LABORATORY DIRECTIONS FOR ELEMENTARY BOTANY; PP. 1-99

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649419876

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Edited by Trieste Publishing Pty Ltd.
Cover @ 2017

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LABORATORY DIRECTIONS

FOR

ELEMENTARY BOTANY

JAMES B. POLLOCK, Sc.D.
ASSOCIATE PROFESSOR OF BOTANY
UNIVERSITY OF MICHIGAN

GEORGE WAHR, PUBLISHER
ANN ARBOR, MICH.
1922

PREFACE

This manual is the product of twenty five years' experience in teaching elementary botany to students in the University of Michigan. At the beginning of that period the author started with a similar manual used by his predecessors and associates, the late Professor Volney M. Spalding, of revered memory, and Professor Frederick C. Newcombe.

The outline of work has undergone considerable change since the time when the writer was given charge of the elementary course in botany at this institution. For these changes he has been largely responsible. As the students increased in numbers other men have coöperated in giving the laboratory work and lectures, and in the most recent years numerous discussions have been carried on as to how the course could be improved. Among those taking part in these discussions have been H. H. Bartlett, R. M. Holman, B. M. Davis, W. W. Tupper and others.

The work outlined is essentially that now given at this University, but the present edition contains some material not previously included in the manual as used here, and for this as well as for the arrangement and composition, the author assumes sole responsibility. It is hoped that in its present form it will be especially useful to the instructors in botany in the junior colleges associated with city high schools. In recognition of the fact that in most cases those instructors will have limited library facilities, material has been incorporated into the present work that might properly be reserved for a text book rather than a laboratory manual. The reason for so doing is that some of the work herein presented is so new that it has not yet found a place in any textbook of botany. This is the justification for the paragraphs on vitamins and the newer knowledge of nutrition.

Other topics are presented so inadequately in most textbooks that it has seemed worth while to give a new presentation. For this reason the carbon and nitrogen cycles have been included.

Whether the results justify the attempt at a new presentation by the writer, may be left to the judgment of the experts

in the field concerned and of the teachers who may find the manual adapted to their needs.

At the University of Michigan the elementary course in botany is given for one semester, followed or preceded by a semester of Zoology. The two give credit to the students as general biology, 4 credit hours each semester. After the present date each student will have one lecture, two quizzes, and 6 hours of laboratory work per week. Previously he had two lectures and one quiz with the same amount of laboratory work. The time given by the student, counting that spent in both study and recitation, is counted as equal to a study in which there are four recitations per week without laboratory work.

Among the changes in this edition as compared with earlier ones are:

1. The students are given more information directly, enabling them to understand more quickly the facts they are really expected to work out for themselves. In any case much of this must be done for each student, either by the instructor orally or by means of printed directions. With small classes the former is probably more advantageous. With large classes the latter seems necessary.

2. Experiments in plant physiology have been added. It is expected that these will be done almost wholly by demonstration. Lack of laboratory space, time, apparatus, and teaching force make it impossible to do this as individual work for each student.

The advantage of experiments is that they give the student an opportunity to see as a unit all phases of the scientific method as used in research, of which a noted educator has said that it is the only method by which progress is made in any subject. It is especially important that the student should see clearly the difference between observed results and conclusions drawn from them, and the necessary logical relation of the latter to the former. It is believed that these experiments, to a more adequate degree than any other one phase of the work, will give to students the "discipline of science," which is a training in the scientific method of work, in particular as it is applied to the field of plant life.

3. It was agreed by the men coöperating in the teaching

of elementary botany in the University of Michigan, that students should be asked to learn the Divisions and Classes of the plant Kingdom and their characteristics. To facilitate this, the author has given a characterization of each Division and Class for which material is presented for study. He has attempted to give a few of the most distinctive characters, without too much technical material and also to indicate briefly the general biological significance or the points of contact with human life. No attempt has been made to teach applied botany specifically, but in the discussion of some topics it is pointed out how the principles of plant life underlie certain applications to practical affairs.

4. In certain parts, the work has been made less intensive and more extensive. Formerly a few forms were studied in great detail. That custom has been changed gradually, and in this edition, specifically in the study of the gymnosperms, a Key is provided for identification and brief description of as many species as time and material allow. The Key was prepared with the material in mind that is generally available in Michigan. It is recommended also that laboratory or field studies be made of the commoner angiosperms, though no special Key is provided for them.

There is more work outlined than can be completed in one semester. This leaves room for a choice of material by the teacher, in those institutions in which elementary botany is given for one semester only. The selection may be determined by the teacher's interest or the material available. In the University it is shortened by leaving out some of the algae and fungi and omitting parts of the study of liverworts, mosses, and ferns. It is not necessary to study in detail the life history of both a gymnosperm and an angiosperm. An external study of several of the former and a detailed study of the latter are recommended. A year's work may easily be provided by adding systematic botany of the angiosperms.

JAMES B. POLLOCK.

Jan. 2, 1922.

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THE PLANT CELL

All plants are composed of cells, which are sometimes called units of structure. The material to be studied first is an aquatic flowering and seed-bearing plant, whose leaves are suitable for the study of the cell. This plant is Elodea canadensis.

A. Note that the Plant grows submerged in water. It is therefore aquatic. As in seed plants generally, it has **stems, roots,** and **leaves;** but is able to grow in jars in the laboratory without roots. It therefore must absorb all the materials necessary for its life from the surrounding water and through the surfaces of all its organs. Note the arrangment of leaves on the stem. Are they in whorls, that is, circles of several at the same level? Are they opposite, that is, two at the same level on opposite sides of the stem, or are they alternate, that is, in a spiral arrangement?

B. **The Leaf.** Remove with the forceps a fresh leaf from a growing tip and mount in water. Is the leaf petiolate (having a stalk), or is it sessile, (attached directly to the stem by a broad base)? What is its size, expressed as the greatest length and width? What is its shape? Examine it with the low power of the compound microscope. What is the character of the margin? Notice a dark line through the middle of the leaf from the base to the apex. This is the mid-rib. The broad expanded portion is the blade, or lamina. Dark lines running parallel to the mid-rib are not secondary ribs, but intercellular spaces, filled with some gas, which in bright sunlight is likely to be pure oxygen. Why?

Looking at the finer structure of the leaf, note the boundaries of individual cells, showing as very thin white lines. Examine all parts of the leaf and note differences in size, shape, and color of cells. If the diameter of the field of your microscope has been measured, you can easily estimate the size of objects quite accurately. What is the actual size of the cells?

Draw in outline the leaf as a whole and draw on a larger scale a portion showing the relative size and arrangement of cells in outline.

Before going farther write in your notebook a description of the plant and the leaf as you have studied it.

C. **Individual Cells.** With the high power study individual cells.

1. Note first **the cell wall,** its color, its position, its thickness estimated as a fraction of the short diameter of the cell. This wall is composed of **cellulose,** whose chemical formula is approximately $n(C_6 H_{10} O_5)$, the value of **n** being unknown. The wall is the most rigid part of the cell, and helps to give rigidity to the plant as a whole. Does each cell have its own separate wall or are the walls common to two adjacent cells?

2. Observe in some cells a substance in motion carrying green granules, the **chlorophyll bodies** or **chloroplasts,** around in the cell. Choose a cell in which the chloroplasts follow each other in single file along the wall, with some distance between them. Note the continuously flowing, granular, very transparent substance. This is the **cytoplasm.** Does it carry the chloroplasts along or do they move the cytoplasm? Give a reason for your answer. How thick is the layer of cytoplasm and chloroplasts estimated as a fraction of the cell diameter?

3. **The nucleus.** Somewhere in the cell, lying imbedded in the cytoplasm, is a rounded body, much larger than the chloroplasts. It is nearly transparent, but is generally more dense than the cytoplasm. It is the nucleus, and usually a denser body, the nucleolus, may be seen within it. What shape is the nucleus? What is its diameter as compared with that of the cell? Where is it located?

4. **The vacuole.** The space within the cell, completely surrounded by the layer of cytoplasm and chloroplasts, is called the vacuole. It is filled with a watery solution called cell sap, which is composed of water and various substances dissolved in it. Sugar is one of the most common substances in the cell sap, but many others may be present, as, inorganic salts, organic acids, and their salts, etc. What is the shape of the vacuole? What proportion of the cell volume does it occupy?