COLLECTION AND CARE OF BOTANICAL SPECIMENS

RESEARCH BRANCH
CANADA DEPARTMENT OF AGRICULTURE

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CANADA DEPARTMENT OF AGRICULTURE

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INTRODUCTION

This handbook is intended for both amateur and professional botanists. It is unlikely that anyone will be interested in all the topics but the material is arranged for ready reference to a particular subject or type of plant.

Concise accounts are given of procedures and devices that have been tried at the Plant Research Institute and found to be best for collecting and preserving botanical specimens. Outmoded equipment such as the vasculum is not discussed.

The instructions for preparing specimens of vascular plants and fungi are much more detailed than those for bryophytes, lichens and algae. This is because, first, some of the methods described in the first two chapters are applicable to the others. The reader who has learned to use presses and driers in Chapter 1 can readily apply this knowledge to other groups of plants without specific instructions. Second, the Institute is at present concentrating much more on the vascular plants and fungi than on other groups. It is, accordingly, chiefly in the collection and handling of these plants that we have original ideas to offer.

The later chapters are included for the beginner and the general collector rather than for the experienced bryologist, phycologist or lichenologist. They contain very little original material but include enough information to enable the beginner to collect any group of plants unassisted and with some success.

It is hoped that this manual will be of some assistance to advanced workers in phanerogamic botany and mycology. They may add to their own methods what appeals to them in this work. The advanced worker in other fields will find what he needs in more specialized works. For example, the treatment of the microscopic algae does not go beyond field operations. The further handling of these plants is remote from the methods used with most botanical specimens and properly belongs in a course on phycology.

Although many of the methods described are applicable to the tropics, this manual does not deal with problems peculiar to tropical regions. It is based mainly on experience gained in temperate, arctic and alpine Canada and is most useful to collectors in countries with a somewhat similar climatic range.

Considerable emphasis is placed on arctic and alpine collecting. This is a field that has until recently been neglected, both in quality and in quantity of specimens, and is only now coming fully into its own. In his training as a student in the temperate zone the average botanical collector never encounters, or even learns of, some of the problems that will beset him on his first trip up a mountain or into the north. Arctic collecting offers a variety of problems that, if not solved promptly, may be serious and unpleasant in a region where the field season is very short and travel costs are high. Both the comparative inaccessibility and the small but highly dispersed flora of the arctic make it desirable that arctic collectors be prepared to collect all groups of plants with the smallest possible loss of time. Varied experience in several parts of the Canadian arctic and in the alplands of the northern Cordillera has given our field parties the opportunity to overcome many of the difficulties.

This book is based on the experience and suggestions of various staff members and is accordingly to be regarded as a product of the Institute. I must explicitly acknowledge the help of Mr. W. J. Cody in drafting much of the material on herbarium methods found in Chapter 1, and of Dr. W. G. Dore, who has long been accumulating information on field and herbarium techniques. For the last three chapters it is a pleasure to acknowledge the advice in the field or through correspondence of Drs. Howard A. Crum, Herman Persson, William C. Steere, William Randolph Taylor, and William A. Weber. Much use has been made of the instruction booklets for naturalists in the armed forces, written by Dr. Steere and Dr. Taylor and published by the University of Michigan. Some use has also been made of the revised edition of Dr. Taylor's *Marine Algae of the Northeastern Coast of North America.*

INTRODUCTION TO REPRINT EDITION

I am grateful to the many colleagues who commented on the original book. I recently received notice that immediate reprinting was planned; but at such short notice extensive rewriting was not possible. Many comments accordingly had to be omitted.

New material and the comments that seemed to have wide usefulness and could be handled concisely have been incorporated in numbered addenda at the back of the book; but controversial items that would have required lengthy discussion have been omitted. Footnotes at appropriate places in the text draw attention to each of these addenda, which are also referenced back to the pertinent text page. I apologize belatedly for the dictatorial style of much of the text, which resulted from changes made after it left my hands.

Most of the additions stem from Mr. W. J. Cody, Mr. K. W. Spicer, Dr. J. A. Parmelee, and myself.

D.B.O. Savile
Ottawa
October 1972

CHAPTER 1

VASCULAR PLANTS

Collecting

The Specimen

Making satisfactory specimens of flowering plants, ferns and fern allies requires ample and well-pressed material labeled with all pertinent information.

In collecting small herbaceous plants, take the whole plant, including the root system; the type of root system or the presence and shape of bulbs or tubers may be diagnostic. Fold tall plants neatly to a length slightly less than the width of a newspaper. They will then fit on a standard sheet of herbarium mounting paper ($16\frac{1}{2} \times 11\frac{1}{2}$ inches).

Large and bulky plants must be trimmed in various ways. Split the lower part of a very thick stem, or a fleshy crown. This treatment hastens drying and, by enabling the elements of the press to come together more closely, prevents the leaves from wrinkling. Occasionally remove some leaves; otherwise they will lie several deep on the sheet. Do not try to conceal the removal of leaves, but cut them off close to the stems, leaving short stubs that will enable an examining botanist to see the number and positions of the leaves. Do not remove too many leaves from one part of the plant, for the leaves may vary in form from the bottom to the top of the stem. Leave all the leaves on if you can; spread them out or bend the petioles of some of them to prevent overlapping and crowding.

Tall plants with large leaves, such as *Heracleum maximum,* are difficult to prepare. You may have to make a two-sheet specimen, with the inflorescence and a small upper leaf on

one sheet and a middle or lower leaf and a short section of split stem on the second sheet. Then include in accompanying notes data not evident from the specimen, such as plant height, size of largest leaf and thickness of stem at base.

If the plants are only about 6 inches high and have a single flowering stem, take six or eight of them for mounting on one sheet. Select plants that show the normal range in variable characters such as height. When collecting minute plants, take a dozen or more, as many of these bear only one or a few flowers or fruits. If plants are to be sent away for identification take enough for at least two sheets, one for the collector and one for the determiner.

Specimens of trees and shrubs should include vegetative shoots, flowering or fruiting shoots and patches of bark, cut to fit the sheet. Make notes on estimated height, trunk diameter at breast height (d.b.h.) and habit (tree or shrub, spreading or columnar, branches erect or pendulous, or similar information).

It takes very little time and is helpful to include extra flowers or fruit with the specimens. They are eventually put into packets, and can be used for dissection without the mounted specimen being mutilated.

With various plants, fruiting material is more important than flowering material. This is particularly true of the Cruciferae (mustard family), Onagraceae (evening primrose family), Umbelliferae (carrot family), Juncaceae (rushes), Cyperaceae (sedges), and (young fruit only) the genus *Salix* (willows); but this recommendation applies in different degrees to a variety of plants. Even fruits that are not important to the taxonomist may be necessary for a proper understanding of the natural history of a plant. Most herbaria contain inadequate fruiting material of many plants. It is thus generally advisable to collect both flowering and fruiting material whenever possible. Sometimes flowers and fruit occur at the same time on the same plant; sometimes flowers may be found in a shady spot or moist depression after most of the colony has gone to fruit. With the complex genus

Crataegus, in which flowers and fruit do not occur simultaneously, you should, if possible, tag the tree from which flowers are taken and return later for the fruits. Collect grasses after they have started to flower, when the anthers may be seen hanging from the florets. They may be taken somewhat later, after the anthers have shriveled; but if they are taken fully ripe the seeds usually shatter out badly and a poor specimen results. Sedges (Cyperaceae) should be taken in nearly full fruit; some species that shed their fruits readily when fully ripe must be collected before the heads break up when pressed between the fingers.

Remove as much of the soil as possible when you dig the plants, to avoid disfiguring them. It is often impossible to remove soil particles from plants that have viscid hairs; and sand grains may bruise and blacken delicate leaves. The more soil you remove at the time of digging, the more thoroughly you can clean the plants before putting them into the press. A difficult problem is presented by glandular-viscid beach plants, such as *Glehnia littoralis,* which are usually encrusted with sand when you collect them. Such plants are always robust, however, and may be washed in the sea or in a pool or stream without damage. By soaking them for a few minutes and wiping the submerged leaves, you may remove most of the sand. The roots of plants growing in clay or bog soil must generally be washed in water. The dense tangle of roots of some rhizomatous grasses and sedges often presents a difficult problem. You may often save time by standing some clumps in water while working on others. If you are near a fast brook or a beach with breaking waves, weigh down the plants with stones so that the roots are in the moving water, but the tops out of it, and leave them while collecting other plants.

Some arctic and alpine plants have several years' accumulation of dried leaves at their bases. Do not remove all of these leaves, because they are sometimes an aid in identification (for example, in *Potentilla*). Similarly, fibrous remains of old leaves (for example, in some *Carex* or Umbelliferae) should not be cleaned off completely.

Field Notes

Make notes in the field on any items that may not be obvious from the dried specimen. It is from this information that the final label must be prepared (Figure 2). Include colors, especially of flowers, which often change in drying; scent; records of blossom-visiting insects; height and habit of plants too large to be included intact in the specimen; associated vegetation, such as type of forest or grassland; degree of shade; approximate soil type and soil moisture; elevation, at least in mountain country; exposure; slope; locality; date; collector's name; and collection number. All collectors should regularly use collection numbers. A simple numerical sequence that goes on from year to year is much better than a complex system that starts anew each year. Apart from other uses, the collection number greatly simplifies the citation of specimens by students who use the specimens in later years.

If the stature or habit varies greatly with soil moisture, shade or any other factor, record the extremes of variation. Elevation is important in mountainous country, and the elevation range is equally important; but the range of elevation may differ markedly on the two sides of a mountain or ridge. Exposure is important, especially in mountainous areas. A southern exposure generally speeds flowering in the north temperature zone. In the arctic, however, exposure is often more important for its relationship to the direction of the winter wind, and the snow that accumulates on the down-wind slope of a steep hill, bank or cliff and covers the ground for most of the summer. Near a seacoast the seaward slope is generally much wetter than the landward one. The insect relationships of many genera—even of some entire families—are still almost unknown. It is therefore important to record as precisely as possible the type of insect visitor whenever one is seen at a rare plant or one that grows in inaccessible places.

The method of recording data depends on circumstances and personal preference. A simple method is to use a field label, an example of which is shown in Figure 1. This is

DEPARTMENT OF AGRICULTURE, OTTAWA, CANADA

FORM SB 245
15516-MX-751

NAME Astragalus
eucosmus Rob

LOCALITY Yellowknife, N.W.T.
Baker Creek at Giant
Mine 62° 27'N 114° 22'W

HABITAT clay soil in valley
of creek

DESCRIPTION fls. purple
plant ascending

local- rare

DATE June 30, 1949

No. 2339

COLL. Cody & McCann

DET. B B Boivin 1950

Figure 1.—Example of completed field label. The printed form is generally filled out in pencil at the time of collection. The name of the plant is added later.

generally a printed form with headings for the different types of data. The information is recorded, usually in pencil, on the spot when the collection is made, and the label is put in the field press with its specimen. When the permanent labels (Figure 2) are prepared by someone other than the collector, some kind of field label is necessary.

PLANTS OF MACKENZIE DISTRICT
NORTHWEST TERRITORIES, CANADA

Astragalus eucosmus Robinson
det. B.Boivin 1950

Plant ascending; flowers purple.
Rare in clay soil in valley of creek
Local.

Yellowknife: Baker Creek at Giant Mine.
62°27'N 114°22'W

2339 W.J.Cody & J.B.McCanse June 30,1949

DEPARTMENT OF AGRICULTURE, OTTAWA, CANADA SA 165
23268—PM—957

Figure 2.—Permanent label prepared from field label shown in Figure 1.

When time in the field is at a premium, and the collector is making 50 or more collections a day, making out field labels takes too long. Under these circumstances we have used the following method. Data that may be forgotten or confused before the day is over, such as altitude in mountain collecting, are written on the sheets in the field press (and stroked through at the end of the day, since the sheets will be used for other collections next day). At the end of the day, generally as the plants are being pressed, collection numbers are assigned and the data are written in the field notebook. Suppose that 15 species are collected from a

particular habitat such as an alpine meadow at 6,200 feet. For the first specimen, let us say "10,844, *Claytonia lanceolata,*" we record full information. For the others we write "Hab. 10844" and other data peculiar to each specimen. By this method as much as an hour may be saved in the time spent in recording the data for a heavy day's collecting. Even more important, you may save about two minutes per specimen in the field. Such a saving is vital when you climb a mountain in the morning and must be down again before dark, or when you are put ashore for a limited time from a boat or aircraft. True, a little of the time saved is later lost when you are making up the permanent labels, for you often have to turn back a page in the field notebook to check a habitat. The field notebook is the key to this system and must be most carefully preserved. It should not actually be carried in the field, but should be kept in the vehicle or building that serves as a field base.

Various modifications are possible in the method of recording data. Some workers take a portable typewriter into the field and in the evening type a master label and one carbon copy for each of the day's collections that will yield more than one sheet. (The original label stays with the specimen while the carbon is being used for making copies.) This method allows labels to be made with a minimum of reference to notes, and it certainly saves time after the return from the field. But it cuts into one's time in the field and demands a more punctilious adherence to a timetable than most of us can achieve when the collecting is good. Another alternative that we are starting to test, and that should prove practical when the collector is based on a place with a standard power supply, is to dictate label details into a portable tape recorder (complete except for the name of the plant, which would involve the stenographer in too many spelling problems). This method has already been tested at Ottawa, and seems to depend only on adequate stenographic service. It should certainly be less exhausting than using the typewriter at the end of a heavy day's work.

Equipment

Besides a container for the specimens, which is described in the next section, several items are needed for general collecting.

The most important item is a sturdy instrument for digging plants. A really stout sheath knife will serve, but a cut-down bayonet is much better. I prefer a well-made botanist's trowel, but it must be made of heavy-gauge tool steel and should be strongly curved for added stiffness. Some trowels on the market are flimsy; rather than attempting to use one of these, get a blacksmith to make you one. A light digger soon bends or breaks when used in stony ground or for cutting through a heavy sod.

Those of us who are absent-minded prefer to drill a hole through the handle of the digger for a lanyard of rawhide or lacing cord (*not* string, which quickly unravels). Tie a knot in the end of the cord to secure it to the digger. Make a loop in the other end and slip it over the belt. The digger may then be carried, handle down, in a pocket; or, preferably, in a scabbard on the belt, hand-sewn with heavy waxed thread and a sailor's palm out of a piece of wide webbing strap (Figure 3). Support the scabbard from approximately the height of the top of the digger. If the loop is too low the heavy-handled digger will turn upside down and fall out. When you are wearing a parka or other long-skirted coat, carry the digger on an extra belt worn outside the parka; otherwise you will always be groping for it.

A sharp knife should be carried for cutting and trimming large specimens. The digger should not be used as a knife. You cannot keep an edge on the blade near the tip; and if you keep a keen edge on the basal part of the blade you may suffer a seriously cut hand.

Pruning shears are useful especially for cutting spiny plants, and should always be carried when there is much likelihood of collecting such specimens; but they cannot replace a knife for some purposes, and may be omitted when you must travel light. The compact type whose blade cuts against a soft metal pad is preferred.

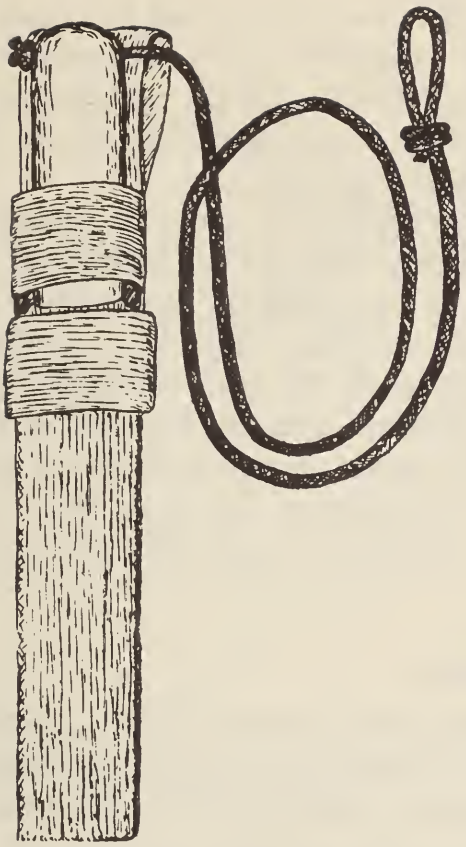

Figure 3.—Digger in sheath made from webbing strap.

In mountainous country an altimeter is necessary unless large-scale topographic maps are available for the whole area, and even then it will be a great convenience. Some of the cheap altimeters sold for installation in cars are practically useless; they are inaccurate and subject to such severe hysteresis that they may read about 1,000 ft. different on the ascent and descent at a given point. A reasonably good pocket aneroid is satisfactory. It is neither necessary nor desirable to use a highly sensitive surveyor's instrument, since an error of 100 feet or so is of little importance in determining plant distributions on a slope of several thousands of feet. For use in a car an old aircraft sensitive altimeter cannot be beaten, being easy to read and sufficiently sturdy. Every few years it should be recalibrated and a correction

table taped to the case. Any aircraft instrument shop will be able to do the calibration; or, if necessary, it can be done in the laboratory under a bell jar, with the aid of a vacuum line and a sensitive manometer. The method is described in aircraft instrument manuals.

There is little need to list here the general run of non-botanical equipment for field and camp; but one item may be mentioned. If you expect to spend much time in a tent with next to no furniture, there is a problem involved in keeping books, notebooks and miscellaneous small items from becoming damp, dirty or dispersed. A large brief-case of the type that stands up and opens like a gladstone bag is excellent for the purpose. For brief trips, when you are traveling light, such items as you need can be put in a plastic bag.

The Field Press

Of the many means that have been used to carry plants until they can be transferred to the press, there can be little doubt that the best, under nearly all circumstances, is what has come to be called the field press. Actually, it is a satchel or portfolio rather than a press, but the name is now established. The field press seems to have been predominantly a North American development. Various institutions have evolved serviceable designs from crude early models. The one described below, and illustrated in Figures 4 and 5, is the joint development of several members of the Institute. In its present form it has proved satisfactory under a variety of arctic, alpine and lowland conditions.

Construction.—Basically the field press is a satchel of lightweight waterproof fabric. Until recently we used waterproofed canvas, but we have now changed to a rubberized nylon fabric, which, although initially more expensive, is very light and almost indestructible. The dimensions are based on the corrugated cardboard ventilators, 18×12 inches, used with the plant press, described later in this chapter. A ventilator is slid into a pocket at each end of the

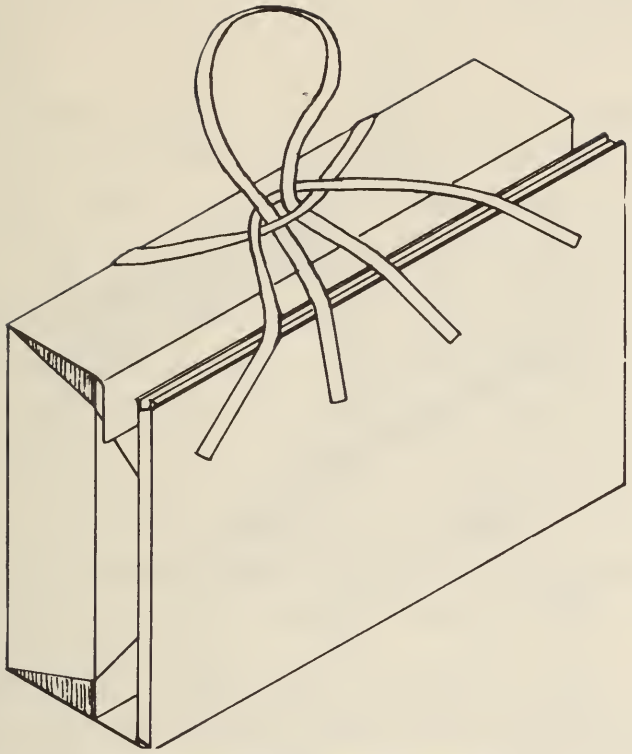

Figure 4.—Field press in use.

field press to stiffen it. These pockets also serve to hold small pieces of equipment, such as labels, paper or plastic bags, maps, and often the collector's lunch if he is out on foot for the whole day. It will be seen from the illustration that there is a flap at one side which covers the top of the closed press, reducing drying of the specimens and protecting the paper and cardboard from rain. At each end of each half of the press there are other flaps that are folded inward to reduce drying and prevent the loss of small specimens. These flaps hook together, being closed with a strong but quick-releasing hook-and-eye fastener that may be made or bought locally. They are mounted on light webbing straps with a sliding length adjuster. The webbing is attached to a loop of shock cord (rubber strands with a woven cotton covering), which slides through a casing in each side of the flap. The shock cord is securely sewn into the base of the flap, by hand sewing with heavy thread through both rubber and canvas, with the

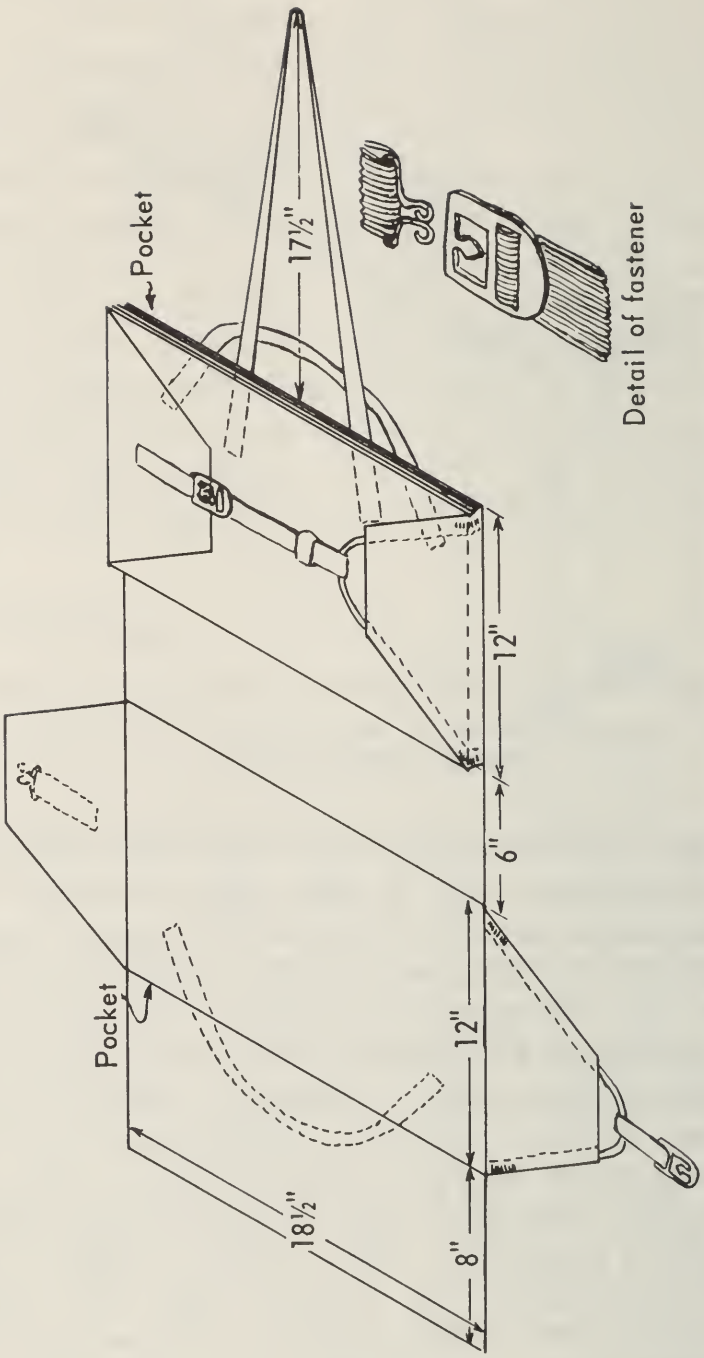

Figure 5.—Field press opened to show construction. For details see text.

aid of a sailor's palm. Attempts to anchor the shock cord by pinching it with machine stitching have always proved ineffective, but stitching repeatedly through the cord anchors

it for the life of the field press. The shock cord must be anchored at the base of the flap to allow adequate extensibility.

Use.—Place a supply of cut and folded newsprint in the side of the press without the covering flap. The paper is held in place with a cardboard ventilator and the tension of the shock cord. As specimens are collected, lay sheets of paper in the other side with the hinge towards the center of the field press. Place specimens as neatly as possible on the sheet and fold the sheet over them. Add a cardboard and hook the flaps together over it. Start with the webbing straps adjusted so that the specimens are held snugly. As the bulk of the specimens increases during the day it may be necessary to slack off the straps. If this side of the press becomes very heavily loaded, start inserting specimens in the opposite side with the supply of paper, which will now be greatly diminished.

On hot, dry days spread a few handfuls of grass or other foliage over the bottom of the press before the first specimens are inserted, otherwise wilting will soon occur. Under very arid conditions it is advisable to start with damp paper. If the paper is not sufficiently damp from the previous day's work, sprinkle a little water here and there between the sheets. There are a few plants, such as *Melampyrum lineare,* that are very hard to collect without the leaves wilting and crumpling. If possible take a press to the colony and press the plants directly. If this procedure is impractical, lay the plants in the field press in soaking wet paper.

Some collectors prefer to lay out their plants for the press directly in the field press, and to transfer them to the press in the same paper. Others use fresh paper in the press and do their final laying out after returning from the field. Whichever method is adopted depends partly on personal preference but largely on field conditions. If one is working in very hot weather, when rapid wilting is to be expected, there is an advantage in pressing the plants without rehandling; for limp leaves and petals may easily be damaged. When this method is used it is important that the

tension on the specimens should be strong, to prevent their slipping. The webbing straps should be tightened and it is as well to use two cardboards over the specimens, including one with the corrugations running lengthwise.

There are various circumstances that make the final laying out of the specimens in the field impractical or even quite impossible. In windy situations, such as predominate in arctic, alpine and seacoast areas, rearrangement will always be necessary. Many plants that form dense rosettes are too heavy to keep their relative positions in the field press completely. (Fortunately such plants usually are not delicate and may generally be piled in without injury.) When biting insects are a serious pest, as is generally true in the boreal forest and subarctic, even the most stoical collector will do a worse job of laying out specimens in the field than indoors. Whenever collecting time is scarce—on short stops ashore from a boat or plane, stops on a trip with an inflexible schedule, or day trips up a mountain—the time needed for perfect cleaning and final laying out in the field is completely unjustified, for it may halve your collecting volume.

Under more favorable circumstances one must balance the risk of damage to possibly flaccid specimens against somewhat dirtier specimens of whole plants (since the first cleaning can hardly ever be complete), a slightly longer drying time that results from putting damp paper into the press, and the occasional annoyance of having to write on a sheet of paper that has parts of plants under the corner on which you wish to write. In using the direct layout method you put clean dry paper in your field press each day; but there is some advantage in using slightly damp paper from the previous day if the weather is at all conducive to wilting. Except where the plants are flaccid, somewhat better looking specimens almost always result from transferring them to fresh paper in the press; this is particularly true of herbaceous plants, which usually bear some loose soil no matter how carefully they were cleaned when collected. If soil particles are pressed on the leaves they cause permanent disfigurement.

The length of time that plants can be kept in the field press without damage varies widely with the weather. On scorching days in the Upper Sonoran regions of southern British Columbia we have found it advisable to press the morning's collections before lunch and those of the early afternoon at about 4 p.m. The presses are carried in the panel truck that is used as a mobile base. Usually in southern Canada, plants can be kept all day in the field press if it is kept tightly closed and out of the sun and wind. In the arctic, at the other extreme, we have kept plants up to eight days in good condition in a field press kept tightly closed and sheltered from the sun and wind. If necessary, in the arctic you can peel off a layer of mosses or other plants and place the field press under them within a few inches of the permafrost. Although long delays are not ordinarily recommended, they may occur if one is weather-bound away from one's base. It is much better in cool, moist climates to keep the plants fresh in the field press than to put them in presses without adequate heat, when browning always occurs. For short boat or plane trips away from base the presses may be left behind at a substantial saving of space and weight.

It will be seen from Figure 4 that the field press has both handles and a sling that serves as a shoulder strap; both are made from several layers of the fabric used for the construction of the field press. The handles are used for carrying the field press during active collecting. When the press is heavily filled, or when one is returning from a long hike, the sling, which is passed through both handles and slung over one shoulder, provides considerable relief. The sling serves two other functions. You can put your head and one arm through it and hang the field press across your back, leaving both hands free on cliffs and steep slopes or when pushing through dense thickets. The sling can also be put through the handles and pulled over the end of the field press, holding it closed—a feature that has proved useful when frequent loading and unloading of cars, boats or planes has been necessary.

Special Clothing

Although clothing requirements for field work in temperate regions are usually readily settled by experience and common sense, there are some special conditions that are worth considering.

Boots.—When collecting is to be done in a great variety of habitats, boots probably cause more trouble and argument than any other single piece of equipment. No one type of boot is well suited to all circumstances. If you are working continually in the humid forest of the Pacific coast, with moss-grown logs lying everywhere, there is nothing to beat the logger's caulked boots of good solid leather. Leather boots without caulks are preferable for general work in warm regions, where rubber boots keep your feet perpetually wet with perspiration. Caulked boots are impractical in settled country, for you will be most unpopular if you wear them into restaurants, cabins, or people's homes. Keep leather boots well greased with a commercial leather dressing or a mixture of one part beeswax and three parts mutton tallow. If frequent trips are to be made into bogs or marshes, and time is at a premium, take along a pair of pull-on rubber boots to wear over your shoes. For collecting aquatic plants in fairly deep water waders are generally satisfactory; but, if the water is warm, swimming trunks and canvas running shoes will serve. If the area is dry ordinary low shoes may be practical for some conditions. But they are uncomfortable for rough ground; and in the dry range lands of British Columbia, where *Bromus tectorum* is thick along the roadsides and its seeds riddle your socks each time you leave your car, you will soon abandon them. The type of boot with rubber below the ankle and leather above is a fair compromise when much bog or marsh collecting is involved. However, the leather uppers do not remain fully waterproof for long; and this type of boot is hard on the heels of socks unless thin leather 'sock savers' are used. In cool conditions, when much wet ground is anticipated and perspiration is

not a serious problem, laced rubber boots reaching nearly to the knees are satisfactory. They should be large enough to fit snugly over two pairs of heavy wool socks. The double socks absorb most of a day's perspiration better than the traditional single socks and heavy insoles. They also creep less than insoles when you are walking all day. Such a boot proved much the best in the cool bog country of the Queen Charlotte Islands, where the colloidal material of the bogs quickly emulsified and washed out the grease from leather boots.

Water-repellent clothing.—Some sort of water-repellent clothing is necessary for the collector who is continuously in the field in regions of high rainfall. Rubber- or neoprene-impregnated clothing is almost essential for wear in heavy rain. Its disadvantage is that it is water-vapor-proof; and, if you are doing strenuous work or the weather is warm, the perspiration condensing inside it soon makes you wet. People who first experience this phenomenon often refuse to believe that the garments are not leaking. It seems to be impossible to ventilate either a full suit or a long coat of such material sufficiently to prevent this trouble without letting the rain in. Opening the neck and 'pumping' at frequent intervals by moving the garment to and from your body helps to ventilate it. In a continuous drizzle in the Queen Charlotte Islands we found that we stayed drier without such suits than with them, and generally wore field jackets and trousers of heavy cotton drill, which could be dried out at a campfire. I have used a neoprene-nylon suit with considerable success in cold arctic rains, when camping in small tents where the drying of clothes was very difficult. Trousers or leggings of such material are also excellent for travel through brush or long grass in wet weather. Mere water-repellent clothing is soaked in a few minutes under such conditions. If the trousers are worn with a jacket or coat that is water-repellent but is pervious to water vapor it is possible to stay reasonably comfortable. Raincoats or jackets should have hoods; but if you wear glasses a cap with a long peak is also advisable.

Windproof clothing.—Windproof clothing is often desirable for alpine collecting and is essential on most days in the less benign parts of the arctic. Arctic-alpine conditions are sufficiently variable to prevent any single type of clothing from being ideal. You will likely be warm enough while climbing a mountain to be comfortable in cotton shirt and slacks and hip-length unlined zippered jacket with a hood. Unless the weather is obviously warm and windless and your time above treeline is to be short, you should also carry a sweater in your field press or a rucksack to put on just before leaving the shelter of the trees. The jacket should be worn open, for ventilation, until its full warmth is needed. Throwing up the hood, without drawing it tight, nearly doubles the warmth of such a jacket when you are working in a strong wind. Under conditions of variable temperature, but not extreme cold, the unlined windproof jacket with a good sweater or a mackinaw woolen shirt is better than a heavy parka because it gives you greater range of protection.

In most parts of the arctic, wind is the botanist's chief enemy; it blurs vision, makes it difficult to handle collecting equipment, and causes considerable discomfort. The choice of clothing again depends on circumstances. On a sunny day with an air temperature of 50° F. you may be perfectly comfortable in cotton shirt and slacks, or even without a shirt, as long as there is no wind. But even a moderate breeze makes at least an unlined parka necessary, and you should always carry one unless you are working very close to camp. Two jackets can be used with benefit. A front-opening parka, either with a detachable lining or supplemented by a mackinaw shirt, is best for general use when working from a building in moderate weather or for short intervals. If it closes with a zipper there should be a supplementary buttoned flap to keep the wind out. For really strong winds (you may have to work in winds of 30 to 40 m.p.h. because you cannot afford to wait for improved conditions), and especially if you are going to be out for long periods, a true parka or anorak is preferable. This is a loose jacket

of closely woven duck or other stout and windproof material, opening only at the throat with a short bellows insert that is closed by a zipper or lace. The hood is sewn on and should fit snugly, even without use of a drawstring, when the throat is closed. The jacket should be long enough so that a strap can be buttoned under the crotch. This last feature prevents the wind from whistling up your back each time you stoop. The anorak should be a slack fit even with heavy clothing under it, not only because of the extra warmth that results from a loose fit, but to make it easier to pull off without assistance. If you find you are getting too warm, open the throat and pump some air in and out; for if you let your clothes get damp with perspiration you may chill badly before you can get back to camp. All parkas should have large side pockets, and they should also have extra pockets at chest level to hold objects that would be crushed in the lower pockets when you bend down.

Windproof trousers of heavy duck that pull on over regular trousers are nearly ideal for windy weather. Some are supplied with tapes to tie under the instep, which keeps them from working out of your boots.

What you wear under your windproofs is largely a matter of personal preference. If you must do your own laundry in camp with a minimum of hot water you are unlikely to favor long underwear. My own preference is for cotton shorts and a string undershirt, which are easily washed. The string undershirt holds your shirt away from you, making a layer of still air with good insulating value. A flannelette shirt with either a sweater or mackinaw shirt over it will provide enough warmth for most conditions; but on extremely bitter days both may be appreciated. The mackinaw shirt is better than a sweater because it hangs loose and is not as likely to ride up around your waist. Cotton slacks are usually adequate under the windproof trousers, but woolen ones may be preferred on exceptionally bad days.

New synthetic materials both for the covering and for the insulation of parkas have been appearing on market recently.

Garments made from them are very light, yet warm. New closures, to improve windproofness, are also becoming available. You should check with all the suppliers in your region before making a choice.

Biting Insects

In much of the Canadian boreal forest and subarctic, biting insects are numerous enough to constitute an actual hazard to health rather than a mere annoyance. Collectors new to such country, who have acquired no immunity to the toxins of these insects, should treat them with respect. Some minor groups are intermittently annoying, such as the tabanids, which give a painful bite but are seldom very numerous, and the minute nosee-ums, which may alight on you in a cloud and cause a diffused burning of the skin that is, fortunately, seldom prolonged. However, the important insects are the mosquitoes (mostly *Aedes* spp.) and the blackflies (Simuliidae), of which several species will almost always be present in any northern spruce forest and muskeg area.

Although mosquito bites may be sharply painful at first and the irritation may last for some hours, the toxic effect is usually slight. If you wear tightly woven but loose clothing, closely fitted at neck and wrists, any good modern repellent on hands and face will generally reduce their annoyance to a minimum. An unlined parka with a hood and zippered front is a great help. A significant aspect of the mosquito nuisance is the psychological effect of hundreds of the insects humming about you. The novice must cultivate a philosophical attitude and remind himself that he will not actually be sucked dry; for otherwise he may spend more time in the unproductive occupation of swatting a minor fraction of the horde than he spends in his work.

To most people blackflies are a much more serious menace than mosquitoes. Being short-legged and more robust than mosquitoes they often get inside one's clothes unobserved and uninjured. They may bite repeatedly, unnoticed, for the

bites seldom start to itch for several hours and may then itch for days. Even the stoic who does not scratch the bites while awake may do so in his sleep; and the scratched bites often fester, making a sore that is slow to heal. Blackfly bites are much more serious on untanned skin than on the tanned and thickened skin of hands and face. Preventing the insects from getting under your clothing is therefore most important. When applying repellent, pull up your sleeves and loosen your collar, and apply the material several inches above the wrist and low on the neck. Blackflies will not cross such a barrier. A gaping buttoned shirt invites trouble. Cover it by a hip-length zippered jacket of light material or an unlined parka. Fasten trousers securely inside your boots. If you wear two pairs of wool socks, one inside and one outside your trousers, a blackfly can seldom penetrate by this route. Always fold the trousers at the back of the leg, for the fold is always higher than the rest of the cuff; if it is in front it is easily pulled out of your boot when you bend your knee.

Repellents are seldom effective for more than three hours, and wear off considerably faster when you perspire freely. Always carry a bottle of repellent—in a buttoned pocket to prevent accidents. When you must use it in the field, take care to pile cap, glasses, wrist watch, etc., on the field press, so that nothing will be lost.

Special Collecting Techniques

Some of the information in this section involves pressing and drying rather than collecting. However, some duplication will be eliminated by including it here. Moreover, since some of the precautions must be taken before the specimens are pressed, their discussion at this point is not seriously out of order.

Aquatic plants.—Although some aquatic plants are firm enough to be handled like land plants, many others, such as *Ruppia, Zannichellia,* and some species of *Potamogeton* and *Utricularia,* are so delicate that surface tension clumps all the leaves together as soon as they are taken from the water.

Float such plants onto sheets of paper; raise the sheets horizontally until the plants are caught on them and then gradually tilt and withdraw the sheets. Sheets of herbarium mounting paper or other high quality paper should be taken on field trips for this purpose. Cut the sheets in half or quarter size for this purpose, as it is hard to float out several small plants on a single large sheet. Preferably, wash the plants in the field, bring them back to your base in mass in the field press, and float them out in a sink. If there are no facilities for floating plants in camp, it may be best to float them in the pool from which they are collected. If there is much wind, floating plants in the field may be very difficult, and you may need to transfer the plants to a more sheltered pond.

For filmy aquatics prepasted mounting paper has been tried with some success at this institute. Not all the dry paste washes off in the brief immersion of the paper. However, to prevent adhesion of the newsprint to the mounting paper, cover the specimen with wax paper.

Many aquatics are covered by a mucilaginous slime, often the product of microscopic algae, which sticks them to the mounting paper. Cover very delicate species with wax paper; otherwise they may adhere more firmly to the newsprint than the mounting paper and you may ruin the specimen in trying to remove it from the paper. Aquatic plants dry so quickly that, although the wax paper halves the drying rate, the delay is not serious. These plants may adhere so firmly to the mounting paper that they need only reinforcement at a few points to complete the mounting. See also discussion of floating marine algae in Chapter 4.*

Sticky plants.—A few plants, such as *Drosera,* are so sticky that when they dry it is hard to open the newsprint to remove them. Unless you experiment first with a very few plants, *do not* try to avoid this problem by inserting waxed paper on one side of the specimens before drying them, for some plants, including some species of *Drosera,* stick more firmly to wax than to plain paper. With some of these plants

* See addendum 1.

you might try the phycologist's practice of covering the specimens with muslin, as described in Chapter 4, but there is no certainty that the technique will work. Until better means can be devised, it seems best to press the plants in the ordinary way, and later to pull back the paper at an acute angle, rather than to lift it up, easing it away from the plants with a sharp knife where necessary. If some paper cannot be freed by this means, dampen it with a wet cloth, or use a wetting agent, and peel the paper off as soon as it loosens. If this is done quickly the specimen remains almost perfectly dry and will not curl. This technique also applies to various berries.

Fleshy plants.—Many fleshy plants dry very slowly, partly because of a heavily cutinized epidermis but perhaps chiefly because the water is colloidally bound within the cells. Occasionally the delay merely calls for patience. We have had specimens of some populations of *Montia parvifolia* in the presses for a month with nearly constant heat yet the specimens finally came out with excellent color retention. Unfortunately the delayed drying is often more serious. *Portulaca* may be pressed in flower and removed in mature fruit with leaves shriveled, detached, blackened and sometimes moldly. *Opuntia* may produce etiolated shoots that grow right out of the press and bear little resemblance to the original specimen.

Large fleshy plants may sometimes be split and most of the pulpy contents either left in place or removed. This method has obvious limitations. It is too tedious to use on small plant parts; and it would take both skill and fortitude to split any great number of *Opuntia* pads covered with needle-sharp, barbed spines.

For many fleshy plants the key to the problem of drying seems to lie in the fact that cells that firmly retain their contained water in life lose it readily when they are killed. It remains to find the most effective killing agent, one that is cheap, readily available, does not discolor or otherwise modify the specimen seriously, is not irritant, and preferably

leaves no residue on or in the specimen. No fully satisfactory killing agent seems to have been found, although many have been suggested. Limited trials at this institution, with *Portulaca oleracea* as a test plant, suggest that a brief dip in boiling water or dilute methyl or ethyl alcohol (25-50 per cent) is about as effective as any more elaborate killing agents. Prolonged boiling must be avoided, since it simply causes soft tissues to disintegrate. For small-leaved plants a dip of 5 to 30 seconds seems to be adequate. For large cacti, etc., longer periods are needed to ensure adequate penetration, but large variations sometimes have little effect on the quality of the specimen. If for killing a plant you use any chemical that leaves a residue on or in the plant, include a note to that effect on the label, for the treatment might affect a biochemical test applied at a later date.

Barrel cacti and similar difficult subjects must be treated differently. Slice off a superficial patch large enough to show any pattern, for example, of spine arrangement, and cut a thin transverse slice to show the form of the stem. Photographs of the whole plant are important. Although you will wish to keep a few cactus flowers attached to show how they are borne, most flowers should be detached and pressed on separate sheets, some face down and some on their sides. If they are pressed on the same sheet as the rest of the specimen the petals will usually wrinkle from inadequate pressure and their drying may be delayed. By themselves, many cactus flowers dry readily and retain their color well.

Spruce and hemlock.—Christmas-tree buyers as well as botanists know all too well the way *Picea* and *Tsuga* shed their needles once they start to dry. This shedding may be prevented by killing the cells at the leaf base before abscission starts. Unfortunately all the killing methods that have been suggested cause considerable browning of the foliage. Chemical treatments to prevent the browning or to substitute other green compounds for the natural green of the needles have been suggested, some of them very elaborate and quite impractical for use in the field. All chemical treatments have

some inherent drawbacks: they may change the appearance of leaves or twigs sufficiently to suggest genetic differences; they may interfere with the later application of chemical tests for diagnostic or other purposes; and any foliage parasites on them may be rendered useless as specimens.

Most collectors press these plants without treatment and later put the loose needles into packets mounted on the sheets. This method does not make a pretty specimen, but the twigs and needles are preserved with a minimum of change and the specimen is satisfactory for taxonomic purposes. An alternative that has been used with some success at the Institute is to spread adhesive on the back of the fresh specimen, lay it on a sheet of mounting paper, cover it with wax paper (in case surplus adhesive should well up between the needles) and press it in the ordinary way. The needles separate from the stalk but are held in position on the sheet. This simple method is very satisfactory on day trips, when the specimens are processed in a well-equipped preparation room; but it is unlikely to be popular on long trips, since it involves taking along the paraphernalia for mounting and means a tedious extra job at the end of the day's work. It is somewhat less satisfactory for spruce, with its needles scattered round the twigs, than for hemlock, with its two-ranked needles; for some of the needles on the upper surface will come loose unless an undesirable excess of adhesive is used.

Arctic and alpine collecting.—In arctic and alpine collecting strong winds often make the use of the field press difficult. The individual plants of a species too, may be so widely scattered that you may cover as much as a mile in securing an adequate collection. Under these circumstances it is impracticable to try to lay the specimens into the field press in the orthodox manner. Fortunately few arctic-alpine plants are so delicate that they must be handled with great care. Most are stout, firm-leaved and protected by hairs. When working under such conditions fill the specimen side of the press with enough sheets to last the working period. As the plants are collected slide them down into the folded sheets.

After a few sheets have been used it becomes hard to tell at a glance which is the inside of the sheet and which the gap between two sheets. Be sure, then, to number the sheets consecutively before starting, putting the numbers inside and in a standard position. This method has the added advantage of making it easier to find the right sheet as you gradually add to a collection of a widely scattered plant in the course of a day. One soon remembers, for example, that *Arenaria rubella* is on sheet 4, *Cardamine bellidifolia* on sheet 6 and *Pedicularis flammea* on sheet 11.

When the wind is exceptionally strong it may be impossible to use the field press at all. Take along some plastic bags and drop the plants into them. Inevitably species become mixed in the bags, which means tedious sorting later; but this is better than wasting the day. The mixing can be minimized if you put collections that can be completed at a single colony into a paper bag (about 4-pound size), and then put it into one of the plastic bags. Plants that cannot easily be cleaned as they are dug should also be put in individual paper bags to prevent soiling other plants. Use individual paper bags also for fragile plants that might become damaged if left loose in the main bag. Always put rusted or smutted plants into individual bags, for mixing of the spores can cause serious difficulty for the mycologist who examines the specimens. If you use about four plastic bags, say two in each pocket of your parka, and can remember always to put a species into the same bag, the work of sorting will be greatly reduced.*

Pressing and Drying

General Principles

These two processes are discussed together because pressing techniques depend to some extent on the drying facilities that are available.

Plants must be pressed firmly and continuously during drying, or the leaves will wrinkle. For many generations

* See addendum 2.

botanists dried their plants without heat, depending upon a daily changing of felts and papers for removal of moisture. This method is so time-consuming that it seriously limits the volume that can be handled, and it never yields really good specimens except of the relatively small proportion of plants that dry very readily.

Today nearly all botanists use heat in some form to speed the drying process. To secure the best retention of color with freedom from brittleness, dry the specimens rapidly but with only gentle heat. The role of heat in the drying process has not been fully appreciated, and some remarkable and completely erroneous statements on its use have been made. Too high a temperature in the press causes both browning (incipient scorching) and brittleness. The term brittleness itself has been used loosely. When specimens break up readily it is sometimes due to inadequate pressure, which causes wrinkling of the leaves. Such specimens break up from the mere weight of other specimens filed on top of them. A high or even moderate temperature may cause browning through oxidation processes if there is inadequate air movement to carry away the moisture that is withdrawn from the specimens. Drying without heat causes a slow killing of the plant cells and oxidational browning inevitably results. As explained earlier in this chapter, during discussion of the field press, a delay in the application of heat after the plants have been pressed always causes browning, for drying (and killing of the cells) starts as soon as the plants are in the press. Discoloration due to slow drying affects the color not only of leaves and flowers, but sometimes even of hairs. In a recent monograph a distinguishing character of *Heuchera chlorantha* was stated to be the brown hairs in dried specimens; but in specimens dried by suitable methods the only brown hairs are those on senescent leaves or those where overlapping delayed drying.

Removing the water quickly and safely from the specimen necessitates a steep water-vapor pressure gradient between the specimen and the outside air. There are two ways to steepen the gradient: decreasing the moisture content of the

outside air, and shortening the air path. The simplest and most economical way to reduce the relative humidity of the air is to warm it; but desiccation would be equally effective and possibly more so. Cool, dry air might give good results with plants that discolor very readily, and comparative tests with such plants are desirable; but the cost of desiccating the volume of air needed to dry large numbers of specimens seems to make it quite impractical for general use. The short air path is achieved by putting a layer of paper felt on each side of the specimen and beyond the felt a sheet of corrugated cardboard. Warm, dry air is kept moving through the passages in the corrugated cardboard sheets or ventilators.

The procedure outlined below is widely used at this institution; it yields good specimens and is economical of time and labor.

Laying Out Specimens

Take the specimens individually from the field press (except when, as described above, they have been laid out in the field press as they are collected) and lay them out on a felt in the open press in a clean sheet of newsprint. There is little objection to laying out most tree and shrub specimens in the paper from the field press, except that drying is slightly delayed; but use of clean paper makes cleaner and often much better specimens of herbaceous plants. As you take the specimens from the field press, shake or wipe off any residual dirt that is on them. When the field press has been emptied, tip the dirt out of the papers and replace them in it in readiness for the next day's collecting. Their being slightly damp helps to keep the new collections fresh.

On the sheet into which the specimens are laid mark the collection number and the name of the genus on the outside at the lower left (hinge) corner; putting the marks at this corner speeds sorting of the specimens later. When several sheets are filled with a single collection put the number only on the second and succeeding sheets; for when the specimens

are taken from the press these sheets are slipped inside the first one. Other notes may be written on the sheet occasionally. Thus, if the collection includes material of a parasitic fungus, "MYC" (for mycological) serves as a reminder that this material is to be extracted when the plant is identified. Parasites are usually less conspicuous in the dried than in the fresh specimen. Therefore, it is better to group the parasitized plants on a single sheet marked as such; otherwise it may be necessary to scrutinize the entire collection under the dissecting microscope. If specimens of poison ivy or any other plants that remain irritant after drying are collected, be sure to put a suitable warning on the outside of the sheet.

In laying out the specimens, avoid overlapping as much as possible. If the panicles of two plants overlap in the press it is sometimes impossible to separate them later without breakage. When a single specimen fills a sheet be sure that some leaves show the upper and some the lower surface, for only one such plant will constitute the final herbarium specimen. When it is practicable to do so, press some flowers with the inside revealed. Plants that dry quickly, like most grases and sedges, can be crowded closely together on the sheet, for a little overlapping of the leaves and culms causes no serious disfigurement. If they are a little more than half the length of the sheet put them in two rows with the roots at the top and bottom of the sheet and the inflorescences alternating in the middle. Do not put the roots at the bottom of every sheet or the press will soon become lopsided. If you have ample press space but a poor source of heat for drying, space the plants widely on the sheet.

Fold plants to somewhat less than the length of the sheet. This presents no problem in slender plants with few or no stem leaves and a compact inflorescence, but in those with a large panicle or numerous large stem leaves it is hard to make an attractive specimen that shows all the characteristics of the plant clearly. If the plant is only slightly longer than the sheet it is sometimes best to make the fold near the base or to make a zigzag bend in the lower part of the

stem to bring the panicle down sufficiently (Figure 6A). With tall, leafy plants, such as *Lupinus* or *Delphinium,* it is often necessary to remove several leaves (with a stub of petiole left to show their positions) in order to avoid serious overlapping of the leaves when the plant is folded.

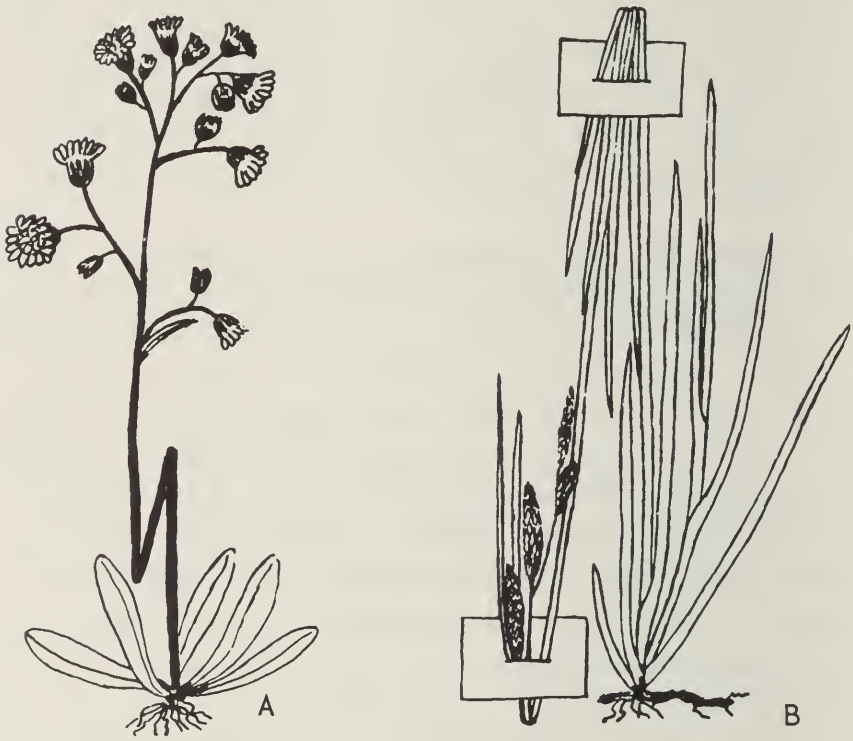

Figure 6.—A. Plant with large panicle, prepared for pressing with zigzag fold. B. Use of papers on sedge to keep folded parts in position for pressing.

Soft-stemmed plants usually fold easily and remain in position after folding. Some plants have brittle stems that tend to break at the fold. This difficulty can often be obviated by bruising about half an inch of the stem at the place where you plan to fold it, using any hard rounded object. Very dry stems are sometimes best treated by wetting and softening then gently between the front teeth. Unless the plants are very large try to avoid cutting them into sections, for if several plants go on a sheet there will often be doubt as to

which top goes with a particular base. Wiry plants, particularly those with linear leaves such as grasses and sedges, do not usually stay folded. Such specimens are greatly improved in appearance by being 'papered'; in this process you take pieces of paper roughly $2\frac{1}{2} \times 1\frac{1}{2}$ inches, with a slit about $\frac{3}{4}$ to 1 inch long cut or torn down the middle, and slip them over the folded part to keep the culm and leaves neatly together (Figure 6B). Do not remove the papers until just before you mount the specimens. Grasses or sedges only slightly longer than the sheet are occasionally laid in diagonally to avoid folding. There are several objections to this practice. It limits the amount that can be put on a sheet even if two clumps are crossed (which may mark the plants seriously); if the plants shift in the papers after pressing they will project and be damaged; and the specimens must be mounted diagonally, which causes a bulge in the middle of a stack of specimens if many are so mounted.*

Some ingenuity is needed to make presentable specimens of certain plants. In many species of *Viola,* for example, the cordate leaves curl up very readily; and, as a result, the basal lobes may all be folded over the body of the leaf in the press. Not only is the resulting specimen unsightly but it is unsatisfactory because the true leaf shape is not clearly shown. When 10 to 20 small plants are packed on a sheet it is scarcely possible to be sure of pressing all the leaves flat, but a reasonable proportion can be assured. The best method seems to be to start by laying out plants adjacent to the hinge and fold the sheet over them before removing the fingers. By gradually working across to the open side of the sheet and keeping pressure with the arm or some felts and ventilators on the completed part, you can be sure that some leaves, at least, of each plant will be flat. The job is easier to do with an assistant.

Although old newspaper, carefully folded in the half sheet, is satisfactory for small-scale collecting, machine-cut and -folded unbleached newsprint, done up in packets of 250 or 500 sheets, is better for extensive collecting. This paper is easy to handle; packs into a much smaller space

* See addendum 3.

than old newspaper; is somewhat more absorptive; is easier to mark with the necessary data; and, as many botanists have ruefully declared, saves all the time that would otherwise be spent in reading old advertisements. Furthermore, when many duplicates are to be collected on a long field trip, the time needed to collect, cut and refold the necessary amount of newspaper becomes grossly uneconomical. In less than four months one of our field parties, aiming at securing at least twenty duplicates of all species in the area under study, used well over 12,000 sheets of newsprint.

The Press

Make up the press from its various components, as shown in Figure 7. Lay the press frame on the bench or other available working surface and put a ventilator and a felt on it. Then add the first specimen in its folded newsprint. Continue this sequence of specimen—felt—ventilator—felt —specimen to the top of the press, ending with a ventilator and press frame, and close it with two straps. The press frames, ventilators and felts are all 18×12 inches. This size is just enough larger than the size of the sheets of newsprint to make it simple to ensure that the newsprint and its specimens will not project.

Frames.—The frames are made of slats, about 1×¼ inch (dressed) of ash or some other tough and springy wood. (Any wood suitable for ax and hammer handles is satisfactory for the frames.) The frame is made up of five longitudinal and seven transverse slats. All the outer joints and some of the inner ones are fastened with heavy copper harness rivets and washers. Some of the inner joints, however, are fastened with two brass brads, set diagonally, driven through, and clinched; this practice ensures that the frame remains rectangular.

Ventilators.—The ventilators, of double-covered corrugated cardboard, are cut so that the folds run across the press. The air spaces gradually become constricted with use. Badly flattened ventilators should not be used in the presses,

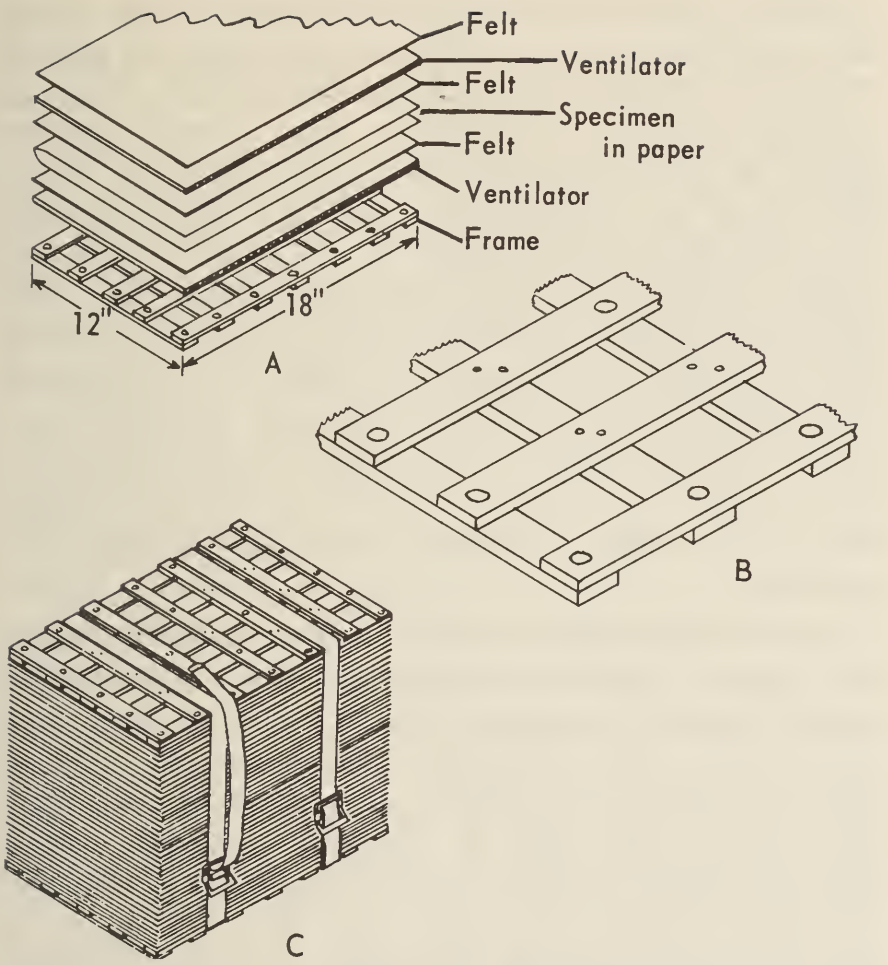

Figure 7.—The press. A. Exploded view, showing arrangement of parts. B. Detail of frame, to show construction. C. Assembled press, showing position of straps.

but some of the discards should be kept for use in the field presses and for packing specimens for shipping. Corrugated cardboard covered on one side only is occasionally recommended for ventilators, on the belief that it gives faster drying. However, the gain is slight, and it is more than offset by the flexibility and rapid collapse of this type of ventilator. Moreover, the pattern of the corrugations may show on the leaves of the specimen unless the felt is thick and firm. This same disadvantage holds for the corrugated aluminum ventilators that are sometimes recommended for collecting in humid tropical regions where cardboard ventilators soon disintegrate.

Felts.—The felts are cut from the paper felt that is used under linoleum on floors. This material comes in rolls 36 inches wide, which allows cutting with no waste. Felts and ventilators may be cut to size by hand if only a few are needed by the amateur collector; but if many are needed they should be cut by machine, because slight irregularities in size result in rapid damage to the edges. If you have trouble buying cut felts from the manufacturer, buy a roll and have it cut up on the bench shears in a sheet metal shop. Very thin felts give inadequate padding to the specimen. The material should be fairly thick and moderately soft. If it is extremely hard it will not give enough pressure on leaves close to thick stems. If it is very soft is soon goes fuzzy at the edges and tends to close the openings in the ventilators.

Straps.—The straps should be of heavy webbing about 6 feet long and 1¼ inches wide. Longer straps are sometimes useful for very large presses, but usually they leave a lot of loose end to be tucked in. Wider straps are often too stiff to grip well in the buckle, and narrow ones are short-lived. Thin straps, such as are often used with car-top carrers, grip well but wear out very quickly. The slide buckles of webbing straps often tend to slip after long service. If this occurs do not sharpen the prongs, but use a small flat file to resharpen the bar on the back of the slide, which presses into the back of the strap. This bar becomes rounded with use and should be recut to a 90 degree angle. If in doubt, compare it with the bar of a new buckle.

Emergency presses.—In an emergency you can make quite serviceable, but heavy, press frames by using any boards of uniform thickness. Be sure to clinch the nails through the cross pieces. In place of straps take lengths of ¼-inch rope, put an eye splice in one end and whip the other end. Put the ropes round the press with the eyes pointing up, in the position normally ocupied by the buckles. Thread the free end through the eye; haul up until tight; and fasten by pinching the rope at the eye with one hand while pushing

a loop of the free part under the taut rope and back through its slack bight, and finally pulling this loop tight. Pulling out this slip half hitch instantly releases the rope.

Tightening the press.—When a press has been made up with specimens, preferably to a height of 12 to 18 inches, fit two webbing straps around it between the second and third transverse slats from the end of the frame. True up the felts and cardboards as well as possible and tighten the straps a little. Complete the truing by turning the press on its side and end and pressing the components firmly against the floor. If felts or ventilators project from a tightened press they will be crushed and air will not move through the press. After truing, finish the tightening by sitting on the press and hauling up alternately on the straps until no further movement can be obtained. The buckle side of the press tends to tighten most thoroughly because of the friction of the straps over the frames. To equalize presure, press down on the edge of the upper frame away from the buckles, after the straps have been pulled moderately tight; then complete the tightening. Now pinch the buckles tight, run the straps through the lower loops of the buckles, and tuck the ends of the straps between the slats of the frame. The press is now ready to be put on or in the drier. *In some 8 to 12 hours, however, it must be removed and the straps retightened* to take up the slack that results from the increasing flaccidity of the specimens. If this retightening is omitted some wrinkling of leaves usually occurs, and this means that specimens may break up in future handling.

Presses more than about 18 inches deep are very awkward to handle when they are tightened. A press much under 12 inches deep lacks the resilience necessary to maintain adequate pressure, so we aim at a press that will tighten down to about 15 inches. If only a few plants are to be pressed, make up the press to normal height with extra felts and ventilators.

Driers

Driers may be classed as installed, portable, or emergency types.

Installed driers.—In the laboratory a permanently installed cabinet drier is desirable for reasons of safety and economy of floor space, and to minimize heating of the room in which it is placed. We prefer a cabinet about 6 feet 6 inches high, 4 feet long, and 20 inches deep, inside, as shown diagrammatically in Figure 8. This drier has four shelves at 15-inch spacing and holds 12 average-sized presses. The cabinet has a frame of angle iron in the corners and horizontally for shelf supports. The walls and doors are of double sheet steel interlined with asbestos sheeting and painted with aluminium paint to increase internal heat reflection. The shelves are of heavy-gauge galvanized screen of 1-inch mesh. If it is expected that specimens not in presses, such as fleshy fungi, will be dried in the cabinet, finer screening of about $\frac{3}{16}$-inch mesh should be laid over the coarse mesh to prevent any specimens from falling through. Such a fine screen should in any event be placed on the bottom shelf to minimize the risk of objects falling on to the heat lamps. The source of heat is six 150-watt reflector-type bulbs mounted in heavy-duty sockets on the floor of the drier. They are wired in pairs or threes, so that if only a few specimens are to be dried in hot weather only the bulbs at one end need be turned on. Air inlet holes about 2 inches in diameter are spaced around the cabinet walls as close as possible to the floor. An exhaust fan draws air from a duct in the center of the top of the cabinet. The fan should have sufficient capacity to allow air movement through the cabinet of at least 2 feet per second. The exact size needed will depend on the length, size and number of bends in the exhaust duct. The manufacturers of such fans supply tables for the calculation of their performance under varying conditions. The fan may be ducted to the outside through a wall or a section of window, and the exhaust should open on the side of the building away from the prevailing wind. If

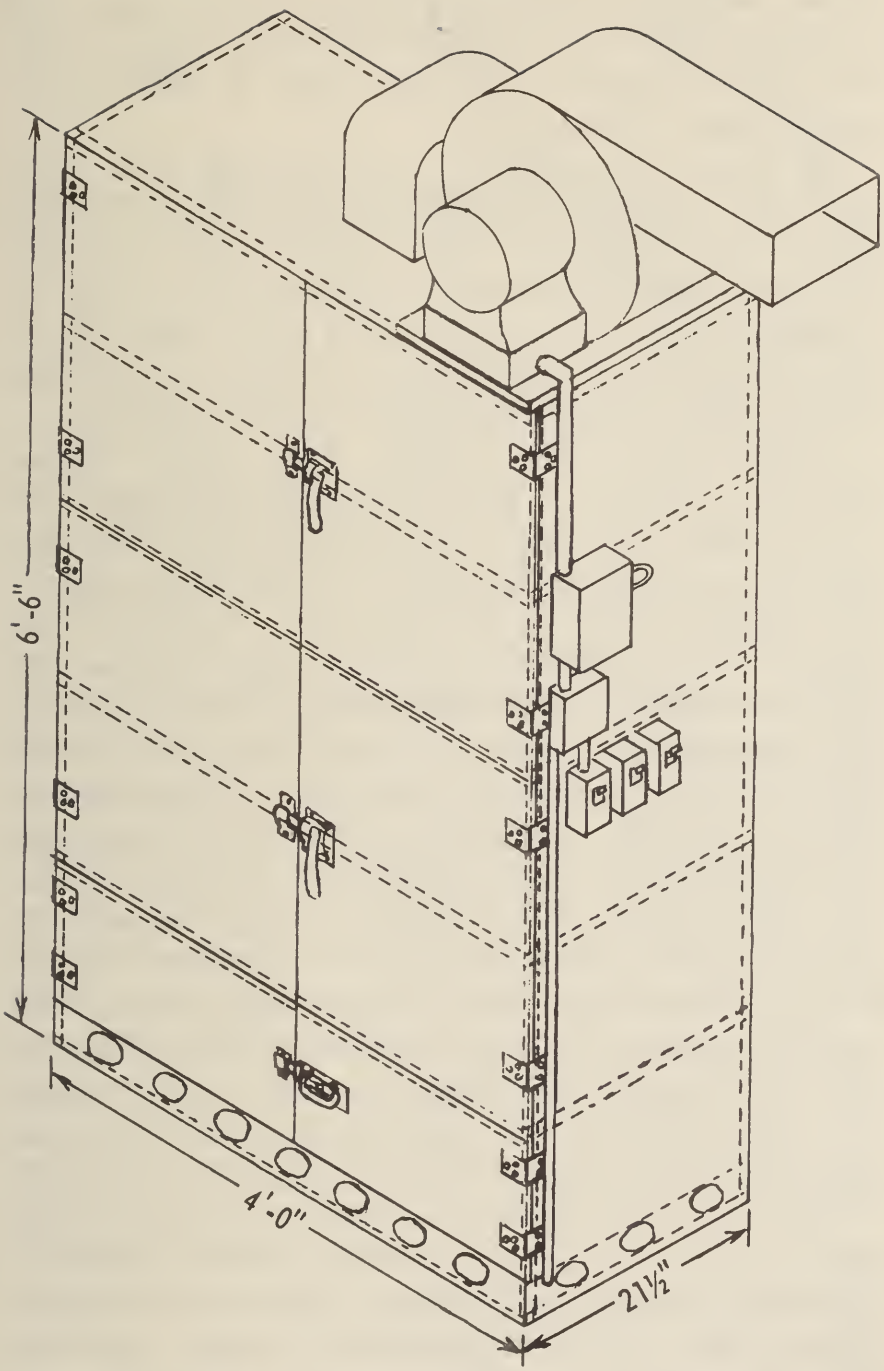

Figure 8.—Installed drying cabinet. Broken lines show position of frame made of 1-inch angle iron. Shelves are 15½ inches apart, giving 14½ inch clearance between supports.

exhaust ducts are incorporated in the building they may, of course, be used, provided that the flow rate through them is adequate. The fan should be wired to the master switch of the drier, to ensure that it will always be running when the heat lamps are turned on.

The presses are stacked in the drier with their length from back to front of the cabinet and with the corrugations of the ventilators vertical. When the drier holds less than a full row of presses they may be pushed to one end, felts or ventilators placed on the unused part of the shelf, and the lamps at the unused end turned off. By this means efficient drying is achieved with the minimum heating of the room.

Portable driers.—The portable drier shown diagrammatically in Figure 9 is about 4 feet long. The inside width of 18½ inches is a slack fit for presses placed with their length across the drier, allowing for slight irregularities in the alignment of the press components. The drier frame consists of six panels of ¼-inch plywood. The four side panels bear battens ¾ inch wide, attached 1 inch below the top to support the presses. Air inlet spaces are provided either by cutting several large holes near the base of each panel, or preferably by cutting away the base of each panel for a height of about 1 inch to within about 3 inches of each end. The panels are held together by large hinges of the draw-pin type in which the pins are replaced by loosely fitting common nails. The nails are easily inserted and removed, allowing very rapid erection and dismantling. The nails of the upper center hinge on each side are replaced by a wire spacer with the ends bent down and the points tapered for easy insertion into the hinges. It is advisable to make the spacer slightly more than the estimated length, then try presses in position and, if they tend to slip down, shorten the wire slightly by twisting a jog into it with pliers. Adjacent sides of adjoining panels are marked in paint with the same number to guarantee that the hinges will mate when the frame is erected. However, the positions of the hinges should correspond closely, as the drier can then be

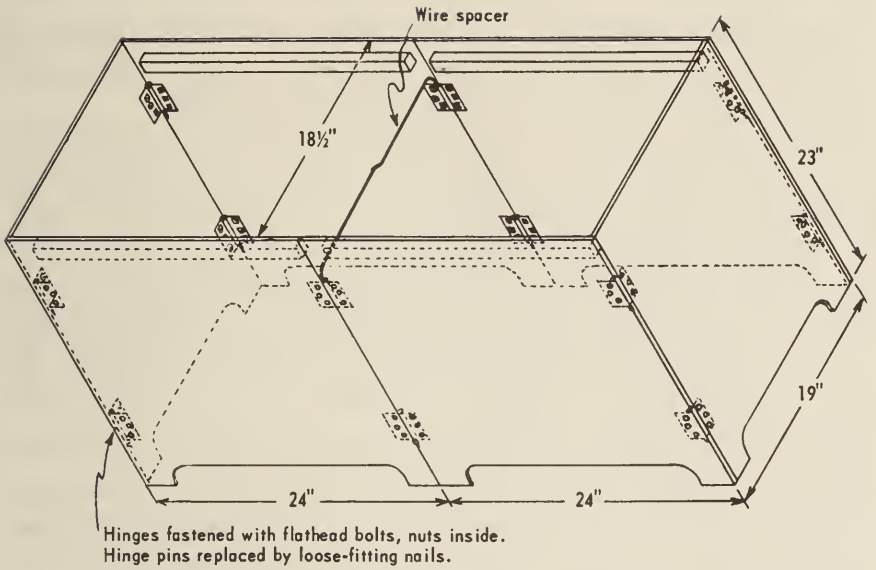

Figure 9.—Portable drier, of ¼-inch plywood.

used at half length, with two side panels left out. You can expedite the interchangeability by filing the hinges to a slack fit—not a practice favored by good mechanics but quite justifiable in this instance. In crowded tents and with small plants and a limited flora—common circumstances in the arctic, for example—the shortened drier is a decided advantage. Heat is normally supplied by four 150-watt light bulbs with reflector bases, mounted in pairs on wood blocks about 15 inches long. One block carries a plug on a foot or so of heavy-duty rubber-covered wire. The other block carries an outlet on one end to connect with the first board and a plug on about 10 feet of wire on the other end. Also carried is an extension cord about 20 feet long in case no wall outlets are adjacent. Strip heater elements may replace the lamps if suitable ones are available.

For transportation the six panels are held together with a webbing strap in a single bundle. The light sockets, extension, wire spacer, and can of nails go in one box. The light bulbs (with spares) go in a separate box with appropriate packing.

The height shown for the drier frame is a little more than is considered essential for reasonably even distribution of heat from light bulbs close to the floor; but it allows for possibly greater height of some sources of heat.

If electric power is not available the best substitute is unquestionably the kerosene stable lantern or hurricane lantern. The smaller types, standing about 10 to 12 inches high, are most suitable. One such lantern is approximately equivalent to a 150-watt lamp. If the wick is trimmed flat with a small amount cut off each corner, such a lantern will burn steadily for 24 hours or slightly over. It is necessary to check the height of the flame shortly after the lantern is lit, as the flame tends to rise and smoke when the lantern warms up; but afterwards it needs no attention. Pressure lamps, either gasoline or kerosene, are practically useless for drying plants. They burn with a dangerously intense flame for a short time, and have scorched many specimens. They are also a serious fire hazard.*

We have also used a drier frame similar to the one described but made of sheet aluminum, with aluminum alloy angle strips riveted on to support the presses. This modification saves a little weight and bulk, making it somewhat preferable when you are traveling in light aircraft. The corners of the sheets are somewhat of a menace to tents and other fabrics, and should be smoothly rounded. The aluminum sheets also become battered easily with constant handling, and are not recommended for road trips where you expect to load and unload almost every day.

The plywood drier panels will gradually splinter with rough use. To reduce this minor hazard, paint the edges with shellac or varnish each year before starting out into the field.

This type of portable drier will hold three large presses. Any surplus space beyond the ends of the presses should be blocked off with ventilator cardboards, in order to direct the heat through the presses. Any small gaps at the corners or between presses may be conventiently chinked with socks

* See addendum 4.

that need drying. Socks, or anything else that needs drying, can also be put on the floor between the lamps. As with the laboratory drier, the presses should be removed and retightened after 8 to 12 hours, at which time they may also be turned upside down to equalize the drying of the contents. If necessary, a second layer of presses is put on top of the first row. This practice does not seriously delay the drying rate of the lower presses, but makes drying in the upper row rather slow. The relative positions of the presses are changed when they are removed for retightening.

Emergency driers.—If weight limitations prohibit the carrying of a drier and the necessary fuel, various makeshifts may be adopted. Very few places where you may stay are completely without sources of heat. A space heater, drum heater, the shelf over a kitchen range, the radiator of a diesel generator, a hot-water tank, and the boilers of central heating plants and laundries have all been used to house presses. You must be careful that the heat from a drum or space heater is not too intense, but the other sources are generally quite safe, although not always fully adequate.

If no heat at all is available the presses can be stood in the sun and wind, in suitable weather. However, unless you have nearly continuous, adequate heat, you must cut down on the number of duplicates to be taken, space the specimens more widely than usual on the sheets, and change the felts daily. Even with these precautions the quality of the specimens will generally suffer at least slightly; and some plants, such as *Castilleja,* will blacken seriously. It is not good practice to attempt preliminary preservation of plants by immersing them in formalin solution. Formalin gradually destroys natural colors, reducing all tissues to brownish gray or black. Liquid preservation of small selected parts of plants is necessary for material intended for anatomical or cytological study; but liquid preservation of whole specimens is tolerable only for algae, and then only under certain circumstances (see Chapter 5). Cytological

and anatomical material should be preserved according to the instructions of the person who will eventually study it; different working techniques may require different fixing solutions, plant parts and developmental stages.

Packing and Shipping Dried Specimens

Specimens that are dried in the laboratory are generally sorted at once into folders, for identification and labeling. Specimens dried in the field must be packed securely for shipment. Cartons such as those used for cans of condensed milk are a convenient size for holding specimens, being a trafle larger in area than the folded newsprint. A good procedure is as follows. When a pile of specimens becomes about 6 inches high place a corrugated cardboard (a battered ventilator will do) on a table and true up the stack of specimens on it. If there are small specimens or conifers with loose needles in any of the sheets, wrap them in newsprint before bundling. To prevent the possibility of plants slipping out put duplicate sheets with their open sides into the hinge side of the master sheet. Then put a second cardboard on top of the stack. Cut a length of cord or of cotton tape long enough to go once lengthways and twice sideways round the stack and tie a loop in one end. Now loop the string sideways round the bundle towards one end, pull it tight and cinch it with a half knot; loop lengthwise, but, without completing this loop, hold the cord down and make a lateral loop; tighten this loop round the cord where it is held and cinch again; finally, complete the longitudinal loop by drawing the junctions of the two lateral loops toward each other and fastening with several half knots.

Such a bundle holds the specimens firmly enough to prevent them from sliding against each other or slipping out of the papers. Ship bundles in cartons if there is a reasonable certainty that they will not be exposed to moisture. Otherwise, cover them with extra wrapping or ship them in

suitable plywood boxes. We use field boxes of ¼-inch plywood with outside cleats and screw-down lids; inside dimensions are 18×12¼×20 inches. These boxes are ideal both for shipping supplies into the field and for shipping specimens back. We pack the bundles of specimens flat and fill the small space left at the end of the box with folded cardboard or miscellaneous small items.*

Processing Dried Specimens

Preparing Labels

When the collections have been identified the plants may be laid out for mounting. As soon as it is seen how many duplicates there are, the final labels may be made (Figure 2). In the Institute, if there are only a few duplicates the labels are typed individually; but if there are many the duplicate labels are printed from stencils. A stencil will hold six labels. The master labels are therefore sorted into groups of six for which nearly the same number of copies are needed. A stencil is cut for each group of labels and enough sheets are run off to provide for the largest group. The printed sheets are cut up and the labels returned to the herbarium. The duplicates are now ready to be sent out in exchange and the master sheet is mounted and inserted in the herbarium. If you expect much delay in getting the labels printed, it is a good idea to postpone laying out the specimens; estimate the number of labels needed and send the master labels for duplication as soon as the collections are identified.

Laying Out for Mounting

Although it is desirable to have a liberal amount of material on the sheet, the sheet must not be crowded. There must be space for the label, perhaps also for a field label. As the years go by, a succession of specialists may examine the sheet and each may attach a small annotation label.

* See addendum 5.

Although annotation labels are generally attached by one edge only, they should not overlap the specimen. Furthermore, someone may sooner or later remove flowers for boiling and dissection, or dig seeds out of a capsule. This material is put in a packet attached to the sheet, so that the next examiner will not have to mutilate the specimen further. In, for example, *Isoëtes,* microscopic mounts are needed for identification; and these preparations may usefully be ringed and attached to the sheet in packets. The specimen then, should not occupy more than about three quarters of the sheet. When the plants are very small it is neither necessary nor desirable to pack a very large number on the sheets. Put enough on each sheet to show the variation in size and other characters and to provide ample flowers and fruit. If you overload exchange sheets the mounter at the receiving institution may simply mount what he considers adequate and throw out the rest. Rather than risk such waste make extra duplicates.

Lay out the master sheet directly on herbarium mounting paper. Lay out the duplicates on sheets of newsprint or other light paper, which is bought cut to size in unfolded sheets when the volume of exchange is great. As a check against the mixing of labels, write the collection number on each sheet.

When you consider the cost of materials, field travel, salaries, and other incidentals, the actual value of fully processed specimens is often more than a dollar per sheet; if there has been much travel by chartered airplane, the cost can be much more. The careful laying out of duplicates to avoid waste is therefore a matter of economic as well as scientific importance.

Mounting

Except for occasional minute plants, which may better be placed in packets, stick specimens to mounting paper and then reinforce them with strips of linen tape or, preferably, by the plastic strip method. The following materials are needed.

Mounting paper.—The standard size is 16½ by 11½ inches. A good quality paper that will not become brittle with age is essential. The weight should be fairly heavy, to reduce flexing when mounted specimens are picked up. A mat-surfaced paper provides better adhesion than a smooth paper.

Mounting board.—A piece of plate glass, sheet aluminum, arborite or other inert and water-resistant material about 24 by 18 inches is required. The surface must be smooth and easily cleaned.

Adhesive.—A neutral, opaque library paste has been found satisfactory. A neutral adhesive minimizes the change in flower colors, the pigments of which are often indicators. It is difficult to prevent mold growth on neutral pastes; consequently most commercial pastes are strongly acidic. Various pastes and mucilages may be used provided that they do not become brittle with age and can be easily cleaned from the mounting board. The paste should be freely miscible with water, since it is necessary to dilute it occasionally on the board, especially when the air is dry and it may quickly become very stiff.

Brushes.—An inexpensive 1½-inch paint brush is ideal for applying adhesive to the mounting board. A fairly large artists' brush is useful for applying glue to individual leaves that are too flexuous to place in the film on the mounting board.

Forceps.—Forceps with spatulate tips, such as stamp collectors use, are excellent for picking up specimens. The type with offset tips is particularly useful for applying gummed linen strips.

Gummed linen tape.—Gummed linen tape of the type used for repairing books is cut into strips about ⅛ inch wide with the warp running lengthwise. The tape should be pliable and have good adhesive properties.

Plastic stripping.—The method used at the Institute is that described by Archer (Rhodora 52:298. 1950). The plastic is made of the following ingredients:

Ethylcellulose (ethocel) standard 7 cps	250 g.
Dow resin 276 V-2	75 g.
Methanol	200 cc.
Toluene	800 cc.

The plastic is dispensed from a trigger type of oil can with a small nozzle. The nozzle should be provided with a cap with a pin in the center, which should be replaced when work is stopped for any great length of time. Copper or copper alloy (brass or bronze) cans or internal parts should be avoided, since their use discolors the plastic.*

Mounting procedure.—Moisten the brush and mounting board with water and apply a thin coating of paste to the board. The best thickness of the layer of paste depends upon the coarseness of the specimens to be mounted. The size of the patch will naturally depend upon the size of the specimens. Place the specimen on the paste and gently tamp it down to make sure that the lower surface is well coated. Then carefully pick up the specimen. Peel the leaf surfaces away from the paste slowly, to avoid breaking, and drop the specimen gently on the mounting paper in the desired position.† Delicate specimens need a thinner mixture of paste than coarse ones. Special techniques for specimens that are hard to handle will soon be developed through practice. If any pasted leaves tend to droop, a slight upward flip just before the specimen is lowered into place will ensure that the leaves land fully extended. Leaves that do come down somewhat buckled can be extended by running the forceps under them. Keep a glass of water handy for cleaning off the forceps and diluting the paste. Some grasses and sedges droop too much to be handled by flipping. In handling such plants let them hang vertically and bring the paper slowly into contact. With very flaccid specimens, such as the linear-leaved species

* See addendum 6. † See addendum 7.

of *Potamogeton*, spread a layer of thinned paste on one surface and lower the mounting paper on top of them. When the sheet is lifted the specimen will come with it.

The specimen should be located carefully on the sheet, preferably so that it does not come within an inch of the edge at any point. Do not mount solitary small specimens or packeted specimens in the center of the sheet, since, if several accumulate in one folder, there will be a bulge at this point, space may be wasted and specimens may be damaged. Practice a rotation in mounting such specimens; for example, start at upper left, then place in upper right, middle left, middle right, lower left, lower right. Although it is generally better to have the base of the plant toward the bottom of the sheet, the position should be varied in plants that have very thick bases, to ensure that the sheets stack evenly and occupy the minimum of shelf space.

If your own technician does the mounting he can be trained to keep most of the inflorescence out of the paste and to attach it carefully with plastic stripping. However, this method is seldom practicable with specimens sent out to relatively unskilled contract mounters.

Fragments of specimens, very small plants, seeds, and extra flowers or fruits may be placed in packets and pasted to a convenient part of the sheet.*

The label is preferably attached to the lower right corner of the sheet. Paste it by a narrow strip along the top edge or, if the specimen is so large that there is insufficient space for the label, attach it by the right-hand edge and allow it to overlap the specimen. Do not paste down the whole label as this generally makes the corner of the sheet curl.†

After the specimen has been pasted down and the label attached, cover the sheet with a piece of wax paper, then with a felt, a heavy cardboard and any convenient weight. Additional specimens, each covered by wax paper and felt, may be stacked under the cardboard and weight. The specimens should be left to dry under the weight for several hours or preferably overnight.

* See addendum 8. † See addendum 9.

After they are dry, remove the specimens from between the wax paper and felts and reinforce them at various points to ensure that the paste does not give way with flexing of the sheet. Use either linen tape or plastic stripping and reinforce the stem every 3 inches or so. Reinforce large leaves near the tip and, if wide, on the sides. Also reinforce large inflorescences at several points. Try not to conceal areas of possible diagnostic value. Stem reinforcements should be in the middle of an internode. If tape is used do not cover the actual tip of the leaf. In reinforcing the inflorescence try to ensure that a particular structure is not covered repeatedly.

If tape is used, see that the strip extends about half an inch beyond the part to be covered. Moisten the tape and hold it down firmly with bent forceps. If the fingers are used it is almost impossible to avoid the occasional grimy mark on the sheet. Long tapes covering broad masses of grass leaves and stems give almost no support and should be avoided whenever possible. *Never use cellulose tape or surgical tape for reinforcement.* The adhesives in these materials ooze out at the edges of the strip, picking up dirt and disfiguring the specimen. Cellulose tape also becomes yellow and brittle with age.

For neatness, strength and speed of application, plastic reinforcement is better than linen tape. Being fully transparent it does not conceal details such as leaf teeth. If a specimen reinforced with this material is put under strain the paper tears before the plastic breaks. With a little practice you can apply it from the oil can very quickly and neatly. Apply a strip of plastic across the stem or other part and anchor it to the sheet on each side. With large leaves put a circular blob here and there, half over the edge. A blob squirted into a mass of fibrous roots will anchor them more firmly and much more neatly than a long linen strip.*

Occasionally it is necessary to sew a very coarse stem, a cone, a heavy piece of bark or some other large specimen to the sheet. Heavy linen thread should be used. Pass it

* See addendum 10.

twice or more over the specimen and knot it on the back of the sheet. With some objects, such as large pieces of bark or *Opuntia* pads, you may have to drill pairs of small holes through which to pass the thread. Use strips of gummed paper to cover the threads on the back of the sheet and so prevent damage to the specimen immediately below.

Herbarium Packets

Packets of the style shown in Figure 10 are used at the Institute in the following sizes (inches): $1\frac{1}{2}\times\frac{7}{8}$, $3\times1\frac{1}{2}$, 4×2, 5×3, $5\frac{1}{2}\times4\frac{1}{2}$, $9\frac{1}{2}\times3\frac{1}{2}$. This selection covers the requirements for mosses, lichens and fungi as well as for vascular plants. This style of packet was adopted mainly because it is easily made by machine. If they are purchased in large lots, such packets are much more economical than hand-folded ones. The bottom flap is cut so that it almost exactly fits inside the folds of the other three. It is folded in first; then the side flaps are folded across and finally the top flap is folded down. The weight of specimens on top will

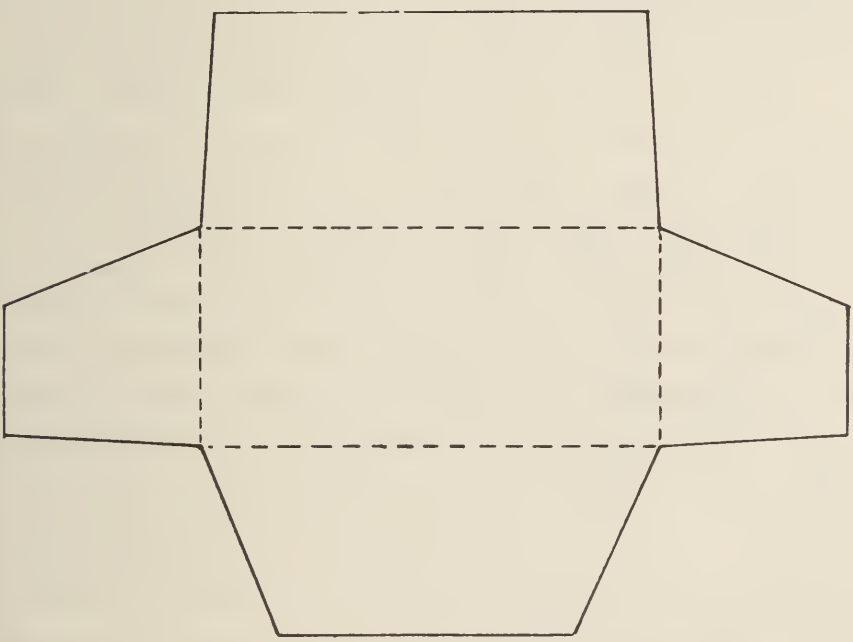

Figure 10.—Pattern of machine-made herbarium packet.

keep the packet tightly closed. Exceptionally small seeds, which might sift out through the folds, may be put in a small packet within a larger one, but all normal-sized objects will be kept securely in a single packet.

Herbarium Sequence

The operation of the phanerogamic herbarium of the Plant Research Institute may serve as an example of herbarium management. The size, rate of growth and other circumstances of a herbarium will govern the details of some practices. This herbarium currently holds more than a third of a million sheets and is growing at approximately 20,000 sheets a year. The collection is predominantly Canadian; but there is a good representation of the European flora and that of the northern United States, and a smaller representation of other parts of the world. The geographic bias governs the sequence of specimens within each species.

The main sequence used for the herbarium is that of Dalla Torre and Harms (Genera Siphonogamarum ad Systema Englerianum Conscripta, Lipsiae. 1900-1907). The ferns and fern allies are filed in the order of Copeland (Genera Filicum, Chronica Botanica, 1947); and the grasses follow the sequence of Pilger (Das System der Gramineae, Bot. Jahrb. 76: 281-384. 1954). Within the genus the species are generally arranged alphabetically; but some large, complex and abundantly represented genera are arranged by subgenera and sections. Thus *Carex* follows the sequence of Mackenzie (North American Flora 18: 1-478. 1931-35). Subspecies, varieties and forms are filed alphabetically after the typical phase. The use of an approximately natural sequence has the considerable advantage of keeping related plants close together. On the wall of each room of the herbarium an index gives the families in alphabetical sequence and the number of each in the Dalla Torre and Harms sequence, enabling a family unfamiliar to an enquirer to be located without delay. For large families the arrangement by genera is recorded on a table in the first case that

houses it; and a similar table is inserted at the beginning of any large genus that is in a nonalphabetical sequence.

Within each species or smaller taxon the specimens are separated geographically, the primary division employing distinctively colored folders. Canadian specimens are filed in manila folders. Specimens from the continental United States follow in salmon folders; and these, in turn, are followed by Mexico, Central America, South America, West Indies, Bermuda and Bahamas (yellow); Europe, Asia, Africa, Australia and Oceania (blue); and cultivated plants from any area (green). For phytogeographic reasons Greenland and Alaska specimens are filed in the Canadian sequence, in which the order is by territories and provinces from east to west across the north and east to west across the south, thus: Greenland, Franklin, Keewatin, MacKenzie, Yukon, Alaska, Labrador, Newfoundland, Nova Scotia, Prince Edward Island, New Brunswick, Quebec, Ottawa District (Quebec), Ottawa District (Ontario), Ontario, Manitoba, Saskatchewan, Alberta, British Columbia. Occasionally a part of some province may be segregated if it has been intensively studied. The folders are marked in ink on the lower left corner with the genus number, name of the plant, and geographic division.

Herbarium Cases

The specimens are housed in steel cases very similar to those used in the National Mycological Herbarium and described in Chapter 2. The principal difference is that the case is 7 feet 6 inches high rather than 6 feet 7 inches. It has 16 shelves on each side with a spacing of 5⅛ inches, and the top shelf is approximately 7 feet from the floor. The higher case is slightly less convenient to use, and the doors are a little harder to close smoothly. It has the advantage of leaving less waste space above the cases.

Full utilization of space in a herbarium is always a problem, for the normal office or laboratory ceiling height cannot be utilized without resorting to step ladders, which

clutter the aisles and reduce working speed. Ideally the herbarium units should be built like library stack rooms with a smaller ceiling height than that of the surrounding offices; but not every architect can handle the problems involved, and such designs are not often seen. Apart from space utilization, floor to ceiling cases have two advantages: they reduce the space in which dust or litter can accumulate; and, by restricting convectional circulation, they greatly reduce the chance of a fire becoming strongly established.*

Protection from Insects

Any large, active and rapidly growing herbarium is occasionally bound to suffer from infestations of dermestid beetles. If the building and cases are of suitable design and accommodation is ample, a few simple precautions rigorously followed will prevent any appreciable damage. Unfortunately these conditions all too often cannot be met. The herbarium staff does not necessarily have control over the building plans, cases may be far from perfect, and, in particular, accommodation is often seriously inadequate for prolonged periods.

Provided that the conditions listed above are met, the following precautions will minimize damage. (1) The whole herbarium should be in insect-proof cases. Each staff member should have one or more cases in his room to house specimens on which he is working at the moment, and all specimens should be returned to these cases at night. (2) Unless the herbarium, or the whole building in which it is housed, can be conveniently and economically fumigated with, for example, methyl bromide, and is so fumigated about once a year, all cases should contain a volatile insecticide such as naphthalene or paradichlorobenzene.† The problem of building fumigation is further discussed in Chapter 2. (3) All incoming specimens, whether from other institutions or from the field, must be opened promptly on arrival, checked for dryness and put in the drier if necessary, and then put directly into

* See addendum 11. † See addendum 12.

regular herbarium cases that contain abundant naphthalene or paradichlorobenzene. The alternative is to have a fumigating chamber, with a properly designed exhaust system, in which boxes of specimens can be fumigated with methyl bromide, but this is a tedious undertaking when many large collections are coming in. (4) All cases must be kept tightly shut when not actually in use. (Having plenty of naphthalene in the cases makes this regulation much easier to enforce.) (5) The herbarium, preparation rooms, supply rooms, etc., must be kept uncluttered, so that thorough cleaning can be carried out, particularly of odd corners of the floor. Cartons of unworked specimens stacked on the floor are an invitation to trouble. All litter may house beetles, and the greater the insect population the smaller the probability of a perfect kill in a fumigation. It is a regrettable fact that a theoretically perfect fumigation, which kills all test insects set about the herbarium, often does not give a complete kill of the infesting beetles. In some instances a few probably survive behind baseboards of outside walls where the gas concentration is low. The herbarium and associated rooms should be designed to eliminate baseboards, and to have no crevices between wall and floor, in the manner generally followed in hospitals.

Unquestionably the best protection currently available is to keep *all cases* (those in offices and those for new collections or exchange as well as those in the regular herbarium) stocked with plenty of naphthalene or paradichlorobenzene. Methods of using these materials are discussed in Chapter 2. The sudden introduction of these chemicals into a herbarium that has not been using them will probably be met with vigorous protests from some of the staff. However, it is remarkable how one quickly gets used to the smell and eventually fails to notice it except when it is in great concentration.

Under crowded conditions, with specimens stacked everywhere in boxes, the parts of the above routine that can be followed will not be fully effective, and regular building fumigations will be necessary.

Loan and Exchange

In an active herbarium the volume of specimens sent out and received on loan and exchange requires that a regular system be adopted both for the mechanics of handling and for the maintenance of records.

Records.—At the Plant Research Institute a file is kept for each exchange institution. This file contains correspondence, loan and exchange forms, and a ledger sheet on which the balance can be read at a glance (see also final section of Chapter 2).

A triplicate form is used for recording the details of each shipment of loan or exchange specimens. It has spaces for the name and address of the recipient; the number of specimens and whether sent as loan, gift, exchange or return of loan; number of packages and method of transmission; special notes; signature of transmitting curator; statement of exchange balance; signature of recipient; and return address. The original (white) and first carbon (yellow) are sent to the recipient. A note on the forms, which are all identical in content, specifies that the yellow copy is to be signed and returned as a receipt. The second carbon (pink) is kept as a file record. When the specimens are returned, the curator may sign and date both yellow and pink copies, and send the pink one to the borrower in cancellation of the loan; but the method of marking completion of the loan is a matter of choice and some institutions make no further use of the pink copy. These instructions sound complicated, but their practice soon becomes routine and they save much correspondence. However, the procedure should be outlined in a conspicuous place, such as the front of the container in which the current supply of forms is kept, in case an inexperienced person should have to handle any loans in the absence of the curator.

Handling specimens.—The method has already been described by which the specimens are laid out on individual sheets of paper after identification, in order to determine the

number of labels to be made. Because of the inevitable delay between laying out and the return of the duplicated labels, some regular routine must be adopted for keeping track of the duplicates. When up to 20,000 duplicate sheets, representing possibly 5,000 collections, are sent out in a year, the need for some system is obvious. The duplicates are generally kept in taxonomic sequence because the specimens are sorted into such a sequence when they come from the field. Very small collections may be integrated, but generally one field party's duplicates are kept as a unit. If a batch of duplicated labels is received for specimens collected by Black in 1957, we can go straight to the cabinet marked "Black 1957" and slip each set of labels into the appropriate species folder. When the specimens are taken out for sorting the labels are distributed to the individual sheets. Small collections worked up by a single botanist and integrated into a single sequence must be adequately marked, for example, "Smith 1955, Jones 1956, Brown 1956". Very small collections with a substantial number of duplicates are generally received only from a collector specializing in some particular group of plants. They may all be put in one cabinet with an appropriate label on the outside, but the individual shelves should be labeled, for example, "Black, Gramineae 1957" or "Johnson, *Carex* 1957-58." Miscellaneous collections received from collaborators generally contain few, if any, duplicates; and any labels needed may be typed individually when the identifications are made.

Sorting requires a great deal of shelf and bench space when exchange specimens are to be sent to many institutions. A pigeon hole or bench area is set aside and marked for each institution. Sorting is preferably done co-operatively by the whole taxonomic staff who, between them, will know the special needs or preferences of many institutions. If a particular set of specimens is reserved for some institution it should be so marked in advance of sorting; otherwise, if the staff member who arranged its disposition should be absent at the time of sorting, the reservation may be overlooked.

Individual preference is, of course, only one factor of several to be considered in the allocation of specimens. The preferences of some institutions may not be known; others merely require a representative set of your flora without a preference for particular groups of plants. Inevitably the disposition of specimens is substantially governed by the standing of the exchange account: an institution to which you are heavily indebted naturally tends to get a larger share of your specimens than one with which you have a credit. However, the exchange balance has little bearing upon the most desirable disposition of important specimens. If an institution with a heavy debit balance is the logical depository for particular specimens, they should be sent there if there is reason to believe that the account will eventually be balanced. It is desirable to keep informed of the activities of your exchange institutions as far as possible. If you know that one is doing field work in an area important to you, it is advisable to build up your credit on the understanding that you will eventually get a set of the duplicates.

Packing.—Stack the specimens and labels neatly, each on a sheet of paper, wrap them in paper, and bind them firmly between sheets of corrugated cardboard. Specimens may be shipped in folded newsprint, but this practice hinders sorting and examination. The bundles must be tight enough to maintain pressure on every plant and label. If the plants slide to the edges of the paper they are likely to be broken. (See remarks above under packing and shipping of dried specimens.) The bundled specimens should be packed in substantial corrugated cartons. Old grocery cartons of suitable size may be used for occasional shipments, but if many lots are sent out each year the job of locating enough suitable cartons becomes time-consuming. It is therefore preferable to have a supply of cartons made up to your specifications. Two sizes are advisable, about 4 inches and 8 inches deep. Large shipments, if consigned to domestic institutions, may be packed in wooden boxes and shipped by

express. However, for foreign shipments, parcel post has proved much more reliable than express, both for promptness and to avoid customs difficulties. Of course, large shipments sent by parcel post must be divided into cartons within the maximum sizes allowed.

When a few sheets are to be sent on loan and your smallest box is too large, pack them, well padded with paper, between several sheets of corrugated cardboard. Use about four sheets on each side and place some with the corrugations running crosswise and some lengthwise. Address the cartons and bundles and then wrap in several layers of heavy brown paper and address again. Tie thoroughly with several rounds of strong twine knotted at several points. Parcels must, of course, be plainly addressed, preferably in black ink and directly on the wrapping paper, since gummed labels occasionally come off. Any parcel going out of the country must have a customs declaration form stuck on to it; but varying numbers of dispatch notes and loose customs declarations are also needed for shipment between certain countries, and full instructions should be obtained from your post office. The declaration should read "Dried Botanical (or Museum) Specimens—No Commercial Value." Avoid any wording that might suggest living plants, or the parcels may be opened and the contents disturbed by a quarantine inspector.

CHAPTER 2

FUNGI

Collecting and Drying

Introduction

One key to the successful preparation of specimens of fungi, as of vascular plants, is rapid drying with gentle heat. Rapid drying is necessary with most fungi to prevent discloration through oxidation, overgrowth by molds, or bacterial decay. It is even more desirable with foliicolous parasites, in order to preserve the appearance of the host plant; and, with mushrooms and other fungi, in order to preserve the color, form and surface texture to the greatest possible degree. However, the use of only gentle heat together with rapid air exchange is fully as important with fungi as with vascular plants, in fact probably more so for fleshy fungi; for heat without rapid removal of moisture simply increases discloration. The main function of the heat is to reduce the relative humidity of the air that passes the specimen; but it is also responsible for part or all of the air circulation according to the type of drier. A possible method of securing improved drying of fleshy fungi, especially, is to draw desiccated air at approximately room temperature past the specimens. With sound engineering design such a drier might be economical enough for regular use, at least for critical material, but such a method has probably not yet been investigated. Another method, which has been tested to a limited extent for mushrooms, is freeze-drying. The lifelike appearance of such specimens is very good and they may prove satisfactory for display purposes, such as a demonstration of the characters of poisonous species; but

the specimens are too fragile to be practicable for a taxonomic collection, and the preparation and housing of them would be too expensive and time-consuming.*

The laboratory drying cabinet described in Chapter 1, and illustrated in Figure 8, with an adequate exhaust fan, has been satisfactorily used for drying all types of fungi at this institution for several years.

Small parts of specimens of fungi may be fixed in the field in a fixing solution such as F.A.A. (formalin 7 cc., glacial acetic acid 7 cc., 50 per cent alcohol 100 cc.), in which material may be left indefinitely without injury, if it is anticipated that anatomical or cytological studies will be made. *No other specimens of fungi should be subjected to liquid preservation.* Fungi for taxonomic specimens are never improved by liquid preservation; most are made more difficult to study, and many become completely unrecognizable. The color of mushrooms is destroyed by such treatment.

In the following sections, suggestions are given for the collection and drying of various groups of fungi that present special problems. The fungi are grouped principally by handling methods rather than by strictly natural groups. The required equipment varies widely from group to group.

Field Notes

Full information should accompany every specimen, either as a rough label or as an entry in the field notebook and linked to the specimen through the collection number. The data should include: date, locality, collector, collection number, abundance, host or substrate, general habitat, and elevation if from mountainous country. It is from this information that the permanent label must be prepared, and a specimen without an adequate label is of very little value. Particular data for various groups of fungi are discussed below. See also "Field Notes" in Chapter 1. A consecutive system of collection numbers like that used by phanerogamic botanists, is highly recommended for mycological collectors. It is particularly useful for foliicolous fungi, as outlined below.

* See addendum 13.

Foliicolous Fungi

Included here are the rusts, smuts, downy mildews, powdery mildews, a variety of ascomycetes and imperfect fungi, and a few other minor groups. The collecting, pressing and drying of foliicolous fungi are so similar to these processes for the vascular plants on which they grow that the reader is referred to Chapter 1 for general information; but a few points are emphasized below. Thorough pressing is important, for wrinkled leaves gradually shatter in the packet.

Because of the similarity in field methods, phanerogamists and mycologists concerned with foliicolous fungi can often combine their field work to their mutual benefit. This is particularly true of inadequately botanized and relatively inaccessible regions, where general collecting of all groups of plants is usually desired. This end may be attained either by the mycologist and phanerogamist working together or by one assuming the collecting duties of the other. The latter is the more economical alternative in the arctic where the flora is too limited to warrant two trained collectors working together; but it cannot be effective unless each is well versed in the field methods and requirements of the other. Because of this the mycologist and phanerogamist should work together for at least one season before undertaking double duty; otherwise too many valuable opportunities will be wasted through ignorance. In countries such as Canada, where relatively few botanists must cover a vast area, this interdisciplinary approach to field work can be a big help.

A prime requirement in specimens of parasitic fungi, and indeed of many saprophytic species, is positive identification of the host plant. A name applied in full confidence to the host when the collection is made may be shown, by future studies, to embrace a group of closely related species. Therefore, adequate material for identification of the host should always be taken. It may be possible to include whole plants in the packet when small herbs are involved; and tall, slender herbs, such as grasses and sedges, may often be

included by cutting them in sections. Alternatively the critical parts for determination of larger plants may be included, although selection of appropriate material sometimes requires a knowledge of the taxonomy of the host genus. If good phanerogamic material cannot be included with the mycological specimen, take an ample phanerogamic specimen, to be inserted in the phanerogamic herbarium under the same collection number as the mycological specimen. When combined phanerogamic and mycological collecting is done, the taking of host and parasite under a single collection number should be routine practice. If more than one fungus occurs on the host segregate the specimens by letters added at the end of the number. Then if doubt later arises as to the identity of the host, you can check in the phanerogamic herbarium.

Although the habitat of the parasitic fungus is approximately that of the host plant, it often happens that the parasite occurs in only part of the host colony. Note any discernible feature of the habitat that correlates with the occurrence of the fungus such as low ground, shade, exposure or, in mountainous country, altitude.

Mycological specimens of herbaceous plants should be freed from soil even more sedulously than phanerogamic specimens. If soil particles are scattered through the sheets in the press, many become embedded in the specimens and are carried into the packet. If they cover the fruiting surfaces of the fungus it is difficult to avoid picking some of them up with the fungus when a microscopic mount is made. Even a small piece of grit under the cover slip may make it impossible to press the cover glass down enough for proper examination of the mount. Attempts to flatten the mount may cause breakage of the cover.

Be sure to collect ample material of these fungi, for a specimen may prove to be fruiting much more sparsely than appearance in the field suggests. In any case at least one sheet should be filled, any surplus over personal requirements being used for exchange. If you keep phanerogamic

and mycological material on separate sheets whenever practicable, you will reduce the time lost later in sorting. Some parasitic fungi are much less conspicuous after drying than when fresh, and the sorting may have to be done under the dissecting microscope.

Many of the rust fungi have in their life cycle several spore forms, which may differ considerably in appearance. Try to secure all states that are present, for some species are difficult to identify from a single one. Many rusts bear their aecial (cluster cup) state on one host and the uredinia and telia (commonly yellowish-brown and black respectively) on another, unrelated plant. For example, most grass and sedge rusts bear their aecia on various dicotyledons. In late spring and early summer both hosts may be found rusted together. Both should then be collected with notes on the association. If the rust is heavy where the two plants are closely associated, and progressively lighter as they become further apart, the presumption that they are the alternate hosts of a single rust is strong. Any such information should be recorded. In spring it may be possible to find the old telia on stems of the previous year associated with the aecia; or in mid- to late summer the spent aecia may be recognizable under a lens on blackened areas of the leaves of the aecial host, close to the fresh uredinia and telia.

In temperate regions most foliicolous ascomycetes do not mature the ascigerous state on the living leaves in summer, although a conidial state may be produced. If it is not feasible to return to collect the overwintered leaves in the early spring, take a large amount of infected leaves in late summer or fall; dry without heat (or take them home without drying if this can be achieved without their becoming moldy); place the leaves in net bags or wire screen containers, and put them in a place that resembles the natural habitat as closely as possible. In early spring check the leaves periodically and press and dry them as soon as the ascospores are plentiful.

In the arctic, where phenomena of spring, summer and fall tend to become telescoped, fruiting of the ascomycetes is not usually confined to spring but may last into August, or even start in August and be completed next spring. The old stems and leaves of most plants bear a variety of such fungi, which form a large proportion of the total fungus flora. Since there is a good chance of finding some fruiting material at any time during the normal field season, it is desirable to collect old stems and leaves with phanerogamic specimens. These fungi may be scarcely visible, let alone distinguishable from each other, by the naked eye, but the addition of a few dead stems to the specimen takes so little time that nothing is lost if the material proves to be sterile. The fungi are finally 'collected' in the laboratory under the dissecting microscope. Not much is known about these arctic-alpine saprophytic microfungi. They have generally been taken accidentally with phanerogamic specimens. The specimens are usually extremely inadequate; for the few affected leaves in a specimen may bear five or six different fungi, some represented by only one or two fruit bodies. The general collector should therefore refrain from cleaning all the old leaves and stems off his plants. Even if they yield no fungi, the stems may be left on the plant specimen as a means of comparing the plant heights in successive years. Bacterial action is so meager in the arctic that even delicate leaves and stems may remain attached to the plants for two or three years. It is as well to include both the stems of the previous year, which are usually yellowish brown, and those of earlier years, which are usually ashen. The latter may bear only spent fruit bodies but occasionally yield species that are lacking from the younger stems.

There is one characteristic of the downy mildews that the collector should bear in mind. These fungi fruit only in saturated or nearly saturated air, especially during dewfall. In wet or foggy weather it is possible to obtain good material at almost any time of day. But in clear weather the conidiophores and spores are produced at night and may collapse

before midmorning. In such weather the best collections are generally made within an hour or two of sunrise, although morning fog or a heavy dew may prolong the useful collecting period until about 10 a.m.

In addition to the field equipment regularly used for vascular plants, a hand lens of 10- to 15-power should always be carried. Paper bags should be carried in the field press for small specimens, fragile ones or for solitary infected plants taken with a phanerogamic collection, which might otherwise be overlooked. Tags and painted stakes may be needed for marking plants to which return trips are to be made.

Fleshy Fungi

This term is here used to include the mushrooms (Agaricales), puffballs, etc. (Gasteromycetes), clavarias (Clavariaceae), the larger cup fungi (Pezizales) and a few minor groups. These fungi are generally both fragile and ephemeral. If presentable and satisfactory specimens are to be obtained they must be handled carefully, and examined and dried promptly. They must *not* be put in formalin or other preserving liquids. When it is practicable to do so, as is often the case in forested country, fleshy fungi should be collected separately from other plants, because they require distinctive equipment. Thus, even if one is doing general collecting of all groups of plants in an area, days should be set aside for fleshy fungi. Such a day will generally be about three or four days after heavy and prolonged rain.

For fleshy fungi you need a light but rigid and easily carried container of ample size, such as a large, flat-bottomed basket, in which the specimens may be carried without being crushed. Keep the fungi separated by placing them in paper bags or wrapping in wax paper. If you are visiting a wide area jot down the particular habitat and include this information with each specimen as it is taken. Some of these fungi have narrow ecological limits. Habitat details may therefore be important. If the fungus is growing on wood,

get a little piece of it, too; it can often be identified later even if you do not recognize it in the field. By describing the forest type in your notes you immediately narrow down the range of possible hosts. It is important that at least some of the plants in each collection be complete. For example the base of a mushroom stem should always be included, because the presence or absence of a cuplike basal volva, more or less buried in the ground, is an important diagnostic character. Remove as much dirt as possible when the specimen is dug; otherwise the final cleaning is greatly complicated.

Fleshy fungi present a serious problem to the general collector who, because little time can be spent in an area or because the fungi are scarce, cannot afford to set aside special days for them. For example, you may be doing general collecting in the arctic or above tree line on a mountain, where you may see only a single species of fleshy fungi in a full day's walking. Under such conditions you would not want to carry a basket for fleshy fungi, because you will be devoting most of the day to collecting vascular plants, foliicolous fungi, mosses and lichens, all of which may safely be put into the field press. Unfortunately the very scarcity of these fungi in arctic-alpine regions makes it important that good specimens be taken whenever they are seen. A reasonable compromise is to carry one or more rigid cardboard boxes about 2 inches deep (arctic-alpine mushrooms and puffballs are generally small) into which the specimens may be placed in paper bags. The boxes are carried in the pocket of the field press, in a small haversack or even in large parka pockets. The folded-down paper bags prevent the specimens from rolling about in the box, and the box prevents them from being crushed. If you are caught in the field without a box it is sometimes possible to bring back a specimen in fair condition by putting wads of moss above and below it in a paper bag and putting the bag between wads of paper or any other bulky objects in the pocket of the field press; but this is a poor substitute for a rigid container.

As soon as possible after the fungi are collected, make notes on their colors, shape, size and consistency, for all these properties change to varying degrees with drying. There are some other characters that are occasionally very important, although usually of little significance. The general collector, who may not know when to record a particular character, often records those that are least significant. At one time we provided a printed field label for mushrooms with space for every imaginable kind of information. This method tends to defeat its purpose when mushrooms are plentiful; for, after spending three hours writing up a dozen specimens, the collector, burdened with other duties, often abandons mushroom collecting altogether.

The following suggestions may be of some help to the general collector with little knowledge of mushrooms. A few genera or species have some striking character that is lacking in all others: its absence is unimportant, but its occasional occurrence is vital to complete identification. Record the presence of watery juice, and the presence, color or color change of milky juice exuded from a broken specimen. Record any strong or unusual taste or smell; a few species have a peppery taste when chewed slightly between the front teeth and touched to the tongue. (Do not swallow any pieces of raw mushrooms; but tasting is perfectly safe except in the Amanitas, which combine white gills, a ring and a basal volva.) Do not waste time trying to describe a faint 'mushroomy' taste or smell. Record any color change that occurs when, especially, a bolete (tube mushroom) is cut or bruised; such changes are diagnostic but the colors may later fade. Record briefly the color or color range of the cap, flesh of the cap, gills and stem. The color of the young gills is important in *Cortinarius,* which is distinguished by its very heavy cobwebby veil over the gills. The shape of the gills and the surface markings of cap and stem are generally obvious in the dried specimen and may be ignored if time is scarce. Although it is occasionally of no great importance, a spore print is vital in some genera, such as *Russula,* and is

always useful. It should be taken whenever possible. Cut the stem off, lay the cap with the gills down on a sheet of white paper, and cover it with a glass dish or anything else that will keep it from drying out. In a few hours, provided that the mushroom is neither very young nor very old, a visible deposit of spores in radial lines corresponding with the gills appears on the paper. (If the spores are colorless the pattern shows up when the paper is held at an angle to the light.) As soon as you have made notes put the specimens in the drier on sheets of paper or in open paper bags and lay the notes, including date, collector's name and number, alongside them. After you get the spore print put the specimen in the drier with the rest of the collection. Write the collection number on the paper bearing the spore print and file the print with the dried specimen. Small specimens dry overnight, large ones in about a day, and extremely large ones in about two days in an efficient drier.

When traveling in settled country it is simple to take along a small collapsible drier powered by electricity. The design will depend on the type and quantity of collecting that is being done. If you are doing general collecting use a portable drier of the general type described in Chapter 1; the relatively small number of fleshy fungi you collect can be put in open paper bags in the bottom of it. If you are collecting only fleshy fungi, and space is at a premium, make a drier with a folding frame of wood or heavy wire, wire screen shelves, and walls of flame-proofed canvas. An electric light or a kerosene lantern in the base supplies the heat. Be sure to leave ample air inlet space at the base.

The handling of fleshy fungi in camp in the north, with several people competing for the space available in a small tent, can be very difficult. There is little or no space for setting up moist chambers for spore prints; there are probably no work tables, and yet the floor space must be kept clear; and the time that the general collector can devote to the handling of individual specimens is usually very limited. Yet the spore print is perhaps more important, on the average,

than any written data and should not be neglected. Drying the specimens and packing them and the prints also present problems. It has been found that the small number of mushrooms that are likely to be taken by the general collector can be processed in identifiable, if not perfect, condition as follows:

Take a piece of white paper about three times as wide as the cap of the mushroom, and of a length a little more than this amount. Along the center line punch one to several holes with the point of a pencil. Make the holes large enough to take the stems of the mushrooms and spaced so that the caps do not overlap. Push the stems through the holes; turn up the sides of the paper and fold them across the cap (see Figure 11). Then turn down the ends of the folded paper at right angles; in this way you will secure the fruit bodies and form a support in which they can be stood upright. Stand the paper, with its contained mushrooms, upright in a paper bag (other fruit bodies of the same collection may be put in with it), and put wet moss in the top of the bag to prevent drying out of the specimens. Set the bag upright in a cool moist place (for example, under the eave of the tent) for a few hours. One to several specimen bags can be enclosed in a polyethylene bag to prevent dessication. Wedge the bags in a vertical position; the gills of a mushroom are closely spaced, and if the bag is tilted much nearly all the spores will fall on and cling to the adjacent gill instead of reaching the paper. If the specimens are processed in the evening, leave them for deposition of the spore print overnight. Mark the collection number on the bag and also on the paper in which the fruit bodies are folded. The rest of the data are generally put in the field notebook, although if it is preferred, they may be put on a slip of paper and included in the bag. At the end of the spore-printing period remove the moss and place the bag, open, in the drier or on the floor between the lamps, if the drier described in Chapter 1 is being used for general collecting. In such a drier small specimens dry in about 24

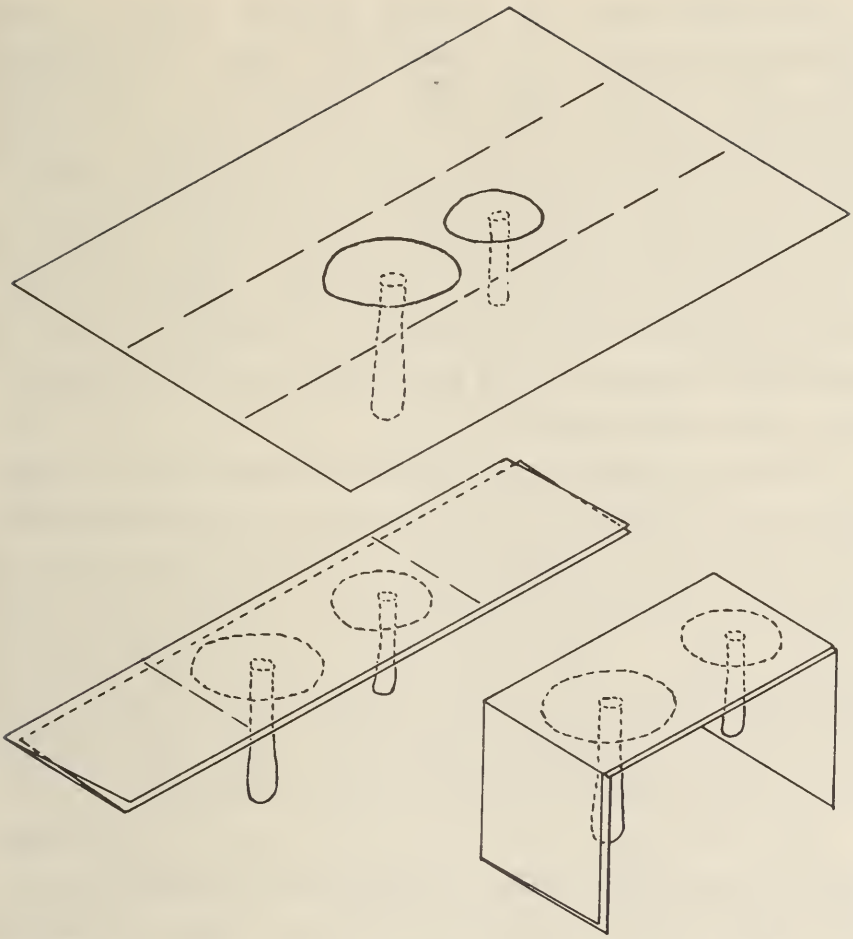

Figure 11.—Preparing mushrooms for making spore prints in the field.

hours, large ones in two to three days. Once the specimens are dry fold down the tops of the bags and secure the fold with paper clips, rubber bands or gummed paper strips, then put the bags in a box in a dry place. By this method the individual fruit bodies are not touched after they are set up for spore printing, and the spore print cannot become separated from its specimen. The folded paper and the paper bag combine to make a springy support for the specimens, simplifying packing and reducing the risk of damage in transit. Pack the accumulated specimens in a box with crumpled paper or other light material that will fill up any space.

The identification of puffballs depends partly on gross external characters of the fruit body (color and markings) and partly on the microscopic characters of the spores. Specimens should therefore be mature enough to contain spores, that is, they must be colored and preferably powdery inside. But they should not be so old that the outside has become weathered. In the arctic, where the growing season is short and decay slow, it is sometimes possible to collect young specimens of the current season, showing the external characters, adjacent to old fruit bodies of the previous year that still contain spores.

One interesting genus is *Cordyceps,* whose brightly colored, more or less clavate fruit bodies may be found protruding from forest litter or moss. These fungi parasitize insects and the slender stalk of the fruit body grows up from the buried larva or pupa of the insect. The fungi should be dug with extreme care, in order that the insect may be recovered, preferably still attached to the fruit body; there is some degree of host specificity in these fungi, and at least approximate determination of the host is always desirable.

The subterranean fungi, both the truffles and their allies and the superficially similar underground gasteromycetes, are not often collected because few people think to look for them. Bear them in mind when digging up plants or fungi. If you find one search the surrounding area carefully. These fungi are sometimes found in rodent caches. When you see squirrels or other animals digging it is worth investigating to see what they are taking. When general collecting is being done only briefly in an area a systematic search for hypogeous fungi is impractical. However, a more systematic search should be made in the collector's home territory. For this purpose a trowel can be used to turn over sample areas of forest floor periodically in different associations.

Wood-destroying Fungi

The wood-destroying fungi include the Polyporaceae, many of which are conspicuous bracket fungi, the more or

less appressed Thelephoraceae, and the tooth-bearing Hydnaceae, as well as some of the true mushrooms. The first three groups are relatively firm, and leathery or woody, compared with the mushrooms. Because of their bulk these fungi are usually carried in large baskets; but, if you are working in rough terrain and must keep your hands free, put the individual collections in paper bags and carry them in a haversack or pack. These fungi are less fragile than mushrooms, though some of the delicate ones may be quite brittle when dry. They also change less in color, size and shape as they dry. They include all the important causes of timber decay and are thus of great economic importance. The specimen should be accompanied by the name of the host, if this can be determined in the field, and should include enough wood to show the type of decay. If the decay organism is to be cultured, cut out a substantial block of wood with a saw. Otherwise use a heavy knife, small hand ax, or machete for cutting the specimen away from the substrate.

Although for preservation of color and form rapid drying is less critical for these fungi than for the fleshy fungi, it is important in preventing loss of the spores and should always be practised.

Microfungi on Twigs, Bark, etc.

These fungi are generally not very fragile, and may be collected into paper bags and carried in a haversack or basket. Take along pruning shears if you are looking for twig-inhabiting species. You will also need a heavy knife for trimming specimens from wood, bark or large twigs. When identifiable material of the host is available it should be included.

Heat should be used for drying, but it is not a critical need if the specimens are not extremely bulky and are taken in fine weather.

Coprophilous Fungi

A distinctive fungus flora develops on the dung of various animals but particularly of herbivorous mammals. Students of these fungi are glad to have dung samples from out-of-the-way places and from rare or localized animals. Take the fresh, moderately dry pellets, which are easier to handle and yield more of interest than do very old, weathered pellets. Put the samples in paper bags, cardboard boxes or tins. If they are not intended for immediate study dry them in the air for one to several days according to size. Use only very gentle heat. If specimens are in tins leave them uncovered during this period. When it is desired to develop the fungal fruit bodies place the pellets in moist chambers for several days and keep them under observation. Quite a succession of fungi may occasionally develop, but the details of such studies are beyond the scope of this manual. Remove the mature fungi and dry them in the ordinary way. On the label include date, locality, collector and number; also record the time and temperature used for development of the fruit bodies and the identity, if possible, of the animal that made the droppings. The locality and habitat will help to narrow the choice. Identifiable tracks may be present. Experienced zoologists, trappers or naturalists will often be able to help. A few natural history books (such as O. J. Murie, A Field Guide to Animal Tracks, Houghton Mifflin Co., 1954) give information on this subject.

Myxomycetes

The slime molds are one of the most frequently collected groups of fungi—and one of the most poorly collected. Unless the delicate structure of the fruit bodies is well preserved, specimens are often completely unidentifiable. Because of the difficulty of preserving them from damage most collectors take only a small amount from a colony, and thus duplicates are seldom available for distribution. Even when we receive specimens large enough to divide, their condition seldom warrants making duplicates. This is

one group of organisms that *must* be preserved from crushing and battering. Take specimens with a substantial amount of the log, twig or other substrate on which the organism is fruiting. The substrate can then be used to wedge the specimen into a pill box, salve tin or other receptacle. If you are caught in the field without a suitable box make one of cardboard of other material. In an emergency, fold a sheet of paper several times, and then fold it into a rectangular box; stiffen the sides by whittling thin slivers of wood and putting them between the layers of paper, and fasten the box shut with string. In the laboratory you can stick the specimens to the bottoms of permanent boxes.

Although myxomycetes take no nourishment from the substrate upon which they fruit, but merely climb up it, they show considerable restriction in habitat. The substrate may reflect the habitat and should be recorded along with other habitat data. Thus *Lamproderma cribrarioides* is commonly found on living plants of *Lycopodium;* presumably the acid, organic soil on which the *Lycopodium* grows is suitable for the slime mold.

Bulky specimens should be dried with heat, but small ones will dry readily at room temperature in a dry building.

Plant Disease Specimens

The instructions given for foliicolous fungi and microfungi on twigs cover many of the requirements for specimens that show diseases of garden or crop plants. However, diseases may attack the roots, crown or main stem of a plant, although the principal symptoms show on the leaves as wilting, marginal scorching or general discoloration. If such a disease is suspected, dig the plant, free it from soil, flatten it between several layers of newspaper, bind it between sheets of cardboard, and send it at once to the nearest plant pathologist. Plants so packed will preserve many of the original symptoms; and it is often possible to isolate the causal organism from them. Never ship plants wet and wrapped in waxed paper unless you can be sure that they

will be delivered within about 24 hours. Remember that a slight delay in delivery may result in a weekend intervening before the specimens reach the recipient. If they are in a warm place during this time they will ferment and blacken beyond recognition or become covered by molds; in either case the symptoms will be obscured and isolation of the pathogen becomes impossible. If you are close to a plant pathology laboratory it is generally best to pot up the plant with the minimum disturbance of the soil about the roots and deliver it personally.

Plant disease specimens are sometimes put in liquid preservatives in an attempt to preserve the symptoms for demonstration purposes. Such specimens are bulky and messy to store; the liquid has to be replaced periodically; and the tops of the jars sometimes are impossible to remove for renewal of the liquid. The colors generally fade eventually, even when special color preservatives are used, so it is usually better to keep only herbarium specimens and to use color transparencies to show the symptoms. If specimens are kept for anatomical study do not use color preservatives that contain metallic salts, for electrolytic action quickly ruins the edge of a razor when such material is sectioned.

Processing Dried Specimens

Introduction

The methods by which specimens are filed and housed depend somewhat upon the size and scope of the herbarium as well as personal choice. Some practices are more or less universal, but details vary greatly from one institution to another and also from one group of fungi to another. The principal requirements are: (1) protection of the specimens from mechanical damage, fire and insects; (2) ready accessibility of the specimens for study; and (3) a system sufficiently flexible to allow normal growth of the herbarium without frequent laborious reorganizations. The methods in use in the Plant Research Institute are outlined below for

some of the groups of fungi that were treated in the first part of this chapter. This outline will serve as an example of satisfactory methods rather than a full acount of all the possible alternatives. Experienced curators will certainly not agree with all our methods, but may benefit from some suggestions. The mycologist faced with starting a new herbarium will probably benefit more extensively; for recent sharply accelerated growth and changes of emphasis in the National Mycological Herbarium have forced us to cope with problems that might not otherwise have seemed significant.

Before outlining our methods it may be well to mention a few practices that often seem desirable to the beginner but become increasingly unsatisfactory as the herbarium grows. The first is the practice of filing packeted specimens like index cards, on edge in a cabinet rather than mounting them on sheets. The beginner is inevitably impressed with the apparent logic of this method, but it has several disadvantages. If the packets are stored on edge the specimens tend to work to the bottom, and fragile material is easily broken up. If the packets are filed on edge like index cards, they are handled like index cards. The amount of handling in an actively used herbarium is substantial, and the wear on the tops of the packets eventually becomes serious. Thus repacketing may become necessary long before it should, causing much extra work and often posing a problem in the disposal of manuscript annotations on the old packet. Finally this method demands an essentially uniform packet size. With very small specimens this treatment is merely somewhat wasteful; but with the large dimensions often needed for good specimens of foliicolous fungi the brutal chopping that it entails is positively procrustean The method also necessitates the repacketing of many exchange specimens, which reach you in packets of various sizes.

Another practice that may seem innocuous in a small collection is the adoption of a completely arbitrary arrangement of the specimens, unmounted, in a numerical sequence. The less objectionable variation of this system is one in

which each species is allotted a number. All the specimens of a species bear this number and are filed together. In order to find a species, reference is made to a species index, in which the nomenclature must be kept up to date. Related species seldom, and only by chance, occur together in the herbarium. This system throws extra work upon every user of the herbarium; and, when loan requests are received, it greatly increases the work of record keeping for the curator, who must mark the withdrawal of the individual species of a genus instead of merely the genus. Another minor disadvantage of this method, which was employed in the private harbarium of the late Dr. John Dearness, is that workers who borrow specimens often interpret and cite the species numbers as collection or accession numbers. A much more objectionable variation of the numerical filing system is that in which the specimens are filed in the sequence of their accession numbers. In this system not only are related species scattered but even the individual collections of each species are dispersed. Specimens must be sought through the use of an elaborate index and found only with considerable labor; and the index must be kept continuously up to date. In searching for a group of related species one must think of, and check, all possible names to which specimens may have been referred through the whims of earlier staff members, to be reasonably certain of finding all the available material. The one minor advantage of this system is that it simplifies insertion. As we shall see below, a more logically arranged herbarium serves as its own index, allowing the clerical staff to be more usefully employed.

We shall now follow the stages of processing newly acquired specimens before dealing with other aspects of herbarium practice.

Packeting and Labeling

When a collection has been identified, ample material for a specimen is put in a packet together with a slip of paper

bearing spore measurements and other microscopic characteristics. Surplus material is put into other packets for exchange. If the collection is not large enough to divide, a single label is typed, or printed with black ink, and is clipped to the packet. If there are duplicates they are attached to the master packet with a separate clip or with rubber bands, but the master label remains associated with its own packet. If there are only a few duplicate packets the labels for them are typed individually. If there are more than five, one label and a carbon copy are typed initially. The carbon stays with the duplicates. The required number of duplicates is marked on the original. When a number of such labels have been accumulated, they are sorted into groups of six for each of which nearly the same numbers of duplicates are needed. A stencil is then cut for each group of labels and the necessary copies are printed. The labels are cut up and sent back to the herbarium, where they are attached to the packets; the duplicates are then put in boxes to await the next distribution of exchange specimens.

Attaching an individual label as it is made is time-consuming. It is generally preferable to accumulate specimens in appropriately marked boxes until a considerable number are on hand. Labels can then be attached quickly, and without using a great surplus of mucilage, as follows. Spread a thin film of mucilage on a glass plate, renewing it periodically with a brush and adding a little water as it becomes too stiff. Touch the top $\frac{1}{8}$ inch of the label to the film of mucilage and press it into position on the packet with a wipe from a pad of cleansing tissue. Do not use more adhesive than is actually needed. The excess runs out from under the label, staining it and the packet, and often causing two packets to stick together.*

Four sizes of machine-made packet, similar to that shown in Figure 10, are used in the mycological herbarium: (1) $3\times1\frac{1}{2}$ inches; (2) 5×3 inches; (3) $5\frac{1}{2}\times4\frac{1}{2}$ inches; and (4) $9\frac{1}{2}\times3\frac{1}{2}$ inches. The first of these packets is used to hold a microscope slide, a very small specimen or a selected part of a specimen; it is always kept within a larger packet.

* See addendum 9.

The third size of packet is used most extensively. It will hold a relatively bulky specimen, notes, and a slide in a thin cardboard container. The second size of packet saves considerable space in housing small specimens; it will house a slide in the No. 1 packet, but the bulkier cardboard slide holder is inclined to prevent the flaps of this small packet from lying flat. (Recent trials have indicated that the No. 1 packet is a satisfactory slide holder for slides sealed with a sealing material, such as clear nail lacquer, which is not sticky when dry.) The long No. 4 packet is useful for specimens on twings or shoots, especially where a short piece does not show the symptoms satisfactorily; but it is particularly valuable for parasites on slender herbs that are often included in their entirety. It will hold complete or nearly complete grasses and sedges, avoiding the common and exasperating situation in which doubts about the identity of the host cannot be resolved. The number and exact sizes of the packets selected are a matter of choice; but, in the one chosen to correspond to No. 3, it is essential that the length be slightly less than half the width of the herbarium sheet (11½ inches). Two such packets may then be mounted side by side and the sheet filled with the minimum waste space.

Bulky specimens such as mushrooms, or fungi on thick twigs, cannot be kept satisfactorily in the type of packet just described, for the flaps tend to fly open. They are kept instead in hand-folded packets made from paper measuring 8½×11 inches, which are made as follows: Fold up the bottom of the sheet to within 1½ inches of the top, and score the fold; fold the top 1½ inches down over the first fold; finally turn the paper over and fold each end back for 1½ inches. This method gives a packet 4¾ inches high and 5½ inches long. The precise height of the packet is not important, but the length must be carefully controlled. If the length is much over 5½ inches two packets will not fit side by side on the sheet. A much shorter packet will have such long flaps (unless they are trimmed) that little space will be left under the center of the packet for attaching it to the sheet. In

making this style of packet, which may of course be made in other sizes also, the first two folds are made in one stage; then, when several have been folded, they are turned over and the end folds made. A simple jig may be used as a folding guide, but a board marked with guide lines gives close enough control and is simpler to use. The method is shown in Figure 12. The folds are scored with the back of a finger nail or with a smoothly rounded hardwood stick. When such a packet is stuck to the sheet by its center and the flaps are turned under, it stays firmly closed even with quite bulky contents. After mushrooms are identified they are placed for 4 to 8 hours in a moist chamber (but not in contact with water), which relaxes them slightly. They are then pressed

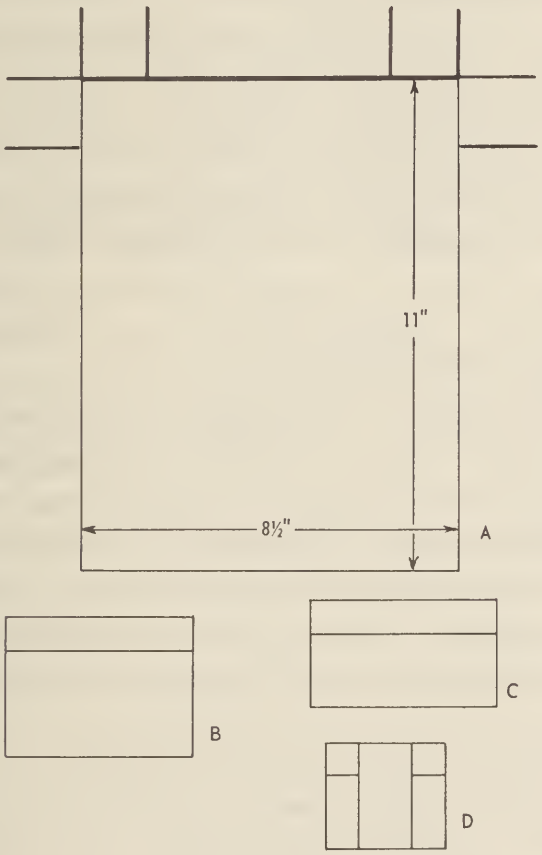

Figure 12.—Method of preparing hand-folded packets. A Sheet of paper in position on guide lines. B. First fold (up). C. Second fold (down). D. Packet turned over and final folds made.

gently, so that they will fit easily into a packet, and redried. Extremely bulky specimens are filed separately in special boxes, as described below. Large sheets of paper should be kept on hand for making extra large packets to house mushrooms which, though reasonably flat, are too broad to go in a standard packet.

Packets must be made of bond paper of high quality. Sulphite paper must never be used because permanence is essential. If good bond paper cannot be obtained, heavy kraft paper may be used. It is actually rather more durable than most bonds, but the color is objectionable, annotations do not show up well on it, and less light is available for examination of specimens in the open packet.

Cellophane envelopes about $4\frac{1}{2} \times 4$ inches are sometimes used inside packets to hold exceptionally dusty specimens, such as some of the smut fungi, whose spores tend to sift out of any packets; the open side is folded over. These envelopes are also useful for some other types of specimens, notably dried agar cultures whose appearance is diagnostic. They may be handled in the envelope without becoming rubbed.*

Accessioning and Indexing

Two other steps are taken before the specimen is inserted in the herbarium. When it has been identified and the label made, it is entered in the accession book. Opposite the accession, or serial, number in the margin of the book are entered the name, host or substrate, locality in brief, collector and date. The number is then written on the label. Duplicate labels are made after accessioning and the number is typed on them.

The accession books are kept in the form of four-ring foolscap binders. The entries are made on the left side of the page, the right side being kept for redispositions. When specimens are to be entered the date of entry is written in the margin below the first accession number. This procedure allows a quick estimate to be made of the specimens added

* See addendum 14.

to the herbarium in a given period; and it helps in the locating of specimens that are in course of being processed for insertion.

The accession number serves two main purposes. It occasionally helps in tracing a specimen that has been mislaid or redisposed; and it allows brief but unequivocal citation of specimens. If all mycologists used collection numbers this second use would disappear, since the collection number would then be cited. Unfortunately many mycologists still do not use collection numbers, and it accordingly seems advisable to continue the accessioning system. It is time-consuming and its value is somewhat in doubt. The accession number has, moreover, frequently been confused by citing authors with a collection number. For this reason the space for the accession number on our label forms is now headed by DAOM, the abbreviation of the herbarium. An accession number does not altogether replace a collection number. This is particularly true for parasitic fungi in which the collection number, with a qualifying letter if it is preferred, can refer both to the fungus specimen and to a specimen of the host plant. For bulky specimens that must be kept in boxes the accession number serves another purpose. The number is printed both on the label and on each separate piece of the specimen. Thus there is no risk of accidental mixing of adjacent specimens.

The final step to be taken before the specimen is inserted is to check that the species is recorded, on the particular host or substrate, in the host index. The host index is a relatively recent innovation in this institution and a most useful one. No attempt has been made to list all the hosts and substrates that have been recorded for any fungus, but only those represented in the herbarium. Host plants are recorded to genus; and other substrates such as wood and bark, dung, bone, paper, textiles, soil, etc., are broadly categorized. At the top left of each 3×5 inch index card is typed the host or substrate category. At the top right of each card is marked the major group to which the fungus

belongs (listed below under Insertion). The name of the fungus is typed below the headings. A blue marker card with a tab on the left marks the start of each host or substrate; and a buff marker with a right-hand tab marks each fungus group under a given host, but the buff markers are not used if there are only a few fungi recorded on the host. A few groups of fungi are excluded from the host index. The Agaricales and Gasteromycetes are not entered because most of them grow on soil or decayed wood. The wood-inhabiting Hymenomycetes are separately indexed in connection with studies of wood-destroying fungi, and so are excluded from the general index.

The host index is supplemented by a synonym index. Whenever a redisposition is made a card is put in the synonym index, under the old name, to show the new disposition. The purpose is simply to aid users in the location of specimens, and not to record the full synonymy for a species. When the name of a very well-known fungus, such as a common plant pathogen, is changed, we may leave an empty folder in its former place, directing the enquirer to the new name. Such blank folders can usually be removed in a year or so as the new name gains familiarity.

Exsiccata*

In the National Mycological Herbarium most of the sets of published exsiccata are kept as such, rather than being distributed through the herbarium; but some small or incomplete sets, and some that contain plants other than fungi, are distributed in normal sequence. These sets are indexed under the names allocated to the specimens when the sets were issued. In using the index one must accordingly be prepared to look for specimens under possible synonyms. An asterisk on a card in the host index warns the user that there is material in the exsiccata. There is much to be said

* Exsiccata: neuter plural of *exsiccatus*, literally anything dried. Also used in masculine when specifically governing fungi or musci, or in feminine when governing *plantae* or algae. Refers to sets of specimens published, like a book, with printed labels.

for incorporating all sets of exsiccata in the main sequence of the herbarium, where they are readily available and thus more useful. The counter arguments are that, if they are in the main sequences, the exsiccata tend to be used in preference to other specimens and may become exhausted; and that a cited exsiccatum is more promptly accessible for reference if it is in the set. If it is in the general herbarium it may have been redisposed to a name unfamiliar to the person seeking it, or it may be somewhat buried if the fungus is represented by a great many specimens. Because the specimens are often scanty in some of the older sets, permanent mounts should be made of any specimens that are examined. The exsiccata are often in small packets, crowded on the sheets, and the mounts are accordingly usually put in packets in the general herbarium. More serious than the separation of the slides from the parent specimens is the fact that the exsiccata are not utilized to their full possible value if kept in sets, because much time is involved in locating the required specimens and there is the possibility of overlooking some under obscure names.

Herbarium Sequence

Before we discuss insertion of the specimens, the arrangement of the species in the herbarium should be considered. The fully processed specimens are sorted alphabetically under the major categories used in the herbarium. These are: Myxomycetes; Phycomycetes, general; Peronosporales; Ascomycetes, miscellaneous; Taphrinales; Erysiphales; Discomycetes, operculate; Discomycetes, inoperculate; Pyrenomycetes; Tuberales; Phomales; Melanconiales; Hyphomycetes; Mycelia Sterilia; Miscellanea (especially bacterial, virus, nematode and physiological diseases); Ustilaginales; Uredinales; Agaricaceae; Boletaceae; Clavariaceae; Lycoperdales; Nidulariales; Sclerodermatales; Hymenogastrales; Phallales; Auriculariaceae; Tremellaceae; Tulasnellaceae; Dacrymycetaceae; Hydnaceae; Polyporaceae; Exobasidiaceae; Thelephoraceae.

Within these groups the specimens are filed alphabetically by genus and species, with some exceptions to be noted below. We are sometimes asked why we do not divide some of these categories further, in order to bring related genera closer together. The Pyrenomycetes are an obvious target for such criticism. The use of smaller categories may give rise to several difficulties. There may be no general agreement on what these categories are, or what their limits are. There may be numerous embarrassing intermediates that must be assigned arbitrarily to a category. Those inserting specimens and those using them for study must either memorize the system of classification that is chosen or continually refer to an index that will tell them where to find a particular genus. An elaborate classification with small categories would be satisfactory if none but a specialist in a group ever worked on that group. Thus a uredinologist might divide the rust fungi by families and tribes, to bring related genera together; but this action would merely hinder someone who seldom worked with these fungi. We do keep an index of genera, giving assignments to the categories listed above, but, with the relatively simple system in use, it need be referred to infrequently. Because the Ascomycetes contain so many pathogens of economic plants, and because many of them have conidial states, many mycologists who are not specialists in the class must work with them occasionally; and a complex arrangement consequently has appreciable disadvantages. However, when the classification particularly of the Pyrenomycetes becomes more stable, with a single system gaining wide acceptance, we shall probably adopt a more elaborate filing system.

For the parasitic fungi and for those saprophytes that have a limited range of host plants, sorting by hosts is extremely useful. Some degree of geographic sorting is generally useful also. Accordingly specimens of a species of fungus on different hosts are mounted on different sheets. We also use separate sheets for specimens on a given host from Canada,

from the rest of North America, and from other parts of the world.

For some of the parasitic fungi that have narrow host ranges, it has proved a great convenience to group the species of each genus by host family. This has been done for the Peronosporales, Taphrinales, Ustilaginales and most of the Uredinales. It is impractical to use such a subdivision for the Erysiphales, because several species occur on hosts in a number of families. Some caution is needed in deciding how far such a subdivision may be carried. It might seem desirable to break down large host families, such as Gramineae, to tribes; but many parasites occur on two or more tribes of this family. It is, however, occasionally practicable to divide a host family. Thus we segregate Alliaceae from Liliaceae in our arrangement of *Puccinia,* for this segregate family bears a distinctive group of rusts. Similarly Hydrangeaceae, Grossulariaceae and Parnassiaceae are removed from Saxifragaceae, leaving a more natural unit. When such subdivisions are made, a penciled warning is printed on the first folder of the main family, directing attention to the segregates. This arrangement is a great help when one is studying all the rusts, let us say, of a particular family of plants, or must identify a rust of some unfamiliar complex, or again when the loan of the rusts on some particular group of hosts is requested. All the species are together and no reference need be made to the host index. Heteroecious rusts are filed under the family of the telial host in this system. Very rarely a rust may attack plants in two families. Then they are all filed under one family and a cross reference is put in pencil on the first folder of the second family; for example *Uromyces sparganii,* which attacks *Acorus* and *Sparganium,* is filed under Sparganiaceae, but the note "see also Sparganiaceae" is put on the first folder of Araceae.

Insertion

Although insertion is sometimes regarded as a purely mechanical operation, it should be done as far as possible

by the mycological staff rather than by technicians. In a large herbarium it is preferable that each mycologist should insert those groups of fungi in which he specializes. By this means misdeterminations and invalid names are caught, and interesting specimens occasionally come to light. It is the specialist in a group who is most likely to be suspicious of the correctness of a determination, perhaps because of an unusual host or unrecorded locality; and it is he who will recognize the significance of an important but hitherto disregarded specimen.

For insertion the specimens are sorted by the major groups recognized in the herbarium. Within these groups they are then sorted alphabetically by genus and species, except that those groups that are segregated by host family are sorted accordingly before they are sorted to species. Insertion is done on a narrow wheeled table, which is easily moved through the aisles between the cases. The sorted specimens, stacked in a shallow box, and a jar of mucilage with a brush mounted adjustably in the lid are carried on the top of the table. A supply of mounting paper and folders is put on the lower shelf. It is sometimes advisable also to have one or more reference books on the lower shelf, in order to check host or fungus names during insertion. It is all too easy, for example, to have a single host filed under two names; and a substantial amount of such minor revisionary work in the herbarium is done during insertion.

The table now in use in the Plant Research Institute is a stainless steel hospital table 4 feet long, 20 inches wide, and 3 feet 2 inches high, with 4-inch casters. This is a stock article whose dimensions and construction happen to be ideal for herbarium use.

When several specimens are to be inserted in a folder, it is advisable to work from the last to the first. By this method there is no need to move sheets to which specimens have just then been attached. Risk of the specimen moving before the mucilage hardens is thus largely avoided. Before inserting specimens the worker runs his hand over the

closed folder to see whether there are any low spots. Specimens are then stuck to that part of the sheet insofar as space on the appropriate sheet permits. When a new sheet is needed it is generally best to start at the extreme top or bottom, for there will generally be enough sheets in the folder rather more than half full to cause the middle part to bulk fairly high. If the first specimens are often put half way down the sheet, not only does the middle of the folder bulge unduly, but the sheets often will not be filled economically; for there may be room for one but not quite for two above and below the first one. When balance demands that the first specimen should not be at the top or bottom, it is put slightly more than the height of the most commonly used packet from top or bottom; the chance of the space being used economically is thus enhanced. Except for long packets that nearly span the sheet, the packets are always put within about $\frac{1}{8}$ inch of the edge. Even quite small packets are treated in this manner because a specimen in a packet more than half the width of the paper may later be received from another institution. It is exasperating to find that there is not quite enough space on a sheet for a new specimen because an earlier one was put $\frac{3}{4}$ inch from the edge.

Packets are attached with the smallest practicable amount of mucilage—a light streak about $\frac{1}{2} \times 1$ inch in the middle of the packet. The mucilage is dispensed from a jar with a screw top, through which the aluminum handle of the brush passes and to which it is attached by a clamping ring. The brush is set so that it barely touches the mucilage. By this means a controlled amount may be put on the packet without the messy procedure of wiping the brush on the neck of the jar. The hand-folded packet with flaps that are tucked under it must, of course, be attached only at the center or it cannot be opened. If a packet must be removed, the sheet is turned over with the packet face down; then the packet is held flat and the paper is bent back and pulled off it slowly, using a sharp knife if necessary. If the tear starts to go too

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deeply the sheet is pulled from a different direction. By this means all but the flimsiest packets may be removed intact. Those packets that do tear can be patched with a square of paper stuck over the back.*

Various attempts have been made to find a means of attachment that will allow packets to be removed readily. Rubber cement was once thought to be a good solution to the problem; but after a few years this material releases its grip completely. Specimens have been pinned to the sheet in at least one institution; but pin points must be exposed either inside the packet, to the detriment of the specimen, or on the back of the sheet, to the detriment both of the packets on the sheet below and of the fingers of mycologists. Pinned packets may also become loose with enlargement of the pinholes. Some years ago a sheet with five pockets across it was developed at this institution. This is in effect a large-scale version of a type of album leaf used by philatelists for storing duplicate stamps. It is discussed further in Chapter 3. This type of sheet has proved impractical in the mycological herbarium because packets containing slides or heavy specimens easily slip out of the pockets once they become slightly stretched. The method seems to be more suitable for bryophytes, which are generally very light, than for fungi; but whether it would be wholly satisfactory in a collection of mosses that was being used very actively is still uncertain. The most promising suggestion is the use of an adhesive paper hinge somewhat like a massive stamp hinge. Although we have not yet adopted this method, tests have indicated that such a hinge will withstand all but extremely rough handling; but that for long packets one hinge should be used near each end to reduce the risk of twisting. It is also important that the hinge be firmly attached right to the hinge line or movement of the packets will be possible. To remove a packet one simply slips a paper cutter under it. The practicability of the hinge system will depend partly on the local cost of the hinges and on the development of a quick and efficient method of wetting them for use.

* See addendum 9.

The specimens are housed in the standard manila covers used in the phanerogamic herbarium, $16\frac{3}{4} \times 11\frac{3}{4}$ inches. Originally the markings were put on the lower right corner of the cover; but it was realized some years ago that markings on the lower left corner, adjacent to the hinge, are much more readily inspected, and all new covers are now so marked. The permanent data are printed in india ink or black printer's ink, and those that are subject to change are lettered in pencil. For those who can do draftsman's script, the quickest and most satisfactory means of lettering seems to be the use of the finest available felt marking brush, with black ink in the reservoir. The more time-consuming method of a lettering guide and stylographic pen is preferred by those without facility in printing. A disadvantage of this method is that it requires the use of a drawing board and square; so that folders cannot be marked during insertion, the time at which the need for new folders generally arises. Although neat lettering is commendable, the prime requirement is legibility, and it is not desirable that undue time be spent on marking folders.

Figure 13 shows some examples of marked folders. The heavy letters represent the permanent data printed in ink and the thin lines the temporary pencil markings. The first example, *Mycosphaerella* K—ME, illustrates the system used in most of the herbarium for species represented by few specimens. Individual folders are used for species that are heavily represented. Thus there is a folder for *Mycosphaerella ribis,* a well-known parasite of cultivated *Ribes* spp.; and there are several for *M. tassiana* and its varieties, which occur on a wide variety of plants in the north. The remaining examples illustrate the handling of the species of *Puccinia* attacking Polygonaceae. (*Puccinia,* like most genera of the rust fungi, is filed by host family.) Each folder bears "PUCCINIA" in capitals and, below it, "Polygonaceae" in small letters, both in ink. The first folder contains several minor species with the initial letters A and B, the letters being in pencil because the folder will probably

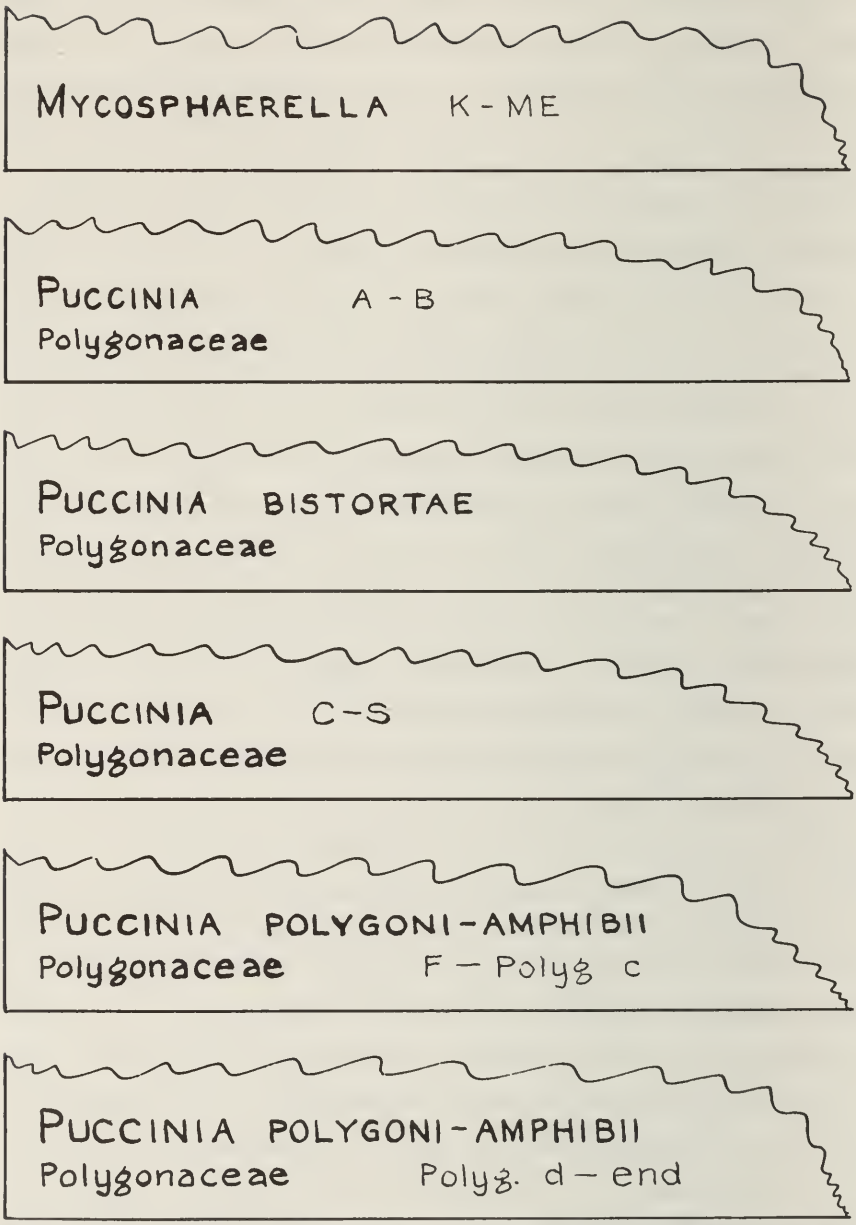

Figure 13.—Method of marking folders in mycological herbarium. Bold lettering represents permanent ink markings; light lettering represents temporary pencil markings.

eventually have to be split. Next comes *P. bistortae,* a major species, in its own folder; as the material of this species accumulates the folder will be split. All but one of the remaining species fit in the next folder (C—S); but there

is one more major species, *P. Polygoni-amphibii,* which already requires two folders; the first holding specimens on hosts from *Fagopyron* to *Polygonum c.* and the second those on *Polygonum d.* to the end (*Polygonum* spp. indet.). The host designations are in pencil because it is anticipated that before long the specimens will have to be divided between three folders.

Herbarium Cases

Specimens in the National Mycological Herbarium are housed in steel cases two shelves wide and 6 feet 7 inches high. The top shelf in this case is about 6 feet from the floor. The door is closed by a handle that operates bolts at top, center and bottom, pulling the door tightly against felt strips when it is closed. The door and walls are of double steel sheet construction with corrugated asbestos in the intervening space. This is a highly fire-resistant case and has proved very satisfactory when produced by a competent builder. We have stuck to the design largely because it can be obtained from a reliable and skilled manufacturer reasonably close to Ottawa, and one who can give prompt service when installation, leveling or minor repairs are in order. It is not a cheap case, but, after one experience with a 'bargain' case, we believe it to be reasonably priced.

It is doubtful whether such a case will be the best choice under all circumstances. In areas where wood is cheap and good cabinet work is available at reasonable cost, a suitable plywood case painted with fire-resistant paint will probably give as good protection to specimens at a lower cost than a good steel case. However, the workmanship must be good if the case is to be thoroughly insect-proof. Steel shelving is preferable to wood, regardless of the type of case used, because of the saving in space.

We use this steel case in two models, one with twelve shelves each side and a shelf spacing of 6 inches, and one with fourteen shelves at a spacing of $5\frac{1}{8}$ inches. The closer spacing is preferred for the less bulky specimens, such as the

predominantly foliicolous fungi, because a deep stack of such folders sags under its own weight when lifted, and this may cause damage to the specimens. The wider spacing is preferred for moderately bulky specimens, such as Agaricaceae, Boletaceae, and Thelephoraceae, which are light for a given volume. The wide shelf spacing is also needed for the boxes that are used for the bulkiest specimens (Polyporaceae, some Gasteromycetes, etc.).

Boxed Specimens

A system of nesting boxes, of hard cardboard reinforced with fabric, is used for housing the bulky specimens. The largest box is a slack fit in the shelves of the case having 6 inch shelf spacing. Three sizes of nesting boxes are fitted into the main box; half length and half width; half length and quarter width; and quarter length and quarter width. All these small boxes are slightly less than half the height of the main box; unless some of the specimens are unusually high they may thus be fitted in two deep, with an intervening cardboard divider having a finger hole near each end. The label is placed in the box with the specimen. Because of the possibility of specimens becoming mixed through an accident, each specimen bears the accession number, in india ink, located, for example, on a smooth part of the supporting wood. A metal holder on the front of each box carries a card indicating the range of specimens in the box. The range may embrace several species; but a common species will fill several boxes, and the card then bears the name of the species and the range of accession numbers of the contained specimens. (The wood-destroying fungi are not segregated by hosts; thus they may be filed strictly in numerical sequence, one box being used until full before another is started.)*

A special problem is posed by groups of fungi most of which will fit into packets but of which a proportion must go in boxes. To simplify study of all the available specimens it is preferable to house the boxed specimens in the same

* See addendum 15.

case as those that are in folders. For the rusts, which are kept in cases with the narrow shelving, this involves cutting a little off the top of the standard box (mostly simply done with a bandsaw) and using it without a lid. Because one may not expect boxed specimens of a particular species, a copy of the label, with the annotation "BOXED SPECIMEN", is mounted on an appropriate sheet in the folder for the species.

Myxomycetes

As was pointed out above, Myxomycetes must be housed in small boxes, for protection of their delicate structures. Housing these boxes so that the specimens are readily available for study presents a problem. There is a great temptation to pack the boxes into trays or larger boxes, to save space. Solid packing means frequent rearrangement as the collection grows; and it eventually makes study of the specimens so awkward that, in practice, the collections are hardly used at all. During a period of great space shortage, the Myxomycetes in this institution (in boxes of various sizes and shapes) became so packed up within nesting boxes that no serious use was being made of them. When a specimen was received it was simply keyed out and no comparison was made with material on hand. To remedy this very undesirable situation, as soon as space became available the whole collection was reorganized. Any specimens that were in unduly deep boxes were transferred to a standard box 2 inches long, $1\frac{3}{8}$ inches wide and $\frac{1}{2}$ inch deep. (Boxes much smaller than this size are a nuisance, because it is almost impossible to put all the label data legibly on the top.) This box is of white cardboard and is made like a matchbox; that is, the box slides through the cover. The boxes are fastened to herbarium sheets, a single species to a sheet, and the sheets housed in standard covers. Many boxes can be put on a sheet, although space must be left for sliding the box out of the cover. Actually most species occupy substantially less than a sheet. This method is not very economical of space; but the greatly increased accessibility, and consequent heightened interest in the group, have amply repaid the time and space involved in

the change. In study, the box is slid out of its cover and placed under the dissecting microscope for the preparation of a mount. The specimen is glued, by means of its substrate, to the bottom of the box.

Protection from Insects

Not even perfectly insect-proof cases will, alone, guarantee freedom from insects. A case has to be opened frequently and a closed case keeps insects in as well as out. Building fumigations, which must, by law in many communities, be carried out by a licensed professional fumigator, are expensive. If the herbarium is housed in a large building and not in a properly segregated wing of it, the cost in cash and work dislocation may be prohibitive. Dermestid beetles attack fungi more than other plants. Not even frequent and regular fumigation of the herbarium can be completely relied upon to keep the specimens free from injury, especially in a rapidly growing institution with specimens arriving from various places and in all sorts of containers. Some sort of insecticide or repellent should accordingly be kept in the cases. It is both undesirable from the standpoint of effect on the specimens and dangerous from the standpoint of staff safety to use contact or stomach poisons. Volatile materials must accordingly be relied upon, and the choice generally lies between flake naphthalene and paradichlorobenzene. The latter is somewhat the better insecticide, but it is decidedly more volatile than naphthalene and is difficult to keep in the cases in hot weather. The rapid loss of the vapor from a large number of cases results in a substantial concentration in the herbarium, where it conceivably offers a slight health hazard. The time and cost of frequent renewals are further disadvantages to its use. We therefore returned to the use of naphthalene some years ago; and we have suffered absolutely no insect damage to specimens in the steel cases, although unworked collections in drawers or cardboard boxes suffered considerable damage during a period of several years when we were unable to house all such material in steel.

The naphthalene is held in a rectangular wire mesh basket, 12 inches long, 8 inches high and 1¾ inches deep, suspended inside the top of the door by two flattened wire hooks, which are clamped under the heads of two of the screws that hold the door liner in place. This basket just clears the shelves when the door is closed, and the space between the shelves and the door is ample for diffusion of the naphthalene vapor through the case. The basket is lined with two layers of cheesecloth held in place with paper clips. The basket is filled about 3 inches deep with naphthalene scooped from a metal drum with a beaker or cup. A little finely powdered naphthalene sifts through to the floor during the filling, but after a day or two the crystals form a crust in the basket and no more of the material falls out.

In the cases that contain only boxed specimens the naphthalene may be sprinkled through the boxes. This system guarantees a uniform distribution of naphthalene vapor, but it has the slight disadvantage of introducing a certain amount of dirt into the boxes; for the commercial grade of naphthalene, which is usually supplied in jute sacks, inevitably contains minor impurities. It is thus necessary to clean out the accumulated debris from the boxes every few years. We have seen no indication of inadequate dispersal of naphthalene vapor among boxed specimens from the wire baskets, and this method is probably to be preferred even for such specimens.

Loan and Exchange

An increased volume of loans and exchanges has necessitated the adoption of a printed triplicate form (in white, yellow and pink) essentially the same as the one described in Chapter 1 for the phanerogamic herbarium, but with the appropriate return address since the two herbaria are under separate curatorship. The white and yellow forms are sent to the borrowing institution, the pink being held as a record. The borrower signs and returns the yellow form to acknowledge receipt of the specimens. When the specimens

are returned their receipt is noted on both the yellow and the pink forms. The pink form is sent to the borrower to mark completion of the transaction. The same form also serves for notice of the shipment of exchange specimens.

For each exchange institution, records are kept in a foolscap file cover. The correspondence and forms are kept at the back in chronological sequence. In the front of the folder is a sheet of ruled foolscap headed with the name and address of the institution. The left two thirds of the page is used for dates and other details of the exchanges. The right one third of the sheet is ruled in three columns headed *Balance, Specimens Sent,* and *Specimens Received.* This sheet serves as a ledger, from which the standing of the account is immediately visible. The files are arranged alphabetically by name of institution in a correspondence filing cabinet.

When specimens are to be sorted, a box is provided for each institution and marked with its name. The destination of a particular specimen is governed mainly by the known interests of workers at the various institutions, the need for wide distribution of rare or critical collections, and the balance of the exchange account. Occasionally the distribution (for example, of isotypes) is determined in advance by published information. The destination should then be marked lightly in pencil on each packet as soon as the distribution is decided.

After the lots of specimens are sorted, they are arranged alphabetically and the name, accession number and host are entered on card files kept for each institution. This practice prevents the inadvertent sending of duplicates or near duplicates to an institution. It also allows the tracing of duplicates and informing the recipient of name changes. However, it takes a lot of time and, if the volume of exchange continues to increase, it will have to be abandoned in favor of the practice that prevails in most phanerogamic herbaria, in which surplus duplicates are simply put back into exchange to circulate until they find a resting place.

Specimens must be packed in firm boxes that will not be crushed in shipment. It is also important that the specimens are not able to shake about in the box. A strong corrugated carton slightly larger than the bulk of the specimens is selected. Crumpled paper or other elastic packing is spread over the bottom of the carton to add springiness. The packets are laid flat on the packing in overlapping layers, so that any uneven pressure is spread over several packets. A thick packet may have to be balanced by several thin ones before another layer is started. It is usually simplest to group the packets by size to some extent, but if the shipment is a very large one it is preferable to pack them in something approaching alphabetical sequence. If the specimens were sorted before packing this will involve little extra work, and it will relieve the receiving institution of a tedious task. Very large shipments are put in two or more boxes. The boxes are always sent by parcel post rather than express, for promptness, reliability and relative freedom from customs difficulties. Limits for parcel post dimensions must be observed; but in any event a small box is stronger than a large one made of the same material. When all the specimens are in the box, packing is added to well above the top, and the box is closed and tied well with twine. The address of the recipient is marked on the box. The box is then wrapped in at least two layers of heavy brown paper and tied with two lateral and two lengthwise pieces of cord, well knotted. Finally the parcel is addressed and the necessary customs forms are attached (see details in Chapter 1). The contents are declared as "Dried Botanical Specimens—No Commercial Value". Mention of fungi is apt to cause unfounded alarms about dangerous plant pathogens and may result in the parcels being opened by a quarantine officer.

CHAPTER 3

MOSSES AND LIVERWORTS

Collecting and Drying

The bryophytes (mosses and liverworts) are among the simplest plants to collect and handle; but several points must be observed if the collector is to make the best use of his time and opportunities.

These plants may be collected directly into paper, cloth or plastic bags or into folded newsprint in the field press, provided that they come cleanly off the substrate. When they grow directly on mineral soil they should be washed in the nearest pond or stream before they are put into containers; otherwise the drying soil will sift through the specimens spoiling their appearance completely.

Collect plenty of material of each species, enough for at least two generous packets if the specimens are to be sent away for determination, to ensure adequate specimens for yourself and the identifier. If exchanges are contemplated the quantity must naturally be increased. A further reason for collecting liberal amounts is that what seems superficially to be a single species may actually contain one to several inconspicuous admixed species. Even the professional bryologist is accustomed to finding an extra 5 to 10 per cent of species in the laboratory above those that he saw in the field. The general collector, taking specimens on the basis of habitat and gross appearance, may expect a substantially higher proportion of unrecognized species. Ample specimens not only ensure that most of the scarce species will be picked up, but increase the likelihood that each will be adequately represented.

There is some advantage in collecting species individually, since only by so doing can their individual abundance in a habitat be recorded; but the general collector, with little knowledge of the mosses, can safely distinguish relatively few species and should not spend too much time trying to separate them. I recollect painstakingly segregating mosses during my first field season in the north, only to find out later that some of my specimens contained two to five species. It is much more important, where time is limited, to *collect by habitat and record the habitat in detail*. Mosses are particularly sensitive to moisture supply. Thus permanent and temporary pools have different species, as do still and flowing water or upper and lower parts of a shore. Different species occur on the sunny and shady sides of a log or tree, and at different heights up a tree. Shade may be important directly as well as through its effect on moisture; thus some mosses are adapted to dimly lit caves. The substrate is important and should always be recorded. Different species may favor acidic or basic rocks, clay or sand, rough- or smooth-barked trees. If possible record the species of tree from which a moss is taken or include some bark or a twig. Species that grow on twigs should be taken twig and all.

Record the habitat data of the last paragraph together with any others that seem appropriate, and also the date and locality. Write the data in pencil on a slip of paper and put it in the specimen bag, or put the collection number in or on the bag and record the data in a notebook. If all the specimens from one habitat are put together under a single number, as they are sorted out add supplementary letters to denote the individual species.

Carry bags representing the individual sites and habitats in a large plastic bag or a haversack, or in the field press if one is being used. On return to base dry the collections reasonably promptly. The form in which they are dried is not critically important, for mosses can easily be relaxed, by wetting, at any future time, for sorting, identification and flattening. Thus the general collector, with little time to spare

for handling bryophytes, may be best advised to collect directly into paper bags of 2-pound size and to dry the specimens in these bags. If a field drier of the type described in Chapter 1 is in use, place the open bags on the floor inside the drier frame. When the specimens are dry fold the tops of the bags down, and pack the bags into a box in such a way that they cannot shift. Any other source of steady but gentle heat can be used for drying. Specimens cannot be dried in plastic bags, since most of the materials used for such bags are almost impermeable to water vapor; thus drying can take place only through the top of the bag and will be slow even if it can be held wide open.

If time and facilities permit, flatten the specimens somewhat, so that they may be put into packets with the minimum or further processing. Many species may be pulled or teased apart into a layer about $\frac{1}{8}$ inch thick. Species that form a compact palisade may be split apart vertically into thin sheets. Spread prepared specimens on newsprint, either one collection to a sheet or with the collections separated by pencil lines, and mark the specimens with their collection numbers. Press them *gently* in a standard plant press (Chapter 1) and dry them as you would other pressed specimens. The press should be just tight enough to guarantee that the contents will not slide about. If the amount of pressure is used that is necessary to produce good specimens of vascular plants the mosses may be so flattened that diagnostic characters such as stem shape are altered, and they may be so matted together that examination and the sorting out of mixtures are rendered more difficult. If so few mosses are taken that it is undesirable to devote a special press to them simply place them between felts in a dry place, with a small weight on top of the stack, and change the felts every day. Stack the dried specimens in their papers and bundle them firmly between corrugated cardboards, to prevent them from slipping. The extra time and space involved tends to discourage the general collector who is living in camp far from laboratory facilities. If he is in a relatively inaccessible region to

which he is unlikely to return, he must make the best use of his time and is advised to stick to the paper bag method, which is quicker and less prone to accidents.

Processing Dried Specimens

Place the dried and identified specimens in paper packets about $5\frac{1}{2} \times 4\frac{1}{2}$ inches, of the type described in Chapter 1. Type the data on a label and stick the label to the face of the packet. The packets may be either mounted on standard sheets, as described in Chapter 2 for fungi, or filed on edge in drawers. The latter method conserves some space and is quite convenient for a small collection; but it has its disadvantages. All the packets should be almost exactly the same size, which involves repacketing many specimens received from other institutions. This method also makes it more difficult to see at a glance what the recorded distribution of a species may be.

A method of mounting that has been tried with some success at the Plant Research Institute is the use of herbarium sheets with pockets across them into which the specimens are tucked (W. G. Dore. Herbarium sheets for filing mosses. Bryologist 56: 297. 1953). This device is rather similar to one used by philatelists for storing duplicate stamps visibly and accessibly. The herbarium pocket sheet, which, incidentally, was developed quite independently of the philatelists' device, has, of course, much larger pockets. Five pockets, formed of strips $2\frac{1}{4}$ inches deep, run across the sheet. They are glued along the bottom 3/16 inch and the ends are secured by being folded over in a tab $\frac{1}{2}$ inch long and glued to the back of the sheet. The lowest pocket is flush with the bottom of the sheet and there is a clear space between the pockets of $\frac{5}{8}$ inch; this spacing leaves $2\frac{5}{8}$ inches above the top pocket, just allowing insertion in it of a packet $4\frac{1}{2}$ inches high. If specimens are in various sizes of packet it is preferable to put smaller ones at the top. Very large packets must, of course, be put in lower pockets.

This method of filing combines visibility with flexibility. A redetermined specimen is simply lifted from its pocket and tucked into its appropriate place. In a small collection different species of a genus may be grouped together without compromising the future adoption of a more elaborate filing system. You may start with one specimen of each of three species. As you acquire more specimens of one of them you will assign them to a separate sheet. Eventually geographic segregation of each species may be adopted. On the face of it this seems to be an ideal system of filing; but we are not yet prepared to grant it unqualified approval. As noted in Chapter 2, under Insertion, these sheets were tried quite extensively in the mycological herbarium and found unsatisfactory. Although the packets jam tightly into the pockets at first, the pockets inevitably stretch in time. This slight loosening may not be very serious with moss packets, which are generally very light and may stay in position when the sheets are tilted; but some mycological specimens are relatively heavy, and in this institution a slide is often included in the packet. Such packets cascade out of their pockets if, as is usual in a quick search, the sheets are turned like the pages of a book rather than kept strictly horizontal. The latter method of handling is particularly tedious in a long search, for, to keep the sheets in sequence, each sheet, after scrutiny, must be placed beneath the sheets already examined; or else the whole sequence must be reversed after the examination is completed. Such a procedure quickly causes the sequence to become badly muddled. The pocket sheets will probably prove unsatisfactory when the moss collection is in more active use than at present; but the system deserves further trial.

CHAPTER 4

LICHENS

Collecting

Collecting lichens is commonly considered so simple that information on the subject is scarce. Consequently the few important precautions are often overlooked. The following advice is intended for the beginner and the general collector. More-detailed instructions will be found in a forthcoming publication by W. A. Weber and S. Shushan (Field and Herbarium Techniques in Lichenology. University of Colorado Studies, in preparation).*

For collecting purposes, lichens are conveniently divided into three groups. Crustose lichens grow flat and are intimately bonded to the substrate. Foliose lichens have leaflike blades that are more or less flat on the substrate and often have multiple connection to it although they are not inseparably united to it. Fruticose lichens have a small basal attachment and a stemlike thallus that is often freely branched.

Lichens may be carried in the field by any convenient means, but if rock lichens are taken in numbers the substantial weight makes a good-sized rucksack essential. Always collect species individually. If they occur so mixed that they cannot easily be separated, collect enough of the mixture to make an adequate specimen of each.

Although ample specimens should be taken, you are advised against removing far more than you need, especially of crustose species and especially in populous and well-botanized regions. This may seem to be a very trivial point;

* See addendum 16.

but lichens grow extremely slowly and rare species may easily be eliminated from an area by overcollecting. The dressed stone of Fort Prince of Wales, at the mouth of the Churchill River, built between 1732 and 1771, is still much more lightly lichenized than the native rock. I also recall a foot trail through Cladonia parkland just inside tree line, which had been abandoned because it ran between two spruce trees that had grown together. It looked as fresh as the new trail, but examination of the tree branches showed that it had been abandoned for at least 20 years. Even much further south there are rock cuts and slides that remain bare for many years.

Crustose Lichens

Collect crustose lichens wet or dry and, to prevent damage from occurring as they are carried home, wrap them individually in tissue paper as they are collected. Toilet tissue is the cheapest and most convenient wrapping material. Never wrap lichens in absorbent cotton; it becomes tangled in the specimens and causes more damage than it prevents.

Crustose lichens must obviously be collected with a portion of the substrate. If the substrate is a tree trunk or a large branch, cut off a section with a chisel or a heavy knife. If the lichen is on a twig, cut off a section of the twig with a knife or pruning shears; the twig may later be split if it is too bulky to fit easily in a packet. If the species is growing on soil, carefully slide a large knife under it, using a sawing motion to reduce the needed pressure and minimize the risk of the specimen crumbling, and lift the whole thing onto toilet paper. Wrap it and put it in a packet or shallow box.

Crustose lichens give most trouble when they are on rock, for they must be collected with a hammer and cold chisel. If the substrate is sedimentary rock you will have little trouble removing thin but sufficiently large flakes of stone, with a substantial portion of the lichen. However, to secure

a reasonably large patch of a species growing upon igneous rock without taking an inordinate weight of rock requires skill and practice. One hint is offered to those unfamiliar with the use of a cold chisel. Do not grip it rigidly with all four fingers, but hold it, as low down on the shank as practicable, with the third and fourth fingers doing most of the work and the first two fingers slack. Then if, as may happen sooner or later, the hammer glances off the chisel, the first finger or knuckle gives under the blow and little damage is done. A heavy hammer of about 5 pounds and chisels about 12 inches long are sometimes recommended. This recommendation is perfectly sound to the extent that it makes it easier to get large flakes of rock instead of little chips, and it is satisfactory for the collector who expects to work within a few hundred yards of his car. But the carrying of such tools is too much to expect of the general collector, who may cover many miles on foot in the day's work and be loaded with miscellaneous equipment. A 6-inch chisel with a ¾-inch blade may be used if weight is at a premium. If no digger is carried for general botanical collecting, the standard pick-headed geological hammer of 2-pound weight is recommended. Otherwise a ball-peen hammer may be preferred; it is more compact to carry and has a better face for use on a cold chisel.

It is very important that ample material be taken, preferably about enough to cover a card measuring 3×5 inches. More should be taken to supply the identifier if the specimens are sent away for determination. Secure part of the edge as well as the interior of the colony. Distinctive characters may be obscured in small fragments.

Foliose Lichens

Foliose lichens are collected much like crustose species, it usually being desirable to include some of the substrate. However, a compromise is necessary when the lichen is on a rock, where the attempt to take the underlying rock with

it may result in the specimen being severely broken up. Then it is better to cut the specimen away and record the type of rock.

Fruticose Lichens

Fruticose lichens are handled somewhat like mosses because the growth tends to be vertical rather than horizontal. They are usually removed quite easily from the substrate, but take care not to cut off the base of the plant. Dig up species growing on soil and tap the soil off the base.

Foliose and fruticose lichens usually need to be flattened; otherwise they make bulky specimens and are inclined to shatter in the packet. If preferred, pack them into boxes and later flatten them in the laboratory. If possible, collect them when they are moist and pliable. In dry weather they become extremely brittle, so handle them as little as possible in this condition. The general collector can usually so arrange his program that he collects lichens during or soon after rain, fog or heavy dew. If they must be collected in dry weather first relax them by sprinkling with water. A polyethylene squeeze-bottle allows water to be applied economically, a point of some importance if you are collecting far from a source of water. Spread foliose and fruticose species on newsprint and carry them in the field press, but be sure to divide them into portions that will fit into a packet before they are dried; if separated when dry they will break up badly. Press them gently, as you would press mosses.

Drying

To prevent growth of mold, dry lichens thoroughly as soon as they are brought back to the laboratory or field base. Those in presses are dried by any of the means described in Chapter 1. Wrapped specimens may be spread out to dry over any available source of gentle heat. Various means of drying are described in Chapters 1 and 2. If no heat is available spread the specimens out in a warm, well-ventilated place, until they are thoroughly dry.

Labeling

Full label data should be included with the specimen or in the field notebook. In addition to the date, locality, collector, and collection number if used, describe the substrate and habitat carefully. If the substrate is soil, give the type: sand, sandy loam, clay loam, clay, humus or bog. Specimens on trees will include some of the bark or wood, as a rule, but the identity is generally much less obvious from a small sample than from the tree. Identify the tree, for some tree lichens are extremely specific in their requirements. The distance above the ground may also be significant for tree lichens. Identify rock substrates as fully as possible. The local geological sheet will often supply or confirm this information; but if you cannot do your own identifications, ask a geologist to help you. Igneous rocks that to the uninitiated pass as granite may contain a bewildering array of included minerals, which may not all harbor lichens to the same degree. Give pertinent data on slope, direction of exposure of tree trunks, cliffs or steep slopes, position relative to high water mark on stream banks, distance from high-tide mark on sea coasts (species may vary in tolerance to salt spray), proximity to spray from waterfalls or to seepage water, or any other local factor. Also, record the approximate altitude in mountain country.

Since many microhabitats may be visited in the course of a day, it may be necessary to record the habitat of each specimen as it is collected. If the details are put in the field notebook and only the number put in with the specimen much time may be saved in the field; a specimen may be written up by referring back to an earlier collection and noting only how it differs. However, full field labels save some time later when the final labels are typed.

Processing Dried Specimens

Put foliose and fruticose lichens directly into herbarium packets such as those described in Chapters 1 and 2. Stick crustose species to a piece of thin card very slightly smaller

than the inside dimensions of the packet. This practice gives support to a fragile substrate, which in disintegrating would cause the specimen to break up. It also prevents the specimen from being damaged by abrasion due to it sliding about in the packet.

Whether the packeted specimens are mounted on herbarium sheets or stored in filing drawers depends upon the scope of the herbarium and the preference of the curator. The arguments are very much the same as those that apply to fungi and mosses. For a discussion of them the reader is referred to Chapters 2 and 3, particularly the former.

CHAPTER 5

ALGAE

Fresh-water Algae

Collecting

Fresh-water algae are almost all microscopic. They are abundant in almost all bodies of water, but the species vary enormously with the environment. Thus it is important to record whether the water was standing or flowing, and whether the underlying rock was basic or acidic. Although such algae will generally be sought in lakes, ponds and rivers, they occur also in soil, on moist rocks, on tree trunks, even on or in living leaves, and in the superficial layers of mountain snow fields where a common species causes the phenomenon of pink snow. However, the general collector, to whom these brief notes are addressed, will make most of his collections in bodies of free water. From the collector's viewpoint these algae fall into two classes: the filamentous or colonial forms, which are readily picked up and dropped into vials; and the free-floating unicellular species (plankton), which must be secured with the aid of a net of bolting silk or nylon.

Put specimens into small vials, preferably about ½ inch in diameter and 1½ to 2 inches high. Glass vials should be corked, since screw tops seldom give a perfect seal. Small vials of flexible plastic, with a press-on lid attached by a hinge, are now available. These seem to give a perfect seal and are very convenient. They also obviate those unpleasant accidents that involve broken glass to be removed from one's pockets and the trickling of preserving fluid down one's leg.

There is no need to use large bottles because a large amount of material, often containing fifty species or more, can be concentrated in 1 to 2 cc. of water.

Formaldehyde or alcohol may be used as the preserving fluid. Use formaldehyde at 4 per cent strength or slightly over. The concentrated solution is nominally of 37 per cent strength, but is generally somewhat weaker after any great period in storage. It is best, therefore, to use 1 part of the concentrated solution to about 7 parts of water. Carry the saturated solution (commercial formalin) in a small bottle, preferably one with a dropper in the screw cap. Put the algae in water up to half the height of the vial. Add formalin to $\frac{5}{8}$ of the height of the vial, and fill the vial right to the neck with water. If much air space is left, the surging of the liquid as the vials are carried may damage delicate specimens. The plastic vials are easily capped, but it may be hard to push a cork in against the pressure of a full vial. This difficulty may be overcome by putting a thin string into the neck of the vial, inserting the cork beside it, and pulling out the string and pushing down the cork simultaneously. Use alcohol at about 50 per cent strength. Fill the vial slightly less than half full with water and algae, and fill to the neck with 95 per cent alcohol.

Pick up filamentous algae with forceps or on a thin twig. You can use your fingers, of course, but it may not be as easy to insert the mass into the vial. Scrape off attached filamentous forms with a knife, or drop small pieces of stem or leaf, with the algae attached, into the vial. Diatoms are often clustered on stems of aquatic plants and are similarly treated. Aquatic larvae of some insects are commonly full of algae; up to 30 species have been recorded in a single larva. Tadpoles ingest large numbers of algae; and a great concentration of diatom shells may be found in their intestinal tracts, although the more delicate forms are generally broken. Some blue-green algae form a bloom on the surface of the water. Skim these off into a jar and

concentrate further by decanting or pipetting out the top quarter inch or so.

Apart from what may be taken from intestinal tracts, plankton can only be collected adequately by means of a plankton net. This is a conical net of fine bolting silk or nylon that is towed very slowly behind a rowboat. The net should have a mouth diameter of about 12 inches and a length of about 36 inches. The mouth is fastened to a ring of brass or other relatively noncorrosive metal from which three cords lead forward to the towrope. A cotton sleeve on the mouth of the net snaps or buttons round the ring, allowing the net to be removed readily. The net tapers to a rounded apex, to allow it to be turned inside out readily for emptying. When the net has been towed far enough to gather an adequate haul (the distance will vary enormously with the body of water and the season), lift it up and allow the water to drain out. Dip out the concentrate in the end of the net into vials or turn out the contents of the net, wash them and shake them into the vial. Fill the vials and cap them as described above. When no boat is available or the small size of the ponds does not justify the use of one, a smaller net, about 6 inches in diameter and mounted on a long handle, may be used from the shore.

Plankton nets should be washed well in clean fresh water immediately after use, and should be dried in the shade and out of contact with iron or steel. Rust spots in a silk net soon develop into holes. Never let a net dry unwashed because the algal jelly will clog it. Small holes in a net may be repaired with a little clear nail lacquer, an invaluable material for miscellaneous minor repairs in field and laboratory. For this type of repair there is some risk in using cellulose cements, which dry glass hard, since the patch may do more damage than it cures.

The few macroscopic fresh-water algae are handled like marine algae.

The information to be recorded includes the date, locality, name or description of the body of water, substrate of

attached forms, physical properties of the water body (size, depth, current, etc.), underlying rock if known, presence or absence of overhanging foliage or emergent vegetation. The pH of the water may be measured to advantage if equipment is available; but it should be noted that the otherwise convenient indicator papers may prove very unreliable if the water is cold. Since it is usually impossible to include all the data on a small label that can be put in the vial, it is usually best to include a slip bearing the collection number *in pencil* (never in ink unless india ink is used), and to record the data in the field note book. The working method will, of course, be varied according to the number of collections being taken.

Processing

The laboratory processing of the microscopic algae is so remote from the handling of most botanical specimens that no attempt is made to cover it in this manual. As the general collector is not greatly concerned with it, the interested student is referred to textbooks of phycology.

Marine Algae

Collecting

One who collects marine algae will vary his methods with the time and equipment that are available, as well as the local habitats. Marine plankton are collected and preserved exactly as fresh-water plankton; but even in calm weather only inshore collecting can be attempted from a rowboat. A thorough job requires the services of an oceanographic vessel, and such collecting is beyond the scope of this manual. The general collector will usually limit himself to attached macroscopic forms that he can find in the tidal zone. In warm areas he may use a diving mask for taking specimens in shallow water. Cold water calls for a frogman's suit, which may be beyond his means.

Unlike the fresh-water algae, the attached marine algae are almost all large enough to be collected as individual

plants. The collector accordingly collects by the species rather than by the site or habitat, and the procedure somewhat resembles the collecting of flowering plants. The plants vary from very small but individually visible species, of which many may be put on a sheet, to huge kelps many yards long, of which only small portions can be taken.

A rocky coast provides the best collecting, a boulder beach is next best, and clean sand beaches or muddy shores are very unproductive. Collecting is, of course, done at low tide. If you happen to start work during a period of neap tides, concentrate on the intertidal zone at first, distinguishing between open rock, which is left dry, and rock pools, which remain full. The pools may contain species that otherwise occur only below low tide level and deserve careful attention. If you must enter the pools wear either waders or a pair of canvas shoes with stout soles. Even a barnacle cut can be decidedly painful; but if you step barefoot on a sea urchin your collecting season may end abruptly.

If possible, return at extreme low water of a spring tide to collect, in waders or running shoes, in the shallow water just below the tidal limit. Various small species may be found here that do not occur in the actual tidal zone; but they may be hidden among larger plants, and no time can be lost in securing them before the tide flows again.

The larger seaweeds are tough and leathery, and may be handled freely. A heavy knife may be used to pry the holdfast from the rock. Try to remove it intact, although it may have to be split lengthwise if it is massive. Handle the smaller, lacy species carefully. Put them directly into jars or wrap them in paper well soaked in sea water. Keep all specimens as cool as possible and keep them thoroughly wet with sea water until the time comes for preserving or drying. Collect several specimens of all the apparently distinct species, first, because some species are indistinguishable to the naked eye, and secondly, because some species have male, female and asexual plants that can be distinguished only under the microscope. Only by taking plenty of plants

can you have a reasonable expectation of including complete material of all species. Some very small species grow in sand or mud. Collect these in groups, wash them as well as possible in sea water, and wrap them in wet paper.

The large kelps usually grow in quite deep water. It may be possible to gather some of these from a boat with a grapnel, but often they may be found after a gale at the high tide mark. A little study will indicate particular spots where wind and current tend to bring the kelps ashore. Such specimens are satisfactory if they are collected promptly; but avoid any that are bleached or discolored. The very large species cannot possibly be preserved whole. Take a section of the blade, part of the stalk (split lengthwise), and a sector of the holdfast. Any fruiting structures should also be included. Even such partial specimens may have to be mounted eventually on two sheets. Record the total dimensions of stalk and blade for eventual inclusion on the label, before cutting up the specimen.

Preserving

Press freshly collected specimens and dry them at once, if time and facilities permit, or preserve them in various ways for future treatment. The latter method saves some work for the collector in the field, but the total work to be done on the specimens is greater than with immediate preparation.

If the specimens must be shipped unmounted, the collector has three choices. In the first method the plants are spread out in a well-ventilated room until nearly dry; then, while they are still flexible, they are folded to fit into a rigid shipping box. The drying is then completed. Species that are brittle when dry must be relaxed by covering them with wet paper for an hour or two or putting them out on a dewy night. The slightly pliable specimens, dry or relaxed, are packed into the box, labels being included with the individual collections. If the specimens have been relaxed, dry the box thoroughly in the sun or over a source of gentle heat. This

is the simplest method of shipping and is the most economical if the specimens must be sent by air; but the specimens should be well surrounded with springy packing material; and great care must later be taken in unpacking and relaxing them, because those that are brittle may easily be broken.

In the second method the specimens are partially dried and are layered in plenty of coarse salt. Brine will generally weep out of the specimens after a few hours or days. It should be drained off and more salt added before the specimens are packed for shipping in leak-proof containers. This is essentially the method that is used for wet skins of birds and mammals. This method was until recently disparaged by phycologists, probably because the draining and resalting was omitted, a step that is also often necessary with large skins. Prof. W. R. Taylor has used the method, thus modified, very successfully even in the tropics, and has found many species in good condition after 10 years. There are a few species for which it is not very successful; but, all in all, it is perhaps the best method of prevervation.

The third and best-known method of preservation is by formaldehyde. To a gallon of sea water add half a pint of commercial formalin (37 per cent formaldehyde). Place the specimens, without crowding, in this solution for a few days until penetration and complete fixation are assured. Then pack the specimens closely, in fresh solution, into cans that can be soldered shut. Wrap small and delicate specimens in cloth bags. Specimens with attached rocks or other heavy objects should be segregated and the rocks well wrapped in rag. If specimens from different sites are put in one container, use a separate cloth bag, each with its label inside it, for each site. Leave a little air space at the top so that expansion under heat will not rupture a seam. Leave the newly soldered cans inverted for a day or two to make sure the seal is perfect. The recent development of water- and vapor-proof pliable plastic films in sheet, roll, and bag form has made it possible to cut down the weight and bulk of preserved specimens. Cans may still be advisable for large

kelps with massive stalks; but for smaller specimens it is a simple matter to remove them from the original preservative, dip them in fresh solution and put them directly into plastic bags with heat-sealed seams. Tie the tops tightly, fold over and retie, and put several bags, each with its contained label, in an outer bag.

As with all botanical collections, each specimen should be accompanied by a label that includes all pertinent information: date, location, collector, collection number, substrate, position in relation to high or low tide level, exposure, and any special habitat data such as occurrence in tidal pools or in river estuaries. For the last an estimate of the salinity of the water is desirable. Labels that are to be included with preserved specimens should be written in black pencil or india ink (never ordinary ink) on heavy bond paper. In a large can include at least two labels in case one is damaged. If the number is conspicuously marked on back and front of the label, and the data are fully recorded in the field notebook, a partly illegible label will cause no harm.

Mounting

The specimens, fresh or preserved, are eventually mounted, for study and storage, on standard herbarium sheets of high-quality heavy paper. Rough-dried specimens must be soaked before they can be spread, and the formalin must be washed out of preserved specimens with several changes of fresh water. Salted specimens are also mounted from fresh water. However, fresh specimens are mounted directly from sea water.

Coarse specimens need little care. Spread them out between muslin or cheesecloth (to which they do not stick strongly), and then enclose them in newsprint to minimize staining of the felts. It will be found by experience that some species do not stick to newsprint; and for such species the cloth may be omitted. Then, put the specimens in a press, with ventilators separating the felts, and dry them exactly as described in Chapter 1. If no adequate source of heat is available,

change the felts as soon as the surplus water has been blotted from bulky specimens; otherwise the ventilators may soften and the corrugations collapse. Plants longer than the newsprint must be folded with the minimum possible overlap, or cut into sections if folding proves awkward. Prune dense, bushy specimens judiciously to reduce their bulk. Mount the dried specimens exactly like vascular plants (Chapter 1).

Delicate feathery or filamentous species must be handled differently. They are so flexible that surface tension bunches the filaments together when you lift them from the water; and you cannot spread them out without damaging them seriously. Accordingly, spread them in shallow trays of water over a sheet of mounting paper, then lift out the paper with the plant in position on it. In this process pressing and mounting are a single procedure. If any of the plants are large you will need a tray larger than a standard herbarium sheet ($16\frac{1}{2} \times 11\frac{1}{2}$ inches). A large photographic tray is ideal. If the specimens are small float them on half or quarter sheets. A smaller tray will then be satisfactory or, at a pinch, a washbasin or dishpan will serve. Quarter or half sheets should be of thin paper, provided that it is of good quality, for they will eventually be mounted on whole sheets for insertion in the herbarium. Put half an inch or more of water in the tray; fresh water is generally used, but it is recommended that some salt be added if delicate pink species are being handled, since the pigment tends to leach out in fresh water. Put a piece of glass, sheet metal or water-resistant hardboard, cut sufficiently smaller than the tray so that the fingers can be slipped under it, in the bottom of the tray and put the mounting paper on top of it. Write the collection number or other means of identification in pencil on the sheet before putting it into the water. Now spread out the specimen over the paper, arranging it so as to eliminate wrinkles and overlaps. The arranging may be done with forceps and a water-color brush; or water may be swished across the frond with an eye dropper or some such bulb pipette. When the specimen is arranged as desired in the middle of the paper, gently raise the sheet, bringing the paper

and the specimen with it. Avoid sudden movements, which will set up wave motion in the water. Every collector will develop his own technique. My preference, in floating aquatic plants generally, is to raise the end of the sheet bearing the base of the plant slightly ahead of the opposite end. As soon as the base emerges from the water it is anchored. Then, if you are a trifle overeager and the water rushes off the sheet too fast, the branches or filaments tend to be pulled out straight and the risk of disturbance is minimized. Once the specimen is out of the water hold the sheet vertically by one corner for a few seconds to drain off surplus water. Then peel the paper away from the supporting sheet and lay it on a felt. Lay a sheet of cheesecloth or washed (unsized) muslin over it, to prevent sticking, and put another felt on top. Build up layers of felt—drier—felt—mounting paper and specimen—cheesecloth—felt—drier until all specimens are accounted for.

Close the completed press in the normal fashion, tighten it under moderate pressure and put it on the drier. If no heat is available change the felts periodically and put the press in the warmest and best-ventilated place available. When the specimens are dry gently peel off the cheesecloth. The specimen will adhere to the paper by virtue of its mucilaginous coating. Occasionally the specimen does not stick satisfactorily but tends to come away with the cloth. This happens most often with preserved specimens, which constitutes another argument in favor of the direct mounting of fresh specimens whenever possible. If the specimen cannot readily be detached from the cloth and the loose portions refastened with adhesive, resoak it and remount it. When this difficulty occurs, and with species for which experience suggests that it may occur, cover the specimen with wax paper instead of cloth. Few marine algae seem to stick seriously to wax paper although a few sticky flowering plants do so. The only disadvantage of the wax-paper method is that it nearly doubles the drying time because almost all the moisture must be withdrawn from one side of the specimen. When collecting is heavy and drying facilities are limited this may be a serious

disadvantage; but if only a few algae are being handled in the course of general collecting the delay is of no significance and wax paper may be used routinely.

Whenever possible some of the fruiting portion of specimens of the more delicate species should be mounted on mica sheets for later microscopic study. Press them under cloth like the normal specimens. Neatly cut mica squares were formerly available from mail-order stores, for use in the windows of old-fashioned cook-stoves or heaters. Such sheets are probably now almost unobtainable commercially; but mica occurs in many areas, and a geologist will usually be able to tell you where you may get chunks from which sheets may be split as needed. Professor Taylor emphasizes the desirability of splitting (or resplitting) the sheet just before use; if this is not done the mica may not accept water and the specimen will not adhere well. Professor Taylor has not found a plastic sheet that is a satisfactory substitute. If some such material as cellulose acetate sheet must be used, he suggests that the sheet be heavy enough to be as rigid as the mica sheet, and that it have a fine mat surface. Otherwise the specimen will certainly peel off.

ADDENDA

1. (p. 22) Only very gentle heat should be used with waxed paper; otherwise, wax may transfer to the specimens. Alternatively thin sheet plastic may be substituted for waxed paper. However, any unfamiliar material should be tested on a small scale, to make certain that it does not bond to the plants. See addendum 14.

2. (p. 26) A correspondent complained of the lack of recommendation for the use of plastic bags in collecting. Their use was recommended under circumstances that preclude the field press, particularly for compact and sturdy arctic-alpine plants. Like many botanists, I take such bags with me on outings not primarily intended for collecting; but their wholesale use for delicate plants and in warm weather reduces the quality of the specimens.

3. (p. 31) Mr. K. W. Spicer found small elastic bands to be a good substitute for slotted paper to hold folded plants for pressing. The bands are easy to carry and quick to use. They should be large enough so that leaves or culms are not bunched tightly together.

4. (p. 40) Catalytic tent heaters have also come into use as a source of heat, but must be used with caution. They may give excessive heat for some drier frames because they are not as easy to control as a lantern; and they are bulkier, use a fuel with a low flash point, and are more tedious to light. They sometimes burn irregularly after the first season.

5. (p. 43) An amateur collector who may wish to send one or a few specimens for identification should determine each specimen as well as he can; he should then check with the botanist, before sending any specimens, to make sure he is in a position to deal with them. The collector should keep duplicates marked with the same collection number, and pack the specimens carefully as described on p. 57.

6. (p. 46) Several herbaria use slight modifications of Archer's formula. Rollins (Rhodora 57:294-299. 1955) gave the following as in use at Gray Herbarium:

Ethocel (7 cups)	ca 600 g
Dow Resin	75 g
Methanol	220 cm^3
Toluene	880 cm^3

This preparation is much thicker than the original, which is found very satisfactory in our institute, but perhaps dries faster. The same paper gives other hints on the technique. The bead of plastic left on the nozzle apparently forms as effective a seal as the pin. If, after prolonged disuse, the nozzle becomes solidly plugged, it may be soaked in the solvent.

7. (p. 46) One reviewer complained that sticking specimens to the sheet hinders use of them. Well, it also hinders *abuse* of them, as well as the inevitable damage that even the most careful packing and handling causes. It is the curator's responsibility to ensure that specimens remain in usable condition for many students. If each of six students takes a fragment for himself, there will be little of value left. Provided that upper and lower leaf surfaces are visible, and that loose inflorescences are put in packets (pp. 2, 47), the criticism is not valid.

8. (p. 47) Water paste does not hold woody stems and thick, coriaceous leaves satisfactorily. Plastic stripping, preferably the more dilute formulation, may be applied to the undersurfaces of the specimen, which is then held down on the sheet with weights, and plastic strips are run across the stem at strategic points. The specimen must be left under pressure longer than with water paste—for fully half a day. Because of the difficulty in detaching leaves, it is particularly important that both leaf surfaces be visible, and that leaves and inflorescences be included in packets. About one-third of our phanerogamic sheets are now mounted in this way. See addendum 10.

Even small plants should be mounted with their length along the sheet because normal handling causes sheets to flex more crosswise than lengthwise, and transverse stems are liable to be loosened or broken.

9. (pp. 47, 77, 88) About the time this book was published we adopted the use of synthetic resin glues in small flexible plastic dispensers with self-sealing nozzles (for example, Carter's Nu-Glu), both for attaching labels and for attaching packets to the sheets, in the mycological herbarium. The narrowest possible bead of glue is drawn along the top back edge of the label, and the label is then put in place and wiped from end to end with a cleansing tissue. In attaching packets a narrow bead less than 3 cm long is drawn on the center of the packet. The glue spreads to about 5 mm wide when the packet is appressed to the sheet. For very long packets a 2 cm bead may be applied toward each end. The bond is extremely strong and permanent, and the glue does not stain the paper; but if redisposition is necessary, the packet is easily removed with a knife or by folding the sheet back and pulling it.

So little glue is needed and the application is so rapid that the method is economical despite the high initial cost of the glue. The small dispensers can be refilled from large containers to reduce costs. In phanerogamic herbaria in which plastic stripping is routinely used, the label is most conveniently attached by a narrow bead of plastic and put under only very gentle pressure; but the more dilute formula is advisable. See addendum 6.

10. (p. 48) A tall mobile rack with three tiers of 26 shelves for drying specimens mounted or reinforced with plastic was described by W. J. Cody in a leaflet (New herbarium equipment, Canada Department of Agriculture, 1966), obtainable from the Plant Research Institute.

11. (p. 52) W. J. Cody (see addendum 10) has described a set of mobile shelves with spacing as in the herbarium cabinets. These units are a great convenience in moving quantities of specimens between preparation areas or offices and the herbarium.

12. (p. 52) It has been reported that naphthalene and paradichlorobenzene may cause softening of the now widely used plastic stripping. Possibly the reported softening occurred only when specimens were inserted before the stripping was allowed to harden adequately. Rollins (Rhodora 57:298. 1955) noted no effect of a high concentration of PDB in one test. We have very few plastic-stripped specimens in the mycological herbarium, but examination of two specimens after 8 and 10 years in a moderate concentration of naphthalene revealed no damage. Dr. Parmelee has recently run short-term tests with stripped sheets allowed to dry for 24 hours before insertion in cases with normal and saturation levels (subliming freely on the inside of door and walls) of naphthalene. Again no indication of softening could be detected.

In the meantime insecticidal strips were developed for insertion in cases, and Archer (Science 116:223-234. 1952) also developed an effective aerosol bomb for treating cases individually. Unfortunately these methods depend on persistent insecticides that are now widely banned. Consequently, no completely satisfactory protection can yet be recommended.

13. (p. 59) Because of public interest in the fleshy fungi, and an educational obligation in connection with mushroom poisoning, Dr. Parmelee has recently started a collection of plastic models of macrofungi, to supplement dried specimens and illustrations. (See J. A. Parmelee. 1971. Models of fungi for public display. Greenhouse–Garden–Grass 10 (4):73-77.)

14. (p. 80) Cellophane envelopes have limited life. We were accordingly persuaded to change to polyethylene envelopes, which have an indefinite life. These envelopes are excellent for fungi such as smuts and rusts, but some dried cultures bond so tightly to the plastic that they cannot be removed for microscopic examination.

15. (p. 92) Dr. Parmelee has recently introduced boxes half the standard height, but the same width and length, which hold a single layer of the small nesting boxes. These half-size boxes seem to be more convenient in some respects, but it is too early to state whether they will meet with full acceptance. Some deep boxes will still be needed for very large specimens. It should have been made clear in the original edition that the outer boxes have lids, but that the nesting boxes do not.

16. (p. 103) This publication unfortunately did not materialize.

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