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Origins and Status of American Botanists

Charles J. Lyon

Scientists should learn more about themselves than is possible through personal observations. As a basis for maintaining the proper supply of trained men in each of the special fields, we should have accurate information about the number, ages, and professional preparation of the workers in each area. Such items as their academic origins and present fields of employment are also of considerable interest to many administrative officers.

In the absence of a central authority to regulate standards of training and the number of men in each field of science, the responsibility for advising students rests largely with individuals who depend too often on personal impressions and experience. They and the various planning agencies that can influence careers through fellowships and grants-in-aid should have information about the fields that require more men and about where these men can be trained to advantage.

With the exception of the *National Register of Scientific Personnel,* the records for the biological sciences are few and quite out of date. The only recent analysis of the numbers and origins of professional botanists was reported in 1955 by Greulach (*1*), but it was based on the facts for 1943, as assembled in the seventh edition of *American Men of Science.* It was also limited in its objectives, with emphasis on the academic origins of 2015 workers. The publication of the ninth edition, in 1955, with the biological scientists in a separate volume (*2*), has provided the opportunity for a second study of the same group of mature scientists, now grown to more than 2700 in number. In addition to an analysis for some of the points that were developed in the Greulach study, the botanists of 1955 have been tabulated by age classes and nature of employment. The entire group has also been divided into the three major subgroups of (i) plant pathologists, (ii) plant physiologists, and (iii) the other botanists.

For the purposes of this study, a botanist has been defined as a scientist who lists his or her primary professional interest as being in one or more of the plant sciences other than the applied sciences. Botanists are thus taken to include workers in plant nutrition, forest pathology, and economic botany, but the tabulation did not include geneticists, bacteriologists, foresters, horticulturists, agronomists, or plant breeders. Arbitrary decisions were made in the cases of scientists who were identified with some such field as cytology or biology; such a person was rated as a botanist only if a primary interest and activity in plant science was indicated by research titles, by membership in professional societies, or by his department in the organization by which he was employed. For the subdivisions of botany, a worker who indicated two such special fields as plant physiology and plant pathology was tabulated as having a primary interest in the area that he named first.

In tabulating such items as age, academic origin, and type of employment, certain other arbitrary decisions were necessary. For example, the age of an individual for whom no date of birth was recorded was taken to be about 21 years when the bachelor's degree was awarded. Only the first bachelor's degree, master's degree, and doctorate were tabulated. When only the advanced degree was reported, it was assumed (probably sometimes in error) that the bachelor's degree had been taken at the same institution. The occupation of a retired botanist was considered to be that shown by his last position before retirement. An important distinction had to be made in the many cases of botanists who were employed by the state colleges and universities; although most of them do research to some degree, they were tabulated under "education" if their official titles indicated that they were instructors in formal classes.

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Ages and Numbers of Botanists

The data for the birth years of botanists who were alive in 1955 are presented in Table 1, with the numbers recorded by decades through 1930. It could not be expected that men who were born after 1930 would appear in a directory of recognized scientists in 1955, and a correction for those born after 1925 had to be made in setting a reasonable figure for 1921–30. The major adjustment for this was made by tabulating data for the individual years of birth for the youngest botanists and by assuming that the number of men trained in each subdivision of botany would be essentially the same for those born in 1926–30 as for those born in 1921–25 and already listed in *American Men of Science*. This adjustment, plus a liberally estimated 15-percent allowance for such factors as the delaying effects of the military draft on men born in 1921–25, gives the adjusted data for this decade as 189, 235, and 307, respectively, for the physiologists, pathologists, and other botanists. This makes a total of 731 botanists born in 1921–30 in place of the 424 recorded in Table 1.

Comparison of this corrected total with the totals for all botanists born in the earlier decades (Table 1) shows a decrease in numbers of professional botanists trained in recent years. It is evident that the loss has come in the category of general botanists and in specialties other than physiology and pathology. Even with the allowances made for delay in the appearance of these young men in the directory, at least 100 fewer men of this decade have become professional botanists than of the previous decade (1911–20), which showed no great gain over 1901–10.

Plant pathology has continued to enroll men at a steady rate of increase, although the upward trend is slow for workers born in this century. Something approaching an adequate level of supply of workers for the major problems of plant diseases may have been reached early in the century. Plant physiologists are the only group to show steady and rapid gains in numbers enrolled in each decade; in this group there is an increment of more than 40 for each of the last three decades of birth represented.

The failure to add as many men in general botany and in such specialties as anatomy, morphology, and taxonomy is understandable in view of the research trends of the times, but there is a real danger that failure to maintain the numbers of these botanists will result in a serious shortage of these scientists in the years not far ahead. Such men will always be needed, and the supply should be maintained in proportion as the total number of mature botanists rises with increases in population. Even the total increase in number of plant scientists, from 2015 to 2711 between 1943 and 1955, is not large when allowance is made for the relative inactivity of about 15 percent who were born 65 or more years ago. The National Science Foundation data on manpower (*3*, p. 24) in 1951 showed that the percentage of registered plant scientists then under 30 years of age was definitely lower than the percentage for any other field of biology.

To the extent that the trend of doctorates in botany can be used as an index of the training of professional botanists, the data compiled in *Doctoral Dissertations Accepted by American Universities* (*4*) show that the recent trend for botany is not encouraging. During the ten prewar years, 1933–42, the average number of doctorates in botany per year was 105.0 and the corresponding figure for zoology was 112.0. During the inactive years 1943–49, the number of doctorates in botany and zoology fell to 63.0 and 62.9 respectively. The numbers for botany and zoology during the postwar years 1950–55 have averaged 119.5 and 165.1, respectively, with botany falling away from a peak of 149 in 1953 to only 130 doctorates in 1955. These newly trained botanists have been, both relatively and actually, too few in number for the increase in population and professional openings during the past 15 years.

Table 1. Botanists who were living in 1955, listed by categories according to the decades in which they were born.

Birth years	Pathologists		Physiologists		All others		All botanists	
	No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage
1880 or before	18	2.3	11	2.4	95	6.5	124	4.6
1881–1890	71	9.1	31	6.8	164	11.1	266	9.8
1891–1900	156	20.0	58	12.7	253	17.2	467	17.2
1901–1910	189	24.2	99	21.6	367	24.9	655	24.2
1911–1920	216	27.7	143	31.2	416	28.2	775	28.6
1921–1930	130	16.7	116	25.3	178	12.1	424	15.6
Total	780	100.0	458	100.0	1473	100.0	2711	100.0

Table 2. Highest academic degrees of professional botanists, 1955.

	Pathologists		Physiologists		All others		All botanists	
	No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage
Doctor's	660	84.6	418	91.2	1262	85.7	2340	86.3
Master's	98	12.6	26	5.7	211	14.3	371	13.7
Bachelor's or other	22	2.8	14	3.1				
Total	780	100.0	458	100.0	1473	100.0	2711	100.0

Academic Degrees

Although it is now an accepted standard of training for a professional career in botany, as in other fields of biology, that study for the doctorate should be undertaken as soon as possible, we know that this was not required in earlier years. The data in a biographical directory (*American Men of Science*) provide the facts for almost every man; those for botanists have been assembled in Table 2.

The results show a degree of graduate training in line with that of other scientists and higher than that for some. It is not surprising to find that the physiologists are equipped with the doctorate to the extent of more than 91 percent, since it is a strict requirement for all employment in this field of expert techniques.

The academic preparation of those in the "All others" group was not examined in detail because of the diversity of special interests, but no great variation from the average is to be expected. The subaverage showing of the pathologists, many of whom had only a master's degree, may reflect the listing of young workers, since 17 of the 98 who had only a master's degree had been born since 1920. However, the fact that most of the others in this group of 98 were born before 1900 indicates that the master's degree was once, but is no longer, considered adequate training for this specialty.

Undergraduate Origins

It is interesting and instructive to note the colleges and universities that have made significant contributions to the un-

dergraduate and graduate education of the botanists of America. This is the topic so thoroughly treated by Greulach (*1*) for the professional workers of 1943. Since most of the 2711 botanists now listed in the 1955 edition of *American Men of Science* were covered by his analysis, the data can be expected to support many of his findings, and they do. The differences are also interesting, and some new points have been brought out.

The importance of the large universities, notably those that bear the names of the states, in launching professional botanists on their careers can be judged from Table 3. This table shows each American college and university that has 15 or more undergraduate alumni who are now listed as botanists. The 37 institutions listed in Table 3 that are supported largely by public funds account for the training of 45 percent of the 2640 living botanists, exclusive of 71 who took their bachelor's degrees in colleges outside of the United States and Canada. The emphasis on botany as a basic science for the agricultural courses in most of these public institutions accounts for the opportunities that they offer, but few of the 1180 workers trained in these institutions became specialists in applied botany, although some of them do research in that area.

The importance of the opportunity for thorough undergraduate training explains, in part, why 317 alumni of the 14 private colleges and universities that are listed in Table 3 chose careers as botanists. These institutions all have fairly large undergraduate enrollments, but details of staff and equipment to teach plant science are probably more important in view of the absence from the list of such equally large private institutions as Colgate (1 botanist), Northwestern (10), Princeton (1), Smith (11), Swarthmore (5), Vassar (4), and Yale (8). The fact that 14 private colleges are listed in Table 3, whereas many state universities are not listed, is more difficult to understand, unless it be that the public institutions not on this list give more specific attention to botanical instruction for students who are on their way to careers in applied botany.

The marked productivity of certain liberal arts colleges that offer little or no graduate work in botany was noted by Greulach. He found that 12 of them, located, with one exception, in the area from Indiana to Pennsylvania, produced about 39 percent of the botanists from liberal arts colleges other than the University of Chicago, Harvard, Syracuse, and comparable institutions which emphasize graduate work.

His prediction of a change in the membership and ranking of this group has been verified. With the omission of the women's colleges of Wellesley and Smith, which still stand highest in their class, the ranking of these colleges is now: DePauw, Wabash, Oberlin, Butler, Dartmouth, Ohio Wesleyan (10 botanists), Earlham (9), Ohio University (8), Bucknell (5), Lebanon Valley (5), and Wooster (0). The only major change in ranking is that of DePauw, which does have some graduate work. There are now three other small colleges —Acadia, Colorado College, and Pomona, with seven botanists each—that have passed the last three of the original list, while Albion and Beloit now have five each. Without thorough analysis of the reasons for the significant contribution of these 16 relatively small colleges to botanical education, it is probably correct to attribute it to strong teachers and to administrative policies that allow them to work in separate departments of botany or their equivalent, as was noted by Knapp and Goodrich (*5*) in their study of some of the same colleges.

Despite the importance of the 51 institutions named in Table 3 in giving basic training for careers in botany, these account for the undergraduate origin of only 1497, or 56.5 percent of the bachelor's degrees. Although this is a notable contribution by about 5 percent of the colleges of America, it indicates a loss in their influence, since Greulach found that 63 percent of the botanists of 1943 had received their bachelor's degrees in approximately the same 51 institutions. The number of colleges that have at least one botanist on the alumni list rose from 303 to 401 in 12 years. This means that nearly 100 colleges, mostly small,

Table 3. Principal undergraduate origins of American botanists. Institutions that have 15 or more professional botanists among their alumni. (Numbers in parentheses indicate alumni with doctorate in botany awarded 1936–50.)

No. of botanists	Public (37)	No. of botanists	Private (14)
107	California (Berkeley) (67)		
81	Minnesota (39)		
67	Wisconsin (30)		
58	Cornell (30)		
55	Nebraska (23)		
55	Ohio State (20)		
51	Massachusetts (18)		
		43	Chicago (23)
42	Illinois (17)		
42	Washington State (20)		
38	Michigan (23)		
37	Michigan State (8)		
36	Missouri (16)		
		34	Harvard (22)
33	Penn. State (21)		
32	Oregon State (14)		
31	Iowa State (17)		
30	Toronto (4)		
26	Kansas State (8)	26	DePauw (14)
25	Indiana (9)	25	Wabash (6)
24	Maryland (9)		
		23	Oberlin (7)
22	California (L.A.) (20)		
22	Idaho (18)		
		21	Butler (9)
		21	McGill (4)
20	Rutgers (9)	20	Dartmouth (8)
		20	Syracuse (15)
19	Clemson (7)	19	Columbia (13)
		19	Stanford (8)
18	Utah State (9)		
17	Maine (6)		
17	Saskatchewan (6)		
17	Washington (Seattle) (11)		
16	Arkansas (10)	16	Queens (Canada) (2)
16	Colorado A. and M. (8)		
16	Miami (Ohio) (21)		
16	North Carolina (17)		
16	Pennsylvania (9)		
16	Purdue (10)		
16	Texas (9)		
16	Utah (4)		
15	Cincinnati (8)	15	Geo. Washington (2)
15	West Virginia (11)	15	Wellesley (7)
1180	*Totals*	317	

have started botanists on their careers in recent years.

The baccalaureate origins of men who obtained doctorates in botany at American universities from 1936 to 1950 have been reported in tabular form by Trytten (*6*). This analysis covers only the younger men who are sufficiently active as professional botanists to have been listed in *American Men of Science,* and there is bound to be a discrepancy between holders of doctorates and employment as professional botanists. Many such botanists have taken degrees in applied botany or other fields, and it appears that many holders of doctorates in botany from certain graduate schools (for example, Fordham, Catholic University, Radcliffe, and Louisiana University) do not become active enough as professional botanists to be recognized by *American Men of Science.*

For purposes of comparison between the two bases for studying academic origins of "botanists," the number of alumni from each institution listed in Table 3 who now hold doctorates in botany obtained in the period 1936–50 is shown in parentheses after the name of the institution. It is clear that the leaders are the same by either criterion, but the relative rating of some entries below the leaders in each column—for example, Miami University (Ohio) and Syracuse —would be changed appreciably if a recent doctorate in botany were used as the criterion. The reasons for the differences are too numerous to evaluate, and the principal data in Table 3 give a more accurate picture of the origins of the professional botanists of 1955.

Graduate Schools

The work of the graduate schools is not known to the scientific public in any detail in spite of their relatively small numbers. Individuals know the departments of their own specialty, but there is much variation in the productivity of graduate students over the years, as Greulach noted for the 68 American universities represented by 1640 doctorates held by the botanists of 1943. This number has now risen to 2293 doctorates in plant sciences, from 92 institutions; botanists of American college origin hold only a few doctorates from abroad.

The majority of these universities are shown in Table 4, listed in order of the number of doctorates awarded to botanists. The first 12 were also the leaders in numbers in 1943, with minor changes in the order of listing. There are now 56 graduate schools that have a minimum of three Ph.D.'s in plant science. These, as opposed to 46 schools in 1943, provide 98 percent of the total, but the 12 leaders still account for two-thirds of the doctorates, a loss of only 3 percent in the continuing dispersal of graduate training.

There have been some large gains and losses in the ranking of the other 44 most productive schools. Notable rises in rank in 12 years were made by Iowa, Rutgers, Duke, Purdue, North Carolina, and Oregon State, all tax-supported universities with the exception of Duke. Sharp losses in rank are recorded for Johns Hopkins, Pittsburgh, University of Washington (Seattle), Catholic University, Cincinnati, Syracuse, and Colorado, with a clear tendency for the privately endowed schools to be the principal losers. New names in the first 50 places are the University of California (Los Angeles), Kansas State, Northwestern, Fordham, Texas A. and M., and the five that tie with Syracuse, with four doctorates each.

A comparison of Table 4 with a corresponding tabulation of doctorates in pure botany from graduate schools in the United States, as reported by Trytten (*6*) in 1955, shows only minor differences in order of rating for most of the institutions. The first ten are in nearly the same order; the number of doctorates in botany for 1936–50 ranges from 138 for Wisconsin to 52 for Ohio State. Chicago dropped to fifth place, with 89, and Iowa State gained seventh place, with 76 doctorates for the same 15 years.

Of the next ten United States graduate schools that are listed in Table 4, eight appear in the same second group in the Trytten listing of doctorates for 1936–50, with Rutgers and Missouri displaced in rating by Louisiana and with a tie between Indiana and Virginia. Aside from other details of order of rating, the outstanding graduate schools of botany are essentially the same for the two sets of data.

It is of some interest to consider the extent to which the various graduate schools serve students from other colleges, as they must, since there are so few places where a Ph.D. degree may be earned under a full staff of experts. In this connection, a comparison of the first and second columns of figures under the heading "Ph.D." in Table 4 shows some

Table 4. Colleges and universities where American botanists did their graduate study and data on total number of doctorates and master's degrees from each. (Numbers in parentheses indicate candidates who received undergraduate degrees from other institutions.)

Institution	Ph.D.	M.A.	Institution	Ph.D.	M.A.
Wisconsin	257 (222)	146 (103)	Geo. Washington	9 (5)	11 (5)
Cornell	214 (184)	52 (38)	McGill	9 (4)	21 (9)
Chicago	174 (144)	84 (62)	Louisiana	7 (7)	19 (15)
California (Berkeley)	163 (113)	51 (24)	North Carolina State	7 (6)	15 (9)
Minnesota	140 (107)	94 (52)	Radcliffe	7 (6)	8 (6)
Harvard	123 (101)	102 (79)	Kansas State	6 (3)	20 (10)
Michigan	90 (68)	63 (41)	Northwestern	6 (5)	14 (9)
Iowa State	88 (64)	71 (51)	West Virginia	6 (3)	16 (6)
Columbia	86 (73)	45 (33)	Catholic	5 (5)	4 (4)
Ohio State	69 (42)	74 (38)	Cincinnati	5 (4)	10 (5)
Illinois	68 (54)	58 (38)	Fordham	5 (5)	4 (4)
Washington (St. Louis)	53 (44)	26 (16)	Kansas	5 (3)	10 (4)
Iowa	43 (37)	44 (35)	Texas A. and M.	5 (5)	10 (9)
Nebraska	41 (31)	42 (18)	Louisiana State	4 (2)	8 (5)
Toronto	39 (28)	28 (16)	Massachusetts	4 (2)	16 (3)
Rutgers	38 (31)	27 (19)	New York	4 (2)	3 (1)
Yale	38 (34)	23 (18)	Oklahoma	4 (4)	21 (16)
Pennsylvania	37 (26)	16 (7)	Syracuse	4 (1)	13 (3)
Duke	34 (31)	16 (11)	Vanderbilt	4 (4)	2 (1)
Maryland	31 (23)	28 (16)	Manitoba	3 (2)	4 (0)
Missouri	31 (12)	37 (13)	Alberta	2 (1)	10 (3)
Purdue	31 (25)	36 (27)	Arizona	2 (0)	6 (0)
Michigan State	27 (25)	42 (28)	Brown	2 (0)	8 (1)
Washington State	26 (16)	27 (16)	Colorado (U.)	2 (2)	17 (11)
Johns Hopkins	25 (22)	1 (1)	Laval	2 (2)	2 (2)
Stanford	22 (20)	16 (7)	Marquette	2 (1)	5 (1)
North Carolina	21 (14)	22 (12)	Montreal	2 (0)	1 (0)
Indiana	19 (12)	16 (5)	Notre Dame	2 (2)	2 (2)
Oregon State	17 (17)	16 (7)	Oregon	2 (2)	6 (4)
Pittsburgh	16 (12)	12 (6)	Rochester	2 (2)	1 (1)
Virginia	16 (14)	11 (7)	Utah	2 (0)	12 (2)
Calif. Inst. Tech.	15 (14)	1 (1)			
California (L.A.)	10 (5)	12 (3)	25 others with 1 doctorate each (some honorary) and a total of 73 master's degrees.		
Pennsylvania State	10 (5)	22 (9)			
Texas	10 (7)	13 (2)			
Washington (Seattle)	10 (7)	11 (3)			

differences among the universities represented by ten or more degrees. Of the 12 leaders, only Ohio State, California, and Iowa State drew on graduates of other colleges for less than 75 percent of their Ph.D. candidates. Of the schools that rank farther down the list, Oregon State, Michigan State, California Institute of Technology, Duke, and Stanford take at least 90 percent of their successful doctorate candidates from other colleges; Missouri is the exception in granting more than half of its doctorates to its own graduates.

In view of the great variation in data on the award of the master's degree, which is often only a step on the way to a Ph.D., a detailed analysis is not required. The data in Table 4 show the sources of most of the 2000 master's degrees that have been awarded to 2640 living botanists by 172 schools. The table reveals that several institutions frequently give 1 or 2 years of graduate work to their own alumni and to those of other institutions before these graduate students go elsewhere for their doctorates. Oklahoma, Colorado, and Massachusetts are good examples of such active schools.

This practice of beginning graduate work in one place and completing it elsewhere is, of course, not limited to the smaller graduate schools. The data indicate, for example, that Harvard, Ohio State, Iowa, Nebraska, and Michigan State not only award many Ph.D.'s in the plant sciences but also start some men on the road to doctorates from other institutions, although some of the numerous master's degrees from these large universities go to students to whom they later award the doctor's degree.

The relatively small number of master's degrees from Cornell, California, Johns Hopkins, and California Institute of Technology show the strong emphasis on the Ph.D. degree. In fact, the predominance in numbers of plant scientists who have doctorates over those who have only the master's degree speaks for the high standard of scholarship and preparation for careers in plant sciences everywhere.

Employment Categories

The status of botanists in the various professional occupations is of particular interest to young people and to their advisers in the schools and colleges. Teachers know most about opportunities in education and in government work. Openings in industrial laboratories and research institutions are two other possibilities. Until quite recently, few data were available on the relative numbers of such possibilities. The National Science Foundation has published some information from the *National Register of Scientific Personnel* (*3*), and more may be expected to follow.

Table 5. Employment categories of botanists who are listed in *American Men of Science,* edition 9.

	Pathologists		Physiologists		All others		All botanists	
	No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage
Education	257	32.9	228	49.8	1099	74.6	1584	58.4
Government	419	53.7	129	28.2	151	10.3	699	25.8
Industry	68	8.7	52	11.3	86	5.8	206	7.6
Research	24	3.1	47	10.3	119	8.1	190	7.0
Private work	12	1.5	2	0.4	18	1.2	32	1.2
Total	780	100.0	458	100.0	1473	100.0	2711	100.0

Some facts about the employment of the botanists in the 1955 edition of *American Men of Science* have been assembled in Table 5. The two large subdivisions of pathologists and physiologists were tabulated separately because of the special training and employment openings for such workers. The predominance of educational activities for all other botanists, as a group, confirms common knowledge, but the data for this group also reveal that openings can be found in industry and other research projects. It is evident that only the pathologists, as a group, depend heavily on government positions as their major source of employment. Physiologists are the most evenly distributed of all with respect to employment fields.

Industry seems to offer opportunities to a great variety of specialists in botany. These scientists are particularly needed for their skills in connection with industrial products from seeds, fruits, and fibers and from the varied biochemical transformations caused by bacteria and fungi. A study that is now being made by a committee of plant physiologists (*7*) reveals many openings for plant scientists in this area, with a possible shortage of men qualified to meet the needs of some industries. Much of the work in industrial laboratories or as consultants involves research for which botanists are well prepared.

Summary

The biographical data on botanists in the ninth edition of *American Men of Science,* supplemented by limited information from other sources, show a trend toward reduced numbers in the younger age groups, except for a continued increase in physiologists and a stabilized supply of pathologists. The 2640 botanists with bachelor's degrees from American colleges represent 401 undergraduate institutions, but more than half of them are alumni of a group of 37 large universities supported by public funds and 14 privately endowed colleges. More than 86 percent of the botanists have taken doctorates from 92 graduate schools, but 12 of the largest ones, located chiefly in the state universities, have provided two-thirds of these degrees; more than three-fourths of the candidates came from other colleges for their advanced training. Their fields of employment are predominantly in education and in government service, but appreciable numbers are doing research work for industry or in nonindustrial laboratories.

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