NATIONAL ACADEMY OF SCIENCES

EDMUND WARE SINNOTT

1888—1968

A Biographical Memoir by
W. GORDON WHALEY

Photograph courtesy of the Yale University Archives, Yale University Library

Edmund W. Sinnott

EDMUND WARE SINNOTT

February 5, 1888–January 6, 1968

BY W. GORDON WHALEY

EDMUND WARE SINNOTT was born in Cambridge, Massachusetts on February 5, 1888, one of two sons of Charles Peter and Jessie Elvira (Smith) Sinnott. Although he spent the first ten years of his life in Milwaukee, Wisconsin, as far as anyone can determine this interval had little effect on his overpowering dedication to New England. That dedication, however, did not limit his keen interest in worldwide affairs as they related to the advancement of science.

The period during which Edmund Sinnott rose to eminence in science was one in which reductionism had become the dominant mode. Many scientists came to disagree strongly with Sinnott's attempts to meld science with humanism—an attempt he considered essential to the development of what he called the "whole man." He felt only whole men could make proper use of rational science.

His choice of scientific fields was not surprising in view of his background. His mother was a descendent of the Reverend Henry Smith, the first minister in Wethersfield, Connecticut. Both his parents were teachers, no doubt lending encouragement to a career in academic life. He attended a grammar school that was run as a model school supervised by the Bridgewater State Normal School, at which his father spent his life as a geography and geology teacher. When he graduated in 1900 he went to Bridgewater High School, where he worked hard in advanced classical courses. He entered Harvard in the fall of 1904, having first expressed an interest in becoming a writer. Although he devoted himself largely to other pursuits, it certainly can be said that he wrote with style and distinction. He shortly chose zoology as his area of concentration because he had a particular interest in birds. (Many years later he would complete a unique book in collaboration with an ornithologist who had once been a colleague.) During his sophomore year at Harvard, he was offered an assistantship in botany and studied under Professor E. C. Jeffrey, who was engaged in an attempt to reclassify plants on the basis of comparative anatomy. Professor Jeffrey influenced a large number of individuals who became botanists and contributed to many diverse fields. Sinnott's first publications were, appropriately, in the field of comparative anatomy, but no single field in the biological sciences held his exclusive attention. While a Harvard undergraduate, he spent his summers on Cape Cod, where he built up a large collection of plants and became particularly interested in, and published studies on, the flora of Cape Cod ponds. About the same time he came upon some fossil wood in eastern Massachusetts and while still a student published a paper on the subject.

He was stimulated by the Harvard atmosphere and completed his bachelor's degree in 1908, his master's degree in 1910, and his Ph.D. in 1913. By the time he wrote his dissertation, he had turned to the study of reproduction in evergreens. His moves from one biological field to another substantially broadened his knowledge, and this wide base served him well throughout his life. He held various assistantships, the Austin teaching fellowship, and finally a Sheldon traveling fellowship, which allowed him to spend a year abroad, mainly in Australasia, although he managed to stretch it into a trip around the world. He spent this period in association with his roommate, Arthur J. Eames, who was later to become one of the country's foremost plant morphologists and anatomists.

After completing his Ph.D., Sinnott spent two years as an instructor in the Harvard Forestry School and the Bussey Institution. One must suppose that the latter association was particularly significant because some of the earliest studies in plant genetics in the United States developed there. These briefly held positions were followed in 1915 by an appointment to the Connecticut Agricultural College in Storrs as professor of botany and genetics. Here the die was cast, for a strong interest in the developing science of genetics was present. L. C. Dunn had become a staff member of the Agricultural Experiment Station at Storrs and was already pursuing essentially parallel lines of genetic studies with poultry, mice, and rats. Dunn's colleague at the Experiment Station, Walter Landauer, had been experimenting with poultry genetics, while D. H. Jones was conducting a series of experiments that greatly influenced the emergence of genetic studies in maize at the Experiment Station in New Haven. In fact, scientists in the whole lower New England area were concentrating on genetics. The extensiveness of these studies related to T. H. Morgan's studies at Columbia. The result was the interpretation of genetics on a broad biological base.

Sinnott understood this biological base thoroughly and chose to contribute to it with a study of the genetics of the Cucurbitaceae. His initial interest was in pumpkins and squashes, but as he became increasingly intrigued by the relation of Mendelian genetics and the development of form, he turned to unusual forms among the gourds. The relationship of Mendelian factors to the development of particular forms was, and still is, largely an intractable problem. Sinnott tested many different approaches to relationships between genetic background and size and form, but, not surprisingly, he failed to find one that satisfied him. Nonetheless, adhering closely to the ideas extending from Mendel's work prevalent at the time, he related a great many characteristics of cucurbits to specific genes. For a while his life was occupied with page after page of Punnett squares. Then he complicated things with studies of linkage (and "crossing over"), which had been central subjects for T. H. Morgan and L. C. Dunn. Dunn had written his dissertation on linkage. Finally, though Sinnott confined his own work to fundamental genetic studies, he came to a full realization of the interrelationships between genetic and cytological studies as they were so pertinently developed by E. B. Wilson, both in his lectures and ultimately in his book, *The Cell in Development and Heredity*. Wilson's book was revised through a number of editions and has recently been reprinted as one of the classics in biological science. Almost a handbook, it has survived more than three-quarters of a century.

Sinnott followed the same pattern. He developed lectures for a course in genetics, and then with L. C. Dunn he turned the lecture material and other investigations into a book, *Principles of Genetics,* originally published in 1925. As Theodosius Dobzhansky, a collaborator on later editions with Sinnott and Dunn, has written in his memoir of Dunn:

> The second edition was published in 1932, the third in 1939, and the fourth and the fifth in 1950 and 1958 in collaboration with Th. Dobzhansky (although Sinnott's name was retained as the senior author). During the last years of his life, Dunn was sketching parts of what was meant to become the sixth edition. Translations of *Principles of Genetics* appeared in several languages (and so did a pirated edition in English printed in Taiwan). Most interesting is the fate of the Russian translation in the 1930s, more copies of which were published than the English original. It was widely used for several years, until Trofim Denisovich Lysenko and the Soviet government outlawed it, whereupon it came to be passed from hand to hand like a subversive tract.[1]

[1] "Leslie Clarence Dunn," in *Biographical Memoirs,* vol. 49 (Washington, D.C.: National Academy of Sciences, 1978), p. 82.

This book, too, became a handbook with worldwide distribution. It is still useful in interpretations of early classical genetics and modified illustrations from it are still used in such modern texts as James Watson's *Molecular Biology of the Gene,* which Watson introduced with a chapter on "The Mendelian View of the World."

Sinnott early became the editor of a long series of botanical and biological works published by McGraw-Hill. His own major works were a part of this series, as were those of several of his early colleagues, including Arthur Eames. This editorial position provided a means through which he could maintain his earlier interests while expanding his knowledge in related fields.

Perhaps Sinnott's most direct scientific contributions were his investigations of the development of form. Many of these pertain to animal studies, but botanically trained, he preferred to work with plants. He was not the original developer of morphogenesis but he was certainly one of the major contributors to it. He was a pioneer in his attempt to tie morphogenesis to specific genetic bases. In this he established the foundations of approaches being undertaken in the late twentieth century.

In alluding to his direct contributions in the combined fields of genetics and morphogenesis, one must not overlook the importance of his less direct contributions in many areas within the field of botany. Both his publications of investigations and his *Botany: Principles and Problems* stimulated and influenced large numbers of colleagues and students who were to go on to further studies in these areas.

Sinnott belonged among biologists who were as interested in ideas as they were in details of proof—not a popular category at that time. Perhaps this is one of the reasons it is difficult to pinpoint his own specific contributions within the great range of scientific affairs to which he addressed himself. He finally settled on an interpretation of the control of development of form as the result of what he termed "morphological fields." The term was one that few people accepted and even fewer understood. Sinnott's conclusion that development relates to morphological fields was, in effect, his way of saying that he had gone as far as possible at the time because knowledge and techniques still left much unknown.

When Sinnott went to the Connecticut Agricultural College, he succeeded Albert F. Blakeslee, who, though a botanist, had initiated some of the poultry genetics studies at Storrs. Blakeslee had moved to the Cold Spring Harbor Laboratory. These two men had known each other earlier at Harvard, and by the time of the move, Blakeslee had become intensely interested in studying the genetic background of differences in the genus *Datura*. This interest became the central focus of his investigations at the Cold Spring Harbor Laboratory, which, to this day, has maintained a dominant interest in genetic studies. During summers, in association with Blakeslee at Cold Spring Harbor, Sinnott pursued further basic genetic studies on plants in which he was less particularly interested than had been the case in his study of the cucurbits. Once again he had gotten into a situation that broadened his background.

Later he purchased an eighteenth century saltbox house and several surrounding acres in Woodbury, Connecticut, restored the house, and returned part of the land to an arable condition. This became a family summer home, but it must also have been the gourd center of America, for he had set out to study in detail the genetic background of size, form, and color in a plant group characterized by great diversity. Numerous scientists and their students were frequent visitors to his private Woodbury experiment station. He entertained them graciously but never without a lecture on the basic genetics of plants, illustrated by materials he collected on a quick run to the field.

After thirteen years at the Connecticut Agricultural College, Sinnott moved to Barnard College of Columbia University. T. H. Morgan had left Columbia, and one must suppose that someone saw the wisdom of replacing him with the fast-rising team of L. C. Dunn and E. W. Sinnott—one working primarily with animals and the other with plants. They had already published the first edition of *Principles of Genetics* while at Storrs.

It is difficult to establish priority among Sinnott's many contributions, but if the *Principles of Genetics* does not occupy the foremost position, it certainly comes close to it. Sinnott's *Botany: Principles and Problems,* which went through five editions, the last in cooperation with Katherine Wilson, was widely used but did not have the broad influence of the *Principles of Genetics*. His encyclopedic *Plant Morphogenesis,* which was not published until 1960, brought together a phenomenal range of studies on the development of form. It presaged interpretations that have come to the fore since its publication, and it laid a solid foundation for them. In a sense Sinnott's tremendous influence in this field of investigation came to an end when it began to seem possible to work out molecular and macromolecular bases for genetic control. He understood clearly that this was the direction of the future, however, and he turned his own interests to broader matters.

Sinnott was elected to the National Academy of Sciences in 1936. In 1939 he was appointed to the Columbia University faculty, and in 1940 he moved from Columbia to Yale to undertake a reorganization of the botanical work as Sterling Professor of Botany and chairman of the Department. This assignment called forth all his talents as a botanist, but it also brought his emergence as a spokesman for science. In this role he reached his peak when he became chairman of the Division of the Sciences and director of the Sheffield Scientific School in 1945, then, in 1950, dean of the Graduate School.

All along, the issue of stark unbridled science had bothered Sinnott, and he called for a spiritual outlook that he felt had to accompany science because, as he is often quoted as saying, "science alone may make monsters of men." In his later years he expressed his strong religious and philosophical views. His rationale was that the expression of these views strengthened science by indicating relationships among science, humanism, philosophy, and religion. *Two Roads to Truth,* in which he develops parallel rationales for science and religion, and *Cell and Psyche,* in which biological science and humanism are linked, had wide circulation. Though he came to concentrate on this sort of writing, he never forsook his interest in the problem of organic form.

In *The Problem of Organic Form,* published in 1963, he referred to Sir D'Arcy Wentworth Thompson, who published *On Growth and Form* in 1917, as the patron saint of morphogenesis. If Sir D'Arcy was the patron saint, Edmund Sinnott, another dedicated scientist, was fully ordained and occupied a position somewhat similar to that of Jonathan Edwards in the Great Awakening.

Katherine Wilson pointed out in her memorial article on Sinnott in the *Plant Science Bulletin* that:

> Dr. Sinnott's views and conclusions (on this subject) are most aptly summarized in his own words: 'Back of all the phenomena of genetics, biochemistry, and physiology stands the important fact that a living thing is an organism, that there is an interrelationship among its parts which is manifest in development, and that if this system is disturbed it tends, by a process of self-regulation, to restore itself. The most evident expression of this organization is the form of the organism and its structures. Morphogenesis, the study of the origin of form, thus assumes a central position in the biological sciences.'[2]

On the national scene, Sinnott occupied a number of significant positions. He made a notable contribution as presi-

[2]*Plant Science Bulletin,* 14 (1968): 6–7.

dent of the American Association for the Advancement of Science during its centennial year, and he called for the acceptance of science by urging that the brotherhood of man be developed through the brotherhood of science.

Two aspects of Sinnott's career can be summed up by statements accompanying awards to him. At its fiftieth anniversary celebration, the Botanical Society of America initiated annual awards for distinguished contributions to botany. Professor Sinnott was among the first recipients, and the award to him bore the following citation: "Edmund Ware Sinnott, morphologist, anatomist, geneticist, and botanical statesman, for his numerous varied and sustained contributions to plant anatomy, histology, evolution, and botanical theory." A later award honoring his contributions to Yale reads: "A loyal son of Harvard, by his stature as a distinguished scientist, administrator, historian, and great humanist he brought honor to this university and warm friendship to a legion of admiring colleagues both here and throughout the world."

He was noted for a view of science that knew no national boundaries and one that knew no division among scientists. He sustained this view with deep knowledge, intensity, articulateness, and affability—all linked to a remarkably stern self-discipline. The extent of his influence in laying solid foundations for succeeding generations is reflected in the posts he held and the honors he received. Lest it be thought that science and its relationship to philosophy isolated him from other things, it should be noted that he was a painter and a sculptor of ability, producing among his works a few deemed by experts to be of museum quality. Not surprisingly, he generally took objects of his beloved New England as his subjects.

Edmund Sinnott died on January 6, 1968. He was survived by his wife, the former Mabel H. Shaw of Bridgewater, Massachusetts, and their three children, Edmund Jr., Mildred, and Clara. Not too long before his final illness, he returned to Storrs, Connecticut to attend a meeting. An historian of science, he had himself long ago become part of the history of science. Nonetheless, he actively attended sessions and commented on presentations from his deep wisdom. In informal conversations he related developments in science, sometimes very specifically to sociological considerations such as the relation of heredity to poverty and disease. By this time the interpretation of the human condition had become for him a very complex weaving. Among the many threads were his concerns with the ever-changing scientific investigations; others had to do with spiritual matters. This thinking was expressed by Sinnott at the early, informal meetings of the Society for Growth and Development, of which he was a member of the organizing committee. The organization later developed into the Society for Developmental Biology.

He saw as other threads the influence of religion and social interactions. He was just as proud of one of his last works—a book on meetinghouse and church in early New England—because he saw this as part of the tapestry.

In a rather tongue-in-cheek article a national magazine once chided Sinnott for taking the crookedness out of crooked squashes and putting it into straight ones—thus giving both new characteristics by his genetic manipulations. One hopes in the present day that genetic manipulations and the wisdom and understanding Sinnott brought to science will combine and prevail.

HONORS AND DISTINCTIONS

ACADEMIC DEGREES

1908	B.A., Harvard University
1910	M.A., Harvard University
1913	Ph.D., Harvard University

HONORARY DEGREES

1940	M.A., Yale University
1948	D.Sc., Northeastern University
1950	D.Sc., Lehigh University
1957	D.Sc., University of the South
1959	LL.D., University of New Hampshire
1961	D.Sc., University of Hartford

AWARD

1966	William C. DeVane Medal

APPOINTMENTS

1908–1910	Austin Teaching Fellow and Assistant in Botany, Harvard
1911–1912	Austin Teaching Fellow and Assistant in Botany, Harvard
1913–1915	Instructor, Harvard Forestry School and The Bussey Institution
1915–1928	Professor of Botany and Genetics, Connecticut Agricultural College
1928–1938	Professor of Botany, Barnard College, Columbia
1938–1939	Professor of Botany, Columbia
1940–1956	Sterling Professor of Botany, Yale
1940–1950	Director, Osborn Botanical Laboratory and Marsh Botanical Gardens
1940–1949	Chairman, Department of Botany, Yale
1945–1955	Director of the Division of Sciences, Yale
1945–1956	Director, Sheffield Scientific School, Trustee and President of the Board, Yale
1949–1950	Department of Plant Science, Yale
1949–1950	Lyman Beecher Lecturer, Yale

1950–1956 Dean of the Graduate School, Yale
1956–1968 Sterling Professor of Botany Emeritus, Yale
1957–1958 Lecturer in Zoology, Yale

EDITORSHIPS

Editor-in-Chief, *American Journal of Botany*
Chief Consulting Editor, *McGraw-Hill Publications in Botanical Sciences*

LEARNED SOCIETY MEMBERSHIPS

National Academy of Sciences, 1936
American Philosophical Society
American Academy of Arts and Sciences
American Association for the Advancement of Science, Fellow (Vice President, 1935; President, 1948)
Botanical Society of America (Treasurer, 1917–1921; President, 1937)
New England Botanical Club
Torrey Botanical Club (President, 1931–1934)
American Society of Naturalists (Treasurer, 1926–1928; President, 1945)
Society for the Study of Development and Growth
Sigma Xi
Phi Beta Kappa
New York Botanical Gardens, Board of Managers (1933–1940)

BIBLIOGRAPHY

1909

On mesarch structure in Lycopodium. Bot. Gaz., 48:138–45.

Paracedroxylon, a new type of Araucarian wood. Rhodora, 11: 165–173.

1910

Foliar gaps in the Osmundaceae. Ann. Bot., 24:107–18.

1911

The evolution of the Filicinean leaf-trace. Ann. Bot., 25:167–91.

Some features of the anatomy of the foliar bundle. Bot. Gaz., 51:258–72.

1912

Pond flora of Cape Cod. Rhodora, 14:25–34.

1913

The morphology of the reproductive structures in the Podocarpineae. Ann. Bot., 27:39–82.

The fixation of character in organisms. Am. Nat., 47:705–29.

1914

Some Jurassic Osmundaceae from New Zealand. Ann. Bot., 28: 471–79.

Investigations on the phylogeny of the angiosperms. I. The anatomy of the node as an aid in the classification of angiosperms. Am. J. Bot., 1:303–22.

With I. W. Bailey. Investigations on the phylogeny of the angiosperms. II. Anatomical evidence of reduction in certain of the Amentiferae. Bot. Gaz., 58:36–60.

Investigations on the phylogeny of the angiosperms. III. Nodal anatomy and the morphology of stipules. Am. J. Bot., 1:441–53.

Investigations on the phylogeny of the angiosperms. IV. The origin and dispersal of herbaceous angiosperms. Ann. Bot., 28:547–600.

1915

With Irving W. Bailey. Investigations on the phylogeny of the angiosperms. V. Foliar evidence as to the ancestry and early climatic environment of the angiosperms. Am. J. Bot., 2:1–22.

With Irving W. Bailey. The evolution of herbaceous plants and its bearing on certain problems of geology and climatology. J. Geol., 23:289–306.

With I. W. Bailey. A botanical index of cretaceous and tertiary climates. Science, n.s. 41:831–34.

1916

With Irving H. Bailey. The climatic distribution of certain types of angiosperm leaves. Am. J. Bot., 3:24–39.

With H. H. Bartlett. Coniferous woods of the Potomac formation. Am. J. Sci., 41:276–93.

Endemism as a criterion of antiquity among plants. Mem. N.Y. Bot. Gard., 6:161–66.

Comparative rapidity of evolution in various plant types. Am. Nat., 50:466–78.

Evolution of herbs. Science, n.s. 44:291–98.

A botanical criterion of the antiquity of the angiosperms. J. Geol., 24:777–82.

1917

The "age and area" hypothesis and the problem of endemism. Ann. Bot., 31:209–16.

The "age and area" hypothesis of Willis. Science, n.s. 46:457–59.

1918

Conservatism and variability in the seedling of Dicotyledons. Am. J. Bot., 5:120–30.

Evidence from insular flora as to the method of evolution. Am. Nat., 52:269–72.

Factors determining character and distribution of food reserve in woody plants. Bot. Gaz., 66:162–75.

Isolation and specific change. Mem. Brooklyn Bot. Gard., 1: 444–47.

1921

With J. Arthur Harris. The vascular anatomy of normal and variant seedlings of *Phaseolus vulgaris.* Proc. Natl. Acad. Sci. USA, 7:35–41.

With J. Arthur Harris, John Y. Pennypacker, and G. B. Durham. The vascular anatomy of dimerous and trimerous seedlings of *Phaseolus vulgaris*. Am. J. Bot., 8:63–102.

With J. Arthur Harris, John Y. Pennypacker, and G. B. Durham. Correlations between anatomical characters in the seedling of *Phaseolus vulgaris*. Am. J. Bot., 8:339–65.

With J. Arthur Harris, John Y. Pennypacker, and G. B. Durham. The vascular anatomy of hemitrimerous seedlings of *Phaseolus vulgaris*. Am. J. Bot., 8:375–81.

With J. Arthur Harris, John Y. Pennypacker, and G. B. Durham. The interrelationship of the number of the two types of vascular bundles in the transition zone of the axis of *Phaseolus vulgaris*. Am. J. Bot., 8:425–32.

The relation between body size and organ size in plants. Am. Nat., 55:385–403.

1922

With Albert F. Blakeslee. Structural changes associated with factor mutations and with chromosome mutations in *Datura*. Proc. Natl. Acad. Sci. USA, 8:17–19.

With George B. Durham. Inheritance in the summer squash. J. Hered., 13:177–86.

Inheritance of fruit shape in *Cucurbita pepo*. I. Bot. Gaz., 74:95–103.

With I. W. Bailey. The significance of the "foliar ray" in the evolution of herbaceous angiosperms. Ann. Bot., 36:523–33.

1923

Botany. Principles and Problems. New York: McGraw-Hill.

With George B. Durham. A quantitative study of anisophylly in *Acer*. Am. J. Bot., 10:278–87.

1924

Plant classification in elementary botanical tests. Science, 60:291–92.

Age and area and the history of species. Am. J. Bot., 11:573–78.

1925

With Leslie C. Dunn. *Principles of Genetics.* New York: McGraw-Hill. xviii + 431 pp.

1927

A factorial analysis of certain shape characters in squash fruits. Am. Nat., 61:333–44.

1929

Botany. Principles and Problems, 2d ed. New York: McGraw-Hill.

With George B. Durham. Developmental history of the fruit in lines of *Cucurbita pepo* differing in fruit shape. Bot. Gaz., 87:411–21.

The plant life of Australia and New Zealand. J. N.Y. Bot. Gard., 30:11–18.

1930

The morphogenetic relationships between cell and organ in the petiole of *Acer.* Bull. Torrey Bot. Club, 57:1–20.

Some problems in plant development. Torreya, 30:91–96.

With Dorothy Hammond. Factorial balance in the determination of fruit shape in Cucurbita. Am. Nat., 64:509–24.

1931

The character and inheritance of developmental differences in fruit shape. Science, n.s. 73:507.

The independence of genetic factors governing size and shape in the fruit of *Cucurbita pepo.* J. Hered., 22:381–87.

1932

With Leslie C. Dunn. *Principles of Genetics,* 2d ed. New York: McGraw-Hill.

Shape changes during fruit development in Cucurbita and their importance in the study of shape inheritance. Am. Nat., 66: 301–9.

1934

With Samuel Kaiser. Two types of genetic control over the development of shape. Bull. Torrey Bot. Club, 61:1–7.

With Helen Houghtaling and A. F. Blakeslee. The comparative anatomy of extrachromosomal types in Datura stramonium. Carnegie Inst. Washington Publ. #451. 50 pp.

1935

Botany. Principles and Problems, 3d ed. New York: McGraw-Hill.
The place of botany in a liberal education. Iowa State Coll. J. Sci., 9:243–48.
Evidence for the existence of genes controlling shape. Genetics, 20:12–21.
With L. C. Dunn. The effect of genes on the development of size and form. Biol. Rev., 10:123–51.
The genetic control of developmental relationships and its bearing on the theory of gene action. Science, n.s. 81:420.

1936

Morphogenetics may provide the key to life. Independent J. Columbia Univ., 3:1, 4.
A developmental analysis of inherited shape differences in Cucurbit fruits. Am. Nat., 70:245–54.
The relation of organ size to tissue development in the stem. Am. J. Bot., 23:418–21.
With Vivian V. Trombetta. The cytonuclear ratio in plant cells. Am. J. Bot., 23:602–6.

1937

A developmental analysis of inherited differences. Teach. Biol., 6:49–50.
Morphology as a dynamic science. Science, n.s. 85:61–65.
The relation of gene to character in quantitative inheritance. Proc. Natl. Acad. Sci. USA, 23:224–27.
The genetic control of developmental relationships. Am. Nat., 71:113–19.

1938

Structural problems at the meristem. Bot. Gaz., 99:803–13.

1939

With Leslie C. Dunn. *Principles of Genetics*, 3d ed. New York: McGraw-Hill.
Cell division and differentiation in living plant meristems. Collect. Net, 14:101, 107, 108.
The cell and the problem of organization. Science, n.s. 89:41–46.
Growth and differentiation in living plant meristems. Proc. Natl. Acad. Sci. USA, 25:55–58.

A developmental analysis of the relation between cell size and fruit size in Cucurbits. Am. J. Bot., 26:179–89.

With Robert Bloch. Cell polarity and the differentiation of root hairs. Proc. Natl. Acad. Sci. USA, 25:248–52.

The relation of cell to organ in plant development. Collect. Net, 14:189, 191–93.

With Robert Bloch. Changes in intercellular relationships during the growth and differentiation of living plant tissues. Am. J. Bot., 26:625–34.

The cell-organ relationship in plant organization. Growth, 1st Suppl.:77–86.

1940

The frontiers of genetics. Teach. Biol., 9:121–24, 136.

With Robert Bloch. Cytoplasmic behavior during division of vacuolate plant cells. Proc. Natl. Acad. Sci. USA, 26:223–27.

1941

With Robert Bloch. Division in vacuolate plant cells. Am. J. Bot., 28:225–32.

With Robert Bloch. The relative position of cell walls in developing plant tissues. Am. J. Bot., 28:607–17.

Buildings, equipment and textbooks used by teachers of biology in secondary schools: Data from a questionnaire. Am. Biol. Teach., 3:261–66.

Vitamins and recent biological research. Yale Rev., 31:38–52.

1942

Comparative rates of division in large and small cells of developing fruits. Proc. Natl. Acad. Sci. USA, 28:36–38.

An analysis of the comparative rates of cell division in various parts of developing Cucurbit ovary. Am. J. Bot., 29:317–23.

The problem of internal differentiation in plants. Am. Nat., 76:253–68.

1943

With Alicelia Hoskins Franklin. A developmental analysis of the fruit in tetraploid as compared with diploid races of Cucurbits. Am. J. Bot., 30:87–94.

Make measurable what cannot yet be measured. Q. Rev. Biol., 18:64–68.
With Robert Bloch. Luffa sponges, a new crop for the Americas. J. N.Y. Bot. Gard., 44:125–32.
Cell division as a problem of pattern in plant development. Torreya, 43:29–34.
With Robert Bloch. Development of the fibrous net in the fruit of various races of Luffa cylindrica. Bot. Gaz., 105:90–99.
All flesh is grass. Yale Rev., 32:681–92.

1944

Genetics and geometry. Mathematicians aid biologists in studies of form. Yale Sci. Mag., 18:6–8, 18.
With Harold S. Burr. Electrical correlates of form in Cucurbit fruits. Am. J. Bot., 31:249–53.
Science and the education of free men. Am. Sci., 32:205–15.
Cell polarity and the development of form in Cucurbit fruits. Am. J. Bot., 31:388–91.
With Robert Bloch. Visible expression of cytoplasmic patterns in the differentiation of xylem strands. Proc. Natl. Acad. Sci. USA, 30:388–92.

1945

With Paul R. Burkholder. Morphogenesis of fungus colonies in submerged shaken cultures. Am. J. Bot., 32:424–31.
Plants and the material basis of civilization. Am. Nat., 79:28–43.
With Robert Bloch. The cytoplasmic basis of intercellular patterns in vascular differentiation. Am. J. Bot., 32:151–56.
The relation of cell division to growth rate in Cucurbit fruits. Growth, 9:189–94.
The relation of growth to size in Cucurbit fruits. Am. J. Bot., 32:439–46.
The biological basis of democracy. Yale Rev., 35:61–73.

1946

Botany. Principles and Problems, 4th ed. New York: McGraw-Hill.
With Robert Bloch. Comparative differentiation in the air roots of Monstera deliciosa. Am. J. Bot., 33:587–90.
Substance or system: the riddle of morphogenesis. Am. Nat., 80:497–505.

1947

Science and the whole man. Vital Speeches, 14:111–17.
Plants hold the basic patents. In: Warren Weaver, *The Scientists Speak*, pp. 207–11. New York: Boni and Gaer.
Science needs the humanities. Yale Sci. Mag., 31:9, 16, 18.

1948

Science and the whole man. Am. Sci., 36:127–38.
The American Journal of Science, 1818–1948. Science, n.s. 108: 227–29.

1949

Growth and morphogenesis. Science, n.s. 109:391–94.
Man and energy. Yale Rev., 38:640–53.

1950

With Leslie C. Dunn and Theodosius Dobzhansky. *Principles of Genetics*, 4th ed. New York: McGraw-Hill.
Cell and Psyche: The Biology of Purpose (The John Calvin McNair lectures). Chapel Hill: University of North Carolina Press. 121 pp.
Amateur brings fresh viewpoint to science. Science, 57:34.
Science and religion: A necessary partnership (Lyman Beecher lectures). Hazen pamphlet #25. New Haven, Connecticut: Edward W. Hazen Foundation.
Ten million scientists. Science, 111:123–29.
William Crocker—the man and the scientist. Contrib. Boyce Thompson Inst., 16:1–3.
How to live in two worlds. Sat. Rev. Lit., 33:7, 8, 38, 39.

1951

The frontiers of science. Yale Alumni Mag., 14:6, 7.

1952

Oasis in the jungle. Sat. Rev. Lit., 35:19–20.
Reaction wood and the regulation of tree form. Am. J. Bot., 39: 69–78.
Conserving the intangibles. Yale Conserv. Stud., 1:1–4.
The biology of purpose. Am. J. Orthopsychiatry, 22:457–68.

1953

Most universal diversity. Sat. Rev. Lit., 36:37.
Bones we leave behind. Sat. Rev. Lit., 36:13.
Life is the greatest problem. AIBS Bull., 3:4.
Plant morphogenesis. In: *Growth and Differentiation in Plants*, ed. W. E. Loomis, pp. 19–26. Ames: The Iowa State College Press.
Two Roads to Truth: A Basis for Unity under the Great Tradition. New York: The Viking Press. xii + 241 pp.

1954

Biology and teleology. Bios, 25:35–43.

1955

With K. S. Wilson. *Botany: Principles and Problems*, 5th ed. New York: McGraw-Hill.
Cosmos and the brain. Sat. Rev. Lit., 38:20.
Paul B. Sears. Science, 121:227.
The Biology of the Spirit. New York: The Viking Press.
Stalk diameter as a factor in fruit size. J. Arnold Arbor. Harv. Univ., 36:267–72.

1956

Botany and morphogenesis. Am. J. Bot., 43:526–32.
Science and the human spirit. Bull. Atom. Sci., 12:360–64.

1957

Matter, Mind and Man: The Biology of Human Nature. New York: Harper & Bros.

1958

With Leslie C. Dunn and Theodosius Dobzhansky. *Principles of Genetics*, 5th ed. New York: McGraw-Hill.
The genetic basis of organic form. Ann. N.Y. Acad. Sci., 71: 1223–33.

1959

Three dimensions in graduate education. Grad. J., 2:54–60.

1960

Plant Morphogenesis. New York: McGraw-Hill.

1961

Life sciences and the general reader. Yale Rev., 51:165–74.

1962

Man's unique distinction. Grad. J., 5:194–210.

1963

With K. S. Wilson. *Botany. Principles and Problems*, 6th ed. New York: McGraw-Hill.

The Problem of Organic Form. New Haven: Yale University Press. x + 224 pp.

1966

The past as prelude. Plant Sci. Bull., 12:1–2.

The Bridge to Life, From Matter to Spirit. New York: Simon and Schuster.