

LABORATORY  
BOTANY

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CLUTE

# LABORATORY BOTANY

FOR THE HIGH SCHOOL

BY

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"THE FERN COLLECTOR'S GUIDE," "OUR FERNS IN  
THEIR HAUNTS," "THE FERN ALLIES  
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GINN AND COMPANY

BOSTON · NEW YORK · CHICAGO · LONDON

## PREFACE

The object in issuing this little manual is to furnish high-school teachers and students with a set of definite questions covering a year's work in botany that will at once direct the student to the structures he is to investigate and relieve the teacher of much of the labor of directing such investigations. No apology, therefore, is offered for the many and detailed questions, somewhat extended experience with high-school pupils having demonstrated that without specific questions the average pupil is likely to omit many points which should be studied.

By the use of this or a similar list of questions, a great deal of laboratory botany "teaches itself," leaving the teacher with time to prepare such materials as are needed, to set up and to take down apparatus, and to assist such pupils as may be in need of help. If desired, it is quite possible for any student, with this book in hand, to work through the course for himself, taking as much or as little time each day as he can spare from other studies. In class work, also, the questions will be found to conduce to a certain independence of the pupil, and prevent to a considerable extent the copying of one from another.

In preparing the questions an effort has been made to word them so that the pupil will be obliged to carefully examine for himself the structures studied in order to obtain the answers. Instead of requiring him to verify

a set of statements (which he is usually willing to accept without question), he is obliged to observe, compare, and reason. No question is asked that cannot be answered from a study of easily obtained material. The questions have been so arranged that if answered in their order the written work should make a fairly clear and logical presentation of each subject. The questions are numbered to facilitate reference to them, and this will enable the teacher to omit questions that are undesirable for lack of time, proper material, or for other reasons. It will also permit of elaboration at any point. The physiological experiments have been placed by themselves at the end of the book, in order to meet the requirements of some teachers who prefer to teach plant physiology as a study separate from morphology. The more usual way, however, is to perform these experiments as the necessity for understanding the parts of plants arises, and the place where each should come in the course has been indicated.

In the author's opinion everything in the course in botany that can be studied in the field or laboratory should be so studied. In no other science is there less need for extended recitations or, in the high-school course at least, for reference work of any kind. The permanent notebook should be entirely a record of what the student has observed in the laboratory, and the recitations, held after the laboratory work is completed, should aim to bring this knowledge into proper relation with such facts as must of necessity be obtained from the text-book.

The course is designed to cover a year's work in the laboratory, and falls naturally into two divisions, — one

devoted to the structure and life processes of angiosperms, the other to the structure and evolution of the whole plant kingdom. To each division a half year may be given profitably. The order in which the two parts are arranged in this book is, in the author's opinion, the best one, though they may be transposed, if desired. When but a half year can be devoted to botany, the structure of the angiosperms is unquestionably the most useful, and therefore the best.

The order in which the studies are arranged in this book conforms to the arrangement of topics in the usual botanical text, making it available for use in any elementary course. It is not expected that the teacher will attempt to use every question in a single year's work, but that the studies will be varied to suit existing conditions. Those who may encounter difficulties in presenting botany by the use of these outlines are requested to communicate with the author.

To Dr. H. A. Gleason, of the University of Illinois, and to Professor J. Y. Bergen, author of the well-known botanical texts, the author is greatly indebted for a careful reading of the proof and much helpful criticism, and takes this opportunity to extend to them his sincere thanks.

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## INTRODUCTION

One of the greatest aids to the teacher of botany is a class that is interested in the subject. Teaching is then relieved of its most disagreeable features. To stimulate this interest by every legitimate means is the duty, and should be the constant aim, of the teacher. Whenever material is to be gathered in the field, it is well to devote regular school periods to the work and to require each pupil to collect his own specimens. Such work is usually very attractive to pupils, who accumulate in this way many facts about plants not related to the subject in hand, but which are likely to be useful later in the course. Greenhouses within reach may be visited by the class in place of the regular day's study, and on pleasant days a great deal of the laboratory work may be performed in the field. The nearest vacant lot will often afford opportunities not to be had in a well-equipped laboratory.

Extensive collections of easily preserved materials will be found not only interesting to the student but exceedingly useful for reference during the course of study. Such collections should include seeds, leaves, and fruits of curious form and unusual structure, sections of wood, armed stems, puffballs, earth stars, lichens, shelf fungi, seaweeds, cones, and any other structures that will elucidate such subjects as seed dispersal, devices for protection, methods of climbing, etc. Collections

of roots, rootstocks, corms, bulbs, and fleshy fruits preserved in formalin or alcohol may also be included. Pupils should be encouraged to contribute to such collections. In the laboratory the best students may well be encouraged to follow up any subject related to the work that may most attract them. Those who take pleasure in drawing may be given additional specimens to illustrate, and those who enjoy working with the microscope may be supplied with additional mounts, either fresh or prepared.

The course has been outlined under the supposition that the pupils will have a sufficient number of compound microscopes at their disposal for the work, but even in schools that lack such instruments, the greater part of the microscope work need not be omitted. Very thin sections cut with an ordinary razor and mounted with cover glass and slide, exactly as if for viewing with the microscope, will give excellent results if viewed against strong light with a good simple lens. Such lenses may be had for about a dollar each. When the microscope is not used the study of minute parts will be greatly helped by the use of illustrations in the books.

Fresh material will always be found more desirable for study than the best of material preserved in alcohol or other fluids, and should be used when possible. It is not necessary to depend upon the rarities of the gardener and florist. The nearest grocery or market, a few vacant lots, and the wayside trees and weeds will furnish the great bulk of the material, and a few trips to the woods will add much more. A great number of these specimens may be used year after year if properly cared for.

Just how much notebook work should be required must be determined by each teacher for himself. An impression seems to be gaining ground that notebook work in botany can be easily overdone. In no case, however, should many and exact drawings be omitted, and these should be examined frequently, as the work progresses, to insure that the structures studied have been properly interpreted. The teacher may often find it advantageous to require more drawings than are called for in this book. In drawing, the pupil seems to succeed better with a pencil than with a pen, but all written work should be in ink. It can scarcely be claimed that the time used in school hours for writing accurate accounts of work done is time improperly used, and if the permanent notebook is to be regarded as an evidence of work done in the laboratory, it should be written up there under the eye of the instructor.

If botany is taken up in autumn, it may well begin with a few weeks' study of trees. If taken up in winter or spring, it should end with a few weeks' study of floral ecology. A year's course may begin and end with these two subjects. There are some advantages in beginning with seeds in midwinter, but if one is careful to provide for material for the study of flowers in winter, this course may as well be begun in autumn, as is the usual custom.

It may be pointed out that the present manual may be used in a variety of ways. The most desirable one is to provide the pupil with proper material and require him to obtain his answers by a careful study of it, without reference to the text-book. If time is pressing, the pupil may still be required to answer all the questions,

but he may be allowed to look up the answers in the books and verify his drawings from such illustrations as he can find. The written work may include answers to all the questions in the outline, or after these questions have been answered in a temporary notebook, the pupil may be required to write in the permanent notebook a discussion of the fundamentals only. Suggestive questions will be found at the end of each outline, and the teacher will readily add others, either from the questions in the outline or from other sources. Doubtless it will be found desirable to vary these questions from year to year.

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# LABORATORY BOTANY



# PART I

## THE STRUCTURE AND LIFE PROCESSES OF ANGIOSPERMS

### I. TO THE STUDENT

It should be the aim of every pupil to produce a neat, clean, and properly illustrated notebook. This end will be more easily attained if the following rules are carefully observed.

1. In drawing, use a hard pencil with a sharp point. A drawing pencil, to be used only in this work, should be obtained. Draw no line that does not mean something. Shading should usually be omitted.

2. Do not crowd your drawings. Before putting pencil to paper, consider how much space the drawing is to occupy and allow for it accordingly. If several drawings are to go on one page, be careful to leave plenty of space between them. The dimensions of small objects may be easily estimated by taking some part as a standard of measurement; for instance, the diameter of a rootlet may be estimated as a number of times the diameter of the central cylinder, or the cell may be estimated as a certain number of times wider than the nucleus.

3. Make your drawings large enough to show plainly what you attempt to illustrate. If drawn larger than natural size, indicate the approximate magnification,

especially if two drawings of the same thing, of different sizes, appear on the same page. Drawings are most readily made after you are familiar with your specimen. Answer the questions on it before drawing.

4. Label all parts of each drawing. Beneath the drawing give the name of the object drawn. In labeling the parts abbreviate when possible, as *nu.* for nucleus, *pro.* for protoplasm, *chlor.* for chloroplasts, *vac.* for vacuoles, etc. Draw dotted lines from the parts named to the margin of your drawing, and write or print your abbreviations there and not on the drawing itself. Each page of drawings should be called a plate, and the plates should be numbered consecutively.

5. In your written work use good black ink, and write on but one side of the paper unless directed to do otherwise. Observe the ordinary rules of composition, especially those regarding punctuation, capitalization, and paragraphing. For the sake of uniformity, follow the same style in all your written work. If the school has a standard in this, conform to it. Avoid blots and erasures, and on no account interline words and phrases. Number your pages consecutively and preface your work with an index kept up to date.

## II. EXERCISES WITH THE MICROSCOPE

**To the teacher.** If the compound microscope is available for the study of botany, it will save time later and will serve to fix the attention and interest of the student if the work is begun with exercises designed to give facility in the use of this instrument. Pupils may be required to draw the microscope and label its parts, accompanying the drawing with a description of its manipulation; or this may be omitted and sufficient instruction given the class to enable each pupil to make temporary mounts and to use the high and low powers properly. If several pupils are to use one microscope, it will be well to have each pupil in turn prepare the mount and adjust the instrument. The beginning student finds great difficulty in interpreting correctly what he sees with the microscope, and he should be required to draw carefully the various objects studied, to the end that he may learn to distinguish the essential from the nonessential. Drawings should always be enlarged sufficiently to show all parts clearly, and a sharp distinction should be made between accurate drawings and those that are merely "pretty" or "artistic." Even pupils without talent for drawing can usually draw accurately if they have seen clearly. Hazy and indefinite outlines usually indicate that the student has not thoroughly understood the object drawn. Drawings should be made with a hard, pointed pencil and shading should be omitted.

Before taking up the study of cells in earnest, the pupil should possess a working knowledge of the instrument with which he works. It will therefore be well to devote one or more periods to "showing off" the microscope by examining various minute objects such as diatoms, cells from elder or corn pith, cells from a mealy apple, starch grains, fresh-water algæ, etc. The vast swarms of one-celled animals to be found in water in which hay or dead leaves have stood for some days will illustrate animal cells and should not be neglected. In these studies it may be well, also, to teach the pupil to distinguish between bubbles and the objects he is to see.