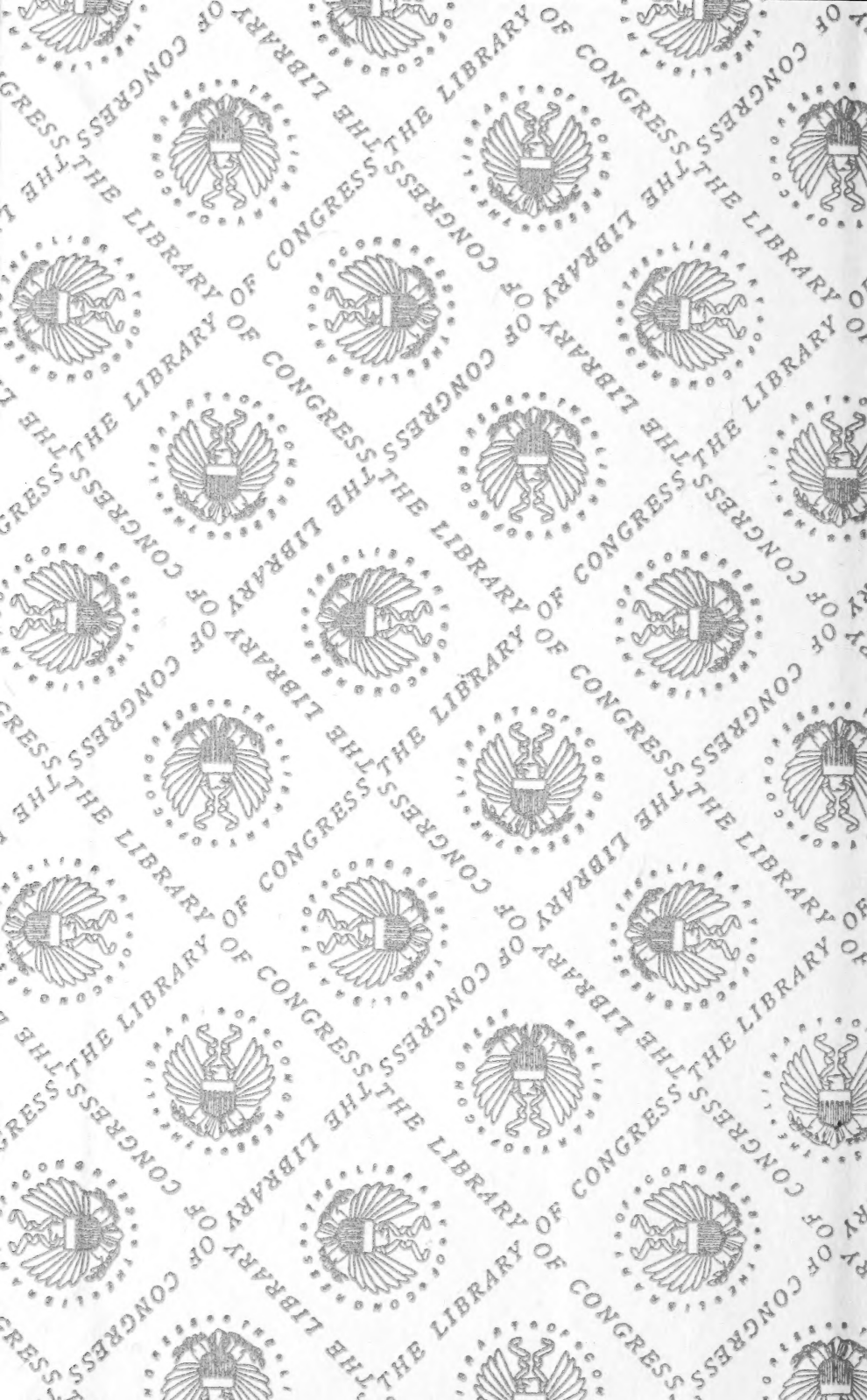
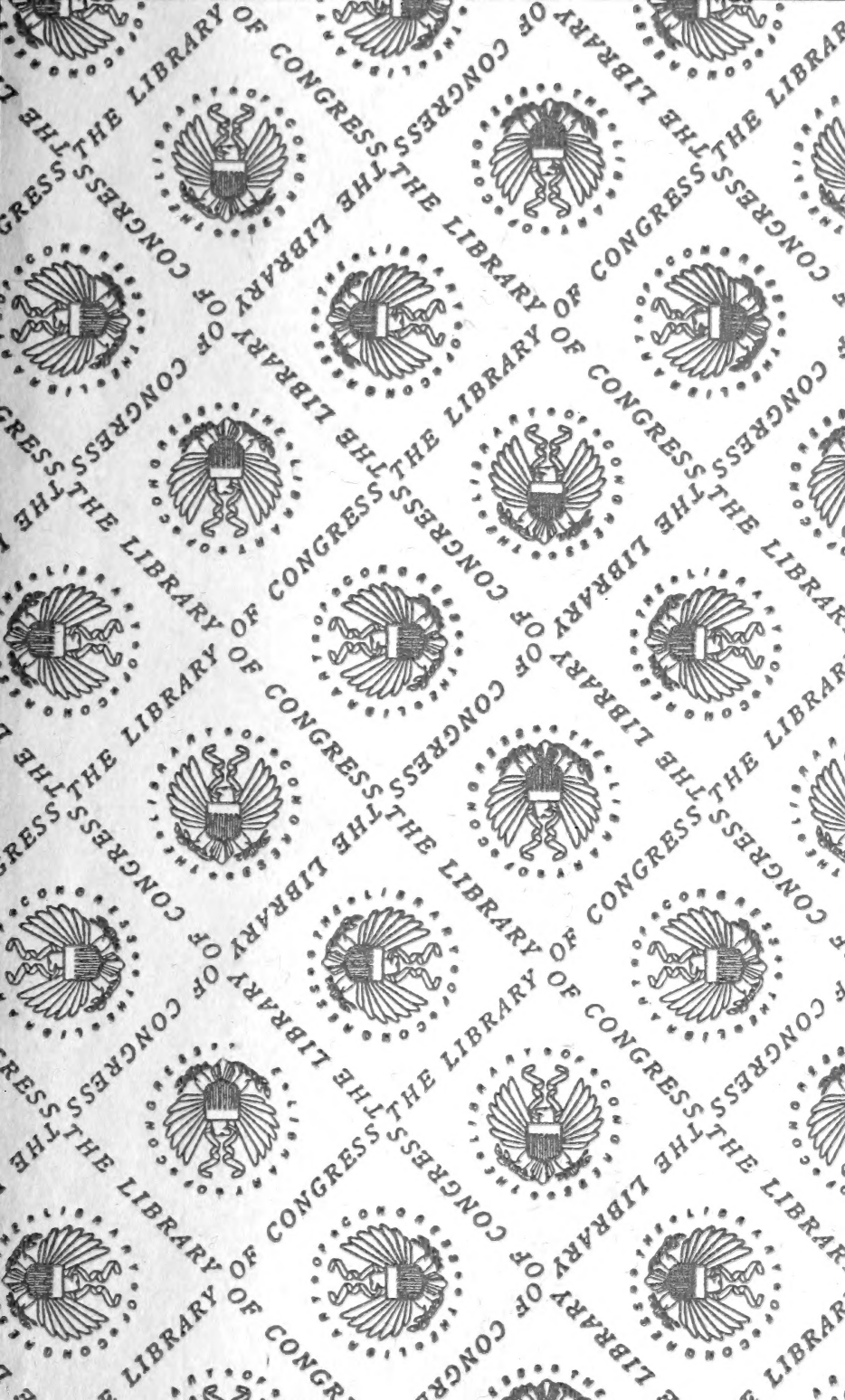


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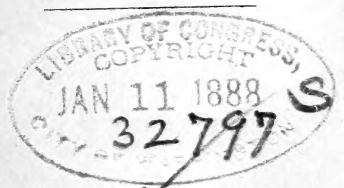
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GUIDE

TO THE STUDENT IN  
BOTANY.

13



By EDWARD S. BURGESS, A. M.,  
INSTRUCTOR IN CHARGE.

*Printed at the Philadelphia*  
*1887*



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The present work is intended for the use of students in the Washington High School, to supply them with the outlines of their course in Botany, and to furnish directions for modes of procedure in laboratory work and in original investigation. It is also intended to include such information regarding the methods followed as will answer the inquiries of parents and others interested. A portion of the matter contained is entirely new; another portion has been for four years in use in the school as a Syllabus of the Botanical Course, and is now entirely rewritten, with such adaptations as have been suggested by experience.

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SYLLABUS  
OF THE  
COURSE IN BOTANY,  
WASHINGTON HIGH SCHOOL,  
1887-1888.

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I. METHOD OF STUDY.

Botany in the Washington High School is made a study of the third year. The student's previous scientific work has been in his first year a General Elementary Course, including Physiology, Physical Geography and Geology, and in his second year a course in Physics, or, if he chooses, in Chemistry. Botany follows as the new science of the third year; its study is made elective.

The method pursued in the study of Botany is primarily objective, and based upon the actual examination of the appropriate material. The aim of the course is double—to promote habits of close observation and to secure knowledge of the life of plants. It is intended not merely nor principally to impart instruction, but rather to lead the student on to learn from Nature direct. Use of text-books as a summary and for reference is considered the appropriate supplement. Lectures are added as a further supplement, accompanied by examination of specimens and illustrated by diagrams. Field-work is esteemed of vital importance, especially in promoting familiarity with habitats and associations of

plants. This is at times continued during the winter by studies at the Botanical Gardens. There, by kindness of the Superintendent, Mr. W. R. Smith, the Botanical Lecture-room, built for this purpose with the advice of Professor Asa Gray, of Cambridge, has been placed at the disposal of the Department of Botany for inspection of plants and delivery of lectures. In this way the student's knowledge is extended to some prominent features of tropical vegetation.

Especial emphasis is laid on the requirement of original work. Each student studies successively the development of seeds, buds, leaves and flowers; preparing description and drawings. Besides this, each student is also given a succession of more generalized topics for investigation. Attention is directed to the breadth of this field of exploration and the littleness of that already known. The results of the original work done are presented in a series of "Observation Papers," prepared from notes and figures taken at the time of observation. Each paper is read before the class and is retained by the laboratory.

Ordinary sessions of the various classes are opened by reports from the class of objects seen or work done, exhibition of specimens brought in, questions from the class in regard to work, and questions to the class in review. In order to keep in mind the relation of flowers to thought, an extract from literature regarding plants is daily placed on the blackboard and copied by the class. The main part of the hour is then devoted either to examination of specimens, or to lecture, recitation (from text-book or lecture) or reading of papers. For the foregoing purposes each class meets four days in the week, with sessions of fifty minutes. Each student devotes also at least one hour to laboratory work every week.

The classes are formed in September, and are then given leaves from which to study venation. Flowers are used from

the first, or nearly the first; the first flowers ordinarily selected being the Soapwort, Morning Glory and Pokeberry. From careful examination of the parts of these flowers the leading characters of Polypetalous, Monopetalous and Apetalous Exogens are learned, with daily explanation of terms as needed. Other flowers follow, and acquaintance with a number of families is at once secured, among them the Compositæ, which is usually taken up the third or fourth week. Excursions to the woods and riversides near the city are taken as opportunity offers. Each student hands in a description of each plant studied. As specimens for analysis become fewer, text-book study is increased, and is nearly finished by the end of December. Material for the illustration of this study has been collected continually throughout the preceding weeks, forming an important object in fall excursions. Students have meantime completed the first or autumn series of observation papers, and their reading follows, while excursions in small companies to the Botanical Gardens now replace those taken to outlying districts. Specimens illustrating fruits, buds, grasses, ferns, mosses, fungi, lichens, algæ, and minor subjects have been collected in quantity during the fall, and are now to be brought in succession into study, with accompanying lectures. These subjects occupy the remaining sessions till early spring. With them there is joined a winter series of observation papers, mainly concerned with buds and branches; and a series of exercises follows by which the student is taught how to make the best use of botanical works and periodicals. With the coming of spring the analysis and study of the phænogams again engrosses attention. Excursions to the woods are renewed, the spring series of observation papers, mainly concerned with flowers, is begun, and the class is actively engaged in enlarging the High School Herbarium. Work is finished about the first week of June, closing with lectures

upon some of the leading generalizations of the science. A tabulated synopsis of the work of the year is given page 42.

## II. REQUIRED WORK.

1. Practical Exercises in the Examination and Analysis of Plants. *Forty hours.*  
To include, besides analysis, General Objective Work, or the study of specimens with a view to deduction of the general principles of Botany.
2. Gray's Lessons and Manual. *Forty hours.*  
A number of copies of Ward's "Flora of the District of Columbia" will be loaned to students as further aids to study.
3. Lectures (supplementary to the text-book, and upon Internal Structure and Cryptogams). *Forty hours.*  
See Outlines of Lecture Topics, page 13.
4. Laboratory Work (devoted to exercises in drawing and describing the details of plant structure, with and without the microscope). *Twenty hours.*  
See Outlines for Laboratory Work, page 21.
5. Studies at the U. S. Botanical Gardens and in Excursions. *Ten hours.*  
See page 40.
6. Preparation of 100 Description Papers, (each stating the characteristic external features of some plant analyzed).  
To be entered in a blank book according to Outline, page 25.
7. Preparation of 3 Observation Papers, (stating results of original observation on some general topic assigned).  
See Outlines for Observation Papers, page 26.
8. Preparation of a Condensed Summary of Structural Botany.
9. Development Studies; one each on Seeds, Buds, Leaves,

Flowers; report to describe, 1st, the object and its parts (with drawings); 2d, its successive stages of development.

### III. SPECIAL OBJECTS OBTAINED BY THE FOREGOING REQUIRED WORK.

Object of Observation Papers.

To cultivate independent and intelligent observation of general facts regarding plants.

Object of Description Papers.

To cultivate close observation of particular kinds of plants.

Object of Laboratory Work.

1. To secure knowledge of Methods of Work.

2. To secure thorough acquaintance with the structure of the component parts of a plant.

Object of Analysis of Plants.

To secure acquaintance with plants which are—

- |  |   |                                  |
|--|---|----------------------------------|
| <ol style="list-style-type: none"> <li>1. Most common,</li> <li>2. Most important,</li> <li>3. Most peculiar,</li> </ol> | } | Characteristics of the District. |
| 4. Types of Orders.  |   |                                  |

Object of Summaries of Work Done.

To condense the leading facts of Botany in a form most easily read and remembered.

Object of Text-book Work.

To secure proper correlation of subjects studied, and familiarity with accepted modes of stating results.

Object of Excursions.

To secure knowledge of habitats and the growing appearance of plants; and to extend the range of collection and observation.

## IV. BLANK BOOKS REQUIRED.

I. For Notes, should contain at least four quires, with stiff cover bearing the student's name and section. It should be arranged as follows :

- a. Pages 1-14. Summary of Work Done.
- b. " 15-40. Drawings and other Laboratory Work.
- c. " 40-end. Notes on Lectures.

II. For Descriptions, should be as above described, having one description only upon a page, with the common name of the plant conspicuously placed at the top; all the descriptions to be numbered, and an index placed at the end of the book. See page 25.

## V. BOTANICAL FACILITIES OFFERED.

A. The Laboratory, in which classes assemble, seats forty students, and is provided, besides usual furnishings for a school-room, with four long tables for class-work, a press and drying-frame, sink in several compartments, shelving, &c. Among others are the following special appliances :

a. Chest of twenty drawers containing collections of fruits, capsules, dried flowers and leaves, examples of stems, roots, buds, mosses, fungi, lichens, &c.

b. Microscope-table, seating five for work with instruments, and provided with twelve drawers for accessories.

c. Glass Case of Specimens of Ferns, &c., of the Coal Period.

d. Glass Case containing Laboratory Herbarium (began March, 1883, and intended to represent the District Flora, with the plan of showing all principal stages and forms of each plant).

e. Glass Case containing Wood Sections presented by kindness of Dr. Geo. Vasey, through favor of the Agricultural Department.

*f.* Glass Case containing Zoological Specimens in Jars, collected by students.

*g.* Collection of Marine Invertebrates, by favor of the Smithsonian Institution. In jars.

*h.* Collection of Lepidoptera and other Insects of the District of Columbia, in cases, collected by students.

*i.* 100 Charts placed upon the walls or hung from wires, illustrating the Structure of Plants; the work of students.

*j.* Charts placed upon the walls to illustrate forms of leaves; other sets to illustrate the Maples and other Ornamental Trees of Washington; another set of 40 varieties of Palms; (all the above consisting of leaves pasted upon manilla paper).

*k.* Crayon picture of Joseph Henry (by kindness of the artist, Henry Ulke), and framed engravings of Darwin and Humboldt (by kindness of Dr. Wm. Bernhardt).

*l.* Index to Scientific Papers contained in the Smithsonian Annual Reports, 1863 to 1881, arranged by authors; made by students.

*m.* Duplicate of the above index, arranged by subjects, and extended to other scientific publications of the Government contained in the Library.

## B. Propagating Room.

A room in the basement, having south and east windows, has been used for this purpose, and furnished with shelving for pots and with growing-boxes. The plan followed is to secure here a supply of plants of different stages of growth for use in illustration, especially in the winter, and to be transferred to the Laboratory as desired.

## C. Scientific Library.

Besides works on general science in the main Library, the Branch Library, in the Botanical Laboratory, contains many

Government Reports on scientific subjects, and many works upon Botany and Zoology, the property of the High School. These can be drawn by the student on leaving his receipt. The following works on Botanical subjects are especially recommended to the notice of classes:

Botanies by Sachs, Bessey (Larger), Macloskie, Koehler, McNab, Miss Youmans, Gray (Structural), Goodale (Physiological), Chapman, (Southern).

Lindley's Vegetable Kingdom.

Rhind's Vegetable Kingdom.

Sargent's Woods of the United States.

Hervey's Sea Mosses.

Underwood's Native Ferns.

Bailey's Talks Afield.

Figuiet's Vegetable World.

Twining's Plant World.

Darwin's Works; and Life, by Grant Allen.

Darwiniana, by Professor Asa Gray.

Also, Beale's How to Work with the Microscope.

Carpenter's The Microscope.

Lankester's The Microscope.

Also, among books loaned to the laboratory by the instructor in charge, to be drawn by students in the previous manner:

Bower and Vines' Practical Botany.

Vines' Physiology of Plants.

De Bary's Comparative Anatomy of Phanerogams and Ferns.

Gray's Synoptical Flora of North America.

De Candolle's Origin of Cultivated Plants.

Gray's Botanical Text-book.

Gray's School and Field Book (containing Garden Plants).

Gray's Manual (containing Mosses and Hepaticæ).



Lesquereux and James' Mosses.  
 Underwood's Hepaticæ.  
 Farlow's Algæ of New England Coast.  
 Wood's Algæ, Fresh-water.  
 Wolle's Desmids; and Algæ.  
 Van Heurck's Diatoms.  
 Tuckerman's Lichens.  
 Cooke's Ponds and Ditches.  
 Arthur, Barnes and Coulter's Plant Dissection.  
 Goodale's Vegetable Histology.  
 Quekett's The Microscope.

#### D. Scientific Periodicals.

Bound volumes of the "American Naturalist" and two of "Nature" are to be found by the student in the Laboratory Library. Files of current scientific publications are kept upon a special table in the laboratory, and may be drawn out by receipt. They include, the property of the school,

The Popular Science Monthly and The American Meteorological Journal.

Also, loaned by the instructor, for use of students,

The American Naturalist,  
 Science.

Botanical Gazette.

Bulletin of the Torrey Botanical Club.

American Monthly Microscopical Journal.

Circulars of the Johns Hopkins University.

Publications of Washington Scientific Societies.

#### VI. OUTLINES OF LECTURES.

The lectures outlined below are intended to secure the student's attention to some important subjects not otherwise sufficiently noticed. The lectures are from thirty to fifty

minutes each ; illustrated by diagrams ; each important statement and each diagram to be contained in the student's notebooks, which are frequently examined, and for which credits are given based on clear and faithful arrangement.

SERIES I.—FLOWERS AND THEIR FAMILIES.

1. The Typical Flower.

*a.* Types ; *b*, formula and diagram ; *c*, type of calyx ; *d*, of corolla ; *e*, fragrance ; *f*, color ; *g*, morphological transitions.

2. Uses of Flowers.

*a.* Uses protective ; *b*, uses attractive ; *c*, in production of perfumes ; *d*, as food ; *e*, for medicines ; *f*, as dye-stuffs ; *g*, other commercial uses ; artificial flowers ; *h*, effect of flowers upon the mind.

3. Influence of Flowers upon Literature.

*a.* Their place in prose ; the Essayists ; *b*, their place among the Novelists ; *c*, their place in prose in general ; *d*, in poetry ; *e*, as sources of imagery ; *f*, as types of beauty ; *g*, as affecting different nations ; *h*, associations connected with flowers ; *i*, favorite flowers of the poets.

4. Palms.

*a.* Structure of stem ; *b*, leaves ; *c*, flowering ; *d*, fruit ; *e*, habits ; *f*, uses.

5. Grasses.

*a.* Characters ; *b*, comparison of rushes and sedges in stem ; *c*, in leaf ; *d*, in fruit ; *e*, characters of each compared ; *f*, uses of each.

6. Lilies.

*a.* Types of Endogens ; *b*, distinctions from related families ; *c*, importance ; *d*, prominent species.

7. Roses.

- a.* Types of Exogens; *b*, distinctions from related families; *c*, importance of the Rose family; *d*, prominent species.
8. Leguminous Plants.  
*a.* Characteristics; *b*, related families; *c*, importance; *d*, prominent species.
5. The Buttercup Family. (Headings as in 8.)
6. The Composite Family. do.
7. The Heath Family. do.
8. Aroids. do.
9. Water-lilies. do.
10. Pines. do.
11. Catkin-bearing Trees.  
*a.* Catkins; *b*, families producing them; *c*, upon shrubs.
12. Cacti and Fleshy Plants.  
*a.* Cactus stems; *b*, fleshy stems of Agave and Aloes; *c*, of Impatiens and other local plants; *d*, of sea-shore plants; *e*, other fleshy parts of plants; *f*, value of succulence.
13. Water Plants.  
*a.* Submerged stems; *b*, leaves; *c*, roots in water; *d*, flowers and fruit; *e*, families of water-plants; *f*, water-plants in other families; *g*, general structure of water-plants.
14. Orchids.  
*a.* Structure in general; *b*, roots; *c*, flowers; *d*, fertilization; *e*, invitation of insects; *f*, position among plants.
15. Trees and Shrubbery of Washington.  
*a.* Native trees along the Potomac; *b*, upon the hills; *c*, shade-trees of the streets; *d*, trees in the parks; *e*, in conservatories; *f*, shrubbery, cultivated; *g*, native.

## SERIES II.—GENERAL TOPICS.

## 16. Buds.

*a.* Development; *b*, conditions of bud formation; *c*, adventitious buds; *d*, budding; *e*, grafting; *f*, bulb-lets; *g*, propagation by buds versus seeds.

## 17. Adventitious Roots.

*a.* To supply air; *b*, to start cuttings; *c*, replacing true root; *d*, from injured stem.

## 18. Plant Hairs.

*a.* Unicellular; *b*, jointed; *c*, feathery; *d*, stellate; *e*, glandular; *f*, stinging; *g*, prickles; *h*, sensitive.

## 19. Fruit.

*a.* From calyx; *b*, receptacle; *c*, peduncle; *d*, compound; *e*, time of ripening; *f*, chemical changes; *g*, germination of indehiscent fruits.

## 20. Seeds.

*a.* Self-sowing; *b*, self-covering; *c*, wind-borne; *d*, animal-borne; *e*, rolling; *f*, sculpture; *g*, development, density, germinating power; *h*, productiveness.

## Vitality of Seeds.

Cases alleged from tertiary beds; from Egypt, mummies, tombs, Athens; cases within modern times; experiments; conditions required; conclusion.

## 21. Plant Galls.

*a.* Characters in common; *b*, gall makers; *c*, inhabitants; *d*, alternation of generations; *e*, unlimited growth; *f*, internal galls; *g*, compound; *h*, hypertrophy; *i*, swelling of petioles; *j*, bedeguar; *k*, double galls; *l*, comparison of leaf-miners, leaf-rollers, and "jumping seeds."

## 22. Distribution of Plants.

*a.* Influence of temperature, soil, light, climate; *b*, rem-

nants of different distribution; *c*, man's agency in distribution; "plants cultivated against man's will;" *d*, distribution by currents, birds; *e*, ancient and modern migrations; *f*, cosmopolitan plants; *g*, acclimation.

23. Germs and Dust.

*a*. Dust as carrier of germs; *b*, their characters; *c*, bacteria; *d*, in decay; *e*, in disease; antiseptics; *f*, Bacillus, characters; *g*, beer-yeast; *h*, permanence.

24. Growth.

*a*. Effect of heat on chlorophyll; *b*, on annular growth; *c*, of light; *d*, blanching; *e*, sensitive leaves.

25. Plant Chemistry.

*a*. Components of plant; *b*, sources; *c*, respiration; *d*, chlorophyll action; *e*, starch; *f*, sugar; *g*, albumen; *h*, tea, coffee, &c.

26. Plant Mathematics.

*a*. Decussate leaves; *b*, cycles; *c*, angular divergence; *d*, phyllotaxy, systems; *e*, fundamental and secondary spirals; *f*, deviations; *g*, flower in 5's, 3's, 4's, &c.

27. Fertilization.

*a*, Exhausting energy; *b*, heat; *c*, rest required; *d*, time fixed, influences; *e*, pollen, characters; *f*, changes on the stigma; *g*, tubes developed; *h*, embryo and sac.

28. Cross Fertilization.

*a*. Fertilization of Primula; *b*, Clerodendron; *c*, Barberry; *d*, Kalmia; *e*, Aristolochia; *f*, Leguminosæ; *g*, Yucca; *h*, Pansy; *i*, action of thrips; *j*, bees; *k*, butterflies and moths; *l*, proterogyny; proterandry; homogonous, heterogonous, dimorphous, trimorphous, monœcious, diœcious, flowers; *m*, wind-fertilized flowers; *n*, flowers alluring insects.

## 29. Self Fertilization.

*a.* Accidental ; *b.* subsidiary ; *c.* cleistogamous. \_

## 30. Adaptations to Environment.

*a.* To water ; *b.* wind ; *c.* soil ; *d.* sand ; *e.* shortened seasons ; *f.* changed climate ; *g.* crowding ; *h.* competition ; *i.* leaf-structure, form, &c.

## 31. Flowers Repelling Insects.

*a.* Why injurious ; *b.* means of defence ; *c.* downward hairs ; *d.* other visitors.

## Flowers Capturing Insects.

*a.* Utricularia, characters, habits ; *b.* Dionæa ; *c.* Sarracenia ; *d.* Darlingtonia.

*e.* Flowers Digesting Insects ; Nepenthes, characters ; habits ; *f.* Drosera ; *g.* Pinguicula ; *h.* others.

## 33. Relations of Animals to Plants.

*a.* Interdependence ; *b.* resemblances, breathing ; *c.* digestion ; *d.* reproduction ; *e.* protoplasmic and chemical composition ; *f.* starch and sugar ; *g.* flexor cords ; *h.* motion ; *i.* dependence on oxygen ; *j.* ability to take animal food ; *k.* differences.

## 34. Motion in Plants.

*a.* In growth ; *b.* sweep of tendrils ; *c.* due to light ; *d.* to heat ; *e.* hygroscopic motions ; *f.* sudden blooming ; *g.* sensitive stamens, leaves, &c.

## 35. Nature in Literature.

*a.* Trees and other objects deified ; *b.* general influences of nature ; *c.* upon different peoples ; *d.* nature to the Greek ; *e.* to the English ; *f.* attitude of modern literature toward nature ; *g.* Wordsworth ; *h.* Emerson ; *i.* nature to other poets.

## SERIES III.—THE PLANT CELL.

## 36. Protoplasm.

*a.* Compared in monera, in algæ; *b*, characters; *c*, history.

## 37. Cell Walls.

*a.* Form; *b*, layers; *c*, sculpturing; *d*, chemical changes; *e*, growth of spirals; *f*, cellulose.

## 38. Cell Development.

*a.* Terminal and uniform; *b*, terminal and attenuated; *c*, radiating; *d*, branching; *e*, intercalary; *f*, intussusception; *g*, unicellular plants; cœnobia; *h*, cell-rows; *i*, cell-surfaces, membranes.

## 39. Cell Contents.

*a.* Protoplasm; *b*, nucleus; *c*, nucleolus, *d*, primordial; utricle; *e*, sap; *f*, starch; *g*, chlorophyll; endochrome; *h*, miscellanea.

## 40. Cell Movements.

*a.* Movements of naked protoplasm; amœboid (myxomycetes); *b*, streaming (myxomycetes); *c*, gliding (diatoms, *Oscillaria*); *d*, movements of enclosed protoplasm; circulation, (*Tradescantia*, Gourds); *e*, rotation (*Chara*); *f*, cyclosis (*Desmids*, *closterium*); *g*, Brownian movement; *h*, movement by cilia; *i*, hygroscopic movements.

## 41. Cell Production.

*a.* Multiplication by buds; *b*, by fission; *c*, segmental division; *d*, free cell formation; *e*, rejuvenescence; *f*, reproduction by conjugation; *g*, by fertilization, (with antheridia); *h*, by pollination.

## 42. Cell Tissues.

*a.* Union of cells; *b*, bordered pits, sieve and ladder cells; *c*, kinds of tissues, parenchyma, palisade, &c.

## SERIES IV.—FLOWERLESS PLANTS.

43. Ferns.  
*a.* Characters; *b*, geological history; *c*, association with coal; *d*, fruit-dots, sporangia, spores; *e*, prothallium, antheridia, archegonia.
44. The Fern Allies.  
*a.* Equisetum; *b*, Calamites; *c*, Water-ferns; *d*, Grape-ferns; *e*, Lycopodium: Selaginella; Lepidodendron; Sigillaria.
45. Mosses.  
*a.* Characters, root; *b*, stem; *c*, leaves; *d*, pedicel; *e*, capsule; *f*, calyptra (cap), operculum (lid), peristome (teeth); *g*, the "flowers of mosses;" paraphyses.
46. Hepaticæ.  
*a.* Frondose Hepaticæ; *b*, Foliaceous Hepaticæ; *c*, elaters; *d*, gemmæ.
47. Lichens.  
*a.* Form; *b*, habitat; *c*, prominent species; *d*, apothecia; *e*, gonidia; their origin.
48. Fungi.  
*a.* Parasitism; *b*, its consequences; *c*, influence upon higher plants; *d*, mushrooms, gills, mycelium; *e*, rust, smut, mildew, mould; *f*, bacteria.
49. Algæ.  
*a.* General character; forms; *b*, colors; *c*, habits; *d*, development; *e*, marine algæ; *f*, fresh-water algæ; *g*, diatoms; *h*, desmids; *i*, volvox and allies.
50. Cryptogams.  
*a.* General character; reproduction; *b*, development; *c*, other comparisons with phanerogams; *d*, relations to higher plants; classifications.



## VII. OUTLINE OF LABORATORY WORK.

A. *General Plan.*

By the laboratory work here outlined, it is intended to secure acquaintance with methods of work, and with the structure of the component parts of plants. It affords opportunity,

1. To learn the preparation of plant specimens and appliances.
2. To learn the use of the microscope.
3. To study external structure in detail (Morphology); examining  
     Germination,  
     The Root, Stem, Leaf, Flower and Fruit,  
     Fertilization.
4. To study internal structure (Histology); see topics following.

B. *Topics of Histological Study.*

The laboratory has recently been well provided with microscopes of its own, and the study of these topics had been made possible before by borrowing from gentlemen friendly to the cause of public instruction. The topics following are not offered as a complete series, but as a thoroughly practicable course, and one which has been tested by trial. The plan has been to select such subjects as combine importance with ease of manipulation. The material is supplied by the instructor, who is present to direct and explain.

## \* Cell-Formation.

Colorless Unicellular Plant,

(See "Practical Biology"), Yeast.

Green Unicellular Plant, (See

"Practical Biology" and

"Plant Dissection"), Protococcus.

Red Unicellular Plant, in Stratum,	Palmella.
Green Unicellular Plant, showing motion, internal,	Desmids.
Yellow-Brown Unicellular Plant, showing motion, external,	Diatoms.
Blue-Green Filamentous Plant, showing motion, external,	Oscillaria.
Green Filamentous Plant, (See "Plant-Dissection.")	Spirogyra.
Cell-Membrane,	Porphyra ; or, Moss-leaf.
Cell-Substance,	Tetraspora.

## \* \* Spore-Formation.

Conjugation, of Simple Cells,	Desmids.
Conjugation, of Filaments,	Spirogyra.
In Special Cells,	Edogonium.
In Cystocarps,	Red Sea-mosses (Florideæ).
In Apothecia,	Lichens.
In Capsules,	Mosses.
In Spore-cases,	Ferns.

## \* \* \* Tissues.

Parenchyma, colorless,	Pith of Sunflower and of Rushes.
Parenchyma, with nucleus and protoplasm,	Pondweed.
Parenchyma, with starch- grains,	Potato-tuber.
Parenchyma, with chloro- phyll grains,	Leaf of Moss (Fontinalis).
Parenchyma, Epidermal Tissue and Stomata,	Mignonette, Selaginella.

Parenchyma, section of leaf, Hyacinth.	
Wood-cells,	Red Cedar.
Bast-cells,	Linden.
Spiral Ducts,	Narcissus.

*C. Directions for Using the Microscope.*

- I. Remove all dust with a handkerchief.
- II. Put Eye-piece and Objective in place.
- III. Obtain convenient position of tube.
- IV. Obtain light from mirror.
- V. Clean a slide thoroughly.
- VI. Place the object to be examined on the centre of the slide in a minute drop of water
- VII. Clean a cover-glass carefully, and place it on the object (to hold it in place and to flatten the water).
- VIII. Put the slide so arranged, on the stage, centering it over the aperture.
- IX. Fasten the slide with spring-clips (unless the stage is horizontal).
- X. Focus the objective; use, 1st, the Coarse Adjustment (draw tube or rack and pinion); 2d, inspect; 3d, use the Fine Adjustment.
- XI. Practice changing focus.
- XII. Practice changing light.
- XIII. Practice finding object.
- XIV. Practice moving object while in view.
- XV. Practice changing focus while in view.
- XVI. Practice changing diaphragm.
- XVII. Practice drawing object.

*D. Order of Parts in Examining a Plant in detail.*

- A. Root.
- B. Stem.

## C. Leaf.

Petiole, Stipules, Bud, Spines, Tendrils, Haustoria.

## D. Flower.

Sepals, Petals, Stamens (Filaments, Anthers), Pistils  
(Style, Stigma, Ovary [Ovules, Placenta.]).

## E. Fruit.

Cells, Pericarp (Exocarp, Mesocarp, Endocarp) Seeds,  
Outer Coat, Inner Coat, Rhaphe, Hilum, Chalaza,  
Embryo (Cotyledons, Plumule, Radicle), Albumen.

## E. Order for Examining a Single Plant in detail.

Color,	as in petal of a single rose, rose-color.		
Outline,	“	“	obovate.
Division,	“	“	undivided.
Margin,	“	“	entire.
Base,	“	“	narrowed, sessile.
Apex,	“	“	rounded.
Surface,	“	“	smooth.
Substance,	“	“	delicate.
Venation,	“	“	free, fine, obscure.
Direction,	“	“	horizontal.
Insertion,	“	“	on a disk on the calyx.
Adhesion,	“	“	0
Cohesion,	“	“	into a disk below.

## Mutual Relation—

In the Bud, as in petal of a single rose, imbricated.

In Maturity, “ “ wheel-shaped.

In Age, “ “ deciduous.

## Figures :

View from Above, flower, ———, petal, ———.

View from Side, flower, ———, petal, ———.

Formula, in single rose,  $S_5 P_5 St + P +$

Diagram (showing all parts as by a cross-section through bud).

F. *Directions in Drawing Plants.*

A. Draw,

- |   |   |
|---|---|
| 1st, a View from Above,                     | } In case of leaf, flower or part<br>of flower. |
| 2d, a Side View,                            |   |
| 3d, a diagram of arrangement (if a flower). |   |

B. Drawing the object as seen under the Microscope, draw a View—

1st. Of Surface, with naked eye or low power; 2d, with Compound Microscope.

3d, Of Cross-Section, with naked eye or low power; 4th, with Compound Microscope.

5th, Of Section lengthwise, with naked eye or low power; 6th, with Compound Microscope.

C. Details:

1. Write under the drawing *natural size, reduced or magnified*, according to fact, in the last case naming Microscope and Objective used.
2. With the microscope make all drawings (within uniform circles  $3\frac{1}{2}$  inches broad) the same proportion of the circle as of the field of view.
3. Write at the side of the drawing any description necessary to indicate characters not expressed by the drawing.
4. The note-book in which these drawings are entered should be brought whenever coming to laboratory-work, and should have each page headed with date and subject.

VIII. OUTLINE FOR DESCRIPTION PAPERS.

The following is a sample of the 100 Descriptions to be entered in the Description Book (not considered a part of Laboratory Work, but done in part in regular class exercises and in part out of school);

Name—Soapwort.

Date— ———.

Root—Fibrous.

Stem—Herb,  $1\frac{1}{2}^{\circ}$ , swollen at nodes, smooth, slightly branched.

Leaf—Opposite, sessile, oval-lanceolate, acute, entire, smooth, 3-nerved.

Flowers—In clusters, large, showy, pinkish.

Sepals—5, united in a tube nearly to the tips.

Petals—5, each with a slender claw and broad blade.

Stamens—10, white, anthers large.

Pistils—1, compound, styles two, stigma the inner surface.

Ovary—1, compound, 1-celled.

Seeds—Many, on an axial placenta.

Fruit—Pod, 1-celled, opening at tip by about four valves.

Order—Caryophyllaceæ.

Sci. Name—*Saponaria officinalis*. Remarks—Common in sandy roadsides near Washington.

#### INDEX.

Four pages at the end of the Description Book should be filled in as an index, of which a sample line may be:

Soapwort, *Saponaria officinalis*, Caryophyllaceæ, [page] 1.

#### IX. OUTLINES FOR OBSERVATION PAPERS.

Three papers, selected from the following lists, are required from each student during the year, to contain results of original observation only; and see page 6.

\* *Autumnal Series of Observation Papers.*

##### 1. Leaves, Asymmetrical.

*a.* Forms; *b*, comparison with symmetrical leaves in numbers, in development; *c*, causes.

##### 2. Leaves, Different shapes on the same plant.

- a.* Differences enumerated; *b*, their association with groups, soil, moisture, season of year, age of plant, cultivation; *c*, their advantage; *d*, their permanence.
3. Leaves, Anastomosing veins in.
  - a.* Directions; *b*, association with special shapes, margins, groups; *c*, veins of ferns.
4. Leaves, Midribs of.
  - a.* Number present; *b*, length; *c*, form; *d*, surface; *e*, color; *f*, interior.
5. Leaves, Relation of veins to outline of.
  - a.* Examples of similarity; *b*, exceptions noted and explained; *c*, free veins but entire outlines; *d*, anastomosing exterior veins, but margin not entire; *e*, palmate veins in leaf not lobed; *f*, irregularities of venation not accompanied by corresponding irregularity of leaf.
6. Leaves, Skeleton leaf compared with skeleton plant.
  - a.* Comparison of angle of veins and branches; *b*, of veinlets and twigs; *c*, apices; *d*, sessile leaves compared with low-branching trees; *e*, with acaulescent plants; *f*, does the leaf repeat the skeleton of the tree?
7. Leaves; Color of veins in its relation to color of leaves.
  - a.* Difference from leaf; *b*, difference of veins from each other; *c*, on different surfaces; *d*, association with special colors; *e*, with groups of plants.
8. Leaves, Lobes of.
  - a.* Variations; *b*, transitions to entire leaves; *c*, to compound leaves.
9. Leaves, Bases of.
  - a.* Association with venation; *b*, special forms; *c*, with petiolate and sessile leaves.
10. Leaves, Apices of.
  - a.* Differences accompanying venation, lobation, family

grouping ; *b*, possession of hair, spine, or tendril ; *c*, preference of leaf for special kind of apex ; *d*, advantages of it.

11. Leaves, Margins of.

*a*. Kinds ; *b*, their association with groups ; *c*, differences on the same plant ; *d*, association with particular development of leaves ; *e*, smooth margins ; *f*, hairy margins ; *g*, margined petioles ; *h*, decurrence upon stem ; *i*, marginal colors.

12. Leaves, Compound.

*a*. Kinds found, most abundant ; *b*, cases with margined petiole ; *c*, subordinate features ; *d*, stipules and stipels ; *e*, termination of leaf-stalk ; *f*, associations.

13. Leaves, Permanence of.

*a*. Examined in pine and other evergreens ; why permanent ? *b*, replacement due to what ? *c*, in grasses ; *d*, in tropical plants ; *e*, associations.

14. Leaves, Scars.

*a*. Shape ; *b*, variations ; *c*, cause ; *d*, elevation ; *e*, date ; *f*, color ; *g*, numbers ; *h*, surface ; *i*, dotted scars ; *j*, scars of sessile leaves.

15. Leaves, Permanence of color after fall.

*a*. Cases of permanence ; *b*, changes how, where, to what ? *c*, effect of moisture.

16. Leaves, Variation in their color.

*a*. Change uniform, through different leaves, different parts of the same leaf ; *b*, gradual or sudden ; *c*, complete, variegated or shaded ; *d*, development of changed color, whence, where greatest ; *e*, relation to succulence.

17. Leaves, Change of color in Maples.

*a*. Stages of color in the same leaf ; *b*, comparison with other American trees, with European maples ; *c*,



variations of color in the different species; *d*, in different leaves; *e*, same leaf.

18. Leaves, Falling of.

*a*. Time; *b*, changes, external and internal; *c*, experiment with petioles; *d*, permanence of leaf.

19. Leaves of Poplars.

*a*. Comparison of shape, venation, surface, &c., of Abele, Carolina P., Balsam P.; *b*, contrasts.

20. Leaves, Horizontality of.

*a*. Object of direction of leaf; *b*, non-horizontal leaves in America; in Australia; *c*, effect produced.

21. Leaves, Reversion to.

*a*. Examples of complete and partial reversions of petals, of whole flower; *b*, reversions in Alder; *c*, contrast with viviparous Junci and Scirpi; *d*, morphology.

22. Leaf Climbers.

*a*. Distinctions; *b*, mode; *c*, effect on petiole; *d*, kind of coil.

23. Climbing Plants.

*a*. Distinguished from twiners; *b*, modes; *c*, examples; *d*, development.

24. Morphology of Tendrils.

*a*. Forms; *b*, morphological value, and accompanying differences; *c*, coils and process of coiling.

25. Twining Plants.

*a*. Examples; *b*, characters; *c*, development of stem, compared with climbers; *d*, sweep of stem, compared with tendrils; *e*, irritation of stem; *f*, comparison with coil of leaf-climber.

26. Hairs on Plants.

*a*. Degree of development; *b*, distribution of hairs and position; *c*, characters; *d*, association with groups; *e*, use; *f*, jointed hairs.

27. Viscid Hairs.  
*a.* Where found ; *b.* characters ; *c.* advantages to plant ;  
*d.* development ; *e.* duration of viscosity ; *f.* source.
28. Stems, Creeping and Prostrate.  
*a.* Contrast ; *b.* cause ; *c.* examples ; *d.* experiments to  
exchange.
29. Flowers, Labiate.  
*a.* Stages of development ; *b.* forms assumed ; *c.* associa-  
tion with families, with labiate calyces, with other  
irregularities ; *d.* efficiency, association with un-  
equal stamens, causes.
30. Late Apetalous Flowers.  
*a.* Examples ; *b.* differences from complete flowers ; *c.*  
difference in peduncle ; *d.* association with com-  
plete flowers ; *e.* efficiency.
31. Seeds, Distribution by the Wind.  
*a.* Adaptation in shape ; *b.* appendages ; *c.* association  
with groups ; *d.* effects, comparison with others in  
holding ground.
32. Milky Juice of Plants.  
*a.* Examples ; *b.* special vessels ; *c.* characters ; *d.* use ;  
*e.* associations.
33. Rhizomes.  
*a.* Description ; *b.* uses ; *c.* conditions favoring ; *d.* effi-  
ciency ; *e.* associations.
34. Bulbs.  
*a.* Characters ; *b.* sections ; *c.* object and uses ; *d.* asso-  
ciation with special groups, soils ; *e.* development,  
changes ; *f.* duration.
35. Galls.  
*a.* Cause and purpose ; *b.* character ; *c.* examples ; *d.*  
double, hairy, simple and compound ; *e.* shapes,  
colors, substance.

36. Protection of Buds by Position.  
 a. Position under bark ; *b*, in axil ; *c*, under petiole ; *d*, in wood ; *e*, comparison with related species ; *f*, comparative development.
37. Seedling Plants.  
 a. Change of growth, in time, direction, form, color, characters ; *b*, comparative rapidity.
38. Seedlings and Cuttings.  
 a. Cuttings in development, production of roots, of buds ; *b*, comparison with seedlings ; *c*, growth in ground, in water.
39. Growth of Plants over Water.  
 a. Different growths, rapidity ; *b*, effect of changes of position, of sunlight ; *c*, form, color ; *d*, comparison with the same started in earth.
40. Relation of Coleoptera to Vegetation.  
 a. Examination of vegetable-feeding coleoptera by families ; *b*, depredations on stem, root, leaf, fruit, flower ; *c*, summary.

\* \* *Winter Series of Observation Papers.*

1. Buds, Vernal of.  
 a. Kinds, single and collective, with examples.
2. Buds, Supernumerary.  
 a. Examples ; *b*, association with groups ; *c*, comparison of members of a bud-cluster in position, form, size, function, development, structure ; *d*, comparison of bud-clusters with solitary buds, on same plant, different plants.
3. Buds, Terminal.  
 a. Examples ; *b*, form ; *c*, size ; *d*, function ; *e*, structure ; *f*, protection.
4. Buds, Adventitious.

- a.* In nature ; *b*, developed in layering, cuttings, slips, pollarding ; *c*, developed artificially from peach, beech maple, poplar ; *d*, from leaves, in nature, in propagation, in begonia, in peperoma ; compare *Primula Chinensis*, *Echeveria*.
5. Buds, Naked.
- a.* Examples, their relationship ; *b*, characters ; *c*, why no scales ?
6. Buds, Dormant.
- a.* Comparison of branches as to extent of simultaneous development of buds ; *b*, proportionate extent ; *c*, development of dormant buds systematic ? *d*, traces left by dormant buds ; *e*, probabilities of a bud becoming dormant ; *f*, can such be made to grow ?
7. Buds, Color of.
- a.* Colors found ; *b*, relation of colors within and without ; *c*, compared with color of bark, wood, leaf, autumn leaf ; *d*, change of color.
8. Buds, Scales of.
- a.* Characters ; *b*, gradations between outer and inner ; *c*, any scales within the leaves ; *d*, number of outer scales enclosing bud.
9. Buds, Form of.
- a.* General form ; *b*, apex ; *c*, base ; *d*, divergence ; *e*, varying on same plant.
10. Buds, Varnishes of.
- a.* Characters ; *b*, extent ; *c*, efficiency ; *d*, consistency ; *e*, source.
11. Buds, Protection by hairs.
- a.* Characters ; *b*, difference from other hairs on same plant ; *c*, efficiency.
12. Buds, Protection by position.
- a.* By covering ; *b*, by angle taken ; *c*, by simple posi-

tion in axil; *d*, development at time axillary position ceases to protect; at time coverings cease to protect.

13. Buds, Phyllotaxy of.
  - a*. Examples; *b*, exceptions.
14. Stems, Creeping and prostrate.
  - a*. Examination repeated from Series I, No. 28; *b*, why should one be produced and not the other? *c*, white clover, Mitchella.
15. Spines, Morphology of.
  - a* Examples, their relationship; stages of development; *b*, morphological value; *c*, compound thorns; *d*, circumstances favoring development.
16. Prickles, Morphology of.
  - a*. Examples, their relationship; *b*, characters; *c*, use; *d*, morphological value; *e*, circumstances favoring or retarding.
17. Tubers, Morphology of.
  - a*. Examples; *b*, characters; *c*, use; *d*, morphological value; *e*, circumstances influencing; *f*, phyllotaxy, scales, eyes.
18. Bark.
  - a*. Comparison of trees; *b*, shaggy and smooth bark; *c*, lines of cleavage; *d*, how ruptured; *e*, bark of perennial plants; *f*, of annuals; *g*, corky layer, in gum, in ordinary trees; other layers.
19. Specks on Branches.
  - a*. Characters; *b*, symmetrical arrangement; *c*, change with age; *d*, cause; *e*, branches without them.
20. Brittle Branches.
  - a*. Comparison, leatherwood, oak, willow; examples? *b*, compared with other parts of same branch; why not brittle throughout? *c*, why not in related species; *d*, object; *e*, relation to bud.

## 21. Transverse Sections.

*a.* Comparison of exogens and endogens in general ; *b*, of medullary rays ; *c*, of varying rings ; *d*, of development of bark layers ; *e*, of development of heart-wood and sap-wood.

## 22. Longitudinal Sections.

*a.* Comparison of exogens and endogens ; *b*, trace knots ; causes ; buried knots ; *c*, examine medullary rays.

## 23. Heliotropism.

*a.* Positive ; degree ; *b*, variations peculiar to different plants ; *c*, to different lights ; *d*, cause ; *e*, negative ; examine tendrils of grape, Virginia creeper ; *f*, aerial roots.

## 24. Winter Growth.

*a.* Examine buds, &c. ; *b*, note influence of warm days ; *c*, ascertain formation of buds for early spring flowers ; *d*, development of mosses, hepaticæ, and algæ.

## 25. Development of Buds.

*a.* Experiment with water, warmth, light ; *b*, compare with natural action ; *c*, artificial change of blossoming-time, of leafage.

## 26. Hairs found in Winter.

*a.* Position ; *b*, use ; *c*, characters ; *d*, hairs developed with the winter ; *e*, hairs disappearing with winter ; *f*, permanence.

## 27. Persistent Leaves.

*a.* Evergreens, trees, shrubs, vines, herbs ; characters ; related species not evergreens ; *b*, dead leaves persistent ; cause ; *c*, leaves late in dying.

## 28. Roots grown in Water.

*a.* Characters ; *b*, differences from similar root grown in earth ; *c*, fibrils ; *d*, root-caps.

## 29. Scars. (See Series I, No. 14.)

30. Growth of Plants in Water. (See Series I, No. 39.)
31. Growth of Seedling Acorns and Horse-Chestnut. (See Series I, No. 37.)
32. Growth of Seedling Maples. (See Series I. No. 37.)
33. Winged Fruit.
  - a. Characters; examples with one wing; confluent wings; two separate wings; *b*, use; *c*, related fruit without wings.
34. Permanence of Berries.
  - a. Examples found in winter; *b*, difference from summer berries; *c*, structure; *d*, persistence; *e*, dissemination of seed; value.
35. Acorns.
  - a. Differences in form, structure, cup; *b*, embryos; *c*, development.
36. Nuts and their growth.
  - a. Examples; *b*, ripening; *c*, dissemination of seed; *d*, development.
37. Seeds working into the ground.
  - a. Into sand; *b*, through cavities in soil; *c*, by weight; *d*, by shape; *e*, by boring; *f*, any other mode of self-burial? *g*, awned seeds working to the ground.
38. Morphology of the Apple, Pear and Orange.
  - a. Development of ovary; *b*, calyx; *c*, receptacles.
39. Morphology of Capsules in the Laboratory.
  - a. Examples; *b*, classification; *c*, characters; *d*, structure.
40. Fertilization of Cultivated Flowers.
  - a. Examine position of organs; *b*, what cultivated flowers produce seed; how are their organs placed? how is fertilization accomplished? *c*, artificial means.

\* \* \* *Spring Series of Observation Papers.*

1. Runners.
  - a.* Characters ; *b*, variations in same species ; in same individual ; *c*, trace development.
2. Twining of Stems.
  - a.* Twining only one way ; examples ; exceptions ; *b.* degree of curve ; where, when and how developed ; *c*, sweep of tip ; when active, what radius, in how many internodes ? *d*, effect of irritation ; *e*, action on reaching object ; *f*, reversing the sweep.
3. Twining of Tendrils.
  - a.* Sweep examined ; radius, direction, continuation ; *b*, effect of irritation ; *c*, preference for support ; *d*, influence of warmth, cold, light, darkness.
4. Glaucous Surfaces.
  - a.* Parts of plant so affected ; *b*, extent, color, depth, substance, permanence ; *c*, use ; cause ; *d*, associations.
5. Bulb and Stem of Addertongue.
  - a.* Collect and rear ; *b*, trace development of bulb ; *c*, characters ; *d*, permanence ; *e*, compare with other bulbs.
6. Heliotropism in Nature.
  - a.* Compare garden plants and wild plants ; shaded trees ; *b*, plants in cellars and shade compared with same in light ; *c*, note sunflowers, &c., for diurnal heliotropism.
7. Comparison of Stipules.
  - a.* Form, size, color ; *b*, confluent stipules ; *c*, stipules of Grasses, Polygonum.
8. Development of Stipules.
  - a.* Trace from the beginning ; *b*, morphological value ; *c*, replacements.



9. Petiole Bases.
  - a.* Forms; *b*, enlargements affecting stem; *c*, decurrent enlargements; *d*, substance; *e*, uses; *f*, development of base.
10. Leaf Substance.
  - a.* Variable thickness in the same plant; *b*, in different plants; *c*, different species; *d*, its cause; *e*, its use.
11. Leaf Forms, Design of.
  - a.* Aquatic leaves, filiform, floating; *b*, wind-beaten, small, acicular; *c*, variation with situation; *d*, variation in new circumstances.
12. Haustoria.
  - a.* Where and how developed, from what substance, into what substance of foster-plant? *b*, do internal tissues enter foster plant? *c*, use.
13. Viscid Hairs. (See Series I, No. 27.)
14. Viscid Floral and Folial Organs.
  - a.* Comparison of relative frequency; *b*, difference of structure; of use.
15. Receptacles.
  - a.* Adaptation to use; modifications; *b*, proof of the flower as a branch; *c*, characters, dry, fleshy, prolonged, with disks.
16. Flower—Buds.
  - a.* Aestivation; *b*, folding of single piece; *c*, development; *d*, form, color, compared with flower.
17. Flower—Development.
  - a.* Successive stages; unfolding bud; *b*, influence of heat, light, moisture, irritation, applications to hasten or retard; *c*, uniform, rapid, sudden developments, duration, persistence.
18. Flowers, Double.

- a.* Developed by culture; *b.* otherwise; *c.* influences; *d.* modifications; *e.* value.
19. Flowers, Dimorphous.  
*a.* In stamens; *b.* in pistils; *c.* compare sassafras, Mitchellia, Houstonia; examine Bouvardia, Polyanthus, Auricula; investigate Sauguinaria.
20. Flowers, Repeated Opening of.  
*a.* Examples; examine Dandelion, Oxalis, Evening Primrose; *b.* associated characters.
21. Flowers, Reversion in. (See Series I, No. 21, and investigate Virescence.)
22. Flowers, Nodding.  
*a.* Examples; *b.* degree; *c.* character of peduncle; *d.* arrangement for fertilization; *e.* nodding of any advantage? *f.* transient nutation, in epilobium.
23. Flowers, Spurred.  
*a.* Examples; *b.* number of spurs; *c.* character of spur in form, size, surface, position, prominence; presence of glands; honey; accessibility.
24. Flowers, Albinism in.  
*a.* Examples; families destitute of; families predisposed; *b.* any attendant changes; *c.* examine Orchids, Labiates, Composites, Epilobium, Pontederia.
25. Flowers Imitated by Insects.  
*a.* Examine all insects making homes in flowers; thrips, etc.; *b.* similarity in color? *c.* other respects? *d.* in any other insects; their habits.
26. Flowers of Mixed Inflorescence.  
*a.* Variation at different times; *b.* in different branches; *c.* variation constant; *d.* doubtful inflorescence.
27. Flowers Cleistogamous.  
*a.* Compare open flowers of Ilysanthes, Epiphegus, Viola,

Oxalis, Polygala, etc.; *b*, proportion seeding; *c*, how fertilized?

28. Flowers Changing Angle.

*a*. Examine Willow-herb; *b*, any others changing angle; mode; *c*, change of angle at fruiting; *d*, object; *e*, mode; examine Acer, Monotropa.

29. Flowers Changing Color.

*a*. Examples; *b*, order of changes; *c*, before and after fading; examine Boraginaceæ, Trillium, Cobæa, Lantana, Virginia Stock.

30. Flowers, Proliferation in.

*a*. Bearing a new stalk and flowers or leaves; examine Mitchella; *b*, or new flower; examine Polyanthus; *c*, how developed; why not made double by cultivation? *d*, examination of Narcissus, Scrophulariaceæ, Erigeron strigosum; *e*, contrasts of color and form.

31. Flowers; Indications of Nectar.

*a*. Relation to bright colors; to dull; *b*, to fragrance; *c*, to ill smell; *d*, union of color and fragrance with nectar; without nectar.

32. Flowers; Position of Nectar.

*a*. Examine Buttercups, Peony, Caltha; *b*, is position always that of secretion? *c*, compare Clovers, Honey-suckles.

33. Flowers and Humming Birds.

*a*. Note all flowers so visited, examine after visits, compare with the unvisited; *b*, effect of visit, reason of choice; *c*, examine Fuchsia, Impatiens fulva, Trumpet creeper.

34. Flowers, Fertilization of Epigæa.

*a*. Position of organs; *b*, probable fertilization; *c*, visited by what insects? *d*, what action of insects observed? influence.

35. Flowers, Fertilization of Rosaceæ.  
*a.* General flower structure; *b*, adaptation to self-fertilization, to insect fertilization; *c*, visits of what insects noted; action seen.
36. Flowers, Proterandrous.  
*a.* Coincidence of maturity of stamens and pistils in same flower; *b*, stamens first ripe; *c*, pistils first ripe; *d*, ripeness partial or complete in head or spike; compare Umbelliferæ.
37. Flowers; Escape of Pollen.  
*a.* Dehiscent anthers, pores, rupturing; *b*, what escape from Compositæ, Lobelia? Orchids compared.
38. Flowers; Pollen dispersed by the wind.  
*a.* Examine pines and other conifers; *b*, any other examples? *c*, adaptations for this; *d*, efficiency.
39. Flowers, Manner of Insects when among.  
*a.* How does the insect light, how get in, out? *b*, where? where beginning and ending in a cluster; *c*, injuries to flowers; accidental, by gnawing in (examine bumblebee in *Pedicularis*; Labiates), rupturing, displacing parts beyond elastic recovery.
40. Flowers and Ants.  
*a.* Examples of ants in flowers; on stems; *b*, if not on both, in same plant, or different, why not; *c*, why undesirable visitors? *d*, how repelled?

X. DIRECTIONS TO THE STUDENT.—HOW TO MAKE AN  
 EXCURSION PROFITABLE.

1. Collect toward your Observation Paper.

Start out with the purpose of looking for some definite class of objects. For instance, if your topic is "Compound Leaves," notice every plant, shrub or tree, to see if in any part it exhibits the form of leaf sought or an approach to it.

Look over the printed headings of your Observation Paper topic before starting.

Be prepared to take specimens of the particular kind sought.

2. Collect for the Herbarium.

The herbarium specimens of a small plant should exhibit it entire, including the roots.

For a shrub or tree, take a branch showing arrangement of leaves, flowers and fruit, twelve to sixteen inches in length.

A complete series of specimens in the herbarium to represent any one of the plants of the District, should show the—

Root.

Stem (with prostrate or underground stem, if any).

Mode of branching.

Leaves, at the base, middle and top of the stem.

Under surface of the leaves.

Buds of the leaves and flowers.

Arrangement of the flowers.

Flowers, expanded, and by side view.

Fruit.

Sometimes a single specimen can be obtained which will show several of these features at once.

Plants collected for the herbarium should be pressed in a book or port-folio while in the field.

3. To collect flowers to be examined afterward or for the class, do not press them, but wrap securely from the air in several thicknesses of newspaper; not too tightly; dampening the flowers a very little.

4. Count the different kinds of plants and trees you find in blossom, and report the number.

5. Bring in any conspicuous or interesting fruits, buds, or other plant specimens, as well as flowers, to be exhibited, named, and preserved.

6. Notice the habits of the plants you see; the soil and situation in which they grow; the neighbor plants with which they are associated; and the way they are affected by shade, moisture, and the contrary.

7. Take with you a small note-book or a slip of paper on which to record observations made. Preserve these for future use and comparison.

8. Cultivate the habit of noticing and recording the day each year when you first see each species in bloom, or with expanded leaves, or with ripe fruit, or with leaves falling.

## XI. OUTLINE OF THE YEAR'S WORK.

*Showing succession and approximate duration of subjects.*

### FALL TERM—September to November.

Class Work; Systematic Botany; comparison, description and analysis of flowering plants (including types of twenty leading orders).

Laboratory Work; Manipulation; Herbarium Work (collecting, pressing and drying, poisoning, mounting, labelling, classifying).

Outside Work; Excursions:

Development Studies; Seeds and their germination.

Observation Paper; involving conclusions from observations on a given topic.

## WINTER TERM—December to February.

Class Work ; Structural Botany ; from laboratory collections  
and Gray's Lessons, with  
lectures and preparation  
of a Summary of Organs.

Laboratory Work ; Manipulation ; Use of the Microscope.

Outside Work ; Studies at Botanic Gardens.

Development Studies ; Buds.

Observation Paper.

## SPRING TERM—February to April.

Class Work ; Histological Botany ; protoplasm ; the cell,  
growth ; tissues (with  
lectures).

Cryptogamic Botany ; Yeast, Bacteria, Diatoms ;  
Algæ ; Fungi, Lichens ;  
Hepatics, Mosses ; Ferns,  
Club-mosses ; Equiseta ;  
with Conifers and Cy-  
cads ; from the objects ;  
with lectures.

Laboratory Work ; Histological Studies.

Outside Work ; Studies at Botanic Gardens.

Development Studies ; Leaves.

Botanical Literature ; involving use of scien-  
tific books and peri-  
odicals in the labor-  
atory ; with reports  
on their character,  
and on current bo-  
tanical news.

SUMMER TERM—April to June.

Class Work; Systematic Botany.

Generalizations of Botany; lectures.

Laboratory Work; Drawings; to show flower-structure, especially adaptations to fertilization.

Outside Work; Excursions.

Development Studies; Flowers.

Observation Paper.





WASHINGTON HIGH SCHOOL.

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GUIDE

TO THE STUDENT IN

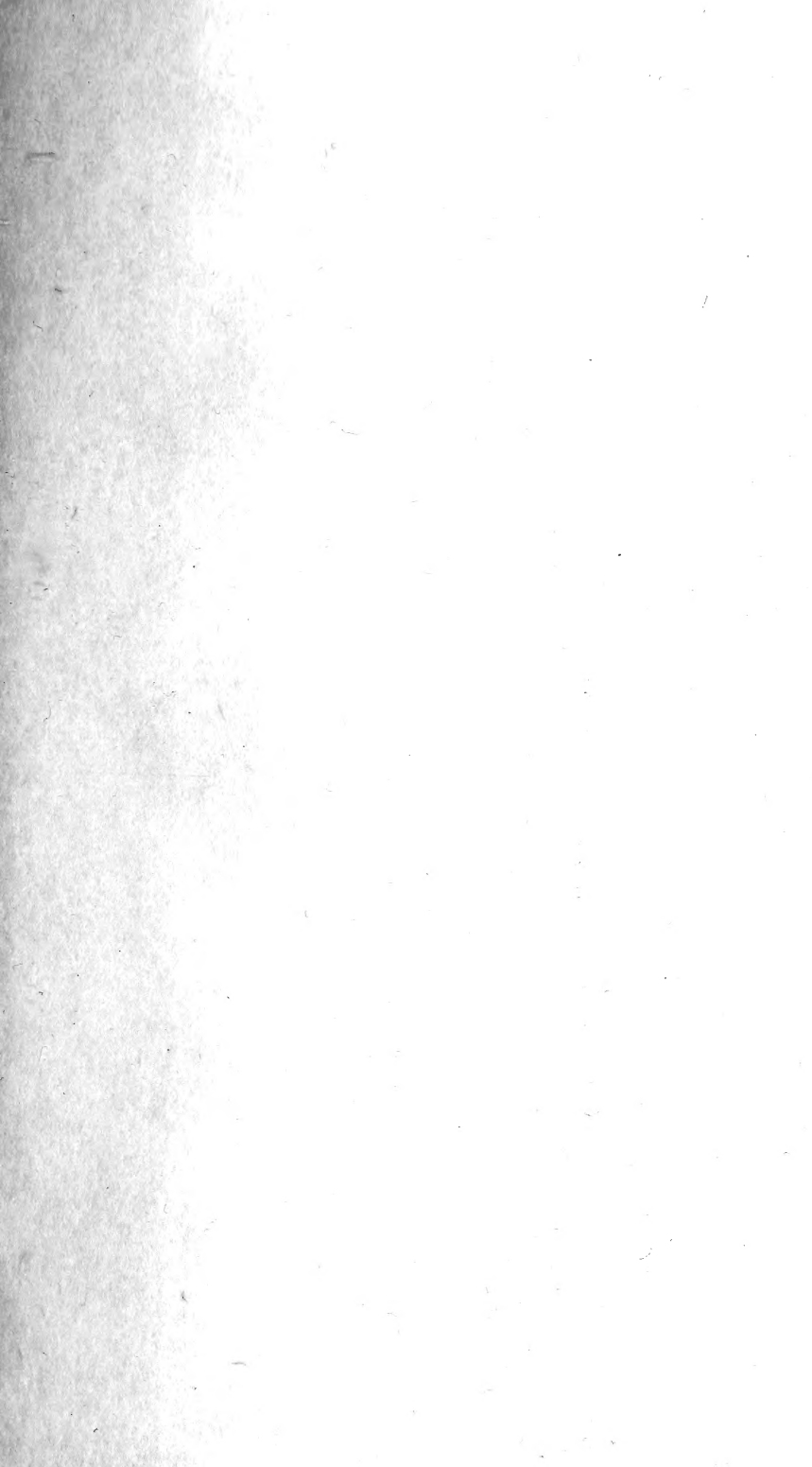
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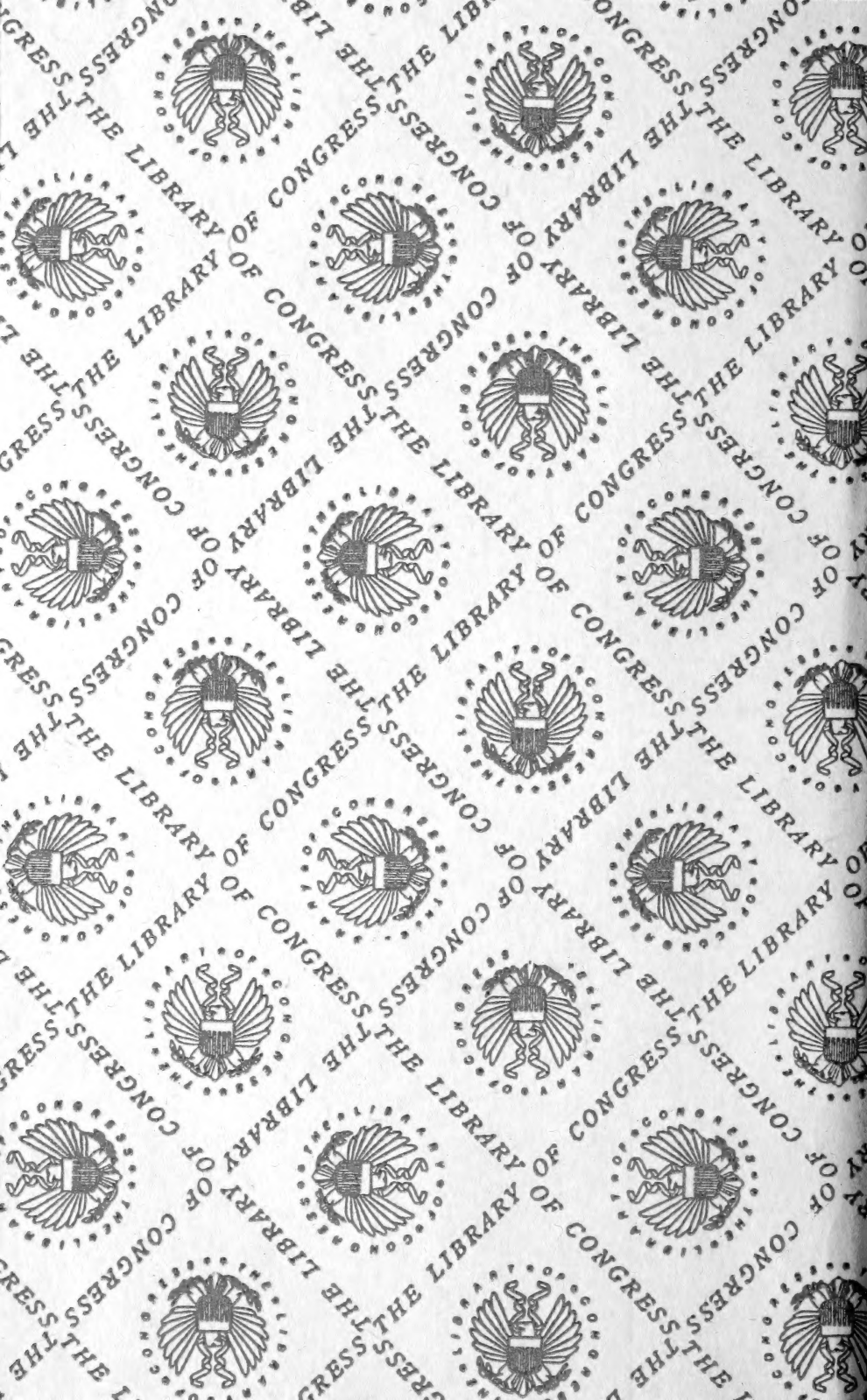
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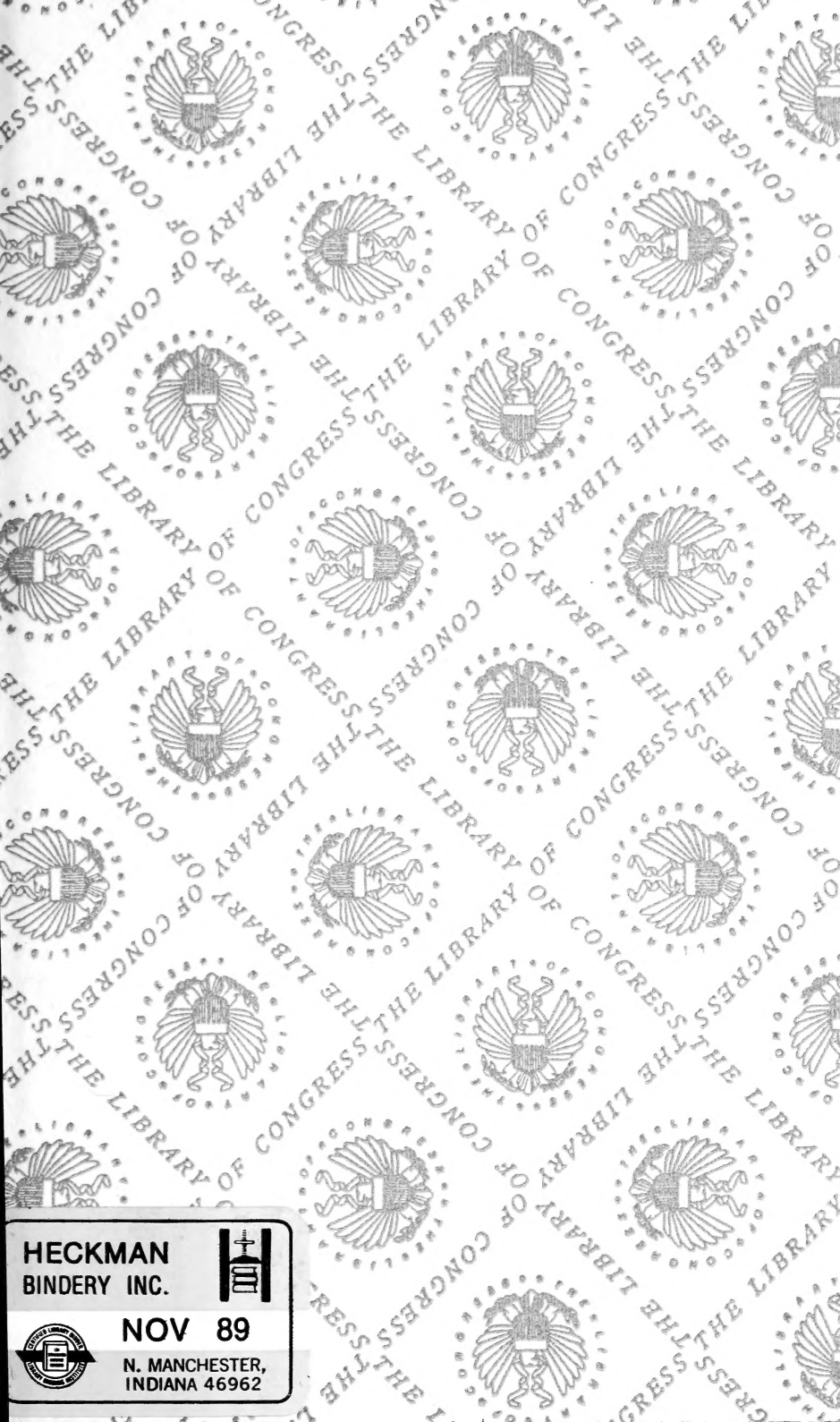
By EDWARD S. BURGESS, A. M.,

INSTRUCTOR IN CHARGE.

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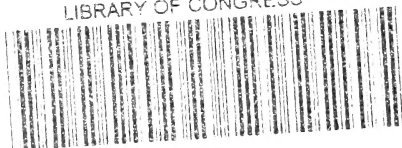


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