CENTENNIAL NOTE

One Hundred Years of Plant Science 1891–1991, With an Ohio Perspective

Emanuel D. Rudolph, Department of Plant Biology, The Ohio State University, Columbus, OH 43210

The major revolution that has occurred in twentieth century biology, the mid-century molecular biology revolution, has been well documented (Olby 1974, Judson 1979, Tiley 1983). Like the mid-nineteenth century Darwinian Evolution Theory revolution, the growth of molecular biology has changed the way all biologists think. The predominance of molecular biology makes it easy to ignore the other major biological developments during this century that were less spectacular and less dramatic.

A primary concern for botanists a century ago was the nature of plant inheritance. The standard explanation, a complete blending of parential characteristics, while seemingly obvious, was of limited value in analyzing specific cases or predicting their mechanisms. Several investigators, for example Hugo de Vries and William Bateson, challenged this standard explanation. In 1900, the rediscovery of Mendel's particulate, or non-blending, explanation set in motion the development of a new discipline, modern genetics (Provine 1971, Stubbe 1972, Bowler 1989). Quickly, plant scientists studied the mechanisms of Mendelian genetics in theoretical and practical ways. Once understood, these studies led to profound improvement of crop plants and to a better understanding of the mechanisms of speciation and evolution. For the first time, American biologists took the center of the international scientific stage. Coupling of earlier knowledge of cell structure with the new genetics, in placing emphasis on the chromosomes, was also a major accomplishment.

Ecology is a part of biology that drastically changed in the last hundred years (Tobey 1981, McIntosh 1985). Plant ecologists in 1891 were concerned with precisely describing and comparing plant communities, and with explaining how individual plants managed to survive in their environments. Early in this century, American botanists began to explain the dynamic nature of plant communities, and later to model and quantify their changes. They became concerned with prehistoric changes, and with energy and substance flows in communities. They investigated and experimented with plant-animal relationships and with how plant and animal populations evolved in particular environmental conditions. In recent years, plant ecologists have been studying environmental damage and human perturbations of plant communities and populations. Ecology is more experimental and predictive than it was a century ago.

Little heralded but immensely important changes occurred in cytology in this century. Better optics, and then electron microscopy, drastically changed how biologists understand cells, tissues, and organs (Bradbury 1967, Bradbury and Turner 1967). The ability to visualize the vast array of organelles and membrane systems in cells has provided opportunities for interpreting how structures can be wedded to functions. Dynamic biochemistry is now a vital part of cell biology. Plant cells have provided special challenges to those using experimental techniques and tissue cultures.

Whole plant physiology has made major strides in the past hundred years. How growth and development is regulated by enzymes and hormones has been clarified (Barton-Wright 1933, Weevers 1949), and molecular biology has aided in the interpretation of development. The importance of trace elements and the mechanisms for water and food transport are better understood. The steps in the photosynthetic pathways are wonderfully clear and the energy transfers are becoming ever clearer. Recently, the use of transgenic mutants has moved whole-plant physiology into a new arena.

Taxonomy and systematics of plants have had a rebirth of vigor and excitement in this century because of the incorporation of new kinds of data and the development of new methods of data analysis (Huxley 1940, Stuessy 1990). First, by introducing experimental methods for studying variation and speciation; then, by using secondary product chemistry, cytology, and macromolecules for comparing and contrasting organisms; and finally, by using computers to analyze much larger data sets, and to analyze them by phenetic and cladistic relationships, has systematics been transformed. New systems for coevolution have been generated. Major floras of large areas of the world have been or are being written with an urgency stimulated by the rapid loss of many natural areas.

Some branches of plant sciences, such as morphology, paleobotany, phycology, and mycology had strong beginnings in the nineteenth century; twentieth century investigators built significantly on these foundations (Steere 1958, Sirks and Zirkle 1964, Evans 1969, Wagner 1974, Morton 1981, Mayr 1982). Better understanding of life cycles and developmental stages have resulted. Ultrastructural studies have made it possible to better relate stages in development of algae, fungi, and fossil plants. Recent interpretations for these groups of organisms has resulted in the removal of the fungi and some of the algae from the plant kingdom into other kingdoms.

The molecular biology revolution mentioned earlier has indeed transformed how biologists interpret plants. Better understanding of nucleic acids and other macromolecules, in relationship to form, function, and regulation of plants, has been rapid. Every aspect of plant biology has been influenced, from cytology and genetics, to morphology and physiology, and even systematics and ecology (Crawford 1990). Sophisticated instrumentation has become part of most biological studies, and cooperative research is normal. The United States became the major center of plant biological research in this century. It truly has been a century of biological revolutions. One reasonably may ask now, have Ohio plant biologists reflected these great strides made during this century?

Ralph Dexter, in several papers (1960, 1962, 1966a,b), reviewed the early history of The Ohio Academy of Science (OAS) and the establishment of its Plant Sciences Section. When it was formed in 1908, it was called Botany; the current name was chosen in 1944. The OAS, from its founding, had a strong plant sciences component. William R. Lazenby, Professor of Horticulture and Forestry, and William A. Kellerman, Professor of Botany, at The Ohio State University, were two of the three members of the original organizational committee in 1891. Since then, botanists have had a continuing role in the development of the OAS. This is not surprising because many of Ohio's institutions of higher education have strong plant sciences components in their programs.

From 1903 to 1943, the various editions of *American Men of Science* recognized the most outstanding scientists in each discipline. During that period, a total of 257 botanists were listed in the volumes, of whom nine had earned undergraduate degrees from Ohio institutions (Visher 1947). These institutions and their scientists were from: Oberlin – Charles J. Chamberlain, Henry C. Cowles, Otis F. Curtis, Roland A. Harper, and Albert J. Riker; Antioch – George H. Shull; Miami – Lee O. Overholts; Ohio State – Robert F. Griggs; Ohio Wesleyan – Paul B. Sears. One other, Melville T. Cook, received a graduate degree from Ohio State. Thus, Ohio had trained about 4% of the outstanding botanists before 1943. This is a reasonable number considering that the centers of botanical research still were predominantly in the coastal areas of this country.

Over the past 100 years, a significant number of important plant scientists worked in Ohio. Some of the best-known deceased ones are: Floyd Bartley, Janice C. Beatley, Glenn W. Blaydes, E. Lucy Braun, Edward W. Claypole, Jane M. Decker, Frederica Detmers, Bruce Fink, Robert F. Griggs, Otto E. Jennings, William A. Kellerman, Mrs. William A. Kellerman, John V. Lloyd, Bernard S. Meyer, Richard A. Popham, John H. Schaffner, Paul B. Sears, Augustine D. Selby, Clarence E. Taft, Lewis H. Tiffany, Edgar N. Transeau, and John N. Wolfe.

Important botanical innovations were developed in Ohio. John H. Schaffner correctly described the events of plant cell meiosis in 1897 (Schaffner 1897, Troyer 1989). In 1907, William A. Kellerman established the first tropical field botany program for students in this country (Lowden 1970, Meyer 1983). Paul B. Sears made pioneering studies using fossil pollen to reconstruct past climates (Sears 1930a,b; Stuckey 1990). In 1926, Edgar N. Transeau published in *The Ohio Journal of Science* the first detailed analysis of the efficiency of photosynthesis in plants (Transeau 1926). Over the years, he and his students mapped the natural vegetation of the state; he recognized the importance of Ohio's prairies which resulted in the first large, colored, published map of vegetation of any state at its time of settlement (Transeau 1935; Gordon 1966, 1969; Stuckey 1981). An important early detailed study of microclimates anywhere was published for Ohio in 1949 (Wolfe, Wareham, and Schofield, 1949). E. Lucy Braun's book on the eastern North American forests (Braun 1950) is a landmark culmination of years of field studies which first recognized the mixed mesophytic forest type. These and other research reports presented at annual meetings and published in *The Ohio Journal of Science* are substantial and important.

Do these activities of Ohio plant scientists reflect the major trends of the science as outlined at the beginning of this paper? One measure is to examine the areas of plant science reported at the annual meetings of the Society in 2,192 papers presented since 1891 (Table 1). It is important to note that additional plant science reports might have been given in other sections after they formed; Conservation in 1952; Genetics in 1960; and Ecology in 1978. Over the years, 10% or more of the plant sciences papers were related to the areas of ecology, floristics, mycology, and physiology; additional significant numbers were given in anatomy-morphology, economic botany, and taxonomy. The variation from annual meeting to annual meeting reflects the interests and research of particular faculty and their students at the various Ohio colleges and universities. It is of interest that the numbers of papers presented increased substantially in the 1960s, and even more dramatically in the 1970s and 1980s. When compared with the areas of greatest botanical emphases in the world, it is clear that early in this century when genetics, and later in this century when molecular biology, were dominant, these areas were poorly represented at meetings of the Academy.

An analysis of the number of pages of plant science papers in *The Ohio Journal of Science* at ten year intervals since 1900 (Table 2) shows similar trends to the oral presentations, with the exception that phycology appears as more important and taxonomy as less important than at the Academy meetings.

How can the absence of genetics and molecular botany be explained? It is obvious that a regional academy would focus to a great extent on regional interests. Thus, floristics, ecology, and various plant groups of the region, such as fungi and algae, should show strength of interest. Conversely, those areas of biology unrelated to regionality, such as genetics, molecular botany, physiology, or taxonomy, in which researchers desire to receive national and international exposure of their research, and which have specialized journals, should show weakness.

One way to compare regional aspects with non-regional ones is to evaluate a general biological journal covering all sub-disciplines. Such an analysis of page numbers of papers for ten year intervals since 1900 is given for *The American Naturalist* (Table 3). In comparison with *The Ohio Journal of Science, American Naturalist* exhibits what one would expect, particularly in the earlier years of this century; the regional sub-disciplines, i.e. economic botany, floristics, mycology, and phycology, are poorly represented, if at all. Ecology, which can have a regional orientation, seems to be an exception, especially in recent years. This anomaly is probably a change in emphasis of ecology as it becomes more evolutionary and less community related, which better fits the bias of this particular journal. The absence of representation in *The American Naturalist* sample of any molecular botany is an anomaly as well. Possible explanations are that this journal has a bias against this approach, or that molecular botanists prefer to publish in more specialized journals that do not have an evolutionary slant.

An aspect of the Plant Sciences Section that warrants

TABLE 1

Plant Science reports presented at annual meetings of The Ohio Academy of Science, 1891-1990.

Years	Total	Anatomy-Morphology		Ecology		Economic		Floristics		Genetics		History		Molecular		Mycology		Paleobotany		Phycology		Physiology		Taxonomy	
	no.	no.	%*	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%
1891–1900	170	22	13	11	6	11	6	64	39	1	1					37	22	3	2	2	1	8	5	11	6
1901–1910	159	15	9	23	14	17	11	40	25	2	1					28	18	2	1	10	6	7	4	15	9
1911–1920	120	7	6	23	19	22	18	20	17	5	4					18	15			8	7	10	8	7	6
1921–1930	171	22	13	28	16	30	18	15	9	6	4					15	9	3	2	13	8	31	18	8	5
1931–1940	162	15	9	33	20	36	22	11	7	3	2	2	1			6	4	6	4	10	6	31	19	9	6
1941–1950	147	10	7	24	16	33	22	4	3	11	7	2	1			9	6	24	16	5	3	23	16	2	1
1951–1960	210	20	10	36	17	22	10	17	8	19	9	5	2			18	9	10	5	12	6	39	19	12	6
1961–1970	270	22	8	45	17	15	6	39	14	10	4	7	3			30	11	1		11	4	69	26	21	8
1971–1980	457	35	8	99	22	14	3	38	8	3	1	3	1	6	1	42	9	37	8	30	7	110	24	40	9
1981–1990	327	12	4	82	25	8	2	37	11	1		10	3	2	1	8	2	30	9	13	4	53	16	71	22
All Years	2192	180	8	404	18	208	9	285	13	61	3	29	1	8		211	10	116	5	114	5	381	17	195	9

* To the nearest percent; if omitted, less than 0.5%.

TABLE 2

Plant Science papers published in The Ohio Naturalist/Ohio Journal of Science *between 1900 and 1990.*

Years	Total Pages	Anatomy-Morphology		Ecology		Economic		Floristics		Genetics		History		Molecular		Mycology		Paleobotany		Phycology		Physiology		Taxonomy	
		pp.	%	pp.	%	pp.	%	pp.	%	pp.	%	pp.	%	pp.	%	pp.	%	pp.	%	pp.	%	pp.	%	pp.	%
1900	68			5	7	22	32	16	24	6	9					3	4			2	3	8	12	6	9
1910	90	2	2	6	7	20	22	32	36							16	18			11	12			3	3
1920	55	10	18					10	18													34	62	1	2
1930	67	19	28					10	15							14	21			12	18			12	18
1940	53					4	8	18	34									1	2	23	43	7	13		
1950	41					16	39	11	27	5	12									3	7	6	15		
1960	83	5	6	11	13	4	5	23	28							5	6	12	14	4	5	19	23		
1970	92	1	1	18	20			6	7							30	33			25	27	4	4	8	9
1980	46			16	26			2	3	7	11			15	24					6	10				
1990	37			12	32	5	14															7	19		
Totals	632	37	6	68	11	71	11	128	20	18	3			15	2	81	13	13	2	86	14	85	13	30	5

TABLE 3

Plant Science papers published in The American Naturalist *between 1900 and 1990.*

Years	Total Pages	Anatomy-Morphology		Ecology		Economic		Floristics		Genetics		History		Molecular		Mycology		Paleobotany		Phycology		Physiology		Taxonomy	
		pp.	%	pp.	%	pp.	%	pp.	%	pp.	%	pp.	%	pp.	%	pp.	%	pp.	%	pp.	%	pp.	%	pp.	%
1900	67	10	15	48	72											9	13								
1910	246	51	21							112	46					14	6	17	7	20	8	22	9	10	4
1920	62	4	6	33	53					14	23					5	8					6	10		
1930	157	5	3	41	26					97	62											14	9		
1940	65	26	40	10	15					13	20											14	22	2	8
1950	79	23	29	10	13					19	24											27	34		
1960	39			17	44					13	33					2	5					7	18		
1970	88			63	72					11	13					14	16								
1980	148			100	68					14	9									28	19	6	4		
1990	244			164	67					31	13											49	20		
Totals	1195	119	10	486	41					324	27					44	4	17	1	48	4	145	12	12	1

notice is that of education. Over the years many students, particularly at the graduate level, have had their first exposure to scientific meetings by attending or presenting a paper at the annual meeting of the OAS. Also, members of the Section were involved in the founding of the Ohio Biological Survey in 1912, and the Ohio Flora Committee in 1951. The OAS, the Biological Survey, and the Flora Committee have over the years published monographs related to Ohio plants that have been used extensively by instructors and their students, including three on the flora (Braun 1961, 1967; Fisher 1989). Training future plant scientists is a very important function of the Plant Sciences Section.

Ohio plant scientists in the OAS for the last 100 years have made valuable contributions. They have reported on research, often regionally oriented, and initiated research projects. They have used the Academy meetings and journal as forums for training their students to become more professional. After all, the Academy is the scientists who constitute it, and thus it reflects their aims and aspirations.

In summary, developments in plant sciences in the last 100 years have been reviewed. At the beginning of this century, genetic approaches were a focus for those studying plants, while in the second half of the century molecular approaches began to dominate. Cytological, taxonomical, physiological, and ecological studies all changed directions during this period. Plant sciences in Ohio are documented in activities of The Ohio Academy of Science, and in its educational aspect. By analyzing 2,192 plant related reports given at annual meetings of the Academy from 1891 to 1990, and published papers at 10-year interval volumes of *The Ohio Journal of Science* since 1900, the importance of various sub-disciplines can be assessed. The predominance of floristic and ecologic aspects illustrate that regional interests are strong. The underrepresentation of plant genetics and molecular botany might be explained by their lack of regional interest as well as by the desire of plant scientists having these reports in specialized and international forums. A comparison of the *Ohio Journal* papers with those of similar dates in a national journal, *The American Naturalist,* shows that it lacks regional-type papers and has more genetics ones; however, it also lacks molecular botany ones.

LITERATURE CITED

Barton-Wright, E. C. 1933 Recent Advances in Plant Physiology, 2nd ed. J. and A. Churchill, London. 341 p.

Bowler, Peter J. 1989 The Mendelian Revolution, the Emergence of Hereditarian Concepts in Modern Science and Society. Johns Hopkins University Press, Baltimore, MD. 207 p.

Bradbury, S. 1967 The Evolution of the Microscope. Pergamon Press, Oxford. 357 p.

———— and G. L'E. Turner, eds. 1967 Historical Aspects of Microscopy. W. Heffer and Sons, Cambridge. 227 p.

Braun, E. Lucy 1950 Deciduous Forests of Eastern North America. Ronald Press, New York, NY, (reprinted in 1964 by Hafner, New York). 596 p.

———— 1961 The Woody Plants of Ohio; Trees, Shrubs, and Woody Climbers; Native, Naturalized, and Escaped. Ohio State University Press, Columbus. 362 p.

———— 1967 [The Vascular Flora of Ohio] The Monocotledoneae: Cat-Tails to Orchids. Ohio State University Press, Columbus. 464 p.

Crawford, Daniel J. 1990 Plant Molecular Systematics, Macromolecular Approaches. John Wiley and Sons, New York, NY. 388 p.

Dexter, Ralph W. 1960 The summer field meetings of the Ohio Academy of Science (1892-1905). Ohio J. Sci. 60: 262–265.

———— 1962 Conservation and the Ohio Academy of Science – an historical review. Ohio J. Sci. 62: 274–280.

———— 1966a Origin of the Natural Science Sections of the Ohio Academy of Science. Ohio J. Sci. 66: 225–228.

———— 1966b Milestones: Ohio Academy of Science, 1891–1966. Ohio J. Sci. 66: 353–359.

Ewan, Joseph, ed. 1969 A Short History of Botany in the United States. Hafner Publishing Co., New York, NY. 174 p.

Fisher, T. Richard 1989 The Vascular Flora of Ohio. Volume Two: The Dicotyledoneae of Ohio, Part Three: Asteraceae. Ohio State University Press, Columbus. 280 p.

Gordon, Robert B. 1966 Natural vegetation of Ohio at the time of the earliest land surveys. Ohio Biol. Survey. Large colored map.

———— 1969 The natural vegetation of Ohio in pioneer days. Bulletin, Ohio Biol. Survey, n.s. 3: 1–109.

Huxley, Julian, ed. 1940 The New Systematics. Oxford University Press, London. 583 p.

Judson, Horace Freeland 1979 The Eighth Day of Creation: Makers of the Revolution in Biology. Simon and Schuster, New York. 686 p.

Lowden, Richard M. 1970 William Ashbrook Kellerman's botanical expeditions to Guatemala (1905–1908). Taxon. 19: 19–35.

Mayr, Ernst 1982 The Growth of Biological Thought; Diversity, Evolution, and Inheritance. Harvard University Press, Cambridge, MA. 974 p.

McIntosh, Robert P. 1985 The Background of Ecology, Concept and Theory. Cambridge University Press, Cambridge. 383 p.

Meyer, Bernard S. 1983 Botany at The Ohio State University: the first 100 years. Bulletin, Ohio Biological Survey, n.s. 6: 1–177.

Morton, A. G. 1981 History of Botanical Science, an Account of the Development of Botany From Ancient Times to the Present Day. Academic Press, London. 474 p.

Olby, Robert 1974 The Path to the Double Helix. Macmillan, London. 510 p.

Provine, William B. 1971 The Origins of Theoretical Population Genetics. University of Chicago Press, Chicago, IL. 201 p.

Schaffner, John H. 1897 Contribution to the life history of *Lilium philadelphicum*. The division of the macrospore nucleus. Bot. Gaz. 23: 430–452.

Sears, Paul B. 1930a Common forest pollen in the Erie Basin. Bot. Gaz. 89: 95–106.

———— 1930b A record of post-glacial climate in northern Ohio. Ohio J. Sci. 30: 205–217.

Sirks, M. J. and C. Zirkle 1964 The Evolution of Biology. Ronald Press, New York, NY. 376 p.

Steere, William Campbell, ed. 1958 Fifty Years of Botany. McGraw-Hill Book Co., New York, NY. 638 p.

Stubbe, Hans 1972 History of Genetics, From Prehistoric Times to the Rediscovery of Mendel's Laws. MIT Press, Cambridge, MA. 356 p.

Stuckey, Ronald L. 1981 Robert Benson Gordon (1901–1981): a biographical sketch emphasizing his studies of natural vegetation mapping. Bartonia. 48: 34–41.

———— 1990 Paul Bigelow Sears 1891–1990: Eminent Scholar, Ecologist, and Conservationist. Ohio J. Sci. 90: 186–190.

Stuessy, Tod F. 1990 Plant Taxonomy, The Systematic Evaluation of Comparative Data. Columbia Univ. Press, New York, NY. 514 p.

Tiley, N. A. 1983 Discovering DNA, Meditations on Genetics and a History of the Science. Van Nostrand Reinhold Co., New York, NY. 288 p.

Tobey, Ronald C. 1981 Saving the Prairies, the Life Cycle of the Founding School of American Plant Ecology, 1895–1955. University of California Press, Berkeley, CA. 315 p.

Transeau, Edgar Nelson 1926 The accumulation of energy by plants. Ohio J. Sci. 26: 1–10.

———— 1935 The prairie peninsula. Ecology. 16: 423–435.

Troyer, James R. 1989 John Henry Schaffner (1866–1939) and reduction division in plants: legend and fact. Amer. J. Bot. 76: 1229–1246.

Visher, Stephen Sargent 1947 Scientists starred 1903–1943 in "American Men of Science." A Study of Collegiate and Doctoral Training, Birthplace, Distribution Backgrounds, and Developmental Influences. Johns Hopkins Press, Baltimore, MD. 556 p.

Wagner, W. H., et al. 1974 Twenty-five Years of Botany, 1947-1972. Annals Mo. Bot. Gard. 61: 1–261.

Weevers, Th. 1949 Fifty Years of Plant Physiology. Scheltema and Holkema, Amsterdam. 308 p.

Wolfe, John N., Richard T. Wareham, and Herbert T. Scofield 1949 Microclimates and macroclimates of Neotoma, a small valley in central Ohio. Ohio State Univ. Publ. Bull. 41 O.B.S. 8: 1–267.