail to protect one's plants.

Mr. M. L. Fernald says: "For two years now I have used a duck or canvas shooting-jacket on my long tramps. Aside from the semi-waterproof quality of such a coat, and its convenient form, I find the large pockets, both inside and out, of great service in storing away mosses, lichens, and the like, thus sav-

ing box-room for more perishable material. The pockets, too, are handy as primitive means of carrying luncheon, bait, and fish-lines."

Again, on extended excursions one should be provided with an ample supply of serviceable stockings, and it is not a bad idea to carry a pair of slippers or even a change of shoes. Nothing can prove more uncomfortable than wet boots. These can, however, be surely and quickly dried by packing them full of bran, which completely absorbs the moisture.

In mountainous regions, like the Sierra Nevada or the White Mountains, we have found it an advantage to have the soles of our shoes thickly beset with hobnails; they are of great advantage in climbing on wet rocks. Rubber soles are sometimes used, but are not durable, and are often dangerous on wet rocks.

Situation, again, must determine the kind of headgear one should wear. In hot, dry regions a broad-brimmed sombrero, or the ventilated helmet such as soldiers wear, is an excellent thing. On windy coasts or mountain tops, on the contrary, a close-fitting cap with chin-strap may be desirable. In any case one wants the most comfortable article to be found: a hat that will not be constantly blowing off.

A botanist who is also an entomologist, as sometimes happens, may carry an umbrella, not so much to shield him from the rays of the sun, as to serve as an implement for collecting. Held upside-down under a tree it serves to catch small insects shaken down from the branches.

Cane or Staff. — A cane is often a useful implement. It is desirable to have it curved at the end so that it may be used for gathering the flowers and fruits which

truth and fable both prove to be not infrequently beyond one's reach. Pond-lilies and pond weeds (Potomogetons) also are often unattainable otherwise. Frequently one would have to wade in for them, while with the cane they can be manipulated, after a fashion, from the shore.

Prof. W. H. Brewer, of Yale University, writes that he has used, as the handiest possible cane, a light staff of bamboo, such as a fishing-pole, the bottom shod with a ferrule, the top furnished with adjustable hook.

In hilly regions a cane or alpenstock of greater length is of use in climbing and descending. It should be stout enough to sustain one's whole weight, and should be armed with a ferrule.

Many collectors prefer to cut a staff for each trip and discard it before returning home. At the thick end the stub of a branch should be left to project one or two inches, to serve the same purpose as the curve mentioned above.

Dredge. — For pond weeds, such as *Potomogeton*, *Naias*, *Vallisneria*, *Anacharis*, and the like, a rake may be used to advantage, as such plants entangle themselves among the prongs and may thus be brought up.

A good but simple form of dredge has been used at the Marine Biological Laboratory at Woods Holl. It consists of a piece of leaden pipe filled with a bunch of iron wires. These are abruptly bent at the end, and form an excellent prehensile tangle.

Another useful form of dredge is that described and figured by T. F. Allen in the "Botanical Gazette," Vol. XI., page 141, or in Knowlton's "Directions for Collecting," page 8. It consists of "an iron rod five-

sixteenths of an inch in diameter, and about twelve inches long, bent to form a small ring at one end, and passing through carries below its centre a disk of lead about three inches in diameter. This disk holds embedded in it twelve or fourteen iron hooks all bent toward the same side. The hooks project about an inch from the leaden disk and curve inward about an inch. The iron rod projects about three inches beyond the leaden disk, so that the rod strikes the bottom first. The lead should be heavier on the side towards the hooks, so that the dredge will fall with hooks downward."

Knife. — A good jack-knife, or, better yet, a long, sharp knife to be worn in a sheath on the waist-belt, is a desideratum. It may be used for many purposes, such as removing mosses or lichens from trees, cutting one's way through obstructive brambles or bushes, or even for rougher dissections. A composite knife, with gimlet, awl, etc., is often useful. There is never a moment in an excursion when a knife may not be demanded.

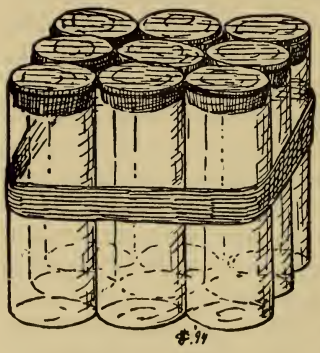

FIG. 1. — Vials.

Pill-boxes and Vials.— The significance of these is not medicinal; they are carried empty, to contain small objects, as algæ in the bottles, or seeds, spores, mosses, lichens, or fungi in the boxes. A set of bottles may be taken in a convenient

and compact form, by inclosing them, as in Fig. 1, by an elastic band.

String, Thread, or Twine should form an essential part of any outfit. Indeed, a reticule containing needles, etc., is often handy. String is used for tying up packages or bundles. Flexible rubber bands should be carried in quantity, as well as pins and safety-pins.

Map. — By all means carry a map of the region to be explored. This point cannot be too greatly emphasized.

Procure some map of the State, county, town, or island, such as is afforded by the United States Geological Survey. Paste this on cloth, varnish, and fold to convenient size, or cut into sections. If this map has the roads marked upon it, all the better. Then, as knowledge is gained, let the springs and streams be added, together with geological and topographical features. Plants often bear a marked relation to the soil and rocks. Indicate these relations by colors. In other words, study the environment of the plants; fill the map with observations.

Compass. — In the above connection a compass is naturally suggested. There are times when a traveller may lose his way, and all his woodcraft will fail to extricate him from an annoying or even dangerous situation. A word to the wise: streams always flow *down* hill. If, then, you are lost on a mountain — unless, indeed, it be in a fog, when prudence would dictate staying where you are — attempt to descend by a ravine. It may be dangerous, but it is sure.

In the absence of a true compass remember that a watch is an excellent substitute. Hold the watch

horizontally, point the hour hand directly towards or beneath the sun, and half-way between the hour hand and twelve o'clock, noon, on the dial will be south (approximately).

Old hands learn to direct their course by the position of the sun, and to a limited degree by the location of mosses and lichens on trees, but when really lost this wood lore avails but little. The compass may easily be carried as a charm on the watch-guard.

Provisions.

"A scrip with herbs and fruits supplied, and water from the spring."
GOLDSMITH.

We cannot legislate as to the kind of provisions one should take into the field. Experience, or the advice of friends, must rule in this regard. It is only necessary to say that all indigestible food should be carefully avoided. As a light and portable as well as nutritious article of diet in case of an emergency, stick chocolate is recommended.

One should have a canteen in which to carry water. In very hot and dry climates the canteen is kept cool by wrapping it with wet blanketing or flannel. It is not well to drink ice-cold water at any time, and especially when heated, though personally the writer has never experienced any ill effects from the water of streams or wells. He is accustomed to drink freely when he desires.

Where lime-water prevails a little citric acid is a good corrective. Those who can avoid drinking much on a journey no doubt have an advantage, and it is easy to cultivate such abstemiousness.

There are many forms of cup that are convenient,

such as some of the telescopic ones made of rubber or metal. Some persons always carry a filter — possibly a wise precaution.

Note-Book. — Of equal importance with the map is the note-book. Here should be entered memoranda bearing upon the work of the day. A note-book of uncalendered paper is advised, for the reason that it is often desirable to make sketches. These cannot be so well done on a smooth surface. It should have strong but light, flexible covers, and be of such form as to be readily carried in the coat-pocket. It is desirable to adopt a uniform size for note-books, which can then be numbered, dated, and filed away. If well kept they become a mine of information, not only to the writer, but to other botanists who may have occasion to consult them.

A very convenient note-book is here figured. It has been used by Mr. Collins for several years, and the prominent features of it consist in its having the lower corner, at the binding, perforated by a hole through which a string is passed and secured. At the other end of this string — which should be once and a half or twice as long as the book — a short pencil is fastened. In closing the book the string is shut in at the page being used (as shown in figure), and thrust into the pocket with the pencil hang-

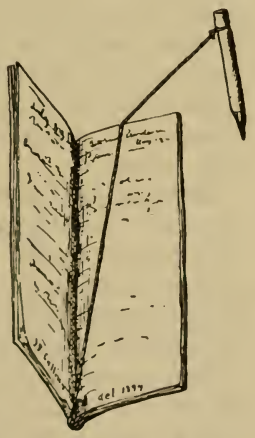

FIG. 2. — Note-Book.

ing outside. When again desired the book is withdrawn by grasping the pencil, and is instantly opened at the page desired, for the string acts as a bookmark and does not interfere with writing in any way.

Pocket Manual. — If it is possible to obtain a pocket manual of the plants of the region in which you propose to collect, it will prove a valuable accessory, provided the time in the field is not too limited to permit of its occasional use. When time is available for consulting it on doubtful points, the field work is much more profitable and fascinating, and a great amount of discrimination in collecting different species is possible even to the novice. In such a book all the plants which are known to occur in your region can easily be indicated by some appropriate symbol or colored ink. It is suggested that these symbols be small, as you may at some later time wish to indicate by other marks the plants known to occur in other regions which you may visit. It can also be used as a check-list for herbarium specimens, and in many other ways which convenience, necessity, or fancy may dictate.

Envelopes and Paper. — A generous supply of both envelopes and paper will always be found useful. The former should be *folded* — not *pasted.* This style of envelope is so generally useful in collecting small mosses, lichens, fruits, etc., and is so easily made that it is well worth a detailed description. In order to make the "4 × 5" envelope, — a very useful size, — have the desired number of pieces of manila paper — of about the same thickness as the regular nineteen-pound mounting-paper — cut at any printing-office or bindery having a paper-cutting

machine, to the size of nine inches long and eight inches wide. (See Fig. 3, *A*.) Four inches from the straight sharp edge of a board (or table) insert two perpendicular pins firmly, having them six or seven inches apart. This forms your folding-gauge. Place one of the short ends of a single sheet of the paper against the pins and crease the paper over the edge

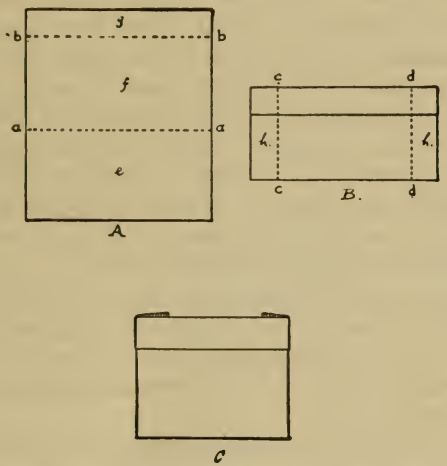

FIG. 3. — Envelopes.

of the board. This should be four inches from one end and five inches from the other. (See *a a*, Fig. *A*.) Remove from the board and crease sharply with the fingers, then place the folded edge against the pins with the short fold down, and again crease as before (*b b*), folding the flap *g* over *e* so that it will appear as at *B*. The flap should be one inch wide. For the second folding (indicated by *c c* and *d d*, Fig.

B) a thin board five inches wide, with sharp parallel edges, is needed. It is held firmly on a table by a weight or clamp, with the end projecting beyond edge for five or six inches. Two gauge-pins are inserted, as before, near the edge, and about four and one-half inches from the end of the board, in such a way that a line drawn between them is perpendicular to both edges. This is to insure the corners of the envelope being right angles. The paper, as previously folded, is placed against the pins, flap up, so that the ends (*h h*) project about equally, and are then creased downward, and afterwards folded more sharply with the fingers. This completes the envelope as shown at *C*. Notwithstanding this rather formidable description it really requires but a few minutes to make quite a number of these envelopes when the two simple gauges are at hand.

Elastics. — Rubber bands of various sizes should be carried on every trip. They are very handy, and used for various purposes: to snap about envelopes and small bundles, about several twigs that are to be kept together, etc.

Tags. — These are used for labelling plants from which a later collection is to be made. They may be made of small pieces of metal with a number stamped on each and fastened to the plant by a small copper or brass wire — iron rusts too easily, and string is generally too conspicuous and is sometimes appropriated by birds or boys. If a tree or large shrub is to be tagged a copper tack with a large flat head, on which a number is stamped, makes an excellent tag. It is easily driven into the bark with a knife, trowel, or rock. On account of the comparatively small size

of this tack it is a good plan to always label a tree on a certain side and at a certain distance from the ground; for instance, the north side, and about five feet from the ground. This system will make the tag easier to find again than when no such system is used.

Knapsack. — On long collecting trips and even for a trip of but a single day — particularly on a mountain — a knapsack is often needed to carry such articles as are not being constantly used: luncheon, rubber coat, blankets, reserve supply of envelopes, paper, etc. It is carried on the back, out of the way when collecting, and in a position where it can be borne with the least possible effort, and with comparative comfort, provided the carrying straps are broad and adjusted to fit the collector's shoulders. A light and strong knapsack with one or numerous compartments, and fitted with straps for carrying blanket rolls, can easily be constructed from brown denim — the material generally used to make overalls — and a few leather straps.

Matches in a small *waterproof* receptacle should always be taken on an extended trip involving one or more nights away from home.

Insect Pests. — These foes of mankind have no more respect for the botanist than for his less scientific brethren, and mosquitoes, black flies, "midgets," moose-flies, and even ticks must be considered when a trip is contemplated into localities which they inhabit. Various compounds of tar, pennyroyal, etc., are on the market and are advertised to keep these pests from biting one, when the remedy is spread well over the face, neck, and hands. Some

of these are more or less efficacious. We have heard a few people remark that, owing to the odor, the "remedy was worse than the disease." It is suspected, however, that these same people would be only too glad to resort to *any* remedy after an hour's attempt to collect in a region which really swarms with any of these foes, such as some portions of Maine during June or July. A mosquito netting with small meshes, or a veil, is sometimes used with good results against most of them, except when travelling through the woods and bushes. It completely envelopes the head, and is gathered by a cord at the top so as to fit tightly around the crown of the hat just above the brim, the latter being sufficiently wide to keep the netting from touching the face or ears. The lower edge is carefully tucked inside the coat or jacket collar, or otherwise fastened so as to allow not the slightest opening by which the insects can enter. This arrangement will not, ordinarily, keep out the "midgets," but is pretty sure to baffle the larger insects. Sleeves should be fastened closely about the wrists and, if necessary to further protect the hands, gloves can often be advantageously worn.

Medicines. — In malarial districts, when the excursion is at least of several days' length, it is well to carry quinine in the form of pills, as a possible preventative of ague. A mild laxative is also desirable. To these we should add a small amount of brandy or whiskey as a stimulant in emergencies, and strong ammonia as an antidote to the bites of poisonous reptiles and the stings of insects.

Trowel. — Under this heading will be included all such instruments as are ordinarily used in digging up

roots, bulbs, and other underground parts. They vary greatly according to individual caprice or convenience. Perhaps the one most commonly used, at least by the amateur, is that represented in figure 4 as *C*.

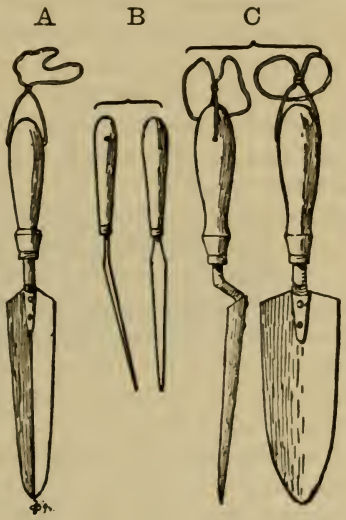

FIG. 4. — Trowel.

A cross-section of the blade of this is a regular curve. It can be bought for a few cents (fifteen or twenty) of almost any hardware dealer. As long as it is not used for prying it answers very well, but as soon as it is used for a lever — which is often desirable — it comes to instant grief. A better trowel, and yet a cheap one, is that represented at *A*. Instead of having a curved blade it has a wide V-shaped cross-section, with the right and left portions of the blade either perpendicular to each other at the keel or forming a more obtuse angle. This is a somewhat stronger trowel than *C*, but hardly strong enough for heavy, constant use.

Probably one of the best trowels is one which is not here figured. It is reported to have come into quite common use among the botanists of Cambridge, Mass., and vicinity. Its important characters are that it is unusually thick (one-quarter of an inch) at

the middle of the blade, tapering to thin edges, and the handle (or at least the handle shank) is continuous with the blade (not riveted on). It is seldom that one of these is broken.

B represents a small, bayonet-like "digger" which is extremely useful in removing mosses, lichens, etc., from crevices of rocks or from the bark of trees. It is made by softening a four, five, or six inch half-round file, removing the cut surfaces with another file or with an emery wheel, slightly rounding the point, bending as shown in the side view, rehardened and retempered, and inserting firmly in a handle.

As has been stated, many other styles and shapes of trowels are in use. They are too numerous to describe in detail, and our object is only to give an idea of the different types. This, we think, has already been accomplished. It is often a great convenience, as well as a preventative against loss, to have a hole bored through the end of the handle and a narrow rawhide thong inserted as shown in the figures of *A* and *C*. The loop is passed over the hand, so that when the trowel is dropped it remains suspended from the wrist.

Some botanists suggest and use a sheath similar to a bayonet-scabbard for carrying the trowel. It is generally, when used, suspended from the waist belt. So attached have certain collectors become to the trowel which has accompanied them through lifelong explorations that they have, in later life, treasured it as a souvenir, and even written verses in its praise.

Vasculum. — Concisely, this is a long tin box with a tightly fitting cover which extends nearly its whole length; it is generally used to collect specimens which

are to be studied later in as fresh and natural a condition as possible. The style which is most commonly used is that shown in the figures, and the dimensions are from 16 to 18 inches long, 7 inches high, and 4½ to 5 inches wide. When closed it is essentially a somewhat flattened cylinder, the ends being oval.

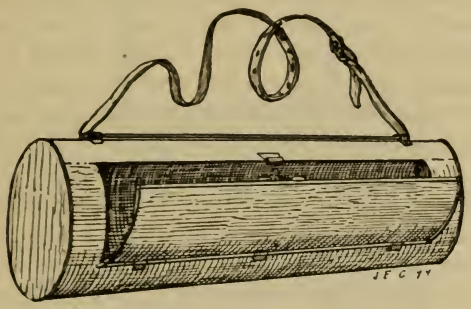

FIG. 5. — Vasculum.

The cover is hinged at the bottom and extends to within two inches of each end. The fastening at the top of the cover should be easy, sure, and positive; one that is not likely to become loosened by jarring. At the top of the box are two tin loops, near the ends, through which a broad carrying strap is passed. If preferred, a handle can also be attached to the top. Larger vasculums than the one here described are often used by professional botanists, and they are quite commonly of different shapes, sometimes, indeed, with the ends square or rectangular instead of oval. The interior may be one large compartment or divided into several, according to individual taste. In a great majority of cases there is but one compartment.

The painting of the vasculum is, to the writer, an unimportant matter; many prefer and advocate leaving it unpainted, and if it is allowed to remain open after each trip till perfectly dry, there will be little or no trouble from its rusting.

Collecting Bags often furnish an admirable expedient for carrying flowering plants home in good condition, and they are generally *preferred* for the collection of mosses, lichens, and algæ. They should be constructed of rubber or enamel cloth, as nearly waterproof as possible, the former being better for very wet specimens that are likely to drip, while the latter is sufficient for drier specimens where the principal object is to check evaporation. Flowering plants are more easily destroyed or injured in a bag than in either the vasculum or portfolio. Plants wrapped in a thin sheet of rubber cloth will often keep for a long time in good condition. Bear this last fact in mind when you visit where, for any reason, you cannot be encumbered with a vasculum or portfolio.

Portfolio. — This is doubtless more extensively used by collectors than the vasculum. Its use generally results in better dried specimens, though it is hardly practicable to use it in a high wind, as on a mountain top or sea cliff. We shall here briefly describe a few types of portfolio and leave the method of using them, which is practically the same in all, to be considered in the following chapter.

The size of a portfolio should never be larger than the sheet of paper on which the plant is to be ultimately mounted, preferably a trifle smaller. Thus, for the herbarium using the standard size of mounting-paper, the collecting portfolio should be about 11½ ×

16½ inches, and the paper which fills it should be about 22 × 16 inches, of a bibulous nature, and folded once. Unprinted newspaper is excellent. All portfolios are generally filled with cheap unsized paper of this nature, called specimen sheets.

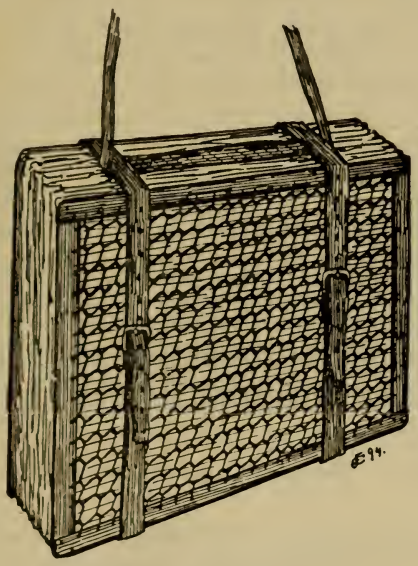

FIG. 6. — Wire Portfolio.

In its simplest form, perhaps, a portfolio consists of two binder's-boards, between which are the specimen sheets, and around which pass one or two tightening straps. The boards may or may not be connected at their edges, or one side, by a loose cloth binding, and may or may not be covered with enamel cloth or even varnish, as one desires. This simple apparatus

is used by some professional botanists who are noted for the excellence of their specimens. It may be carried in the hand, under the arm, or suspended from the shoulder by a strap which passes under the tightening straps.

A portfolio with sides of wire netting stretched across an iron frame, such as is here figured (except that leather straps have been represented in the illustration instead of the elastic or chain-straps which

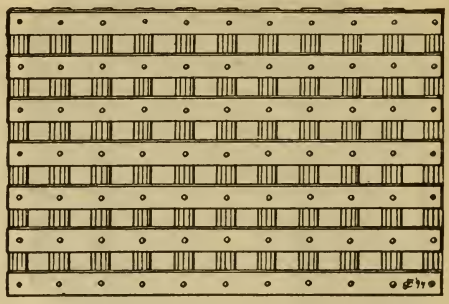

FIG. 7. — Wooden Portfolio.

usually accompany it), is advertised by most dealers in botanical supplies. The open sides allow the sun to partially or wholly dry some of the outside specimens, if the trip be long and the day warm and sunny, while the collector is yet in the field. If the specimens were placed at first as they were intended to remain, this is so much gain; but if, as is often the case, it was the intention to rearrange them before drying, it is a decided disadvantage, one not readily occurring when the sides are of binder's-board.

For the elastic straps which often accompany the purchased portfolio, leather ones can advantageously be substituted. These will not roll into a cord and thus cut the shoulder. Neither elastics nor chain-straps will endure the rigorous usage to which they are often subjected. Hence one may simply draw two leather straps through the wire-work itself, and secure the same pressure without danger of abrasion by rocks, etc.

In wet weather the ordinary form has much the advantage, but in any case the collector should be furnished with a sheet of india-rubber or oil-skin large enough to protect his specimens during a shower. His rubber blanket is an excellent substitute for a vasculum.

Sometimes wooden lattice-work sides are substituted for the wire netting or binder's-board. These can easily be made, and may be (and often are) used as part of a portable press on extended trips where a press is essential.

A very convenient portfolio here figured has been invented and used by Mr. J. Franklin Collins, who thus describes it:

"The leather straps '*A A*' each pass through two leather loops (one at each edge of the back binder's-board of portfolio), and around in front where they are attached to the ends of a one-quarter-inch square or round steel rod. To the centre of the rod the tightening strap is attached, as shown in the illustration. This latter is fastened by two rivets at the upper edge of the front board, and is then loosely passed over and attached to the top edge of the back board, forming the loop '*B*' for carrying in the hand

or on the shoulder by means of the strap and hook shown at ' *C.*' "

A combination of portfolio and box into a sort of knapsack has been employed by a few collectors, but has never come into general use. Any collector with an inventive turn can readily construct such a piece of apparatus.

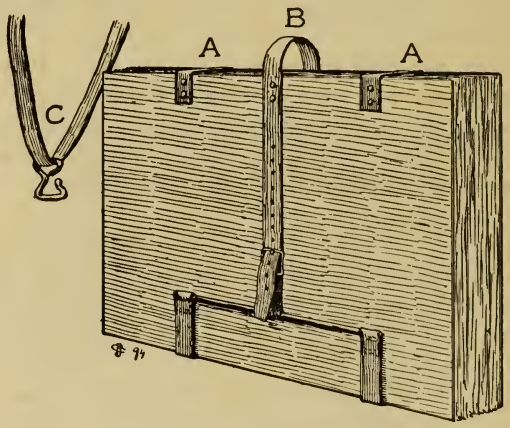

FIG. 8. — Collins' Portfolio.

The collector should have accessible at least *two* portfolios and *two* press-boards with their straps, as well as duplicate lenses, knives, etc., so that in case of accident to one he may not be left unprovided.

For preserving such flowers as rock-rose, chicory, etc., which quickly close or droop when collected in a vasculum or bag, a miniature portfolio is required. It should be small enough to slip into the pocket, and may be secured by one or more heavy elastic bands.

The flowers are detached and placed in it immediately when collected.

Lens.

"These little things are great to little man." —GOLDSMITH.

Every naturalist and especially the botanist carries about him some handy lens or microscope. A good instrument is a Coddington, or Hastings, or achromatic lens of about one-half inch focus. These give a broad, clear field and excellent definition. They are metal mounted, and have sufficient collar above the lens to protect them from being scratched. The price of these instruments varies from two dollars upwards. The mounting is usually of German silver or brass, nickel-plated.

Many cheaper patterns, often with fairly good or even excellent glasses, are on the market. These are, as a rule, mounted in horn, hard rubber, or shell. The so-called Gray microscope illustrates the type. In it the double or triple lenses with their mounting can be dissociated from the stand and carried in the pocket. On the other hand, any one of an ingenious turn can readily extemporize a stand for his hand lens and thus transform it into a regular dissecting microscope.

In purchasing a microscope of any character whatever, the young student should always consult an expert. He is too apt himself to think that what he requires is a high-power lens and any number of accessories. What he really requires most is a low-power lens with a broad, clear field and accurate definition. High powers have their place, but it is later on, and for quite different work. It must be remembered that while they magnify the size of the

hibit at least the leaves, flowers, and fruit. These parts can seldom all be collected at the same time, yet occasionally they may all be found on one specimen.

If not too large, the *entire plant*, both above and below the ground, should be taken (unless by so doing there is danger of exterminating a rare species) and collections made at as many different seasons of the year as is necessary to secure all stages of development.

As of secondary importance (but sometimes of scarcely less interest) are the dwarfed or abnormally developed or diseased specimens. Do not be afraid of collecting a species in its different stages of development. The most interesting series of specimens will be those which show the greatest number of these periods from the seed through the seedling, budding, flowering, fruiting, and seed-dispersing stages to and including the winter wreckage.

If the plants are large, select representative parts, taking particular care to collect leaves from different portions of the specimens in all cases where they differ, and record the fact in your note-book. In the case of shrubs or trees choose characteristic twigs of flowers, fruits, and leaves, and make note of or collect the bark and record the approximate height of the plant.

It is advisable to collect numerous duplicates when possible, with a view of exchanging.

Digging. — This operation may seem simple enough to the inexperienced or careless collector, but, for the best results, great care and patience are often essential. A single injudicious thrust of the trowel may sever an underground shoot or root and thus destroy

what might have been of great interest as showing the subterranean connections of the plant with others of the same species or, in the case of some parasites, even with a species of another genus.

With care what was at first supposed to be several separate plants may be shown to have underground connections, and such specimens form instructive and interesting object lessons, and, later, equally interesting herbarium specimens. In digging up plants which have deep-seated bulbs or roots and delicate shoots (*e.g.*, adder's-tongue and dwarf ginseng) only the greatest care and patience will reward the collector with a perfect, unbroken specimen. Where wide-spreading underground parts, or even parasitic connections, are suspected, commence digging well away from the plant (six or even twelve inches) and work slowly and carefully towards it, removing the earth in small bits, using the fingers as much as possible and the trowel only when absolutely necessary. By this method the parts desired are less likely to be broken, and it is often possible to obtain the subterranean parts many feet or even yards in length.

Cleaning. — Occasionally when a plant has been removed from the soil it is found to be comparatively clean, but generally more or less dirt clings to it. This should be gently shaken out, or, if water is available, washed out. The latter method is much the best when the plant has been removed from wet and muddy soil; the former quite as good in most cases where they are taken from dry or sandy soil.

Notes. — The note-book should be available at any moment. In it one should record colors of flowers which may fade in drying; the nature, color, and

thickness of bark — when none is collected; the winged insects which visit the flowers — if they are known; the nature and composition of the soil, and degree of its moisture; the amount of sunlight or shade; the approximate altitude; the plants which are growing under similar life-conditions in the same group; the height of the plant, when the specimen collected does not show it; the nature of the general locality, such as swamp, river-bank, dry field, woods, etc. In brief, your note-book should be an epitome of any and all observations which cannot (and certainly ought not to) be trusted to memory. In addition, train your observing faculties so that nothing of possible importance may escape your notice. After a little practice you will learn to make terse, condensed notes which cover, without undue brevity, wide observations. Do not expect to always keep a field note-book absolutely clean. It is impossible under some circumstances.

Tagging. — As has already been stated it is well to have some system to the tagging, at least of large shrubs and trees. (See "Tags," Chapter II.) The wire tag is also very useful to separate twigs of nearly allied shrubs (*e.g.*, wllows), as well as other plants, which have been placed in the tin box. The twigs of each plant are tied together in one bundle with the wire of the tag before being placed in the collecting can, and any necessary notes made in your note-book.

Packing the Vasculum. — After the plants have been properly cleaned they are placed in the tin box, if that article happens to be the one in use. Care should be taken, as far as possible, not to lay heavy roots on delicate flowers, etc. Sometimes it is

desirable to transport in the vasculum (for transplanting, perhaps) plants which have the dirt about the roots undisturbed. Before placing one of these in the box wrap paper tightly about the roots, gathering and fastening it about the base of the stem with a stout elastic, and take care not to place it on top of frail or delicate plants. Generally the plants will be found to keep in the best condition (or at least in just as good condition) when they are tightly packed, provided they are not crushed. On a warm day it is a good plan to occasionally sprinkle the plants a little. It is not necessary to have water running about in the bottom of the can; indeed, it is better not to have it there. The specimens should be kept *slightly moistened*, not dripping wet. The latter treatment renders them harder to dry properly, and in some cases delicate parts are completely ruined before reaching home. When in the sunlight always cultivate the habit of carrying the box on the side of the body opposite the sun, otherwise it will sometimes get extremely hot and thus assist in the wilting or destruction of those plants which are easily ruined in this way.

Use of Portfolio. — As previously stated the portfolio undoubtedly provides the best means for collecting plants when the ultimate excellence of the dried specimens is the prime consideration. Indeed, it is the only practicable method by which most ferns and nearly all delicate and sensitive plants (*e.g.*, Herb Robert, oxalis, sensitive-pea) can be obtained and preserved in any presentable condition. All the directions in regard to selecting specimens, removing from the soil, and tagging trees apply with equal

force whether the tin box or portfolio is used, and those about *notes* with greater force when the latter is used; for, in addition to other notes, the natural shape of the flowers and other parts must occasionally be recorded, or else trusted (as is too often the case) to an erratic memory.

To operate the portfolio place it on the ground, on a rock, a stone wall, a log, or even on the knees, — whichever is the most convenient or promises to be most satisfactory, — with the buckles or fastenings of the tightening straps uppermost. (For purpose of clearness we shall hereafter — in this article — speak of the cover which is now on top as the upper cover, and the one on the ground as the lower cover.) Open the portfolio so that both covers lie on the ground, and place all the specimen sheets on the upper. Open one of these folio sheets and place half of it on the lower cover. On this place a field label with brief data, — if memory cannot be trusted until one reaches home, — and carefully spread out one or more plants of the same species, as nearly as possible in the position in which they are to be ultimately dried, care being taken not to have parts overlap excessively.

Leaves, flowers, and other characteristic parts should be well displayed, provided by so doing a false impression is not conveyed as to their original shape or relative position. Do not shut the upper leaf of the specimen sheet on to the plant all at once, but roll it on from the fold. In this way any doubling of leaves, petals, etc., is readily detected and adjusted at once. If another plant is ready for the portfolio place another empty specimen sheet on the one already filled and

treat it in the same manner as the first one. If the specimens are too long, bend them abruptly into a V, N, or W. If they tend to straighten again they may be held in position by a bit of paper, with a hole in it, slipped over the abrupt bend, or by thread or twine wound about it, or even by a blade or stem of grass, or an elastic used in the same manner. Do not try to reduce the length by coiling portions of the plant; it may, in some cases, lead to the supposition that that

FIG. 10.— Plant in Portfolio.

was the way it grew. When bent abruptly it almost invariably shows instantly that it is an artificial expedient. When all of the plants at hand are in the specimen sheets, in the manner described, place the empty sheets on top, but with the folded edges in the opposite direction from those containing plants, so that the two piles can be readily separated when the portfolio is next opened. On top of all place the upper cover and tighten firmly with the straps, and you are ready to proceed on your search for more plants.

It will be seen that more time is required to manipulate the portfolio than the vasculum in the field,

but if the former is used conscientiously in the field, just that amount of work is saved upon arriving home, as the specimen sheets with the inclosed plants are simply transferred from the portfolio to the home press; whereas when the tin box is used the process of placing the plants in the specimen sheets has to be done at home. In either case, when the plants are transferred to the press, temporary labels (with proper data) should be placed with every specimen, or group of specimens, if all of one group are alike, provided these were not supplied in the field.

Always have an abundance of specimen sheets and keep your portfolio well filled. Some collectors take a few driers into the field to separate the plants. This is a good plan, but not essential, while it adds extra weight to be carried.

CHAPTER IV

DIRECTIONS FOR PARTICULAR FAMILIES

Methods with Cactaceæ. — At first sight nothing can appear more obdurate than certain cactaceæ. Many of them are beset with sharp, bayonet-like spines, their points directed simultaneously in several directions. No one touches them with impunity. In hedges they are the despair of poacher, scout, or soldier. They form an impenetrable trocha. The common prickly pear (*Opuntia*), which has not these long, projecting spines, is armed with even more dangerous weapons. Where leaves should be are groups of needle-like prickles, dislodged at a touch, and filling the skin with their painful barbs.

Again, the *Cactaceæ* are coarse, succulent, and, in bulk, unmanageable. One could hardly press a complete specimen, however small. Fortunately this is not required.

In case of the *Platopuntiæ* the joints can be split and the soft interior removed. Again, the flowers may be sectioned, and the portions dried. When the species are cylindric the branches are split and most of the fleshy interior removed. It is then easily possible to flatten the resulting halves. The object in each case is to exhibit the prickly or spiny areolæ. Treated thus, the specimens present no difficulties in drying.

Longitudinal sections of *Echinocactus* are essential.

It is important to display the relative distances of the areolæ, and at the same time the sharpness or bluntness of the ribs. These sections should reach to the utmost extremities in order to show the very important designative character of the tomentum of the areolæ. Count and record on the field-label the number of ribs.

Mammilaria is treated somewhat differently. Large quarter sections are cut from the apex downwards. Remove as much as possible of the soft parts and press the residuum. This will bring out the arrangement of the mamillæ.

In cereus, which presents cylindric or polyhedral columns, always with vertical ribs, the acuteness or obtuseness of these ribs can best be displayed in cross-section. Longitudinal cuttings, on the other hand, will best exhibit the distance of the areolæ. The young and the old areolæ, with their tomentum, should both be shown, and to do this sections should be taken from the the apex downwards. In this genus the flowers, if sectional and spread open at the proper time, well exhibit their peculiar features. It is well, when possible, to show them *in situ*.

Pereskia is the only genus that exhibits leaves. These disarticulate badly, but a possible way of keeping them in place is to pass a hot flat-iron over them while in the specimen sheet. This gives them a good scalding and thereafter they dry rapidly. Another way is to immerse them for a short time in boiling water. This is the familiar process often resorted to for retaining the leaves of spruces, sedums, heaths, and the like.

Says the late Mr. Charles Wright, from whose val-

uable notes this article is prepared: "There is a method which I have proved excellent for Begonias, Peperomias, Portulacas, Talinum, and for Orchids with membranous leaves, such as the Habenarias, Microstylis, etc. Flowers of Cereus can be similarly treated. Take one of the thin press-boards, place upon it a number of sheets containing these plants, one upon another, without driers between; place upon these a few driers and tie up the bundle. Invert it and expose the black press-board to the direct rays of the sun. It soon becomes quite hot and communicates its heat to the plants beneath it, partially scalding them. Leave the bundle thus two or three hours and put the plants again in press with fresh driers. Plants thus heated require more frequent changing than at first, for they part pretty rapidly with their abundant moisture; but they dry soon. The leaves do not disarticulate badly, and the flowers retain their colors as well as when dried by other methods. For flaccid plants, such as commelyna, this plan of killing them is better than putting them in hot water, as the leaves after immersion become still more flaccid and the difficulty of laying them in press and arranging the leaves is naturally increased.

"Still another mode of killing these succulent plants I have followed with success. Pass a flat-iron over the sheets of specimens, especially the joints of the stem where the leaves join it, avoiding as much as possible the flowers; then pressing them as before, they dry rapidly; but the first changes should be made at shorter intervals, lest fermentation take place and the plants become discolored."

Mr. Wright used in his extended journeys in Japan,

Cuba, and the far West but one sort of paper, making this serve first as driers, stitching several sheets together, and later for containing the dried plants. He says: "The specimen sheets should be thin, so as to occupy but little space, so light as to not of themselves make a load, combining at the same time such firmness and strength that all ordinary plants may be raised in them, and moved from place to place without the risk of collapsing, and letting the specimens fall to the ground. The absorbent paper may be of any common thickness up to that of sheathing paper. A good size is twelve by eighteen inches; if a larger size is used, besides being cumbrous, sufficient pressure cannot be applied."

Yuccas and Agaves. — Dr. William Trelease, of the Missouri Botanical Garden, writes: "One of the most imperfectly represented groups of plants in herbaria is that which comprises the yuccas and agaves. Perhaps you will want to note for this kind of plants that one ought to preserve entire leaves, where they are small enough, so as to represent the usual foliage form; also, a series of thickish cross-sections of the leaf, dried like other herbarium specimens; a series of two or three bracts from the scape, and any peculiar flower bracts, such as some of the yuccas possess, in addition to flowers and fruit. Where the leaves are too large for preservation entire, they have to be represented by cross-sections and the marginal portion, showing the teeth and border characters. I have several times had a great deal of trouble with the flowers of the closed gentians, and possibly it may be worth while noting that these are very likely to contain insect larvæ when gathered, so that the flowers ought to be wormed be-

fore being put in press, otherwise a good deal of the interior of the plant is destroyed before the plant has dried enough to kill the insect. I have seen the same thing this summer, in a beautiful campanula from the Azores."

Willows.[1] — The good collector of other things will scarcely need any special instructions for the collecting of willows; nevertheless a few suggestions may be helpful. Staminate aments will be snatched as best they can be between "April showers." The pistillate aments should be taken, first, a little after anthesis, when the vesture of the capsule is best shown, and while the styles and stigmas are still fresh; and again, later, when the capsules are fully grown, but not so ripe as to burst in drying. For the latter, a small twig will suffice. Leaves should be taken late in the season after they have become firm in texture. Better a leaf specimen tinged with the yellow of autumn than one made from the succulent growths of June. Do not make flowering specimens too long, so that the little tuft of young leaves at the tip will be thrust out to the edge of the driers, where it will receive inadequate pressure. On the other hand, let the leaf specimen be ample: a good branch that will show something of the totality of variation exhibited by the leaves under different phases of development. Take leaves to match the staminate specimens from the same plant, and again leaves to match the pistillate specimens. Do not collect, for instance, "No. 7, staminate aments; No. 8, pistillate aments; No. 9, leaves same as Nos. 7 and 8." In this case no one can tell whether the leaves belong to No. 7 or to No.

[1] Contributed by M. S. Bebb.

8; they may be mismated altogether, and at any rate you have prejudged the very question which alone warrants so much painstaking. Willow specimens part with their moisture very rapidly. They should be shifted to fresh driers within a few hours after being put under pressure, and changed again, if possible, in less than twelve hours; after this they may be neglected with impunity. But delay at the start only makes more work in the end and gives a less satisfactory result. It is natural for collectors to begin by taking aments first and leaves to match later, and this is the better way until a good, practical knowledge of the species is acquired; but after this some most satisfactory and often unexpected results are obtained by collecting the leaves first, tagging in autumn every bush which to the practised eye presents any feature out of the ordinary, and then waiting till the next spring for flowers and fruit. I have had in mind the resident collector at a permanent station; from the traveller we are thankful to take what we can get and in such stages of development as he may have chanced to find the plants. Explorers, however, do not as a rule sufficiently appreciate the value of mature leaf specimens unaccompanied, as of course such specimens are likely to be, by either flowers or mature aments. These can almost always be identified, and with our present imperfect knowledge of some western willows are quite as desirable as further collections of the already better known early state of the species.

The Collection of Mosses.[1] — There are few times in the year at which one may not find species of mosses

[1] Contributed by Prof. Charles R. Barnes, of the University of Chicago.

in fruit, so that the collector may have mosses in mind throughout the entire season.

After a rain mosses will generally be found in the best condition for gathering.

Take into the field old pamphlets, in which the stitches have been cut or the staples pulled. The paper will thus be already in convenient size and form for folding into field pockets.

Each specimen should be placed, as soon as collected, in a separate pocket, so that loose parts may not be lost.

Specimens should be freed from adhering sticks, stones, and dirt as fully as possible, particularly when they are mosses which grow in tufts.

Those which are only gregarious should not be completely separated, but should be retained in such condition as to show the habit.

If the specimen does not clearly show the sub-stratum upon which it grew, note should be made on the pocket, indicating its habitat.

Mosses growing in dense cushions should be sliced vertically, so as to show this habit, and yet make the specimen sufficiently thin not to unduly swell the pocket. Slices should be a quarter to a half inch thick, depending upon the density of the tuft and the probable amount of compression in drying.

The weight used in drying mosses should be very much lighter than that used for larger plants. Ten pounds will usually be adequate, and the weight should never *be great enough to flatten the capsules.*

It is particularly desirable that specimens should show accurately the habit of the mosses.

A canvas bag will be found very convenient for carry-

ing paper for pockets, as well as the pockets after they are filled. It should be somewhat like a school-boy's satchel, and may be provided with handle or straps, or both.

If one is collecting flowering plants as well, the pockets may be laid in between the sheets used in the portfolio.

The same data in regard to locality, — as on dry or wet stones, on trees, or in water, — date, collector's name, and habitat should be entered upon the pocket as upon the labels of flowering plants.

Young collectors generally make the mistake of supplying scrappy specimens of mosses. They should be abundant enough to show all the characters that the plants in the field would show.

When the *calyptra*, and, worse still, the *operculum*, is gone, one has to do the best he can in study, which is often poorly enough. Too little attention is paid to collecting mosses in *prime* condition. They should, if possible, be gathered when these essential parts are still present. Often the calyptræ may be found on the specimens, even though off the capsules, but when found thus the student should bear in mind that there is a possibility of these calyptræ having become detached from another species, if two or more species are intermixed. *Search the patch* for them, however. No specimen of moss can be considered "prime" without the opercula, and they should also have the calyptræ. The male flowers, often neglected, vary much. On some mosses they are plain to see, and on others they can be found only by careful dissection. A beginner can form a pretty good idea of them from a polytrichum, in which genus they form

prominent disks, surrounded by a rosette of leaves and terminating the stems. One is sure to see them in a patch of polytrichum. They are more abundant, but harder to find, in bryum. Where concealed, search for them in every budlike collection of leaves.

Mr. J. F. Collins' method of collecting mosses is nearly identical with that of Professor Barnes, differing in that he carries folded manila envelopes into the field with him for collecting. He also recommends the pockets of the ordinary canvas hunting coat as an excellent substitute for the canvas collecting-bag, the coat itself shedding a great amount of water if the collector is overtaken by a shower.

It is generally a good plan to press the mosses immediately after returning from the collecting-trip.

In this connection we quote, by kind permission, from "How to study Mosses," by Mrs. Elizabeth G. Britton, in the "Observer" for March, 1894: "If it be desired to keep mosses fresh for study, they may be placed in a deep dish and kept moist till wanted. If covered with a glass cover, a miniature Wardian case may be made, in which immature specimens will develop and ripen fruit."

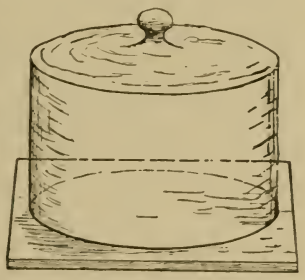

FIG. 11. — Case for Mosses.

The student will find the following books useful in studying mosses:

Lesquereux and James' "Manual of the Mosses of North America"; Gray's "Manual of the Northern

United States," edition of 1863, wherein the mosses were described by William S. Sullivant; Braithwaite's "British Moss Flora"; Paris' "Index Bryologicus"; Dixon and Jameson's "Handbook of the British Mosses"; Barnes and Heald's "Keys to North American Mosses."

The Moss Herbarium.[1]

"No words, that I know of, will say what these mosses are. None are delicate enough, none perfect enough, none rich enough." — RUSKIN.

After being pressed mosses are mounted, for the herbarium, by gluing them to the mounting-paper, as in the case of flowering plants, or they may be kept loose in envelopes which are fastened to the paper. The latter method is preferable if the specimens are to be used for subsequent study. The best method of all, however, is a combination of the two, as a dry specimen can then be readily examined with a hand lens without opening the envelope. The size of the mounting-paper for a moss herbarium is often a matter of personal preference. If the collection of mosses is to form a part of a general herbarium it is best, of course, to have the papers of uniform size throughout. When the collection is to be kept separate, a paper one-half or one-quarter the standard size (or even smaller) is often used, and is more easily handled. A special advantage of sheets one-quarter of the standard size is their convenience if it is ever desirable to transfer them to an herbarium of standard dimensions, as four of them will just cover the larger sheet, and the mosses will be in a vertical position when the small sheets are fastened to the larger.

The envelope used in a moss herbarium should have

[1] By J. F. Collins.

closely folded corners, so that small parts of the specimens and dirt cannot readily work out, the one to be lost, the other to be unsightly. The envelope known as the "Gray Herbarium Envelope" is highly recommended for this purpose, the size varying according to the bulk or area of the specimens. It is not considered necessary to poison dried mosses.

Every bryological student should cultivate the habit of preserving microscopic mounts of the characteristic portions of the mosses which have been studied. A collection of this sort is an invaluable adjunct to the herbarium, and these mounts are constantly being referred to in subsequent studies of the same or nearly related species.

A mica mount has a great advantage over the glass for this purpose, as it can be kept in a small envelope fastened to the herbarium sheet with the dried plant, and is thus always easily consulted and can readily be sent through the mail. The mica slide should be fairly stiff and about two inches by seven-eighths of an inch. The mica cover should be thinner than the slide and of generous proportions, as compared with the ordinary glass cover. Glycerine-jelly is generally used as the mounting medium, and the method of procedure is essentially the same as in making glass microscopic mounts.

It is seldom necessary to use an extremely high power objective in studying the mosses, so that the objection offered by some microscopists to the use of mica slides (viz., that modern objectives have been adapted to a certain thickness of cover glass and any change in that thickness or substance affects the image) is seldom if ever realized.

Lichens.[1]

> "The bleakest rock upon the loneliest heath
> Feels in its barrenness some touch of spring.
> And in the April dew or beam of May
> Its moss and lichens freshen and revive."
>
> BEAUMONT.

As to all external features, lichens are best seen, examined, and enjoyed in a suitable locality after rains or in a thaw. But the plants are then *wet*, and, in that condition, cannot be made available for the herbarium. All the parts become confused and the beauty is lost. The rule then is, if they are wet, to allow them to become almost dry; if dry, to *moisten* them slightly by wrapping them loosely in wet, soft paper, when they become flexible, and can speedily be flattened in a book by means of some sort of weight, say a book on top. When thoroughly dry they are easily attached to pieces of paper of proper size, and marked, the attachment in the foliaceous kinds being only at the middle, so that the under side may be observed. Or else, a second specimen may be mounted face downward, to show the reverse aspect. This last direction applies only to foliaceous forms, although fruticulose kinds are similarly treated, except when growing in clumps, like many common cladoniæ, when one makes a vertical slice or slices from such portions of the clump as will well display all the features, and presses the section like the others.

Crustaceous lichens on bark are removed with a *thin* portion of the matrix, and must also be subjected to sufficient pressure till the living wood is thoroughly dry; otherwise it will curl.

[1] Contributed by the late Prof. Edward Tuckerman of Amherst College.

Crustaceous rock-lichens are secured like other rock specimens, by means of hammer and chisel, practice being the best guide.

Species are preserved in herbarium *sheets*, but not attached. The sheets are kept in covers, when the plants can be put away for ready reference.

Make a separate department for rock specimens. They do not fit in well with the others in the herbarium. Lichens vary so much that one requires many specimens of the same thing, and often excludes old specimens for better ones. Hence it is best to keep them loose in the species sheets. Those suited for mounting are kept in folded pockets. Earthy crustaceous specimens will easily crumble, but may be made imperishable by sufficient *gum* to penetrate every part except the upper surface where the plant is. They may be mounted on paper, easily studied, and preserved.

Mr. Henry Willey, of New Bedford, allows us to quote from his useful "Introduction to the Study of Lichens." He says:

"Unlike flowering plants, they can be collected at all seasons of the year, they need little labor in their mounting and preservation. Many of them are objects of beauty, and there is no daily walk which will not be rewarded by fresh objects of interest to the watchful observer and student of lichens. . . . The observer will have no lack of material, for they will be all around him. Whether on the sea-shore or on the tops of our highest mountains, they will equally abound. He will perceive the larger and more conspicuous ones without difficulty, but it will require experience and a practised eye to detect the minute,

often almost invisible forms, which, however they may seem to differ, have yet a bond of connection with the largest and most beautiful. It is the tracing of such connections that lends its greatest attraction to the study of nature.

"He or she (for ladies are by no means to be excluded from the ranks of the lichenists, and they have been among the best students) who would collect lichens will need a somewhat special outfit. As a place of deposit for the plunder, the common tin vasculum may be used, or, as lichens do not wither, a basket may be carried. I have found it more convenient than either to have a coat with very large pockets on the inside of the skirts, which are very capacious and serve also to carry the hammer and the wrapping-paper, and the indispensable luncheon for an all-day tramp. As lichens are often brittle when dry, it is well to moisten them so as to make them soft and flexible. Rock specimens should be wrapped in paper to prevent bruising by attrition, and the more delicate plants, like calicium, should be well wrapped up and put in a separate pocket or the vasculum. A small sponge is useful to carry water, as dry lichens might be broken in detaching. The crustaceous earth lichens should be taken with a good thickness of soil to keep them entire, and they will crumble less easily if the soil is moist and they are well wrapped up. A well-tempered knife with large blades is indispensable. A very good knife of this kind is made at New Britain, Conn. A poorer knife, which it is not so necessary to keep sharp, is good to separate earth lichens from the soil. The bark of trees is most easily detached in spring and early sum-

mer, and it is advantageous to carry as little timber about as possible. Small branches may be cut off entire. Lichens should not be scraped from rocks. For their collection there is needed a cold-chisel, which may be six or seven inches long, of half-inch steel, well tempered but not too hard, and should be carried in a sheath to be attached to the inside of the coat. If placed in the pocket it will soon be lost. The hammer may be carried in one of the large pockets. A common geological hammer will do, but I have preferred a combined hammer and hatchet, the latter being very useful in many cases where the knife is insufficient, as on large branches or very dry wood. The blade, however, should be inclosed in a strong leather guard, to prevent accidents. A spool of stout linen or cotton thread will hold a large supply for tying packages, or, if something stronger is desired, twine can be obtained on spools at the stationer's. A good pocket lens is requisite. Stones are often difficult things to deal with, but a little experience will enable the collector so to direct his blows as to obtain his specimens with as little as may be of superfluous material. On stratified rocks this is not usually difficult, but the granite rocks are generally refractory.

"Pains should be taken to obtain fertile specimens. Sterile specimens of cladonias and of crustaceous lichens are of little or no value. Inexperienced persons are too apt to collect and send for determination such specimens and the merest fragments. They had better at first confine themselves to large and perfect plants. As they acquire familiarity with lichens they will come to perceive that these inferior things

are often mere conditions of species which they already know. Still, many of the larger lichens occur, without or rarely with fruit, and the collector must be satisfied with the best he can get. He should collect several specimens of each species, and note the localities, so as to be able to return to the spot where a plant has been found in case more should be desired. The colors of lichens are heightened by moisture, and after wet weather they become more conspicuous, and some may be more easily detected at such times. But in description the colors are noted as in the dry state.

"Having returned from a tramp well laden with lichens of all kinds, the next thing is to prepare them for the herbarium. The plants will be separated and sorted. The leafy and shrubby ones will be placed between paper under light pressure to dry and flatten. Those on bark may be reduced in thickness on the under side, and then placed under considerable pressure for several days, till they are thoroughly dry, so that they may not curl and take up room in the herbarium. If they have become curled and hard they may be placed in cold water till soft, and then put in the press. Cold water does not harm recently collected plants, though wetting those in the herbarium that have lost their vitality should be avoided, and warm or hot water is decidedly injurious at all times.

"Rock lichens may, with proper pains, often be considerably reduced in thickness so as to reduce the space they occupy; but pains should be taken to preserve a portion at least of the external contour of the thallus, so as to know whether it is uniform or effig-

urate. The earth specimens should be reduced in thickness while moist, and a thin solution of mucilage applied on the under side, sufficient to saturate the earth, but without coming through to the upper side. When this is dry the specimen will be hard as stone and in no danger of crumbling. The specimens should be cleaned of dirt and extraneous matter as much as possible without injury. When all these operations are completed the plants will be ready for the herbarium.

"The methods for mounting for final preservation will vary with the taste of the collector, the extent of his collection, and the space at his disposal. Some prefer to place the specimens in paper wrappers; others to mount them on paper. In a small collection, and one in which it is desired to make a show of the specimens, the latter is preferable. Nice white paper should be selected, of which it will be well to have two sizes, one for large lichens and the other for small ones. Lichens become brittle with age, and therefore not so likely to get broken when firmly attached to paper. The plants should be perfectly dry when mounted, as if damp they will contract in drying and curl the paper. It is well to attach them first at the centre, and when they have become dry to fasten them at the edges. As the features of the lower side are often important, two specimens of each species should be mounted, so as to exhibit both sides. Some lichens, like the caliciums, are difficult to preserve. These must be softened by moisture and gently pressed till dry, so as somewhat to depress the stipes, and they may then be placed in envelopes, or, if space is not a consideration, in boxes. On the

wrappers or on the paper on which the specimen is mounted should be a written or printed label, giving the name of the species, the time and place of collection, a note of any peculiar features, especially of the internal ones of the thallus or fruit, which may have been observed with the microscope, and a sketch of the spores and note of their dimensions. . . . Handsome specimens, neat mounting, clearly written labels, and methodical arrangement, add greatly to the appearance of a collection."

NOTE.

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All the larger college herbaria, as those of Harvard, Columbia, University of Pennsylvania, Brown University, the National Museum at Washington, etc., contain collections of lichens.

The Collection of Algæ.[1]

"With its waving blade of green,
The sea-flag streams through the silent water,
And the crimson leaf of the dulse is seen
To blush like a banner bathed in slaughter."

It is impossible to give any general rule that will apply to the collecting of all algæ, for they differ much in size and character, and are found in entirely different localities. In this respect the range is greater than in any other class of plants, for the largest plants known are algæ, and so are the smallest, except bacteria, which are now hardly to be classed as algæ.

Even if we limit ourselves to marine algæ the range is enormous, and the habitat very varied. The only condition common to all is the presence of moisture and salt. Both of these, however, may be in some cases present in very small quantity, but only inconspicuous forms, or very stunted specimens of other forms, would be found under such conditions.

The typical seaweeds, those noticeable for their size or beauty, are to be found in water of the standard salinity of the ocean; the more brilliant ones in spots where they are seldom or never exposed to the air.

They range from high-water mark to a depth of some hundreds of feet; only a few forms, however, to be found in the lower part. Few kinds of shores are entirely barren; a sandy beach exposed to the waves is about as unfavorable as any, but even here there is generally, at or near low-water mark, some rock large enough to keep its place against the waves,

[1] Contributed by Mr. Frank L. Collins, of Malden, Mass.

and on this, as well as on any woodwork, a growth of algæ soon forms. A muddy bottom also is unfavorable, but if the water is quiet and warm, a considerable growth soon forms, loosely attached to the muddy substratum ; as it grows older it often loosens, floating or drifting ashore in considerable quantities.

Rocky shores are far the richest localities, especially where the character and stratification of the rock are such as to form pools, which continue filled with water when the tide goes out and leaves bare the rock around them. In these tide pools one can often find species which otherwise would not be found above low-water mark.

The outfit for a collector can be as elaborate or as simple as desired. If one wishes to provide for every emergency he will find himself supplied with so many impedimenta that active movement will be out of the question, and he may wish for a less elaborate outfit. The following is a fairly complete list of what will be useful in a trip along the shore:

Rubber boots: these should not be too heavy for comfort, but should have long tops; the kind known as "light thigh" or "sporting" boots is the best.

A bag or pail for carrying home the spoils. The pail can be obtained anywhere, and so will be oftenest used on impromptu or unexpected excursions, but a waterproof bag, with a strap by which it can be slung over the shoulder, is on the whole better, as it leaves the arms free.

A strong knife for scraping off encrusting algæ and for loosening the heavier brown weeds from their attachments. An ordinary pocket knife will do, but a sheath knife to be worn in the belt is perhaps better.

A geologist's hammer and chisel for detaching bits of rock with the stony algæ attached. If these can be kept in the belt it will also be handy.

A small net for scooping up floating weeds.

A scraper for woodwork, piles of bridges, and the like.

Bottles or jars for keeping in salt water such plants as had best not be exposed to the air. The best plan is to have a number of wide-mouth bottles about six or eight ounce size. This enables one to keep separate different kinds or gatherings from different localities; pint or quart preserve-jars are also good, either screw top or other kinds, but they are heavier than bottles, and when on a long climb over slippery rocks, weight is quite a consideration.

Pocket lens: a large size double or triple glass for ordinary use; if necessary, one can have also a Coddington lens or triplet.

A supply of small envelopes, "pay envelopes," are cheap and serviceable; any small plant which it is desirable to keep separate, any bit of scraping from the rock can be kept distinct, and if desired notes can be made on the envelope, showing exact place where obtained and such other particulars as are wanted.

Of the various appurtenances mentioned the really necessary ones are the boots and the bag; the others are more or less important, according to circumstances.

Of course, one can walk along a beach and pick up a few things, with only the ordinary footwear; but one always sees the best specimens floating just out of reach; while in clambering over the rocks one finds the rubber boots not only a protection against unex-

pected waves and a means of exploring the largest pools, but also a great advantage in giving a much surer footing on sloping and slippery rocks than any leather sole can furnish.

Women are usually at a disadvantage in such matters; boots of the kind in question are difficult for them to obtain, and, indeed, would be impracticable with the ordinary female costume; though there is no reason why an enthusiastic "algologiste" should not, like an enthusiastic bicyclist, wear a costume specially adapted to the favorite pursuit; still it is hardly likely that many will vary much from the traditional attire.

In collecting on a rocky shore the whole range from high to low water mark should be explored.

A variation of even one or two feet vertical range will be quite distinctly shown in the character of the flora. The upper part of the range is accessible for several hours of each tide, but the lower and richer part only for a very short time, and every moment when the lower pools and rocks are accessible should be utilized.

Twice each month, just after the new and full moons, the high tides are higher and the low tides lower than ordinarily; and at these times, generally known as spring tides, a belt is exposed which is quite inaccessible at other times.

Half way between these tides is what the shore people call a low run of tides, when much less of the shore is accessible at low water. The most favorable tides usually occur rather early in the morning, from six to eight o'clock; though this varies largely, as the time of the tide is governed considerably by local con-

ditions in all places removed from the open shore. The government publishes annually a little book giving full particulars of the time and extent of the tides at the principal points along the coast. The collector, especially if going from one place to another, will find this quite useful.

In localities other than rocky shores some modification of detail will be necessary, but one principle remains the same: the best time is that when the water is the lowest.

The richest yield will be obtained from the tide pools, but other localities should not be neglected. Many species grow on flat, sloping, and even perpendicular rocks. When a coating of fucus covers a perpendicular or overhanging rock, we often find that lifting it will disclose seaweeds which otherwise we would not see. *Plumaria elegans* grows exclusively in this way in northern New England. The "runways" through which the pools empty are excellent places to examine, as are also the clefts in the rocks. On the coast of Maine the cliffs often are composed of rocks softer below than above, and the action of the waves scoops out shallow caves locally known as ovens; their walls are usually covered with species of Ectocarpus, Rhizoclonium, Calothrix, etc.

Whenever and wherever we collect, our aim should be to get as perfect specimens as possible. The plant should be removed from its place of growth with care, keeping intact the organ of attachment, usually called the root, though the name is really not appropriate; normally developed plants should be chosen, not dwarfed or mutilated individuals; and fruiting plants in preference to sterile. In some cases it is almost or

quite impossible to tell whether a plant is in fruit or not; in such cases we must take our chances, but when there is any difference in appearance among the specimens, get some of each kind to examine later. Many of the Phæosporeæ have two kinds of fruit, and nearly all the Florideæ have three kinds; all of these are necessary to a representation of the species. With rare species, of course, we must take what we can get, fertile or sterile, perfect or imperfect; but the aim should be to secure the best.

The flora grows richer as we approach low-water mark, and extends to quite a distance below low-tide level; farther, of course, in some places than in others. There are species whose whole range is out of our reach; these we can ordinarily obtain only as they are washed ashore. During calm weather, very little is to be obtained this way, but a hard blow will often bring ashore great quantities, and especially when these drift into coves or in the curves of beaches, the masses of floating plants are sometimes astonishing. Promptness is necessary in collecting them; in a day or two all but the coarsest will be spoiled or much damaged.

Salt marshes have a flora of their own, almost entirely of green or blue-green algæ, growing in tufts or spread in thin sheets on the ground, attached to stalks of juncus or spartina, or floating in the shallow pools. Closed basins, connected with the sea only at high tide, are interesting localities, especially in summer; the water often becomes warm enough to support species which are found in open water only considerably farther south.

As soon as possible after the algæ are collected

they should be mounted. In hot weather an hour or two in the bag or pail will seriously injure some species; and even when in bottles and jars delay is dangerous. And care should be taken not to crowd too many plants into the same jar or bottle; and not to put among new specimens any decaying plant, or a desmarestia, which has a very destructive effect on plants with which it comes in contact.

Salt water should be used in mounting, if one is at the shore, the actual sea water; when this is not practicable, and only fresh water can be obtained, add common salt enough to make a three or four per cent. solution; it is not quite as good as sea water, but will do. In case of need, the apparatus for mounting can be reduced to a tin or earthenware basin, but it is more convenient to have some special apparatus. The writer has found nothing better than the following simple outfit:

A pan of heavy tin plate, from three-quarters to one inch deep, a little larger each way than the largest paper intended to be used; sheet of heavy zinc plate, one-half an inch smaller each way than the paper, perforated with quarter-inch holes, about an inch apart; two wash bowls, and a pair of metal forceps. The plants, or such portion of them as can be attended to at one time, should be put in one of the bowls and rinsed thoroughly; then one at a time picked up by the forceps and transferred to the pan. This should be placed with one end toward the operator, the zinc plate with the end from the operator resting on the bottom of the pan, the other end resting on the edge of the nearer end, projecting slightly toward the operator. The pan should be rather more

than half filled with clean salt water. The paper on which the plant is to be mounted should be laid on the slightly sloping zinc, the specimen floated over it and spread out in a natural position on the paper, proceeding from the part nearer the operator to the other part, gradually raising the zinc as the work goes on, so that as fast as a part of the plant is ready it comes above the surface of the water; all these movements to be very gradual so as not to disturb even the delicate fronds of a callithamnion or an ectocarpus; the lifting being done by the left hand, the right hand is free to attend to the arranging.

As soon as the preparation is complete the card should be taken from the zinc and laid on a sloping board to drain. It is convenient to set the board on end in the second basin, and almost upright; the wet paper will stick to it without trouble, and ten minutes or so of draining on this board will generally save a day or two in press, from what would be needed if the paper and specimen were to be transferred directly from the pan to the driers.

The paper on which the algæ are mounted should be of good quality and weight. Standard herbarium paper is suitable. It can be obtained from dealers (the Cambridge Botanical Supply Company, for instance) the size of the herbarium sheet, and the half, quarter, and eighth of the same. These will give sizes suitable for almost all needs.

The drying paper should be heavy. It is better economy, in the long run, to use a much heavier paper than for ordinary plants. Where that weighing two pounds to the yard can be obtained, it should be used in preference to lighter weights. There should

be a supply of cloths, of almost the same size as the driers. Common white cotton cloth will do, and when one can obtain old cotton it is better than new; discarded sheets and pillow-cases furnish excellent material.

In arranging for the press a drier should be laid down, then on this lay the papers with the specimens face up; when the drier is covered with the specimen papers lay a cloth over the whole; do it with care, so as not to disturb the delicate fronds; then another drier, more specimens, a cloth, and so on. When the pile is complete, carefully turn it upside-down; take off the drier now on top, and remove to a fresh drier the cloth and specimens. The specimens will now be above the cloth and face down. Continue through the pile, substituting new driers for the first lot, which will now be quite damp. Then put the whole in press. Any kind of press used for plants will do, but the simplest and best is merely two boards, one each side of the pile of driers, fastened with one or two straps. The whole can then be hung out on a fence in the sunshine, laid on a rock, put behind the stove or over a register, according to weather or time of year.

Driers should be changed at intervals; the oftener the better at first; and the specimens finally removed only when absolutely dry. Some collectors recommend changing the cloths as well as the driers, but the writer has obtained the best results, on the whole, by letting the cloths remain from the first putting on to the press till the final removal of the specimens.

In removing the cloths from the dry specimens it is often necessary to use much care; gelatinous algæ are

likely to adhere more or less to the cloth. Species which do not adhere to paper can be laid between two cloths, or it is sometimes more convenient to float them on paper in the ordinary way, but using any kind of paper of little or no value, to be thrown away when the plant is taken from press. With ordinary algæ it is well to strap up the press as tightly as possible, but if corallines are in press, or very soft gelatinous algæ, a less pressure should be used. Some very soft and gelatinous plants, such as *Castagnea,* should not be put in press at all; after being removed from the pan they should be laid on driers and left exposed to the air (but not to the sun) until they are dry.

Some of the lower algæ, mostly blue-green, form slimy coatings on rocks and wood-work; these do not need the treatment described, but should be spread in a very thin layer on a small paper, in much the same way as an extremely economical person would butter a slice of bread; some few species may then require a light pressure, but most will need only to dry in the open air. Instead of spreading on paper, it is often well to spread these very minute algæ on pieces of mica; such plants can only be examined by the microscope, and if on paper must be scraped off and put on the slide, while the preparation on mica has only to be moistened to be immediately available. With such plants as form a coating on the rocks, adhering too closely to be detached except in fragments, we must use the hammer and chisel mentioned in the list of articles needed for the outfit, fragments of the rock being broken off, with the alga attached; this includes both stony forms, such

as lithothamnion, and thin soft coatings, such as hildenbrandtia and petrocelis. No treatment is necessary for such specimens; they dry on the rocks, which are then more conveniently kept in small boxes and drawers, the same as specimens of minerals, rather than in the ordinary herbarium.

In many species of algæ the fruit is distinguishable only by the microscope; but it is important to know whether an herbarium specimen is or is not in fruit; in some cases it may save much time in sectioning and examining one specimen after another, if each specimen is marked as it is placed in the herbarium. The following marks are useful to indicate the kind of fruit. ♂ for antheridia; + or ⊕ for tetraspores; and ⊙ for cystocarps. For the two kinds of fruit of the phæosporeæ, the unilocular can be indicated by the sign ○, the plurilocular by ○○. When a handsome specimen, well showing the habit of the species, has been mounted, it is a good plan to add a small fruiting branch in one corner of the paper; material for microscopic examination can be taken from this without defacing the specimen.

As to preparing smaller algæ or portions of layer species in the form of microscopic slides, that is really an art by itself, and instructions in regard to it would hardly be in place here. It is hoped that the advice and instructions given in the preceding pages will enable the ordinary collector for the herbarium to obtain fairly good results; but only long practice joined with natural aptitude will make the work easy and the results sure and satisfactory.

One point more deserves mention: it is not always the case that when we have the opportunity to col-

lect algæ we have also the time and facilities for mounting them; and it is exasperating to the enthusiastic student to see a feast of which he cannot partake. It may be of interest to him to know that most species can be preserved for a considerable time before mounting; they will not be quite equal to freshly mounted plants, but will not be much inferior. The simplest way to keep them is to dry them; rinse a handful thoroughly in salt water, then by easy pressure with the hand squeeze out any superfluous moisture; leave it exposed to the air, but not to the sun, in a rather warm place; as it grows dry, pack it close together, and when it is thoroughly dry it can be kept an indefinite time, and put in boxes to be sent by mail or express. Care should be taken not to let it grow moist again after it has begun to dry. Some algæ do not do well under this treatment. Fine species of polysiphonia, ectocarpus, and the like sometimes form clotted masses, which will not float out again; but the great majority of species can be floated out after months or even years, and make excellent specimens.

Still better results can be obtained by salting the fresh specimens. A water-tight receptacle is necessary for this: the best is a preserve jar with screw or some other air-tight cap. Squeeze out superfluous moisture from the specimens, and place a layer in the bottom of the jar; then sprinkle on them a layer of common powdered salt; another layer of algæ, and another layer of salt; and so on until the jar is full. In a few hours you will find that you can push down the mass to not much more than half its bulk, and a considerable quantity of water can be drained off.

After doing this, fill up the jar again with more algæ and salt, and then after another interval drain off the water once more. When little or no more moisture will drain off, fasten up the jar; it will now keep, not for an indefinite time, but for months, and the specimens will be more like the natural plant than those prepared from dried material. Fresh water should be used in mounting them, as the salt in which they are packed will be ample.

In what has been written here as to collecting and preparing algæ, the collector for scientific purposes has been addressed. It may not be below the dignity of this work to add a few words to those who, without caring to study structure or growth, admire the beauty of color or form, and wish to keep specimens to show these qualities as much as possible. Instead of collecting the mature, fruited plant, they should generally select a younger plant, which would usually be more delicate or brighter. Many of the darker colored red algæ show much brighter colors when mounted in fresh water, and plants which are washed ashore sometimes are variegated in a way which, though caused by incipient decay, makes beautiful effects in the mounted specimen. Instead of paper, cards can be used for mounting, and bevelled edges, gilded margins, and the like can be used to heighten the effect, and though no true algologist would ever combine two species in one specimen for his herbarium, it cannot be denied that a dasya or ptilota, with its rich red set off by a background of feathery ectocarpus, is a beautiful sight. But this is a scientific heresy.

In collecting fresh-water algæ a less extensive outfit is needed than is demanded by marine algæ.

Rubber boots will sometimes be useful in rivers and ponds, though wherever one can have the use of a boat the boots will hardly be needed, while for ordinary collecting the usual footwear is sufficient. If intending to collect in considerable quantity, the bag slung over the shoulder may be convenient, but not otherwise; smaller bottles should be provided than those used for marine algæ, and more of them. Hammer or chisel will not be called for, but a dull knife for scraping films from rocks is needed. The scoop nets will seldom be wanted, but a large spoon is often convenient for collecting fine scums. The small envelopes are very necessary, and a good supply should always be taken. The pocket lens every botanist has always with him as a matter of course.

In winter, when ponds and streams are frozen, little can be expected, though even at this season, when there is a few days' thaw, something may be found on dripping rocks and similar localities, while at all other seasons there need be no lack of material.

In early spring small brooks and streams are the best collecting grounds; ponds and rivers are at their best later in the season. Standing pools almost always contain a flora, unattractive to sight, but interesting to examine; dripping rocks, and places wet with spray from waterfalls, also abound with algæ.

On moist ground in shaded places there will almost always be found a growth of green or blue-green plants, as also on the shady side of tree-trunks, fences, and the like. In fact, algæ are to be found wherever there is moisture.

Fresh-water algæ attain much smaller size than marine, the genus which most resembles a seaweed proper, lemanea, sometimes reaching a length of a foot, but such a size is quite exceptional, and the great majority of species are of microscopic dimensions. But sometimes the smallest forms occur in such enormous quantity as to cover the surface of large ponds, or form a dense coating on the bed of a stream for miles. With most species of marine algæ one can tell at a glance whether the specimens are in suitable condition, and one can at least approximately recognize the genus if not the species. With fresh-water algæ the opposite is the case. The species that can be recognized at sight are very few, and in nine cases out of ten a microscopic examination is needed to determine whether a plant is or is not of interest enough to preserve a specimen. So that the only safe way is to carry an ample supply of small bottles and envelopes, and bring home a little of everything, noting the exact locality in each case, so that if the plant proves to be something new or rare, you can return and get a quantity.

After the examination has shown you what you are to throw away and what to keep, you can mount the latter much in the same way as marine algæ; the larger and coarser by pan and press, the fine and soft by pan, but to be dried without pressing; the minute and, to the eye, formless masses by spreading on paper or mica. But while the greater part of marine algæ are to be treated in the first of these three ways, very few fresh-water algæ require or will endure it — only such plants as *Lemanea*, *Cladophora*, *Tuomeya*, and the like, which seem more like seaweeds that

have wandered from their home than they do like real fresh-water algæ. The blue-green algæ, after being dried on paper or mica, are ready for study at any time, recovering their form almost perfectly when moistened; but with most of the green algæ the case is different: *Cladophora*, *Rhizoclonium*, and, to some extent, *Ulothrix* and *Confera*, preserve their general habit and cell shape, though of course characters derived from the arrangement of chromatophores or formation of zoospores are lost. But in the conjugatæ the arrangement of the chromatophores gives a great part of the specific characters, most of the remainder being obtained from the size and shape of the spores. The latter are fairly well preserved in the dried plant, but the former are usually entirely lost; while it is not uncommon to find fruit formed in such quantity that it is hard to discover a normal vegetative filament. In preparing specimens of these plants, such as spirogyra or lygnema, it is a good plan to put on the same paper, side by side, specimens of both fruiting and vegetative states; and also with the specimen you are to put in your own herbarium a drawing of how both appeared when you examined the fresh plant. If it is desired to study the plant later, material should be preserved in fifty per cent. alcohol. Practised microscopists will know of many solutions that can be employed for this purpose, but the alcohol can be obtained anywhere and at any time, which is not the case with the other substances.

Such algæ as the œdogoniceæ and vaucheria have an elaborate sexual fructification; sterile specimens alone are quite worthless; many species of both of these are diœcious, and there is often still a third (asex-

ual) fruit. All of these must be known to determine these species, and when the collector finds that it is a common habit of œdogonium for several species to grow inextricably mixed together, he will realize how thorough collecting and how careful study are necessary. This habit of various species growing in company is so common that in many cases it is practically impossible to obtain pure material of a species.

The directions for collecting fresh-water algæ are of necessity much less clear than those for the collection of seaweeds; but after a while the student will find a sort of intuition developing, which will tell him that this green mess is liable to be of interest, while that similar one will not be worth gathering. He will find it hard to tell any one what difference in appearance has led him to this conclusion, but he feels it. The intuition is not infallible, but it grows with practice, until at last one is surprised to find how much one depends on it.

The collector should study "Marine Algæ of New England," by Prof. W. G. Farlow.

For Prof. W. A. Setchell's method of collecting marine algæ, see "Erythea," Vol. 7, p. 24 (1899).

The Collection and Preservation of Fungi.[1]

"Shall we glorify a mushroom?"—BEN JONSON.

The fungi are a group comprising such various forms that it is hardly possible in a work of this scope to give methods of collection and preservation that are applicable to all. Yet all except the distinctly fleshy forms are either easy of preservation by simply drying, or are so minute as to be best preserved in the form of a microscopical preparation. There are very

[1] By H. Metcalf.

various methods of killing and preserving fungi to bring out particular points of structure. For these the reader is referred to more special works. Only the most general methods are here discussed.

When and Where to Collect. — There is no group of plants so widely distributed as the fungi. From the ubiquitous bacteria to the puff-balls, there is hardly a place or time when some representatives of every group may not be found. In the winter various forms of fungi occur growing on the bark of trees, on dead wood and leaves, and on stored fruits and vegetables. Pieces of bread or cheese, or of various vegetables and fruits, or dung of various herbivorous animals, if kept moist in closed vessels, will yield a most interesting and varied crop. The forms that grow under such conditions are mostly microscopic, such as the zygomycetes and various hyphomycetes, but not infrequently fleshy forms, like small coprini, appear in profusion. For all such cultures the writer is accustomed to use shallow bowls or crystallizing dishes, covering them with panes of glass. These are in many ways easier to handle and watch than the conventional plate and bell-glass.

Many ascomycetes and several coprini mature their fruit surprisingly early in the spring, often before the snow has disappeared. As soon as the trees are in full foliage certain forms, parasitic in the leaf tissues, may be expected. As the season advances the mushrooms become more numerous and generally attain their greatest profusion in "dog-days." Warm, damp, showery weather is sure to bring them out in field and wood, in places that the mycophagist soon learns to find. Many mushrooms are quite restricted

in their habitat, growing only under particular conditions of soil, moisture, light, and shade. Consequently a region of varied topography is more productive of them than one more uniform, though the latter may be very favorable to a few varieties. Generally speaking, deep, dense, and extensive forests, undisturbed by the axe of the woodman, are less prolific of fleshy fungi than interrupted woods.

Not a few mushrooms grow in profusion during the autumn months, and many characteristic summer forms persist in sheltered places; while the puff-balls and certain phalloideæ are perhaps most numerous and in best condition for study at this time. The leaf-inhabiting forms have now matured their spores, and produce discolored spots on the leaves which attract the collector's attention.

Two much-neglected groups — the aquatic fungi and those parasitic upon insects — should receive passing mention. The first may be found at any time of year growing upon submerged sticks or water-plants, or free in polluted water. The second from their economic importance alone deserve far more attention than they have ever received. Frequently at various times of summer grasshoppers and locusts will be found firmly clasping a blade of grass or a stick up which they have climbed to die. Almost invariably the bodies of these will be found to be full of the mycelium and spores of a fungus. Butterflies and caterpillars and many other insects are similarly affected, though not all die in the characteristic position of the fungus-infected grasshopper. The house-fly, fastened to a window-pane by a halo of mycelial threads, is a familiar object at any time of year.

How to Collect. — For collecting any except the fleshy fungi but little equipment is needed other than that used in collecting flowering plants. A sufficient number of boxes for the more delicate forms, such as the myxomycetes, and envelopes for leaf-parasites and such forms as will not be damaged by pressure, should be taken in the vasculum or pockets. A strong hand lens is a necessity — the writer much prefers the Hastings on account of its small size, large, flat field, and long working distance; but some cheaper instruments serve the purpose. For cutting off limbs and pieces of bark upon which fungi are growing, and for detaching large, hard polyporeæ from their hosts, a small narrow-blade hatchet which may be carried in the belt is very useful. Aquatic fungi may be collected and carried home in wide-mouthed bottles, like small algæ.

Three general rules hold good for all fungus collecting. First: *never mix different species* of fungi; put only one kind in an envelope or box. Even large fungi had better be wrapped up in paper, as is hereafter directed for mushrooms, before being piled into the vasculum; this will prevent the spores of different species from mingling, which might cause endless confusion in determining the plant. Second: secure always *a sufficient amount of the specimen*. A perfect herbarium specimen should exhibit all characteristic stages of development of the plant. Extra specimens may be exchanged. Be sure to secure all parts of the plant; the portion in the substratum is often of radical importance in classification, particularly in the mushrooms. Third: *take careful notes* of locality, time, surroundings, of anything about the specimen

that seems peculiar or unusual, and especially of all characters that seem or are known to be evanescent. Notes may be made in the note-book, or, better, on a slip of paper which is wrapped up with the specimens.

For collecting mushrooms and other easily decaying and fleshy forms, certain special methods must be employed. It is well not to use a vasculum, unless on a very short collecting trip, as the close damp air causes rapid decay; a stout covered basket is much better. Carry also a number of sheets of coarse tissue paper cut about two feet square — any porous, tough paper that will not break upon being wet will do. Wrap up all the specimens of a particular kind in one of these squares, and place in the basket so that in carrying they will be jarred as little as possible. If desired, a spore print may be taken, by cutting a hole in the centre of a paper disk, and pushing this disk over the stem so that it is brought close up under the pileus; then the mushroom is arranged in its package so as to stand upright, and thus whatever spores are dropped are caught on the paper disk. But unless the collecting-trip is a very long one it is better to defer the spore print until more elaborate methods can be employed. Particularly careful field notes are required for mushrooms, since so many of their characters are evanescent. For just what is required here the reader is referred to special articles, such as that by Professor Burt, mentioned at the end of this chapter.

The Boston Mycological Club furnishes its members a blank for collectors' notes which is very full and suggestive.

How to prepare for the Herbarium. — Fungi that inhabit leaves — indeed most forms that grow on flow-

ering plants — can be preserved by drying the host plant in the ordinary press, and mounting on an herbarium sheet in the usual way. Delicate forms, like the myxomycetes, small puff-balls, etc., are best kept, after drying, in small boxes. Some botanists, for the sake of uniformity, attach these boxes to herbarium sheets; but in a group so diverse as the fungi it is best not to attempt any uniformity in mounting. Certain soft forms that shrink out of shape upon drying, such as the tremellineæ, are preserved in alcohol, or better in two per cent. formalin. For such a purpose flat or square bottles are preferable to round, since they do not distort the view of the object within. While mushrooms can be perfectly preserved in liquid as regards shape, color is generally lost; still it is well to keep both liquid and dried specimens; if these can be accompanied by drawing in color of the fresh specimens their value is greatly increased. Many collectors also preserve a thin longitudinal section through the entire mushroom. Such a section brings out many points not evident in the entire specimens.

Filamentous fungi are often dried in the mass and preserved in this form, but they should always be accompanied by microscopical preparations on glass slides, or, as many prefer, on mica. Similarly specimens of many fleshy fungi, especially the ascomycetes, are not complete unless accompanied by microscopical sections. There are many ways of making such permanent preparations; the writer prefers simply mounting the plant or section in pure glycerine, and subsequently ringing the cover-glass with two coats of Brunswick black. It should be remembered that

fungi growing in the air must always be wetted in alcohol before being placed in glycerine, in order to avoid air-bubbles. The cover-glass should be as small as possible, and only enough glycerine should be used *to just fill the space beneath it*. If the specimen is at all fragile the weight of the cover-glass should be supported by a tiny fragment of a thin cover-glass, or a bit of paper, mounted with the specimen. When the first ring of Brunswick black is put on great care should be taken that the surfaces to which it is to be applied are *perfectly dry and clean*. If these precautions are taken glycerine preparations will last as long as those made with Canada balsam, or glycerine jelly, and they possess the advantage of being prepared far more easily and rapidly.

Mushrooms and all other putrescent forms should be identified as soon as possible after collecting, and then dried. Drying may be accomplished by suspending the mushrooms, each species in a pile by itself, on a shallow wire or tin tray above a stove or lamp. Not enough heat should be used to bake the specimens. After this preliminary drying they may be left until a convenient season for mounting, care being taken that they are not attacked by insects in the meantime. The first drying is likely to distort the specimens; on this account it is generally necessary, just before mounting, to dampen them by placing them in a cellar, or in a box in which wet rags have been placed. This method, which is simply exposing the dried plants to damp air, will be found preferable to sprinkling with water, as is recommended by some. When the specimens are damp enough to be pliant they may be flattened out or bent

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into any desired shape to go on to the herbarium sheets. They are then dried between sheets of unsized paper, as are flowering plants, — only with much less pressure, in many cases none at all. All that is here desired is to dry them, not to flatten them. Of course this entire process of dampening and redrying may be left out if sufficient care is taken to get the plants into shape at the first drying. But this proved in practice a difficult thing to do.

Those who poison their specimens with solutions of corrosive sublimate or strychnine, etc., do so just before this last drying. The writer has never had success with liquid poisons, and much prefers simply exposing the specimens from time to time to the fumes of carbon disulphide.

As soon as the specimens are dry they are ready for mounting. If they are fairly flat they can be glued to cards which are pinned or otherwise fastened to an herbarium sheet of the ordinary size. In this way a number of specimens of the same species from different localities may be mounted on the same sheet. Small specimens, or those not flat enough to be glued to the card, may be placed in an envelope that is pinned to the same sheet. Large, bulky specimens are best kept in boxes, entirely unmounted. Fungi, especially the fleshy forms, are much more liable to insect attacks than other plants, and, when possible, herbarium specimens of them should be kept in insect-proof cases.

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The Collection of Fossils.

"A stone, o'er which there ran
Fairy pencillings, a quaint design,
Veinings, leafage, fibres clear and fine,
And the fern's life lay in every line."

The present vegetable life of the globe is so intimately connected with that of prehistoric times that it becomes necessary to study the remains of such ancient plants as are found in geological formations. Trunks of trees, stems of herbs, leaves, flowers, fruits, are all found in more or less perfect condition. From these fragments is gradually being constructed a history of this ancient life, and by its means we are enabled to trace back to a remote past many a modern type of plant. Often genera survive of which no single living species is identical with those of geologic time. The whole study is most useful and interesting and is being pursued by an increasing number of active workers.

Of course the field outfit of a fossil collector will be quite different from that of the ordinary botanist. He will not require the vasculum or portfolio. Instead of

these he must carry some kind of bag or satchel in which to place the fragments of rock that he collects. The trowel, so useful with living plants, will be replaced by a small pick-axe and a hammer. These can be carried in a belt about the waist. The hammer should have one blunt and one cutting end, and be well balanced. In addition a chisel is often necessary.

The directions for collecting fossils will necessarily vary with the conditions. They may be found imbedded in rocks or in clay. They may exist as impressions only, and are then obtained by splitting the rock or shale which contains them. I have found them at times in water-worn pebbles which I quite accidentally broke open. Again, they may be in clay or sand. Says Knowlton, "The geological horizon from which they come may make certain fossils of the highest interest. A few seemingly worthless fragments from a horizon that rarely bears plant-remains may often be of greater interest than a fine collection from a well-known locality or horizon. Therefore, no one should be discouraged because the remains seem fragmentary, as much can frequently be made out with very poor material. But care should be taken to get as complete a representation as possible.

"In collecting in any locality it is well to get out as large a series as possible before selecting the specimens to be taken. In this way many valueless specimens may be discarded at once, for with a large number to select from, the really good material can be readily picked out. Fragments that illustrate essential or important characters should be taken, such as the tip of a leaf, a petiole with a small part of the leaf attached, a good perfect base of a leaf, or a well-pre-

served portion of the margin. By the comparison of a good series of such fragments a thorough and satisfactory idea of the form, size, and character of the leaf may be obtained. A leaf with no part of the margin preserved can usually be discarded at once, with, of course, the limitations mentioned above. Enough should be taken to illustrate the species if it can be obtained.

"In collecting ferns the most valuable specimens are those found in fruit, and nothing, no matter how fragmentary, that shows the slightest tendency to be fruit-bearing should be discarded. A chance fragment may frequently settle important biological questions.

"Specimens that are accidentally broken are not to be discarded as worthless, for they can easily be mended with strong glue and made nearly or quite as good as before. Parts of the same specimen should be kept together if possible; that is, each should be wrapped separately and the whole wrapped in a single larger bundle. The repairing is best done in the laboratory.

"Counterparts or reverse impressions should be carefully preserved and also kept together. These reverse impressions are frequently of great assistance in the study of the specimen.

"Much work can be done in the field in the way of reducing the size of the specimens; that is, just as much matrix should be removed as possible *with safety* to the impression that is preserved upon it. The distance and means of transportation must be taken into account, and the specimen treated accordingly. If it is preserved, for example, in a thinly

laminated shale very little reduction of the size of the specimen should be attempted, but if the matrix is firm, much can safely be removed. On the other hand, very fragile specimens, such as clay, had best be sent in bulk and broken up afterwards." [1]

[1] From "Directions for collecting Recent and Fossil Plants," by F. H. Knowlton, Washington, 1891.

CHAPTER V

HERBARIUM WORK

"There studious let me sit." — THOMSON.

It would be easily possible to extend the directions and suggestions for field work, detailing the management of special groups of plants and the demands of circumstance and environment, but this would cumber our pages. We have now to speak of certain operations of the closet or study.

Pressing. — While it is possible to secure an amount of immediate pressure in the field, it is generally necessary upon returning home to resort to a permanent press. On longer excursions, indeed, where transportation is possible, a press is an essential part of the outfit. It always consists of two boards seasoned against warping, cleated, and with rounded edges. These boards should be half an inch longer each way than the driers within. A large bundle, backed by such boards, is easily and safely transported for long distances. Instead of wood, the field-press may be made of binder's-boards, covered with enamelled cloth, green, or of some subdued color. While the wooden press is liable to various accidents, as splitting, such a one as this is impervious to water and extremely durable.

Specimens, according to Lindley, may be dried through the agency of sand. He recommends dis-

posing the plants between the specimen sheets and pouring warm sand or dried earth over them. This will press every part flat. The pile should be left exposed to direct sunlight.

When one starts to press his plants at home, after a return from an excursion, he should, while arranging them in their sheets in much the same way as in the field, yet exercise very much greater care and precision. The amount of pressure must be regulated by circumstances, and vary with the quantity and peculiarity of the plants to be treated. Very succulent plants, indeed, might well be kept apart. Delicate, herbaceous plants, like the wood-sorrel, *Oxalis Acetosella*, require but little pressure. Many Orchids, notably some *Habenarias*, cannot, by any ordinary process, be dried in weeks. So, too, would it be with *Symplocarpus* and *Sedum*.

How are we to preserve such very deciduous leaves as those of many *Crassulaceæ*, *Portulacaceæ*, and *Mesembryanthemaceæ? Euphorbiaceæ*, too, as well as other succulent plants, cast off their leaves in drying. The leaflets of *Tecoma radicans*, and other *Bignoniaceæ*, after a day or two in press drop if you look at them. There is no very satisfactory way of handling these things. Gather up the leaflets in envelopes, if they fall. Sometimes they can be prevented from dropping by quick immersion in boiling water. Occasionally the mounting and drying may be simultaneously accomplished, but very few herbaria will exhibit the leaves, say, of spruces, in place. Hot-water immersion is said to maintain the color and original appearance of *Epiphegus* and *Monotropa*. When the number of plants is limited, one may

employ the ordinary office press, but generally cleated boards are used. The power is applied by lever, strap, or weight. A legitimate objection is sometimes offered against the screw presses. The natural shrinkage of the plants is not followed by the necessary pressure, and wrinkling may ensue. Care and frequent change of the driers will, without question, obviate this fault.

The writer believes that the best press is the handiest. Two stout, well-selected boards only are essential. These can almost always be obtained. Between them are placed the driers, alternately with the specimen sheets, and in number to be determined at the time. Any convenient weight may be placed on the upper board, such as books, stones, bars of iron. It is well to keep on hand a number of weights covered with cloth for this purpose. The importance of regulating the pressure must be insisted upon. Crushing must be avoided; drying is the object to be attained. When travelling on other business, or for mere pleasure, it may happen to the amateur or even to the professional botanist to be without any proper press. He can, as an emergency measure, and often with success, use a magazine or atlas, or old newspapers, employing for a weight any handy object. The real enthusiast will find some way to achieve his end. While, as a rule, we shiver when a book collection is sent us, now and then we find it admirable. Small alpines are thus often nicely preserved.

Whether the plants be collected by portfolio or vasculum, they have, upon returning home, to be transferred to the regular press, always in fresh, warm driers and with plenty of them. Economy in the use

of driers is loss of time, and often of specimens. The driers may be heated by direct sunlight, by exposure in a hot loft, in a kitchen, or other heated apartment. *One cannot have them too hot.* With driers often reheated and changed, very obdurate plants may be treated. Orchids even may be made to retain their color, and semi-parasites like *Melampyrum* and *Comandra* be prevented from blackening. The grand secret of good specimen making is the use of numerous warm driers and these frequently changed.

A separation of piles is desirable unless one is forced to economize space. A small pile is of course more easily operated than a large one. It often happens that the collector may desire to separate partially cured specimens from fresh and moist ones. This is accomplished by means of interposed binder's-boards or even blocks of wood. The lattice-work frames can be advantageously used, as they allow the circulation of dry air and the escape of moisture. There is no serious objection to this unless it can be proved that the process of drying is too much accelerated, thus rendering the specimens brittle.

Around the heads of compositæ, especially when very large like those of *Helianthus*, *Silphium*, or *Rudbeckia*, some collectors dispose rings of cotton batting, but we do not advise this. When parts overlap there is likely to be resulting injury at least in neatness of appearance. The consequent discoloration is prevented by interposing slips of absorbent paper.

In one pile there may be the products of several or many excursions, simultaneously drying. Any such details as the disposition of leaves, the spreading

of petals, the separation of stamens, can best be done in the early stages of pressing. Later these parts become rigid and unmanageable. Fooling with them is then a positive danger. The chief end always in mind to be attained is as natural an exhibition of the specimens as circumstances will allow. It may not be possible in all cases to retain the fleeting color of some flowers or even the living hue of certain leaves. Still we strive towards that ideal. An incessant change of the driers, and an abundant supply thereof in every change, is essential to satisfactory results. At first it is well to change them at least twice a day. Later the demand for frequency of action is less urgent.

Airing Driers. — In regard to this subject Mr. J. F. Collins says: "When a collector does not have the necessary space for spreading out his damp driers for airing, he has to resort to such other expedients as circumstances may suggest or permit. In such a strait I found myself a few years ago, and after discouraging attempts with several devices, I finally hit upon the following contrivance, which has proved very efficient. I now use it in preference to any of my former methods.

"Through the upper end of the patent clothes-pin, sometimes known as 'spring clip,' or 'spring clothes-pin,' I bore a quarter-inch hole, passing through both pieces of wood. By this hole one hundred or more of the clips (as may be desired) are strung on a strong whipcord, or any stout line, this in turn being stretched across the top of a room (as in my case) or between trees or posts out of doors. The clips are readily opened with one hand, while

with the other the driers may be placed in them either singly or in twos. As they hang at right angles to the cord there is, of course, an inch, or little less, of space between the driers, and these are aired very thoroughly in consequence. When indoors the several lines, with the driers, may be raised up to the ceiling, out of the way, by means of small overhead pulleys, if so desired.

"I have found two hundred of these clips quite sufficient for collecting more than five thousand specimens in one season. To be sure, it takes longer to place the driers in the clips than to throw them about on a floor, but the air has a free circulation on both sides when suspended, which is an item to be considered."

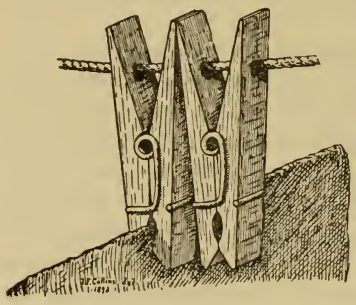

Fig. 12. — Airing Driers.

(See sketch of two clips on the cord.)

The duration of the drying must depend upon circumstances. The process may be slow in foggy or rainy weather. In August, when it is often sultry and the atmosphere super-saturated with moisture, it is very difficult to dry specimens at all. Artificial heat is then often resorted to. In dry, hot weather one can work very expeditiously and well. The experienced operator knows when his plants are cured by their feeling to the hand or cheek; also, at times, by the crisp sound they emit when handled.

As an instance of the "total depravity of inanimate things" it is only fair to mention that plants which one has forgotten in some old pile of papers or magazine sometimes come out better cured than those to which he has given unremitting care. Still, one should not generalize on this fact. These anomalies should not make us less careful, but perhaps set us to investigating causes. It may be that Nature herself is tendering some useful information.

An ample table, with drawers, is a prime requisite for good and expeditious work. Hereon, if one has a sense of order and follows some definite system, he can dispose his work to best advantage, passing things from left to right as he proceeds. Thus he may place his heap of driers to one side, and directly in front of him the specimen sheets. This gives him plenty of space to work in. He makes up his new pile of driers and specimen sheets to the other side. One cannot have too many paper-weights; they are in demand always. Ballard's clips, too, are of frequent value.

It is convenient to place the collecting-box or the portfolio, as the case may be, on the left, so that the plants can be readily removed to the press. It is well to have on hand a basin of water for washing out sand and earth that may still, after every care in the field, adhere to the roots. One should have a pair of scissors, too, for trimming off dead leaves. All refuse should be received in a basket and not left to disorder the room.

Economical Drying Oven.[1] — For drying succulent plants or others that do not readily yield their moist-

[1] Contributed by Mr. J. Franklin Collins.

ure, I have found a home-made oven very useful, especially in damp weather. One that I have used for three or four years is made of a bottomless wooden box, sufficiently long and wide, but twice the depth necessary to accommodate the press. Through the middle of the box there run horizontally two or three rods or supports to hold the press. The box is fitted with legs to stand three or four feet above the floor. Beneath this box is suspended, by wires, an ordinary straight stove-pipe, sufficiently long to extend upwards into the lower half of the box, and downwards to within an inch of the top of a small single-wick oil stove, which is placed on the floor directly beneath. A *loosely fitted* cover completes the oven. The loose cover and bottomless features allow an easy escape of moisture, without excessive heat.

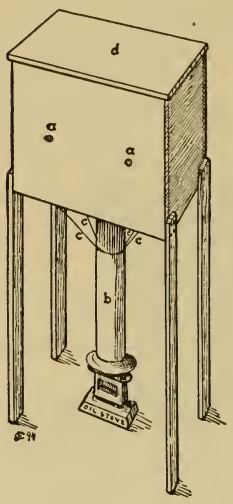

FIG. 13. — Drying Oven.

The stove, with a three and three-quarters inch wick, turned low, affords plenty of heat and requires from twelve to sixteen hours to burn one quart of oil. In an oven of this description I have dried the flowers and stems of the so-called night-blooming cereus, and other species of plyllocactus, in less than two days, without any discoloration, but the specimens when thus forced are apt to be brittle. The best results are

obtained with the majority of specimens by not applying the heat until three or four days after collecting. Care must be taken not to have too many plants in the press at one time, or the top ones may be discolored by the moisture from the lower ones.

Poisoning.

"Troublesome insects of the hour."—BURKE.

One would naturally suppose that after all the work hitherto suggested a collector's work had, at this stage of proceedings, been completed. It is a profound mistake to so suppose. Insects stand ready night and day to surprise the unwary. Like a besetting sin, they are upon him at his most unguarded hour. In a few hours or days they may completely ruin the work of a lifetime.

Just now there is a reaction among some curators even in our largest herbarium against direct poisoning. The late Dr. Watson, of Harvard University, had for some years given it up, relying rather upon dust-proof cases and frequent handling of the specimens. His successor, Dr. B. L. Robinson, views the matter in the same way. He argues that in many cases the poison applied has only a superficial effect, not sinking deeply into the tissues. That after drying, it easily brushes off, and becomes a more positive danger to the curator than to the pests. The application of any solution, too, by use of a brush or by immersion of the specimen, disturbs or removes fragile parts, like hairs or stamens. Discoloration always results, and a solution, to be useful, must be so saturated that the chemical employed will incrust the parts, greatly to their detriment.

In case a preventive is desired, various substances are employed. Some use naphthaline or camphor, the objection to these being their volatility and strong odor. The smell of the first is especially offensive to many. Personally we have not found it efficacious against buffalo-bugs *et id omne genus*.

Long experience has proved that in case a preventive is used at all the best is mercuric chloride (corrosive sublimate) dissolved in alcohol of ninety-five per cent. It is well to keep the solution below the saturation point, as it will otherwise deposit upon and disfigure the specimens with a white incrustation.

We recommend as a working formula one ounce avoirdupois to a quart of alcohol.

According to Henfrey, "the mixture used at Kew Herbarium, England, consists of corrosive sublimate, one ounce; carbolic acid, one ounce; methylated spirit, two pints; mix."

It must never be forgotten that mercuric chloride is a deadly poison. The bottle or other vessel in which it is contained should be clearly marked "Poisonous." The addition of the death's head and cross-bones is also likely to be deterrent. As, in the operation of poisoning, some of the salt escapes into the air by evaporation, it is advised to always ventilate the room during or after the process. We have fancied that the smell of the fluid has now and then produced headache. This may be merely the result of the work. At any rate, it is well to be on the safe side.

Application of the poisonous solution is made by immersing the plants therein, or by going over them with a soft brush dipped in the liquid. This brush should be free of any metal fastenings which would

form an amalgam with mercury and discolor the specimens. Care should be taken to touch the plants lightly, especially such as are downy or pubescent, lest the hairs be removed. A dropping-bottle, much like a chemist's working-bottle, is sometimes used. The arrangement of the tube is the reverse of that in the wash-bottle. The vessel requires merely to be inclined to cause a flow of the solution. As a strainer a wisp of cotton has been advised.

It has been said above that the brush should be free from any metal handles or fastenings. All scissors, knives, and metal apparatus generally must be protected from contact with mercuric chloride, which at once corrodes them. It will, too, remove the cuticle from one's fingers, so that it is well to wear gloves while manipulating. Poisoning is usually done before the plants are mounted, but there are times when it is necessary to repeat the process, or mounted plants acquired from others may need doctoring. The solution in such cases of course stain the papers, but this is unavoidable. Better a good, protected specimen than even a spotless sheet. The poisoning may, in some cases, be done simultaneously with the drying, but it is usually a subsequent process. Of course, when the plants are wet down with the alcoholic solution, they must be again dried, but the process is now simple and rapid, not requiring much paper, and but a very light weight.

To obviate the manifest dangers and inconveniences resulting from the use of mercuric chloride, other methods have occasionally been suggested. Some of these are supposed also to be more effective; thus a German writer advises the application of paraffine oil.

At ordinary temperatures this is not volatile. It holds in solution some paraffine, which, in severe weather, will crystallize it. It is not costly and can be easily procured. Those who have used it claim that it is very efficacious.

One must be reasonably certain that all the plants in his herbarium are in some way poisoned or protected. Duplicates, also, laid aside for exchanges, should in like manner be secured. Good correspondents usually inform one if the plants they send are poisoned. When in doubt always quarantine the plants till an examination assures their immunity. One cannot always tell at a glance if the specimens have been treated, though, as a rule, they evince certain signs that are recognizable.

A little brown beetle, cousin of the voracious carpet beetle, and known as *Annobium paniceum*, is the chief offender. He is ably assisted in his ravages by a species of *Dermestes*, the familiar museum pest. Probably every collector, especially in his younger days, has had the experience of finding his work of months or years ruined by the onslaughts of these predaceous insects. They will even bore through the heavy manila paper of genus covers. One wakes some morning to find a pile of dust in place of his cherished treasures. The perfect beetles are fond of congregating, towards evening, upon the window-panes. Every one in sight should be at once destroyed. They are destructive in both larval and imago conditions. The little mites which sometimes swarm over specimens appear to do no great harm, but they, too, should be rigorously excluded. Make a clean sweep of all visible pests.

Ferns, grasses, and mosses, among the cryptogams, seem little liable to attack. Labiatæ are in a measure protected by the odor of their volatile oils. However, as any of these may serve as hiding-places and points of rendezvous for the enemy, the safest way is to poison all.

Certain orders seem especially liable to attack. These are notably *Compositæ*, especially those with large heads, *Gentianaceæ*, *Asclepiadaceæ*, *Euphorbiaceæ*, *Umbelliferæ*, *Ranunculaceæ*, many *Leguminosæ*, all *Salicaceæ* and their allies, and the genus *Prunus* in *Rosaceæ*. These plants, known by experience to be in especial danger, might receive particular and frequent examination. We have seen curators poison their plants merely at the nodes. This does not render them immune. All plants should be treated. Nothing but a complete immersion will insure safety. Look out for all tubers and other subterranean stems and for the culms of sedges, grasses, and rushes.

When a collection becomes certainly and very generally infested, it may be purified by fumigation of the packages by bi-sulphide of carbon. They are placed in air-tight boxes and subjected to the penetrating and offensive fumes.

CHAPTER VI

STORING AND EXCHANGE

"His constant cares were to increase his store." — JOHN HOME.

In a dry place, free from the attacks of mice, and secure from dust, the collector stores his accumulations of one or more seasons till he can study or arrange them. They are kept in their specimen sheets and arranged in convenient packages, guarded by binder's-boards, wrapped about with stout paper, and securely tied. The contents should be legibly noted on an exterior label. It is well to arrange the plants by their natural orders or genera, so that they can be readily consulted. In some cases an alphabetical arrangement may be the more convenient — especially in such large groups as compositæ, grasses, or sedges. This renders them all easily accessible for exchange. Be sure to record on the outside of the package its special contents, and preserve a catalogue of the whole collection. One then knows just what he possesses and what are his *desiderata*.

In Botany we believe in "the open door"; free trade and exchange are with us synonymous. It is by judicious exchanges that a herbarium mainly grows. No one person can, by any possibility, acquire all the plants even of his own town, or county, or State. Division of labor is necessary. For a full representation of the flora of any area he must

supplement his own work or his purchases by the acquisitions of others. It is amazing how, by a system of exchanges, a herbarium will grow. By such a system, too, one obtains, if he so desires, many foreign plants, or rare species of his own country which otherwise he might never see. To his surprise he will soon find himself possessed of representations of most of the natural orders — at least of his own country. Knowing his *lacunæ*, he can seek specimens to fill them.

We should here direct attention to the importance of securing extended suites of the same plant from different locations. The variations brought about by environment are thus most clearly shown. Extended individual travel could not, perhaps, demonstrate so much.

It requires but a small stock of duplicates in order to initiate an exchange. The consequent increase to a herbarium continues with amazing rapidity. Pleasure and duty both compel one to make any large stock of duplicates available to the less fortunate. Unused they are liable to accident and may really be in the way. Says Lindley: "We may be perfectly certain, for all experience proves it, that to be liberal in the distribution of duplicates is a sign of a liberal, generous disposition, and of a man who studies science for its own sake; while, on the other hand, a contrary line of conduct is an equally certain indication of a contracted spirit, and of a man who studies science less for the sake of advancing it than in the hope of being able to gain some little additional reputation by which his own fame may be extended. A private individual has, no doubt, a right to do as he likes with

that which is his own, just as a miser has a right to hoard his money, if such is his taste; but of the keepers of public collections it is their bounden duty to take care that everything in their charge is made available for the advancement of science."

The collector who intends to correspond and exchange first secures some list of persons similarly desirous. A naturalist's directory, the advertisements in certain popular magazines, or the record of some experienced friend, is consulted. It is somewhat hazardous to trust the published lists.

Having selected a certain number of names, one sends to such persons a "check-list" marked with his desiderata and his duplicates. To this the correspondent reciprocates, if he cares to exchange, by forwarding a similarly marked catalogue. On the best check-lists the plants are all numbered, and one may save time by merely sending the numbers.

Delightful acquaintances are made by this means.

In arranging the packages for exchange be ever careful to select well-prepared specimens, labelled, localized, and even poisoned. Do as you would be done by. Save your correspondent all unnecessary trouble. Write your labels distinctly and let them embody all essential information. The labels, by the way, may be your own or those of some previous correspondent. Even in this last case indicate in some way — as by the words "Ex herbario" — that they have passed through your hands. Send a generous suite of each species, that your correspondent may have ample material for continuing the exchange.

In packing for express or mail employ folds of thin paper, and try in all ways to avoid any confusion

either of specimens or labels. The original collector or possessor may be able to disentangle a snarl, for he knows his plants, but some or all of them may be unfamiliar to the recipient. A wrong name may mislead a beginner for years. Let us assume, for an example, that one receives a dozen or more orioganums, or twenty astragali, from the far West, with mixed-up labels. No one but an expert can solve his puzzles.

With the best of intentions any one is liable to an occasional wrong determination, or to a chance displacement of a label, so that the recipient should subject all immigrants to his herbarium to a close and rigid examination. Thereby he will confirm or question all the records. No plant should be admitted without a proper certificate of health and character. Government and railroad officials have no special regard for our precious bundles, so we must be careful to pack them in a way to withstand any possible ill-usage.

While it is better, on many accounts, to place only one species in a fold of paper, yet, to economize in weight and consequent price, one may include several or many, if small. They should, however, in such case, be kept apart by adhesive straps, by folds of tissue paper, or in some other way. They may even be tied down with thread.

It is difficult to keep informed as to the various and conflicting rulings of the United States Post Office Department, which have fluctuated with almost every administration ; but we believe that at present a printed or even written label does not subject the package to letter postage. Still, it is always well to inquire at the

time, common sense sometimes being in abeyance to the exigencies of politics.

At present any package weighing less than four pounds can be sent within the limits of the Union; larger ones must be forwarded by express or by freight. The charges either by mail or freight on foreign packages are almost prohibitive.

A neat package should always be made, with the plants disposed so as to preserve the level. Papers should be trimmed even, so as to leave no outlying ends to catch or become frayed. It is often necessary to place several layers of paper between the specimens. In all cases the object in view is to preserve the safety of the plants *in transitu*. Seeds and small fruits should be enclosed in paper bags or pockets.

After laying out the set which it is proposed to send, place the whole pile between binder's-boards, securely fastened with strong twine, and cover the whole with stout paper, itself again tied. In case it is to go by sea, the package may be at least partially secured from moisture by wrapping it in oil-skin.

Very excellent botanical students and keen observers are often very poor collectors. The converse is equally true; a good collector may be an extremely poor botanist, and one whose every plant has to be redetermined.

One soon learns the poor collectors, the dishonest, and the tricky. All these kinds exist. There are men who will coolly take one's best, and return rubbish or *nothing*. They get the plants, and you the experience. Some years of practice will perfect an exchange list by a process of natural selection. It

will be reduced to a handy few, tried and not found wanting. With such it is a pleasure to correspond.

Entirely apart from courtesy, self-interest operates to cause one to send only excellent specimens. Failure in this regard results in an evil and widespread reputation, and the increasing certainty of only securing poor material for that issued. The person who seeks an exchange should, in all propriety, be the first to forward his plants. Promptness in answering is equally courteous. There are those who receive and answer not at all, or after so long a time as to try one's good nature. It is nothing but dishonesty to fail entirely to reciprocate with specimens.

No consideration should induce a collector to obliterate a rare species, and he should not publish localities of such in other than botanical magazines, and even then with some caution. It is a strange fact that people, otherwise conscientious, seem to have no regard for things of this kind; yet by enriching themselves they may be doing incalculable mischief to science. Very common things, like dandelions or plantains, need not be laid up in our exchange stock. Still, it is to be remarked always that what is superabundant in one's own vicinity may be rare or unknown to a correspondent. Thus *Leontodon autumnale* and *Ranunculus acris* are common on the seaboard of New England, but are not found, as a rule, in the West. A plant, abundant in its own locality, like *Jasione montana*, on the island of Connanicut, or *Genista tinctorio*, in Essex County, Mass., may be so restricted in distribution that, seeing it, the experienced botanist names its place of origin.

When a person has written a flora of a district, or a monograph of some particular order or genus, all plants received from him and described in his work have an especial value. Our correspondents' tickets should always be retained, and afterwards glued down with our own in the herbarium.

"M. de Candolle, whose experience gives him a better right than any other botanist, has insisted with emphasis that all collections distributed among the important herbaria should be numbered. The number is not to show the collector's systematic reference of the specimen, and it does not necessarily include all his specimens that belong to the same species. It designates merely specimens that belong to the new stock, or such as from locality, data, or other circumstances he can with equal certainty assume to be identical with each other and true duplicates. The citation of such numbers, fulfilling as it does phytography's law of brevity, has become very general on the part of authors of floras, monographs, etc., and every specimen under the same number becomes in this way elevated to the rank of a voucher and original of a description." — J. Donnell Smith, "Botanical Gazette," June, 1886.

As to the duplicates kept in stock, they should now and then be looked at, even though they may have been poisoned, in order to see that they are not injured by larvæ, mould, or mice. If insects once get into a lot of plants, they are sure to cause trouble; only unceasing vigilance will prevent this. One precaution is to exclude dust by all possible means.

If, as may sometimes happen, a correspondent will desire to have living plants sent him, these may be

forwarded in Wardian cases. A Wardian case consists of some kind of dish or pan to hold earth, and provided with proper sub-drainage. Before putting in the soil it is a good plan to fill the bottom of the receptacle with broken pottery and charcoal; then with bits of moss-covered sticks and stones, between which are inserted the plants. A bell-glass or similar glazed covering is placed over the whole, with a provision for semi-occasional ventilation. Most plants do well under these circumstances, and especially ferns and their allies. We have, indeed, seen such plants as *Mitchella* bloom in a Wardian case. Apart from their evident æsthetic uses, such cases are invaluable in the transport of live plants by sea. It insures them against the salt air and sudden changes of climate. They will endure great extremes of temperature. Directions for the proper use of his cases are published in N. B. Ward's little book, to be found in most botanical libraries.

The vitality of seeds is very various. The larger number are not of long endurance; others have vegetated after years. Oily seeds are least likely to survive. If seeds are gathered when ripe and then planted in well-selected mould in a Wardian case they will, according to Mr. Ward, "travel in perfect safety."

Generally seeds must be so packed as to have plenty of air. If they are to go by sea they must not be exposed to salt water. They should be separately done up in papers, and hung in small nets, packed with clean straw. Keep all seeds dry.

CHAPTER VII

THE HERBARIUM

"The advantages of preserving specimens of plants, as far as it can be done, for examination at all times and seasons, is abundantly obvious." — Sir James Edward Smith.

We have now to specially consider the herbarium — or, as the old botanists called it, the herbal, or *hortus siccus*, *i.e.*, the dry garden. Our field excursions and manifold phases of closet work have had in view the amassing of a lot of plants for the herbarium. These dried specimens must be carefully authenticated, neatly preserved, and made easily accessible.

The first requisite is a dry room, light and airy. If fire-proof all the better. Most distressing accidents from fire have now and then occurred, in which the unhappy collector has seen his work of years instantaneously destroyed, and has survived almost broken-hearted. Even the fraternal assistance always tendered must fail to restore many specimens rendered dear by association.

Some think the duty of a curator is, as the word implies, to keep things safe. That is not enough. The plants must be well housed, sufficiently poisoned, and, above all, often consulted in order to render them fully secure. One must not trust to chance, though for a long time it may favor him.

The life of a curator or the value of his charge should in no case be imperilled by the improper location of the collection. A basement room is often, though not necessarily, a dangerous place. When it is otherwise, the building has, in all likelihood, been erected with this special end in view.

Ample working-tables, strong and firm, should be provided. They are essential when the student has to display extended alliances, and are a comfort at all times.

A dissecting microscope should always be handily within reach. If the tables contain drawers, as they should, all necessary appurtenances may be kept therein, including scissors, knives, needles, labels, adhesive paper, and stationery of all kinds. Good work is immensely aided by the convenient location of the necessary tools.

If one's herbarium is rapidly growing, he may retain his plants in their specimen sheets without mounting. There are certain advantages in this. The plants are more easily examined and can be more readily transferred or intercalated. As paper, too, is often an onerous expense, he can in this way economize. Some of the most noted writers urge this as altogether the best permanent disposition of the plants. Even where mounting is resorted to, it is well to leave some loose specimens. Especially should one do so with ferns, so that both sides of the fronds can be seen. A public herbarium, often much consulted, would hardly admit of the plants being so disposed. There would be much herbage, legitimate loss, and too frequent purloining. Many persons, honest and above reproach in other ways, will take specimens

and deem themselves irreproachable. We should not throw temptation in their way.

The plants should then be so affixed as to allow free manipulation without injury, and the most accustomed culprit will hesitate to depart with an entire sheet. Mere study injures such fragile objects as plants, all the more brittle from drying. The drawing of the packages in or out of the pigeon-holes always produces more or less abrasion.

Some persons prefer, and with excellent reason, to mount their plants with adhesive slips of paper rather than with glue. Dr. John Torrey, of Columbia College, recommended and used, besides glue, photographers' albuminous paper, as white, neat, and efficacious. Whatever kind of sticky paper is used, a lot of it should be kept, cut to convenient sizes, in a readily accessible drawer. In case it should happen after a plant is fastened down with this that one should want to displace it, the slips are readily removed. We have seen specimens mounted with small pins or even sewed down with thread. The last is far too laborious a process.

All great public herbaria, at home and abroad, for example, those of Kew, Harvard, and Columbia, follow essentially the same process. The plants are glued to the sheets. The writer has, for a number of years, used liquid glue, which has the great merit of always being ready. By its employment one escapes the inconvenience and discomforts of the glue-pot. No better plan can be followed than that of Mr. Walter Deane, of Cambridge, Mass. It insures absolutely neat specimens. Mr. Deane writes:

"I always keep a pile of sheets of thin blotting-

paper, a little larger than mounting-paper. I use one of these to paste my plant on, getting as little glue on the sheet as possible. The glue left on the blotter is readily absorbed, and the next plant may be laid on a dry sheet to paste. I can make one sheet last for one hundred plants before it is discarded. Of course, in time it gets gluey. When I see a globule of glue on the sheet as I am mounting, I just rub it in with my finger, rub my finger on my apron, and go on. In this way my sheets of mounted plants show *no glue*."

For another method of mounting plants, the reader is referred to W. N. Clute's article in "Plant World," Vol. 2, p. 131. As certain plants are most obdurate and capricious, curling up when wet into an inextricable snarl, the operator has often to call into play all his latent ingenuity to circumvent the culprit. We have been at times forced to place the sheet of paper on the glued plant, or to hold it erect, and quickly bring the specimen against it.

If it should happen, despite one's care, that some glue should ooze out around the specimen and threaten to disfigure the sheet, it should be removed with a moistened cloth. Some plants will require the full strength of the glue ; others need only a thin wash. Use vinegar to dilute it. The ends of stems, coarse bulbs, and rhizomas must be tied down by slips of adhesive paper. A carefully glued plant may be otherwise pulled off the sheet by having some object catch in the projecting or uptilted parts.

Every sheet should be provided with one or more open envelopes or paper pockets, glued down by their backs. In these are kept flowers, small fruits, or seeds for study. They are a sort of reserve supply,

complementary to the specimen proper. They are easily made, but can be obtained in quantity from dealers.

It was said, while speaking of the press, that one's pile should be kept level. Still more essential is it to have the mounted specimens so prepared that a pile will slip easily in and out of a compartment. Manifestly, if all the plants were disposed in the centre of their sheets this could not be done. Here one has to resist the natural impulse to symmetry. Have those on alternate or occasional sheets placed at side, top, or bottom. From the fact that the base of a plant is usually its most bulky part, there is a dangerous tendency to have that end of a pile higher than the other. Labels come there, too, to increase the elevation. The difficulty may be lessened, if not cured, by disposing, where possible, fruits, envelopes, and the like at the top of the page.

The size of the herbarium sheet adopted generally in the United States is 11½ × 16⅜ inches.

The old size, 11½ × 16½, so long used as the American standard, is said to have been a pure accident, resulting from a misunderstanding with the paper makers. It is quite essential that uniformity of size should be generally followed. As in the case of private libraries, the ultimate goal of all herbaria is some public institution. The enthusiast can by no means depend on children, relatives, or friends to maintain and increase his collection. In most cases it is bequeathed or sold. Now, if every one mounted his plants as the whim seized him, and not a few do, when the herbarium reaches its new cases the sheets would either not go into the pigeon-holes, or be ridicu-

lously too small. We build for posterity. A beginner, not knowing that generous space should be allowed for displaying all parts of a plant, is apt to use small, inadequate sheets, thus cramping his specimen. Of course, with the young, expense is often a determining factor, and paper is more or less costly. However, there are some things where economy verges into penuriousness. The sheets should be sufficiently ample to permit a full exhibition of any ordinary plant. Mr. Deane has proved that on the standard sheet may be displayed a most phenomenal length of stem or root.

An originally ill-chosen size may entail discomfort almost in perpetuity. This has occurred in certain foreign herbaria, where, despite the faulty dimensions, it has been deemed inexpedient to change.

According to Dr. Asa Gray, the paper should weigh twenty-eight pounds to the ream of four hundred and eighty sheets, though nineteen pounds to the ream is now used at Harvard. It should be stiff, firm, and smooth.

When one wishes to be economical he may select his paper of manufacturers, and have it cut to suit himself, saving the tailings for field labels. While even our greater herbaria are not mines of wealth, they usually are enough endowed to lift them above an injurious economy. Cheap expedients are too apt to be poor. Other things being equal, get the best materials; it is often economy in the end.

The old botanists were in the habit of binding the sheets into a book. When the volumes increased, they were set on shelves as in a library. At the present time the sheets are left free so as to be readily

intercalated or changed about; moreover, they are thus more easily consulted.

The species of one genus are collected under one cover, known as the genus cover, and made of stiff manila paper. If the species are too numerous, or the same repeated on many sheets, extra covers are provided and numbered, as 1, 2, 3, etc., of that genus. The genus covers ought to be at least a quarter of an inch wider, when folded, than the contained species sheets. In a clear, legible hand, in the lower left-hand corner, the generic name is recorded, and sometimes the name of the family is added. The number of the order and the genus according to our system of arrangement, be it Bentham and Hooker or Engler-Prantl, should also be on the cover. As the contained species vary from time to time, a record of these fluctuations may be made in pencil. It is only large herbaria that indulge in the luxury of special "species covers."

In a small private collection the genera can be gathered under somewhat larger, stiffer covers, marked with the name of the order. In large herbaria, ordinal and even generic separation is secured by distinct compartments of the cases, or by tags of tin or cardboard inserted in the proper places. Other divisions, like tribes and sub-tribes, are similarly indicated.

A very useful, almost indispensable adjunct of a large herbarium is a carefully prepared index of the whole; it should be placed in plain sight. Even better is a card catalogue; this allows of unlimited expansion. A label may be a thing of beauty or a perpetual grievance. There are as many kinds as there are

individual human characters. Personality is largely displayed in them; they illustrate good or bad taste as plainly as does dress or manners. As a rule, the simpler a label the better. One soon learns to abominate either the thin-lined, weak, and watery-looking sorts, or the ornate, flowery, illuminated-border ones. Size, too, is an important consideration. There is a happy mean. It should be large enough to gracefully hold the necessary information, and not so big as to cumber or disfigure the page. If too small, it necessitates very fine writing, difficult to read. Dr. Gray used to pronounce one a nuisance that exceeded four by two inches.

It should be large enough certainly to embrace the full name of the plant, its habitat, time and place of collection, the name of the collector, and any special observation concerning cold, soil, height of plant, sunny or shady position. The paper of the label should be thin enough to take glue easily without curling. Clear type, simple border, if any, general neatness, are the first necessities of a label. Herewith are given some samples, which, while various, are, most of them, good.

Dr. B. L. Robinson, curator of the Gray Herbarium, writes me: "While not advocating any elaborate borders or flourishes, our experience lately has been that to simplify all labels as much as possible is to make them too much alike and to lose the distinctive quality which is highly desirable as a time-saver in sorting. To secure this individuality in the labels of different large sets we have had to employ a considerable variety as well as different sizes of labels and even different colors of paper. But this is not

time wasted, as one soon finds who may have to look up several numbers of a particular collection scattered among some hundreds of sheets of other collections."

It is considered better to attach labels by means of paste than to use glue. Some even leave the labels partly free, securing them merely by a pin or a pasted corner. The object is to allow of their easy removal if circumstances demand their transference to other sheets. It has been our practice to attach them permanently. We occasionally have labels in exchange from England printed on gummed paper. Until fastened they are hygroscopic and curl up in a troublesome manner. In preparation for mounting, especially when the work is to be delegated to some assistant ignorant of classification, and whose work is purely manual, the plants should be laid on their sheets, labels lying loose in the designated places. The whole pile should then be deposited in a deep box or drawer of a slightly greater width and depth than the pile, and with a drop-door in front. Things are thus kept well in place, and, at the same time, are readily accessible.

Mr. M. S. Bebb and Mr. Walter Deane commend the following way of mounting labels: Mr. Deane writes, "I invariably follow this plan: I paste the four sides of the label, touching with the paste as narrow a rim as possible. Then I lay the label in position, put a small piece of paper, which I have in my lap, over it, and rub it down. In this way the label *never* curls, and it requires but a few seconds to affix it. It lies perfectly flat on the sheet."

It will be noticed from these examples that the headings and styles are quite different. All those

presented, however, are good forms. Some, it will be seen, are used in distributing duplicates from an herbarium, or forwarding those of some special region. In the last case they would then have a number attached to each label, corresponding with one in a list which the distributor retains. Indeed, the plants of well-known expeditions are often referred to by their number. The labels sent with the plants, together with the owner's private one, like No. —, are attached to the species sheet. The distribution label only differs from this in having the words "*Ex herb.*," or "From the herbarium of," printed first. As a rule, we would recommend using as little Latin as possible among compatriots. When sending to foreign correspondents it is desirable to employ it as the court language of science the world over. Generally speaking, the only printed parts of a label are the heading and perhaps the word "*legit*," meaning "he collected it," or the English equivalent, "Collected by." All other matters, such as the name of the plant, possible synonyms, habitat, etc., are written in. When eventually mounted, the plants should be arranged in such manner as to be easily inserted in their appropriate pigeon-holes. One's work in this regard may be much facilitated by withdrawing the large families, such as *Compositæ*, *Cyperaceæ*, *Gramineæ*, *Orchidaceæ*, arranging these in separate heaps. One can then proceed with smaller families, and finally with those which contain but few genera. Thus marshalled beforehand, it is an easy matter to relegate them to their compartments.

Herbarium Cases.[1]

"Flowers and weeds of glorious feature."—SPENSER.

Every one who makes a collection of dried plants should have some receptacle in which to keep it. Whatever the size, shape, or constructive material used, one important point should always be borne in mind: it should be made as nearly dust-proof as possible. Very small collections are sometimes kept in pasteboard boxes, or, much better still, in dust-proof tin boxes. The receptacle almost universally used is a wooden case with a closely-fitting door. As may be surmised, there are many styles of these cases, according to individual fancy or necessity. The large college herbaria usually have cases which are occasionally built into the walls. Owners of private herbaria often have specially constructed cases, ornamental as well as useful, sometimes more ornamental than otherwise. It is not my object to here describe any of these more expensive cases, but to confine my remarks to two which have proved very satisfactory and are within the means of most collectors. Indeed, either of them might easily be constructed by a person having a little knowledge of the use of a few woodworking tools, particularly a saw and plane.

A small case of four compartments (pigeon-holes), capable of holding from two hundred to four hundred specimens, is shown in Fig. 14. It is constructed of whitewood; the top, bottom, and sides being one-half inch thick and the shelves (one-quarter inch thick) fitted into grooves in the side pieces. The interior of each pigeon-hole should be seventeen inches

[1] By J. F. Collins.

deep, twelve and one-eighth wide, and four or four and one-half high, if the standard-size herbarium sheet is used. The internal *width* and *depth* of the pigeon-hole is really the only *essential* measurement to be considered in constructing a case. The kind of wood, its thickness, and the height of the pigeon-hole is

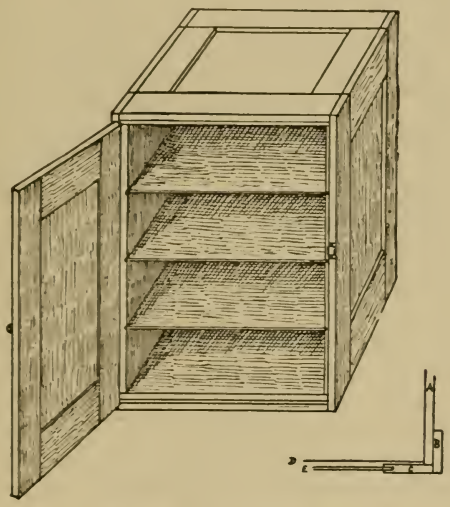

FIG. 14. — Herbarium Case.

generally a matter of personal choice. Whitewood is specially mentioned because it is a good kind of wood for the purpose, as well as one of the cheapest and most easily worked; and the thickness mentioned (one-half inch) will make a case sufficiently strong and rigid for either the case figured or the double one mentioned later.

The outside dimensions of the case figured are eighteen and three-fourths inches high (each pigeon-hole being four inches high), fourteen and one-eighth inches wide, and eighteen inches deep. In the sectional plan showing a section of the front right-hand corner, "A" represents the side of the case, "B" the vertical front corner strip, "C E" the door ("E" being the panel), and "D" the front edge of a shelf.

Several cases of this sort can be placed together so that they will, collectively, have the appearance of one large case. Thus a growing herbarium can be extended from time to time by providing new cases. These cases can, as stated, be placed together, or they may be scattered about a room so as to occupy the most available spaces.

Another style of case which is considerably used is essentially the same in construction as the one figured, except that it is a double case (with eight pigeon-holes in two tiers), with two doors opening away from the centre partition. In appearance it is like two single cases placed side by side, except that in the double one the partition is of a single thickness of wood, whereas in the two single cases placed together the partition would be of two thicknesses of wood with an intervening space.

These small cases are easy to move from place to place, and if space permits should be permanently arranged so that they are raised about a foot from the floor and the top of them not more than five feet high — the intervening space being the most convenient for handling the specimens.

The space below the cases can easily be utilized by

fitting it with drawers for holding bulky fruits, etc., and the space on top for books.

Another method of disposing of bulky fruits is to have small cardboard boxes tacked or glued to a thick, rigid binder's-board which is cut to the size of the herbarium sheet and inserted in the collection in its proper place. These small boxes should, obviously, all be of the same height (three-fourths of an inch or more, according to the bulkiness of specimens) on one board, though their width and length may vary according to circumstances.

For keeping the doors closed the well-known "museum-lock" is by far the best, but for these small cases I have seldom seen anything more than a simple lock or catch used — similar to the one indicated in the figures.

CHAPTER VIII

BOTANICAL MUSEUM

"That within that passeth show." — HAMLET.

Museums of botanical economic products have until recently been much neglected in this country. Almost every great botanical centre, however, now attempts some museum of fabrics, drugs, useful woods, dye-stuffs, etc. As early, perhaps, as any, was that inaugurated at Cambridge by Prof. G. L. Goodale. This is now housed in the famous Agassiz Museum of Comparative Anatomy, and includes, among many *natural* products, the Blaschka collection of glass flowers so graphically described by Mr. Walter Deane, in the "Botanical Gazette," and by Professor Goodale himself in the "American Journal of Science."

At the Peabody Academy of Science, Salem, Mass., Prof. John Robinson has a very instructive exhibit of the woods of Essex County, Mass., together with many fruits and other objects useful to man. The National Museum at Washington, the Jesup Collection of American Woods in the American Natural History Museum in New York, collected under the supervision of Prof C. S. Sargent, the Shaw Botanic Gardens at St. Louis, and numerous other institutions now endeavor to present the economic aspects of plant life. The importance of such displays cannot be overestimated. Besides specimens of

useful trees and shrubs, they should always include fruits, textile fibres, drugs, and all articles used in medicine, the arts, or commerce. Nothing does more to attract the attention of the public to the direct practical uses of science. The adroit curator, wise as Ulysses in his generation, may thus at times direct funds into other channels as well. Indeed, it is the want of means for providing proper storage and display that so long prevented the accumulation and display of our native products. Such collections at Kew, illustrative of the vast resources of the British Empire, attract incessant throngs of visitors.

As a special and very important part of the collection, tree specimens may be attached to pasteboard, and accompanied by drawings, paintings, or photographs of the tree as it appears in life. Mounted specimens of the essential diagnostic features can, at the same time, be exhibited. Trunks of trees and sections may be placed on convenient shelves; smaller portions, as slabs, in drawers. There is danger of warping and cracking in the dry air of the museum chamber, and to prevent this, at least partially, quarter segments are made. The bark is retained, and the section so cut as to exhibit both radial, tangential, transverse, and oblique views. As a rule, slabs should not be polished, though it may well be that the collector desires to show some particular excellence of the wood in carpentry or cabinet making, when polishing is desirable. Then a part only is polished. Warp and crack the specimens will, to a degree. Holes bored in the larger sections partly obviate this difficulty. Dry bark will, too, gather insects, and the writer thinks economic exhibits should never be

made to any extent in the proper herbarium room. Of course all specimens must be carefully named and localized. Even an excellent specimen is valueless when its origin is unknown.

Collections of seeds are important from many points of view, and can be arranged in bottles or boxes, in the natural order of the herbarium. They should always be scrupulously determined and localized. Guess-work in such matters is unpardonable, confusing the student and leading, often, to most erroneous results. This remark, indeed, applies to any part of a museum. Better cast out a specimen than to label it from "inner consciousness." Again, it is expedient to possess an underground railway for aiding the easy disappearance of useless truck, with which every curator is overwhelmed by a generous but often injudicious public.

Very beautiful and instructive sections of wood are made and issued in book form by Mr. R. B. Hough, of Lowville, N.Y. They are accompanied by a descriptive pamphlet. These sections are thin enough to allow free transmission of light, thus bringing out details of structure.

Fruits of various kinds, like cones or woody capsules, may be hung on hooks. It is desirable often to have sections showing the origin of branches. Imbedded cones are also interesting. The alert curator is on the watch for any and all illustrative material, but must never give way to flights of fancy. The accumulation of material simply as such tends to confusion, slovenliness, and finally to contempt. Microscopic slides, well prepared, and selected for demonstrative purposes, not alone for beauty or curiosity, are in-

FIG. 15. — Mounted Plants.

valuable. So are micro-photographs of tissues, and well-made diagrams, and drawings of histological subjects. Every collector should learn ordinary microscopic technique, and especially how to make good slides. Such slides are kept preferably lying flat, in neat cabinets or drawers, with a guiding index.[1]

We have long been convinced of the advantage of preserving some of the many illustrative sections made under the lens in the daily occupations of the laboratory. Too often these are rejected as useless after serving their immediate end. How useful would be a well-prepared set of the sectioned seeds of cruciferæ, showing the folding of the caulicle, and of the fruits of umbelliferæ, so distinctive of genera in that order.

A fine illustrative exhibit may be made, as at Cambridge, of the ravages of insects upon particular plants. Here may be shown the various stages of injury, and the degree of development of the predatory insects at the time of attack. The ordinary botanist probably will not, at the same time, be an entomologist, but without scientific knowledge of insects he can still do much to show up their work. As small fungi, blights, and moulds are almost equally destructive, they too can be exhibited with or on their particular hosts.

In the same museum may be established a teratological exhibit, a thing of vast philosophic interest, as malformations often throw a flood of light upon the morphology and history of plants. Chorisis, poly-embryony, chloranthy, fasciation, suppression of parts,

[1] Mica slides may also be kept on herbarium sheets, — as for mosses, — made practically same as ordinary slides, except mica used for slide and cover. For full directions see "Fern Bulletin," Vol. VI., No. 4, October, 1898; Vol. VII., No. 1, January, 1899.

may all be shown. Of late, too, ecology has assumed so much importance, and is in itself so fascinating a matter, that we would advise some attempt to display certain of its phenomena, like the means of protecting pollen, of the manifold uses of hairs, or the distribution of fruits and seeds. Kerner and Oliver's "Natural History of Plants" has been a great incentive to such investigation, and is a mine of facts, while for teratology one may profitably refer to the volume by Maxwell T. Masters. It is published by the Ray Society.

CHAPTER IX

BOTANIC GARDENS

"Who loves a garden loves a greenhouse too." — COWPER.

Botanic gardens should, when possible, accompany all large public herbaria. Those best known in this country are the Harvard Botanic Garden at Cambridge, Mass., the Government Gardens at Washington, the Shaw Gardens at St. Louis, Mo., and the New York Botanic Gardens at Bronx Park. Others are developing in various parts of the country.

The object of such gardens is to present as many plants, native and exotic, as can be made to grow in our climate. They should be arranged and labelled upon some accepted natural system. In them one has an epitome of the vegetable kingdom. There will be, of course, unavoidable gaps, and the system will not always be that of nature, but plants will be placed in as near relation to each other as the extent of knowledge will permit, allowing for exigencies of environment and circumstance. Thus all plants of one family may not be terrestrial, and hence will have to be separated. Some members of a group may thrive in hot, dry situations, others in cool, moist localities.

Conservatories or hot-houses should, when possible, supplement the garden. Certain exotics, to be known to us at all in their living state, must be grown under

glass. The garden allows the study of affinities and admits of a vast range of physiological investigations.

We can here observe all kinds of vital phenomena, as of movement, respiration, transpiration, irritability, and pollination. We can determine what insects visit particular plants, and whether these alone; how they act upon them, and the consequence to the plant. Indeed, the range of study afforded by such gardens is infinite. The expense is the principal drawback to their establishment, but as the public learns to appreciate those already in existence we can hope for many more.

Even as places of resort for the unbotanical they are not to be overlooked. The garden at Cambridge, for instance, is open to all. There is not a day in summer when it is not visited by many simply for the beauty and restful quiet of the spot. Such gardens are of perennial interest to visitors; often they are an incentive to study and research. They are, too, an influence for good in any community, refining and educating the masses. In a certain sense they more than repay their cost.

These gardens are much commoner in the old world than with us. Nearly every prominent city possesses one. It is perfectly possible for many of our schools to establish small gardens to illustrate the local flora. This is a matter that has been too much neglected. If they contain but a few hundred specimens, provided they are arranged on a scientific plan, children will acquire from them much valuable information, besides supreme delight. We have been glad to see of late the tendency to label the trees and shrubs in our parks. This, if correctly done, is highly educa-

tional. Interest in trees is growing and their preservation demanded. This tree lore is promoted by the institution of Arbor Day, and by many schools and magazines advocating wise treatment of our forests. Out of this frequent familiarity with them may in time issue an intelligent public opinion, and emphatic remonstrance when they are injured or wasted. In these days of object teaching some of the most stately and beautiful of natural objects should meet with due regard.

The most famous foreign botanic garden is that at Kew, England, dating in its present form from 1841, but in its origin much earlier. Its importance has been fully discussed in the introductory chapter of this book. Other famous gardens are those at Edinburgh, the Jardin des Plantes at Paris, and the botanic gardens of Montpellier, Berlin, St. Petersburg, Brussels, etc., in Europe; Melbourne in Australia; Peradeniya in Ceylon; Buitenzorg in Java; Calcutta in India; Jamaica and Trinidad in West Indies. Indeed, almost every foreign city possesses such a garden and regards it with pride. All of these possess besides very valuable herbaria and libraries.

CHAPTER X

BOTANICAL LIBRARIES

"My library was dukedom large enough."

When possible a botanical library should be maintained, rich especially in systematic works covering our own and foreign countries. These books are the working implements of the systematist. They should be arranged in a neat and orderly manner, readily accessible. A private library is slow to accumulate; a national, State, or academic one, representing much money, may be gathered more rapidly. Public institutions, besides any possible endowment, may through their employees or graduates greatly increase their store. In selecting the books exercise care and discrimination.

Collectors residing in cities have a great advantage, for in the book-stores they can see and handle the works as they are issued. On old stalls, moreover, they may find the less frequent classics of an earlier day, often possessing an abiding and more than historic interest. The book-lover with any means at all hates to neglect a homeless waif, but takes it in and makes much of it. Such foundlings often bear princely names and show in many ways their lofty origin.

How great is the advantage of municipal residence at once strikes the collector who by some chance is

deprived of it, as when in the woods or in any distant, barren country.

We are only able to give in this small volume a list of such works as will best avail a student in our own or in the principal foreign regions:

GENERAL SYSTEMATIC WORKS.

Genera Plantarum, by G. Bentham and Sir J. D. Hooker, London, 1862–1883, 8°, 3 vols.

Species Plantarum, by C. Linnæus, Vienna, 1764, ed. 3, 8°.

Index Kewensis, by Sir J. D. Hooker and B. D. Jackson, London, 1893–1895, 4 vols., fol.

Prodromus Systematis Naturalis Regni Vegetabilis, by De Candolle, Paris, 1824–1873, 17 vols., 12°. Now continued by occasional monographs.

The Vegetable Kingdom, by John Lindley, London, 1853, 8°, ed. 3.

Genera Plantarum secundum Ordines Naturales disposita, by A. L. de Jussieu, 1789, 8°.

A General System of Botany, by Le Maout and De Caisne, translated by Mrs. J. D. Hooker, London, 1873, 8°.

Histoire des Plantes, par H. Baillon, Paris, 1867–1899, 8°, 13 vols. published.

Genera Plantarum secundum Ordines Naturales disposita, by Stephen Endlicher, 1836–1850, 4°.

Revisio Genera Plantarum, by Otto Kuntze, 1891–1898, 3 vols., 8°.

Die naturlichen Pflanzenfamilien, by A. Engler and K. Prantl, Leipzig, 1887, 8°. In course of publication.

Thesaurus Literaturæ Botanicæ, by G. A. Pritzel, Leipzig, 1872, 4°.

Iconum Botanicorum Index Locupletissimus, by G. A. Pritzel, Berlin, 1855, 4°.

Nomenclator Botanicus, by L. Pfeiffer, Cassel, 1873–1874, 2 vols., 8°.

FLORAS.

NORTH AMERICA.

Manual of the Botany of the Northern United States, by Prof. Asa Gray, revised or 6th edition, New York, Cincinnati, and Chicago, 1890.

Synoptical Flora of North America, by Asa Gray, concluding parts in preparation by B. L. Robinson, New York, 1878, vol. 1, pt. 2, and vol. 2, pt. 1, 8°. Vol. 1, pt. 1, fasc. 1 and 2, 1895–1897.

Field, Forest, and Garden Botany, by Asa Gray, revised by Prof. L. H. Bailey, New York, Cincinnati, and Chicago, 1895, 8°.

A Flora of North America, by Asa Gray and John Torrey, 1838–1842, 2 vols., 8°.

Flora of Northwestern America, by Thomas Howells, Portland, Ore., 1897– . In course of publication.

Illustrated Flora of Northern United States and Canada, by N. L. Britton and Addison Brown, with illustration, 3 vols., N.Y., 1896–1898.

Bibliographical Index to North American Botany, by Dr. Sereno Watson, Washington, 1878, 8°.

Flora of the Southern United States, by A. W. Chapman, ed. 3, Cambridge, 1897.

Flora Boreali Americana, by W. J. Hooker, London, 1840, 2 vols., 4°.

Manual of the Botany of the Rocky Mountain Region, by John M. Coulter, New York, 1885, 8°.

The Botany of California, by W. H. Brewer and Sereno Watson, Cambridge, 1876–1880, 2 vols., 8°.

The Botany of Western Texas, by John M. Coulter, Washington, 1891–1894, 8°.

A Sketch of the Botany of South Carolina and Georgia, by Stephen Elliott, Charleston, S.C., 1821–1824, 8°.

To the above list of North American floras should be added the superb work on the silva of Norht America, by Prof. C. S. Sargent, many government reports of Pacific Railroad, of geological and other surveys under the Engineer and Interior Departments, together with the numerous reports of the Smithsonian Institution and the Agricultural Department. The object in every case is to possess, or to have access to, the necessary literature for determining the plants of any particular region.

MEXICO AND CENTRAL AMERICA.

Biologia Centrali Americana. The Botany by W. B. Hemsley, 5 vols., 4°, London, 1879–1888. Parts of an important and extended work.

SOUTH AMERICA.

Flora Brasiliensis, by K. F. P. von Martius, 1829 *et seq*. A large and costly work, not yet completed.

Historia Fisica y Politica de Chile, by Claudio Gay, Botany, Paris, 1845, 1852, 8 vols., 8°.

Plantæ Diaphonicæ Floræ Argentinæ, by J. Hieronymus, Buenos Aires, 1882, 8°.

Enumeration of Plants collected by Dr. Thomas

Morong in Paraguay, 1888–1890, by Thomas Morong and N. L. Britton, New York, 1892, 8°.

Plantæ Lorentzianæ. A. Grisebach, Göttingen, 1874, 4°.

Contribution à la Flore du Paraguay, by Mare Micheli, Genève, 1883–1892, 5 parts, 4°.

WEST INDIES.

Flora of the British West Indian Islands, by A. H. R. Grisebach, London, 1864, 8°.

EUROPE IN GENERAL.

Conspectus Floræ Europæ, by C. F. Nyman. An almost indispensable catalogue. Örebro, Suecica, 1878–1882. Suppl. 1 and 2, 1883–4 and 1889, 8°.

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ing certain costly and rare volumes treating, say, of palmæ or orchidaceæ. Upon our American characeæ Dr. T. F. Allen is the authority. Any recognized special student receives many letters of inquiry, and usually answers them all, though it be but briefly, provided the return postage is enclosed.

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