

## The Teaching of Plant Physiology at Purdue in the Nineteenth Century

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The first issue of "The Purdue University Register" was for the academic year of 1874-75 (1). Some thirteen courses in botany were listed as taught by John Hussey, professor of botany and horticulture. These courses ranged from 2 hours of Economic Botany to 10 hours of "Cryptogamic Botany and Work in the Laboratory." Plant physiology was not overlooked, for one 5-hour course was entitled "Physiological and Structural Botany" and another was called "Experiments in Fertilization of Plants".

Something about the method of teaching botany is included in the catalog section devoted to "Natural History". It reads "The instruction in Botany will embrace all the principal branches of this science. After three terms of descriptive and systematic Botany, the student will be expected to do laboratory work, making use of the microscope in Cryptogamic Botany and the study of the physiology of plants; proceeding to experiments in fertilization and to special topics. Herbarium work will be required throughout the entire course."

This account also contains a list of "books of reference" which includes "Wood's, Gray's, Youman's, Greene's, and Chapman's textbooks on botany," as well as "Henslow's Botanical Charts," and the "Prodromus" of DeCandolle. Reference journals kept "in the Reading Room" included "The Gardener's Monthly" and "The American Naturalist".

In the second year (1875-76) "The Annual Circular of Purdue University" (2) had this to say about the course dealing with plant physiology: "Structural and Physiological Botany, same as in the general course, with the addition of the more recondite facts and principles, including the character and relations of parts of seeds, morphology, facts and methods of fertilization, origin of tissues, relations of plants to animals, species, etc."

These descriptions continued to apply over a period of six years and suggest that the courses were taught from year to year in much the same manner during Professor Hussey's tenure.

The "Annual Register" for 1880-81 (3) carries the information that Professor Hussey had resigned and that his successor was "Charles R. Barnes, A.M., Instructor in Botany, Zoology, and Geology". As might be expected, some changes occurred in the catalog description of Barnes' courses in botany. We find: "The second term is devoted to Physiological Botany, including the subjects of food, assimilation, and metastases, growth, fertilization, influence of light and temperature, movements, etc." This course was listed as "Physiological Botany, with experiments and laboratory work."

In 1881-82 advanced work in plant physiology was offered and the writing of a thesis indicated. "The remainder of the term will be

devoted to the study of advanced 'Physiological Botany,' with class experiments and laboratory work." And again: "The student will be permitted to select some special plant or groups of plants which he will study carefully, embodying the results of his investigation in a thesis."

The catalog for the following year indicates that Charles R. Barnes was promoted to the rank of professor. A published list of "Handbooks" for students of biology included: "Lessons and Manual of Botany" by Gray, and "Botany" by Bessey. This catalog also lists "Advanced Physiology, 7 weeks" and "Preparation of Thesis, 10 weeks".

The Tenth Annual Register of Purdue University was for the years 1883-1884. Charles R. Barnes is listed as "Professor of Botany, Zoology, and Geology". Under the heading "School of Science-Botany" the following statements appear: "The study of Botany in the Freshman Year is required in this school and occupies two hours daily. Students may elect it (or Zoology) during the Junior and Senior years". "Lectures upon the anatomy and physiology of plants will be given at appropriate times in connection with the laboratory work".

This brief description suggests that laboratory work constituted a basic part of the course and that emphasis was placed, by means of lectures, upon the study of plant anatomy and physiology.

Opportunity again was given for more advanced undergraduate work in plant physiology including the writing of a thesis. This fact is stated under the heading: "Elective Course—Junior Year."

"In the latter half of the year, work will be assigned in organogeny, embryology and physiology. During the senior year students will devote themselves to original work, upon which, at the close of the year, they will present a thesis".

In the "Annual Register" for the academic year 1885-1886 a course for eight hours per week in "vegetable physiology" is briefly described for the second term. "A laboratory course in experimental Vegetable Physiology, with lectures for this. The preceding course in Histology (offered the first term) is indispensable."

Again, advanced work in plant physiology was possible. In the senior year 35 weeks of botany, eight hours per week could be had. The catalog states that the character of the work was optional with the student and that "the instruction is chiefly personal". This was the year that Professor Barnes was listed as "out on leave of absence".

The following year (1886-87) Professor Barnes returned with a PhD degree but stayed only one more year. The junior-year course in "experimental Vegetable Physiology" was again offered, this time "a laboratory course . . . with reference readings".

Professor Barnes' successor was Joseph C. Arthur who lived a long and productive life resulting in publications spread over more than half a century (4). The university catalog for the period 1887-89 lists Dr. Arthur as: "Professor of Botany—after Jan. 1, 1888 Professor of Vegetable Physiology and Pathology".

The junior-year course in "Vegetable Physiology" was continued by Dr. Arthur under the following description: "The subjects of Nutrition, Growth, Molecular forces, Movements and Reproduction of plants are covered by lectures and laboratory work, special attention being given

to the experimental verification of the chief facts of Science." This description was retained in subsequent Purdue catalogs of the nineteenth century together with the added statement—"The Laboratory is particularly well equipped for this work."

At this time a graduate program in plant physiology, as well as other biological subjects, was available for the M.S. degree. The Purdue "Register" for 1888-90 under the heading of post graduate courses in biology states: "One or more topics will be assigned as subjects for original investigation, in which it will be necessary to determine the structure, development or life history of some plant or animal, or trace the explanation of some phenomenon of growth, together with the history of the subject as treated by other investigators. A knowledge of French and German will be specially serviceable in this course."

"The general study of some department of Biology will be required in addition to the above."

Thus we see that the graduate program included original research work and a study of the literature pertaining to a particular problem. Such a study was obviously to include French and German publications. In addition, a broad knowledge of some subdivision of Biology was required.

One may wonder what laboratory equipment was available at Purdue for course work and research in plant physiology. Under the heading "Apparatus and Appliances" the "Register" for 1888-90 states: "For work in vegetable physiology there is an excellent supply of glass apparatus including Sachs' double bell jars and Christiani's poroscope. Of imported apparatus, the following may be mentioned: "Wortmann's clinostat, Pfeffer's and Vöchting's dynamometers and Englemann's gas chamber. Students also have the use of some of the apparatus belonging to the Botanical Department of the Experiment Station, including Pfeiffer's warm case for the microscope, made by Zeiss, with Moitessier's gas-pressure regulator, Israel's warm stage, ovens with thermo-regulators and appliances for working glass".

Such a list admirably supports Dr. Arthur's statement, previously noted, relative to facilities for work in plant physiology, namely that "the laboratory is particularly well equipped for this work." This applied to an era in which the physiology of plants was attacked by using entire plants or organs in contrast to much modern work in which plant parts are fragmented into microscopic bits before study.

The specific functions of the foregoing apparatus are stated in the 1890-92 "Register". We read: "Wortmann's clinostat: For the study of the relation of gravity and light to changes in the direction of growth, made by Ungerer of Strassburg; auxanometer: For recording the growth of plants. The clock for electrical release and the pulleys for magnifying the movement due to growth were made by Albrecht of Tübingen, while the recording cylinder was made in the University shops. Pfeffer's and Vöchting's Dynamometers: For determining the pressure exerted by growing organs."

High caliber botanical journals publishing physiological papers were now available in libraries upon the Purdue campus. These included the "Annals of Botany", "Berichte der deutschen botanische Gesellschaft,"

"Botanical Gazette", "Botanisches Centralblatt", and "Botanische Zeitung". In both equipment and published literature, Purdue University thus had drawn heavily upon the accomplishments of the active group of German plant physiologists of the latter nineteenth century. Mention also should be made of additional physiological apparatus designed and built under the direction of Dr. Arthur (5).

A noteworthy addition to the Purdue staff is listed in the 1891-93 "Register". He was Daniel T. McDougal, Assistant Instructor in Biology. McDougal held a bachelor's degree from DePauw, later studied in Germany, and eventually took his doctorate at Purdue with a thesis (6) in plant physiology.

Greenhouse facilities for advanced work in plant physiology and other botanical subjects are described in the 1893-94 "Register". "A greenhouse strictly for experimental work, is connected with the botanical laboratory of the experiment station. Students pursuing advanced work in botany make use of this building to some extent in experimental research. The ventilation and heating of the building are under good control, and electrical and mechanical apparatus assist in the carrying on of interesting instruction concerning the growth of plants."

To this was added a supplementary description the following year: "A glass vegetation house, used for protecting plants growing under control conditions in metal pots, is also a feature of this department of the experiment station."

At the close of the nineteenth century we find, therefore, the work in plant physiology housed in the agricultural experiment station. Under the heading "Laboratory of Vegetable Physiology", Dr. Arthur stated (Annual Register for 1896-97): "The work in vegetable physiology and ecology and in cryptogamic botany is provided with quarters in the Experiment Station building. The general laboratory is especially well fitted with convenient water and gas connections, desks and cases. A door opens directly into the greenhouse in which part of the experimental work is carried on. A special laboratory adjoins the general laboratory which is devoted entirely to the use of students and is conveniently fitted for a variety of work."

To the previous catalog descriptions of the available physiological apparatus was added, at the turn of the century, equipment emphasizing the growing use of quantitative and chemical techniques—"Several Springer torsion balances, together with a barometer and other pieces of the more usual chemical and physical apparatus are available" (1900-1901 "Annual Register").

Thus we find a sustained program in the teaching of plant physiology during the first quarter of a century of Purdue University's existence. The importance of laboratory work was early recognized and opportunity was given students for original work. Professor Hussey deserves credit for originating the work and Professors Barnes and Arthur for so ably carrying it forward. Perhaps the academic climax in this program and era was the granting of the degree "Doctor of Philosophy" to Daniel T. MacDougal in 1897 on his thesis entitled "The Curvature of Roots". This was the second PhD degree granted by Purdue University and the first in the biological sciences.

**Literature Cited**

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