the laws of nature and extend the realm of human knowledge.

By every means in our power, therefore, let us show our appreciation of pure science and let us forward the work of the pure scientists, for they are the advance guard of civilization. They point the way which we must follow. Let us arouse the people of our country to the wonderful possibilities of scientific discovery and to the responsibility to support it which rests upon them and I am sure that they will respond generously and effectively. Then I am confident that in the future the members of this institute, together with their colleagues in all of the other branches of engineering and applied science, as well as the physician and surgeon, by utilizing the discoveries of pure science yet to be made, will develop without marvelous new agencies for the comfort and convenience of man and for the alleviation of human suffering. These, gentlemen, are some of the considerations which have led me here in my presidential address to urge upon you the importance of a proper understanding of the relations between pure science and industrial research.

J. J. Carty

THE BOTANICAL FIELD EXCURSION IN COLLEGIATE WORK

The standard college course in general botany occupies a well-defined field, and is concerned with pedagogical problems quite distinct from those of the secondary school on the one hand, and of the university on the other. Many of the defects and shortcomings of collegiate botany as taught have been due to the fallacious idea that college botany is merely university botany pruned down to meet the supposititious mental ability of the college student. The ideas and technique of the university research laboratory have frequently been transplanted *en bloc* into the college classroom, with resultant pedagogic malpractise and scientific inefficiency.

College and university men are coming to realize more and more clearly that the university research laboratory has its peculiar problems, for which work it should be diligently protected and fostered; and also that the American college as an institution has its distinctive field and problems, and that the two fields, overlapping here and there, are on the whole widely separated from one another.

One of the notable lines of weakness of the collegiate course in general botany that has come to the writer's attention, is the comparatively rare or infrequent use of the field excursion. The usual schedule, to be found in most American colleges, consists of one or two trips in the autumn, a long winter session restricted almost exclusively to laboratory exercises, and a few desultory spring trips to collect flowering plants.

There are a number of factors which have combined to bring about this state of affairs. Most botany teachers are primarily laboratory-trained men. Frequently they are not very well acquainted with the region in which they teach. In many instances their own university work in botany was confined largely to the cytological, histological or morphological aspects of the science; with little or no practical training in field work, either from the scientific or pedagogical viewpoint. In most regions a large portion of the academic year is winter time, with much inclement weather, and plant life at a standstill. Laboratory exercises can be planned with much greater certainty and precision than can field trips. The problems of transportation and discipline on the field trip, particularly if the class be large, are often difficult and annoying. It involves much planning and extra work to break up a large class into small sections for field work. Field trips are time consuming, and in many regions the places of greatest botanic interest lie at a considerable distance from the college buildings. There are a great number of excellent printed outlines covering all the standard laboratory exercises and experiments; these laboratory guides and manuals are ready-made for the teacher's use, while field trips require the laborious preparation of special outlines by the

individual teacher.[1] For all these reasons, and for others that might be enumerated, the average college teacher finds it much easier, and on the whole more satisfactory to plan laboratory exercises rather than field excursions.

The present paper is an earnest plea for a larger recognition of field work as an *integral part* of any course in general botany. The field work should not usurp the place of legitimate laboratory studies, but on the other hand it should not be regarded, as it is generally regarded to-day, as a mere accessory, desirable but inconvenient. Ganong's statement may be appropriately quoted here:

> Very important too, are field excursions, the opportunity for which varies greatly. Theoretically, it might seem better if most botanical study could be done out of doors, but practically the greater part of it demands tools and other facilities, including physical comfort, unobtainable away from a good laboratory. In the excursions the teacher will of course direct attention to the larger phenomena of adaptation, the topography or physiognomy of the vegetation, the plant associations, etc. This kind of study will become much easier and more profitable in the near future as the subject becomes more fully systematized, and good books on it become accessible. It is especially important not to allow too great a number of students to go together on these excursions, and in my own experience not over ten can be profitably taken at any one time. The collecting instinct, so invaluable to the naturalist, should at such times receive every possible encouragement.[2]

Botany exists first of all out-of-doors, and the college student should have thoroughgoing training in field work as well as in the laboratory, herbarium and library. The college student, interested primarily in the large, significant, dynamic aspects of the subject, rather than in technical minutiæ, should be deeply imbued with the idea that he is working with an *out-of-door* subject, and that a valuable and essential part of the course is his own training in actual observation of *live* plants.

A pedagogical mistake that characterizes much botanic field work is the failure to place sufficient emphasis upon the vital, ecologic aspects of the studies. As Trafton[3] states,

> The demand for the study of physiology and ecology are protests against the old methods of looking on plants as lifeless things to be analyzed, classified, and laid away like minerals. It is insisted that the student shall be taught to look on plants as possessing life just as truly as do animals, and as having life problems to solve.

All too easily may a trip become a mere dilettante wandering, a grubbing up of plants, a hasty confusion of botanic names, a rude packing of specimens for herbarium or laboratory purposes. The essence of field work is to observe the plant *in its environment,* and to reason scientifically from these observations. As Adams[4] succinctly remarks,

> To learn how to study in the field, and not simply to collect, is one of the most important habits which a field naturalist and the ecologist has to acquire. This is one which he must, to a large degree, master alone, without the ready access to assistance, as is usually the case in the laboratory study. It is also a subject about which it is difficult to give useful suggestions, other than those of the most general character.

The herbalistic or laboratory routine, no matter how scientific and thoroughgoing, can never be more than a weak and shadowy substitute for these fundamental studies of organism and environment. Botany is not primarily in a *room,* it is out-of-doors; the workroom with its equipment and library is an adjunct to nature, and *not* the reverse. How often one finds botany taught as though the field and woodlands were merely a sort of glorified greenhouse, from which a few "types" and "illustrative specimens" were to be culled. Some teachers unconsciously create the impression that the plant kingdom exists primarily for the

[1] As an example of a recent text that does give suggestions for field work, E. F. Andrews, "Practical Botany," American Book Co., 1911, may be cited. Each of the ten chapters concludes with an excellent concise and suggestive section on field studies.

[2] Ganong, W. F., "The Teaching Botanist," Macmillan, 1899, pp. 64–65.

[3] Trafton, G. H., "Comparison of Methods of Teaching Botany," *School Review,* Vol. 10, 1902 (Feb.), pp. 138–145.

[4] Adams, C. C., "Guide to the Study of Animal Ecology," Macmillan, 1913, p. 37, Chap. 3, deals with field study.

purpose of providing material for paraffin sections and balsam mounts. To give college students real knowledge of plant life one must use living plants, and not merely skeletons and sections, no matter how important the latter are in their way.

As a concrete illustration of a general course in college botany that is given in an environment unusually favorable for field work, the writer will refer to the College of Hawaii, Honolulu. This institution corresponds in general status and organization to the state universities upon the mainland. Honolulu enjoys remarkably equable weather throughout the year; there are no storms; no frost, snow, ice or hail; thunder and lightning are very rare. There is no marked dormant season, and very few deciduous plants. The forests are evergreen, and most of the seed-plants have prolonged flowering periods. The climatic conditions are practically ideal for field work. In the immediate vicinity of the college is a remarkable variety of ecologic zones and habitats, ranging from the abyssal ocean to mountain peaks of three thousand feet elevation.

The botany course referred to is a freshman subject. There are two afternoon periods—two and one half hours each—and one lecture period per week. Customarily one of the afternoon periods is used for field work, the other for laboratory work. There are thirty-six weeks in the college year. The total number of field trips made by the class as a whole is about thirty. Students are encouraged to do individual field work and collecting, either on assigned topics, or those of their own choosing. This encourages the botanically-inclined student to develop a taste for original observations, and often prepares the way for special studies of genuine scientific merit.

The trips usually occur on Monday afternoon, as the experience of several years has proved this time to be the most satisfactory in connection with other features of the week's schedule. This permits the keeping-over of material collected, for the laboratory period, and facilitates a close coordination between field and laboratory work. The official period is two and one half hours, but the distances covered by some of the trips necessitate a considerably longer time than this, and field periods of three or three and one half hours are not uncommon. Occasionally, for the purpose of visiting some distant region of special interest, a double period is arranged by mutual agreement, and the excursion will occupy a period of five or six hours. On these occasions each student brings a light lunch, which is eaten at some convenient time in the course of the trip.

There are several types of excursions, which may be classed as follows:

1. *Systematic Collecting.*—To study in the field and collect for laboratory examination the plants of a given group or region; *e. g.*, green algæ; lichens; lycopods; Leguminosæ; strand plants; stream plants; swamp plants It is almost needless to point out that a certain amount of systematic collecting naturally forms a part of any field trip, irrespective of other objects.

2. *Ecologic Studies.*—Field studies of well-defined ecologic factors and adaptations; habitats with strongly marked characteristics; studies of zonation, invasion, competition, succession, etc.; relations of plant organs to environmental factors.[5]

3. *Field Studies of Plant Members and Organs.*—Particularly those organs and structures that are not adapted to bringing into the laboratory, *e. g.*, plank-roots, buttress roots; trunk types; bamboo; lianas *in situ;* epiphytes *in situ;* palm inflorescences; and many flowers.

4. *Phytogeographic Studies.*—Floral zones and regions in relation to their physiographic background; distinctive plants of the coral reef, lagoon, littoral, lowlands, valleys, summit ridges, peaks, etc.

[5] "On ecology of the structures they—the students—can do little better than guess at uses; for removed from their native homes, the plants can give no idea of their habits. Here is where the outdoor study of native plants through field excursions is most valuable." Ganong, *loc. cit.*, p. 206.

"Early in field work one should learn that the collection of specimens is not the primary aim of excursions, that specimens are only *one* kind of facts." Adams, *loc. cit.*, p. 41.

5. *Representative Plants.*—The phyla; important orders, families and genera; typical economics and ornamentals.

In all of the trips the students are encouraged to note any plants that are unknown to them. These are identified and listed; the last pages of the field notebook are utilized for this reference list of common plants. By this method, in the course of the year, the students learn the names of practically all the common plants of the region. As Clute cogently states,

> . . . the identification of plants is the only phase of botany in which the general public is interested; it is frequently the only part of botany in which the pupil is interested; and it is certainly the only part of botany that he follows up after he has left school. Doubtless every teacher has remarked the surprise of pupils when they discover that botany is not chiefly concerned with the names of plants.
>
> In any study, however, we can not do much without knowing the names of the objects with which we deal. Possibly there would be a much larger percentage of the people permanently interested in botany if our school courses early took cognizance of the desire for the names of things.[6]

At the beginning of the trip each student is provided with a typewritten or mimeographed outline which contains the essential topics, questions and directions for the trip. The topics and questions are numbered consecutively on the sheets, throughout the year, and the student numbers the paragraphs of his record to correspond with those of the outline. Inasmuch as the essential purpose of the trip is to strongly emphasize *individual observations* and first-hand familiarity with field material, the topics and questions are specifically planned and phrased with this object in view.

It is the practise of the teacher to devote a period of ten or fifteen minutes, early in the course of the trip, to a detailed explanation of the outline, so that every student knows exactly the character of the observations and studies to be made. At this time any questions are answered, individual assignments made, and every effort made to have the plan for the day thoroughly understood. This is a matter of great importance, as much time can be wasted through students not knowing exactly what is expected of them.

At this point it may be stated that each field trip is definitely anticipated in the lecture and recitation work, and much of the material and observations resulting from the trip are immediately used in the succeeding periods. The field trip is an *integral* working part of the course, and not merely a pleasant adjunct.

Some teachers utilize a somewhat less formal type of trip,[7] but it has been the writer's experience that the scientific results of an excursion are invariably in direct proportion to the fullness and precision of the outline.

An essential part of the equipment of each student is the *field notebook.* This is a small book, 3½ by 5 inches, with durable board covers and ordinary record ruling. In this book all of the original field notes and records are made, usually in pencil, and following the outline supplied at the beginning of each trip. The student numbers the pages consecutively, and the records appear in chronological sequence. At the end of the course a simple index is prepared by the student, listing the trips by subjects and places, and referring to the numbered pages of the book. The index is written on the first few pages of the book, which are left vacant for that purpose.

Much attention is given to the field notes as the record of the student's individual observations. A concise, simple style is encouraged. Technical terms are used when necessary, in a normal way, with no effort either to evade or to exaggerate their importance. Simple outline sketches, sections, profiles, diagrams and maps are used wherever they have

[6] Clute, W. N., "Teaching the Names of Animals and Plants," *School Review,* Vol. 15, 1907 (June), pp. 463–66.

[7] Clute, W. N., "Making Botany Attractive," *School Review,* Vol. 17, 1909 (Feb.), pp. 97–98. "Field trips are frequent, even in cold weather. Some trips are simply in quest of material and are made without an outline. Pupils are required to collect their own material and to note its relation to its surroundings and habitat. The trips with outlines are for the study of some phase of botany that can not well be studied indoors."

a legitimate place; the field drawings are necessarily rough, and are used, never for their own sake, but to supplement and elucidate the written statement.

It has been the experience of the writer that the freshman college student has a very vague idea as to essentials and non-essentials in field work and field records, and must be given systematic training in this. The records for the first few trips are examined by the teacher with particular care, and fully criticized and corrected. This is usually sufficient to give the student an accurate idea of standard field records. Insistence is placed upon the principle that field work must be genuine *field* work, and a rigid *tabu* is placed upon the writing up of notes from memory days after the trip has occurred. Two excerpts from Adams's[8] lucid statement may be pertinently reproduced herewith:

> The processes of observation and field study and note-taking are so intimately related that taking notes becomes one of the essential parts of careful observation. This is also one of the most difficult habits to acquire. The beginner is inclined to write them up, especially field notes, in the evening after his return from the field. Such notes are generally brief, lack details, and are usually of little value.
>
> We sometimes hear that reflections upon the work should be reserved for the return to the laboratory or study. This advice seems to be based on the assumption that study in the field is not particularly stimulating and suggestive. On the other hand, deliberating interpretatively in the midst of the problems under consideration is one of the most favorable conditions possible for the improvement of the quality and quantity of one's work.

A number of articles of field equipment are habitually taken on the trip, and are listed herewith.[9] Not all of these are taken on every trip; the kit is modified from time to time to suit the particular needs of the day.

1. *Vascula*—a number of small ones, one to each student, or to every two or three students, depending upon the character of the collecting; frequently one or two large vascula, for woody specimens or other bulky material.
2. *Diggers or trowels*—one or more, depending upon nature of collecting; the entomological collecting-tool listed by Kny-Scheerer has proved particularly satisfactory. Narrow garden trowels are good.
3. *Pocket-knives*—several large, strong knives, with sharp blades. The writer has been surprised and amused many times by the pocket-knife equipment of the average college student; the girls have none, and those of the men are usually wholly unsuitable for botanical purposes. Students are encouraged to supply themselves with good substantial pocket-knives, for as every field botanist knows, a surprising amount of botanical dissecting and anatomical work can be done with an ordinary *sharp* knife and a Coddington lens.
4. *Coddington lens*—one inch, in folding metal case; one for each student.
5. *Maps*—of the region to be visited, the largest scale obtainable; giving topography, hydrography, etc.
6. *Magnetic compass*—for use in connection with map work.
7. *Compound microscope*—portable type; occasionally taken, to provide for the demonstration, in the field, of certain structures —*e. g.*, algæ, fungi, sporangia, prothalli, elaters, pollen, protonema, etc.
8. *Dissecting kit*—in folding leather pocket-case, with scalpels, scissors, needles, etc., for field dissections.
9. *Field glasses*—prism binoculars; used on trips into the mountainous districts.
10. *Steel tape*—K. & E. 50 ft. Lilliput, very light and convenient; English and metric graduations; useful in many ways.

Miscellaneous vials, tin boxes, paper envelopes, twine, gummed labels, etc., as occasion requires.

For studies along the coral reefs and beaches waterboxes and collecting pails are taken.

[8] Adams, C. C., *loc. cit.*, pp. 41–42.

[9] The little book "Botanizing," by W. W. Bailey, Preston and Rounds, Providence, 1899, contains much useful information concerning botanical field work; especially Chap. 2, on equipment, Chap. 3, on collecting, and Chap. 4, giving directions for particular families.

Occasionally photographic equipment is taken, although this is made distinctly subsidiary to the other work of the trip.

A feature of the equipment that is by no means negligible is the item of clothing. Announcement of the trip is made a number of days, sometimes a full week, before the specified date, in order that all members of the class may have ample time to make any individual arrangements necessary. A statement is also made as to the general itinerary, the character of the country to be traversed, and the general nature of the garb most suitable for the trip.

Nothing is more disastrous to the pedagogical success of a trip than to have students appear in ill-adapted or wholly unsuitable clothing. One simply *can not* botanize in "good" clothes. Khaki trousers or skirts; headgear not susceptible to injury by the weather; leggins or puttees for protection against the numerous thorny and spiny plants of our lowlands; and, most important of all, comfortable, thick-soled, wide-heeled shoes—these are some of the features that make for successful field work. French heels, umbrellas and "wraps" are *tabu,* but the students are encouraged to bring field glasses, kodaks, or other equipment in addition to the botanical equipment, that will add to the interest of the trip.

In the first year course in general botany given at the College of Hawaii the following representative ecologic districts are visited:

1. *The Coral Reefs.*—This includes not only a survey of the plant life of the reef, but also a general study of reef formation; the reef as a habitat for plants and animals; the interrelations of marine organisms; the zonation of the reef and its waters; the rôle of plants as reef builders.

2. *The Beach.*—This includes the plant life of coral, tufa and lava beaches; the relation of plants to wave action; beach zonation; drift material; dissemination of plants by ocean currents; effects upon plant life of elevation and subsidence of beach levels; beach halophytism and xerophytism.

3. *The Lowlands.*—Comprising a variety of habitats—grassy plains; arid and semi-arid wastelands; salt-, brackish- and fresh-water swamps; streams and wet-lands; elevated limestone platforms; lava flows in various stages of disintegration; tufa cones and deposits; plant formations on volcanic ash and scoria.

Particular attention is given to the lowland flora, for although it is composed chiefly of introduced plants, it is the region in which the human population exists, and is therefore of chief interest. Problems of invasion, competition, adaptation, succession; dissemination; interrelations of insects and fungi to common lowland plants; crops, fruits, ornamentals and other economics; studies in xerophytism, mesophytism, etc.

4. *The Forest Zone.*—There are three divisions of the forest zone, lower, middle and upper; each of these has distinct humid and arid sections, with intergrading districts. In the vicinity of Honolulu only the lower and middle zones exist; the upper zone is confined to the lofty mountains of Maui and Hawaii. The forests within reach of Honolulu are chiefly humid or "rain" forests, although there are some xerophytic species. Topics: The conspicuous trees, shrubs and herbaceous plants of the forest; the forest as a watershed; the forest floor; animal life of the forest;[10] lianas and other specialized stem forms; precinctive species and varieties; landslides and other destructive agencies; relation of forest to precipitation, wind, elevation, etc.; conspicuous forest flowers and fruits; changes in the native forest within historic times; planted forests; forest conservation.

5. *Valleys.*—The Oahu Mountains are deeply dissected by steep-walled valleys, ravines and gorges. Many of these valleys are great amphitheaters of erosion. The humidity increases

[10] "Let no one worry if zoology and physical geography creep in hodge-podge with botany. They are apt to do that out of doors. Flowers do not object to the birds singing above them; I think an old tree likes to harbor a squirrel; and as for the boy who can gather spirogyra and not see a peculiar stone close by, he will never make a great naturalist."—Stuart, M. H., 1908, "The Botany Notebook, What it Should Contain and How it Should Be Made," *N. E. A. Proc.,* 1908, pp. 665–67.

progressively and conspicuously from mouth to head. Topics: plant zonation of the valley floor and walls; plant life of the stream and its borders; plants of precipices, spurs, hanging valleys and summit ridges.

The first trips of the course are short—across the college farm, and in the immediate vicinity—to familiarize the students with the general plans and methods of field work. The longest trips come late in the school year, after the class is thoroughly accustomed to field collecting and the ecologic point of view.

TYPICAL FIELD RECORD OUTLINE FOR THE STUDY OF A SEED-PLANT

1. *Name of plant*—Scientific; English; Hawaiian.
2. *Family.*
3. *Location*—as specific as feasible. (Students need training in accurate designation of localities.)
4. *Habitat*—distinctive features; soil; moisture; exposure; elevation; shade; plant associates; etc.
5. *The stand*—solitary; clumps; extensive pure stands; colonial; etc.
6. *Growth-form and duration*—herb; vine; shrub; tree; rosette; prostrate, etc.; outline sketch of profile, drawn to scale.
7. *Stem*—dimensions; characteristics of bark; mode of branching; cross-section of stem; mode of growth; special features and adaptations of stem, water-storage, etc.
8. *Foliage*—phyllotaxy; light relation. Description of leaf: blade—shape, size, color, texture, venation, apex, base, margin, other features; petiole—length, cross-section, etc. Collect six typical leaves for laboratory work. Variation; polymorphism; accessory structures. Leaf fall; leaf scars.
9. *Inflorescence*—abundance; location; kind; season.
10. *The flower*—color; odor; shape; size; flower buds; special features, nectaries, etc. Collect six flowers, in various stages of development, for laboratory work. Pack carefully to avoid crushing. Pollination—method and agents; desirable and undesirable insect visitors; protection of pollen from rain, etc., close-pollination.
11. *Fruit*—abundance; kind; size; shape; color; texture; dissemination. Collect six fruits in various stages of growth, for anatomical studies of fruits and seeds in laboratory.
12. *Seeds*—abundance; size; shape; color; dissemination.
13. Examine the various parts and organs of the plant for fungous diseases and insect pests, malformations, etc. Collect plenty of material for laboratory work.
14. *Root system*—if practicable, dig up several plants and determine character of roots, and area occupied by them. (Studies of roots in the field are very important, and constitute a much-neglected phase of botanical teaching. The writer strongly believes that at some point in the course the student should himself dig up and carefully examine the root systems of several representative plants.)
15. *Relations* of the individual plant to its associates—competition; commensalism; stratification; succession; etc.; visible evidence of adaptation.

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"EXPEDITE THE MAP"

A COMMITTEE to "Expedite the Completion of the Topographic Map of the United States" has been formed on the invitation of the undersigned, and its circulars have lately been sent out to engineers and others in all parts of the country, asking their support of the movement. Although appropriations made by congress have been liberal, although a number of states have cooperated generously, and although topographic mapping has been industriously prosecuted by the U. S. Geological Survey for the last thirty-five years, only about 40 per cent. of our national domain is at present represented on standard topographic maps. The area annually covered was greater at first, when the work was less accurate, than now, since the demand for better maps has arisen: at the present rate, about a century will be required to complete the maps, and long before that time elapses the demand for maps of larger scale and still greater accuracy will retard the rate of progress, unless large funds are forthcoming. For ten years past, something over half a million dollars has been spent annually on field work alone. This large sum should be steadily increased until it is at least doubled, in order that too great a delay before maps of the whole country are available shall be avoided. A rapid increase in appropriations is not desirable, because only a relatively small number of trained topographers are available for the work; but the increase should be continued annually for some ten or fifteen years to come.

Every industry, art and science which demands a knowledge of the lay of the land is benefited by good maps of the area in which it is carried on. The general location of railways and highways, the planning of water-supply, irrigation and drainage projects, the prosecution of geological, soil and forest surveys, the development of water powers and the installation of electric transmission lines, the promotion of large-scale realty transactions such as are common in the less settled parts of the country, are all aided immensely if good topographic maps of their areas are available, and are correspondingly embarrassed if such maps are wanting. Practical men, who have had experience in mapped and in unmapped areas, can testify to the ease and the difficulty of work in the two cases.

It is the wish of the committee to secure letters from such men in all parts of the country as to the value of the maps in the surveyed areas and as to the need of maps in the unsurveyed areas. The testimony thus gathered will be submitted to the director of the U. S. Geological Survey, as the basis of an urgent request that he should ask for larger appro-