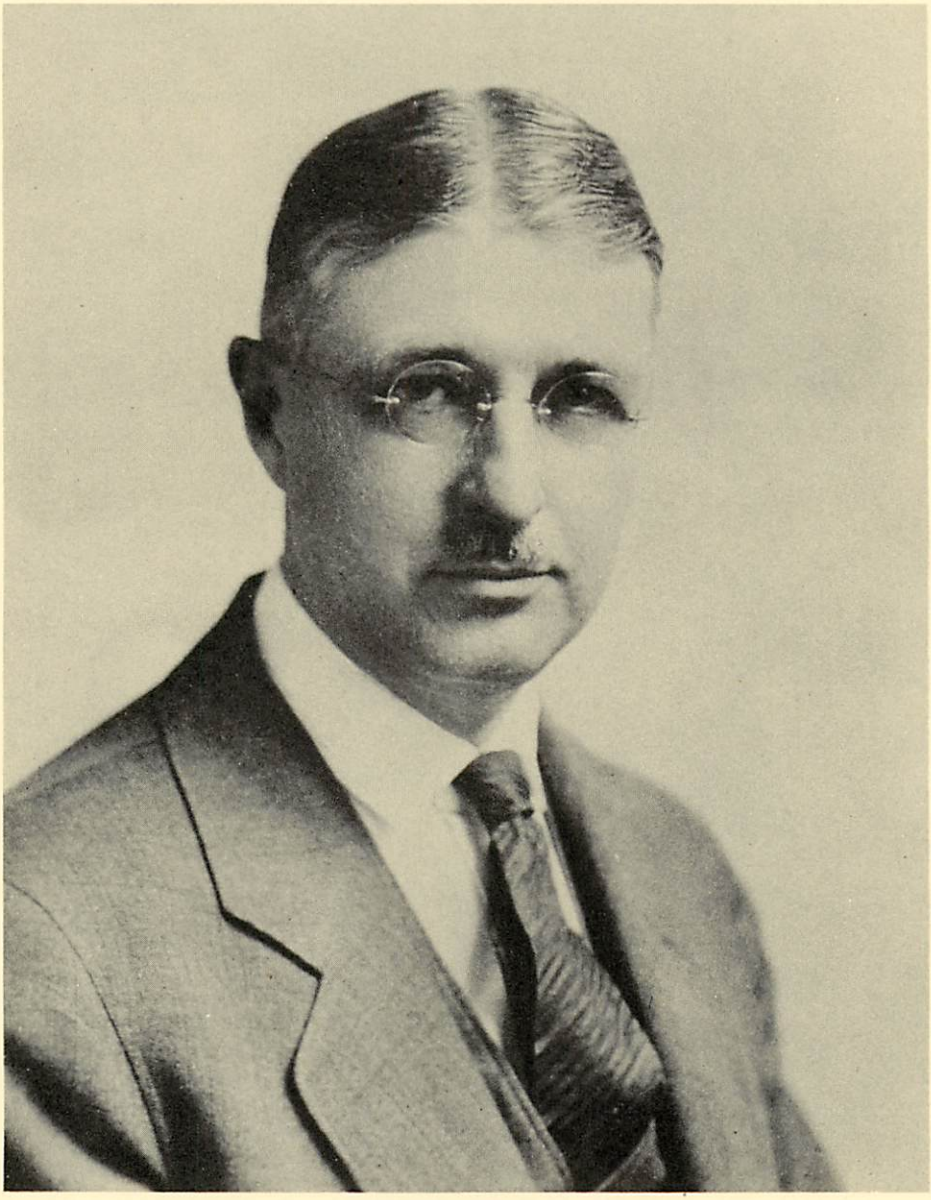

Jos. A. Cushman.

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JOSEPH AUGUSTINE CUSHMAN AND THE CONTEMPORARY EPOCH IN MICROPALEONTOLOGY

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If the life and works of Joseph Augustine Cushman were recounted as a chronicle of his birth, character, acts, and death, the quality and meaning of his work would not be depicted. Cushman lived in an interesting and significant time, and it is my purpose to describe his career in that setting.

Cushman was born of New England Pilgrim stock in Bridgewater, Massachusetts, January 31, 1881, son of Darius and Jane Fuller Cushman. He died at his home in Sharon, Massachusetts, April 16, 1949, at the age of 68 years. He was graduated from the Bridgewater Normal School in 1901 and two years later from Harvard College, S.B. *magna cum laude*, with the class of 1903. As a youth he was precocious in natural history and took a lusty interest in baseball and sailing. Because of his father's ill health, young Cushman was compelled to earn his way through school and in so doing displayed an enterprise that became in later years a great factor in his success as a scientist. While an undergraduate at Harvard he published four brief papers on botany. His exceptional ability as a student attracted the interest of the late Professor Robert Tracy Jackson, who not only supervised his graduate study but arranged for Cushman to have scientific employment while he was a graduate student and subsequently while he was getting established in his career. Cushman held a lifelong esteem for Jackson, as a mentor and teacher.

On October 7, 1903, Cushman married Alice Edna Wilson of Fall River, Massachusetts. Of this union were born Robert Wilson, June 17, 1905; Alice Eleanor, June 18, 1907; and Ruth Allerton (Mrs. Eric Hill), September 12, 1910. Mrs. Alice Wilson Cushman died January 25, 1912. On September 3, 1913, he married Frieda Gerlach Billings who, with his three children and five grandchildren, survive him.

In the six years intervening between graduation in 1903 and receiving his Ph.D. from Harvard in 1909, Cushman had married, supported a growing family, and published 43 papers mostly on cryptogamic plants and marine invertebrates, including Foraminifera. At this stage of his career his interests were chiefly biological, with a preference for the desmids. Before and immediately after receiving his doctor's degree, he found employment at the Museum of the Boston Society of Natural History. While working occasionally at the Woods Hole Oceanographic Institution, 1903–1905, apparently when studying Pleistocene fossils at Gay Head, Marthas Vineyard, he met Dr. Mary Jane Rathbun of the U. S. National Museum, the noted specialist on fossil and living crabs, whose encouragement finally determined him to make the study of the Foraminifera his life work. This acquaintance started the mutually profitable connections with the National Museum which continued until Cushman's death.

Cushman joined the United States Geological Survey in 1912 to work on Foraminifera in the Coastal Plain Section under the direction of Thomas Wayland Vaughan. The employment of a specialist on Foraminifera to work as a stratigraphic paleontologist was somewhat of an event in itself, but for Cushman it was an event of utmost importance. Cushman's training and experience had been largely biological. Duties on the Geological Survey added an invaluable stratigraphic dimension to his work in a decade whose significance for micropaleontology and for Cushman cannot be fully

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grasped without recalling the concurrent developments in oil geology and the status of Foraminifera in paleontology.

During this decade beginning in 1912, the use of geology in discovering oil and gas grew prodigiously. The financial rewards were spectacular and attracted geologists from all other fields of work. The progress of geology in locating subsurface formations and structures favorable for the accumulation of oil and gas was seriously hampered, however, by a simple fact. The bore of a well drill encountered relatively few of the larger fossils on which stratigraphers had depended for recognizing the age and correlation of rock formations. Moreover the drills destroyed the larger fossils that were encountered. To make progress, oil geology required a substitute for larger fossils. It was widely observed that entire shells of Foraminifera as well as certain other microfossils were commonly recoverable in great numbers from well samples, but the Foraminifera were regarded as having no stratigraphic use. As indicated below, a formidable wall of confusion and dogma had to be breached before use of the Foraminifera could be effected.

In England and Europe prior to 1912 the Foraminifera had already become the subject of a large literature as well as of several penetrating attempts at a comprehensive classification. The efforts at classification were fraught in varying degrees with at least six kinds of difficulty: (1) many of the collections described in the literature were not well located stratigraphically, (2) instances of carelessness resulting in contamination and faunal mixture tended to obscure or confuse stratigraphic zonation, (3) the Protozoa in general were regarded as primitive, plastic, highly variable organisms, (4) the Foraminifera constituted a great complex of genera and species whose distinctness was obscured by numerous examples of homeomorphy, (5) the discovery of fossil and living faunas had only begun, and (6) the interest in Foraminifera was rather more biological than stratigraphic, which obscured an essential dimension of classification. These sources of confusion in a large and complex order naturally gave rise to the idea set forth by Williamson and supported by Brady in England that the smaller Foraminifera were so plastic and variable that their species could not be sharply defined biologically or stratigraphically. Dissenting ideas on both aspects of that concept received some expression on the Continent and had to be rediscovered many years later, but the dissents made little impression against the prestige earned by the monumental works in the last half of the preceding century by Carpenter, Brady, and others.

Cushman had worked within the tenets of the British school before 1912 and continued to do so for a time, but the progress of his dissatisfaction became marked in 1914 when he made the earliest attempt in this country to use smaller Foraminifera for determining the age of rock formations penetrated by a well drill (Stephenson, 1914, p. 79–81). In his study of Pliocene and Miocene Foraminifera of the Coastal Plain Cushman (1918) recognized not only stratigraphic zonations but also paleoecologic implications in the faunas. Thirty-five years later those early efforts at stratigraphic, taxonomic, and ecologic discrimination seem diffident and anything but revolutionary. At the time they were actually viewed as radical by a part of the profession.

By 1921, Cushman had published 41 papers and sections of monographs on fossil and living Foraminifera including the chapter on *Foraminifera* in the Zittel-Eastman *Textbook of Paleontology*. These established him as the leading student of the order at a time when the developments in oil geology were beginning to offer spectacular rewards for a workable technique of determining the age of subsurface formations.

In 1921, on leave from the Geological Survey, Cushman completed a private report on Mexican Foraminifera for the Aguila Oil Company of Mexico. In his part of this 379 page report, Cushman gave numerous faunal lists, faunal summaries, detailed local and long-distance correlations, and summaries of the temperature and depth in which the faunas lived. The stratigraphic and ecologic diagnoses were several years ahead of their time, but unfortunately the taxonomic nomenclature that he employed for genera and species was generalized and largely that of the time. Accordingly his taxonomic nomenclature did not adequately represent or express the fine distinctions that he

actually recognized in the species and faunas on which he based detailed correlations. Because of that inconsistency and because of certain areas of disagreement between the foraminiferal and other fossil evidence, Cushman's conclusions were doubted. It is reported that the appearance of discrepancy in the fossil evidence—the result of errors in field interpretation—was later found to be nonexistent.

At the end of the same year at the meeting of The Geological Society of America (Cushman, 1921a, p. 145–146) and in a subsequent paper before the Paleontological Society, Cushman (1921b, p. 206) stated that in extensive studies of the Cretaceous and Cenozoic around the Caribbean and Gulf regions the Foraminifera proved to be abundant, "easily recognizable" stratigraphically, and were more useful than the remains of any other organisms for correlating strata penetrated by wells in anticlines, salt domes, and faulted structures. In his second paper, he took issue with the prevalent idea that the Foraminifera were plastic and did not admit of a finer, more discriminating classification. Following his paper, one by E. T. Dumble (1921, p. 206–207), delivered by E. Richards (Mrs. E. R. Applin), ventured similar ideas. It is reported that in the discussion that followed one skeptic flatly asserted, "Gentlemen, it [stratigraphic correlation by smaller Foraminifera] can't be done!" The issue was clearly drawn. Though a number of economic paleontologists had been and were probing the use of these fossils, Cushman's outstanding position in the study of the Foraminifera caused his positive stand to have a far reaching significance. It marked, more than any other event, the beginning of the contemporary epoch in micropaleontology.

Cushman resigned from the Geological Survey December 31, 1921, and was free to engage in commercial micropaleontology in the United States as well as in foreign countries. While he was employed by the Marland Oil Company in Mexico in 1923 his notable success stimulated redoubled efforts elsewhere. The demand for micropaleontologists and for college courses and literature on the subject quickly exceeded the supply.

As the use of these fossils was still on trial or under attack, and as Cushman wished to settle any lingering doubts of his colleagues in Mexico on that question, he asked them to obtain a number of samples whose source and age were unknown to him in order to test his ability to recognize their age offhand. As I recall his account of the incident, he missed or was uncertain about two or three out of almost 65 samples, but his colleagues were deeply impressed with the worth of the fossils. While in Mexico, he conceived the idea of establishing a foraminiferal laboratory. Ground was broken on his property at Sharon, Massachusetts, April 2, 1923, and the building, housing the Cushman Laboratory for Foraminiferal Research, was ready for work in August of the same year.

The years 1923 to 1924 marked continued and rapid change of attitude toward the Foraminifera. Three incidents at that time give a clear insight into the intense interest and rapid change in micropaleontology and the position occupied by Cushman. The doubts and uncertainties about the usefulness of smaller Foraminifera were described in a paper by T. Wayland Vaughan (1923, p. 517–531) at the Shreveport, Louisiana, meeting of the American Association of Petroleum Geologists in 1923. At the same meeting I attended a luncheon and discussion that was arranged for those interested in the Foraminifera. As I recall, about 15 were there including such well known pioneers in the field as Udden, Ellisor, Knicker, Selig, E. Richards (Mrs. E. R. Applin) and Helen J. Plummer. Udden, taking the lead, was followed by others who stated that their efforts at the stratigraphic use of the smaller Foraminifera were being successful. Udden expressed a strong belief in the usefulness of these fossils but an attitude of caution was indicated by most of those who spoke. Cushman's success was a subject of special mention and encouragement. A year later Charles Schuchert (1924, p. 539–553) was invited to present a paper surveying "The value of microfossils in petroleum exploration." Schuchert's brief paper records the opinions of many specialists and is recommended reading for its historical interest. The change in attitude toward the Foraminifera even within a year was marked. More progress was made in a few years than in the preceding century. The study of the Foraminifera rose

from a neglected place in paleontology to the first position in point of work on a single order of organisms where it has remained.

Cushman once told me that when he was establishing his laboratory he was urged by friends in the oil industry to locate it at one of the great oil centers. Though he recognized the soundness of their reasoning, his love for New England caused him to locate it at his home in Sharon, Massachusetts. In a measure Cushman was the "Proper Bostonian" of Cleveland Amery, who never felt comfortable away from New England. It is interesting to speculate on the significance of his decision to locate the the laboratory here. That a more advantageous location could have been highly successful financially is attested by the fact that he made a modest fortune at a disadvantageous location and did not lose his love for research.

In 1925 Cushman retired from economic micropaleontology to devote the rest of his life to research. In 1927 he visited collections of Foraminifera in Europe to study type specimens so that revisions of the nomenclature and classification could be based securely on actual specimens rather than on a literature with its taxonomic confusions. In 1927 he published *An outline of a reclassification of the Foraminifera* (Cushman, 1927). The following year he expanded that treatise and published it as a manual on "Foraminifera, their classification and economic use" (Cushman, 1928). In this classification the agglutinate (*i.e.*, cemented aggregate of sand) was regarded as the earlier and the calcareous as the later mode of shell building. Moreover, the sac-shaped and tubular shells were treated by him as more primitive than the chambered forms. With the exception of the problematical families Allogromiidae and possibly parts of the Astrorhiziade, the position of families and genera in the geologic column was an important consideration in reconstructing their phylogenetic history.

In previous classifications of the Foraminifera, as with most early efforts at classifying groups of organisms, the phylogenetic kinship of many genera and species was determined largely on the basis of the morphology of adult shells, thereby introducing confusion from homeomorphy.[2] On the contrary Cushman made much use of the so-called law of recapitulation or biogenetic law[3] in working out phylogenetic relationships. The principle of recapitulation was greatly stressed at Harvard when Cushman was a student. Professor Alpheus Hyatt was regarded as one of the first if not the first to discover the principle and Professor Robert Tracy Jackson applied Hyatt's principle with great assiduity in his teaching and work. Cushman's earliest biologic work bears the mark of this influence. As cited in Jackson's memorial (1913) on the life and work of Alpheus Hyatt, Cushman's first publications dealt with growth stages in plants and the foraminiferal family Lagenidae. The question whether Hyatt's and Jackson's emphasis and application of the so-called biogenetic law were overenthusiastic and carried them beyond due consideration of limiting factors in recapitulation may well be raised, but Cushman's application of the principle seems according to present knowledge to have been reasonable and generally in accord with the historical records.

Though the system of classification set forth in Cushman's manual accorded with the historical record for most of the families classed as Foraminifera, the presence of calcareous forms in the Cambrian of England reported by Chapman (1900) comprised an inconsistency with Cushman's theory of the phylogenetic succession of modes of shell building. Cushman ignored this difficulty and was criticized, with some justification, for doing so, but the Cambrian record itself did not quite ring true. The writer had misgivings about the Cambrian or even the Paleozoic age of that material, but the samples obtained for study proved to be barren. Subsequently Dr. Alan Wood (1947) made a thorough and interesting study of the problem and found that the fauna was Jurassic

[2] Homeomorphs are organisms that have similar appearance and appear superficially to be closely related but actually are descended from separate stock; obvious examples are bats and birds, whales and fishes.

[3] The law of recapitulation, commonly attributed to Ernst Heinrich Haeckel (1834–1919), holds that ontogeny recapitulates phylogeny, *i.e.*, the development of the individual repeats the history of the race.

instead of Cambrian. From our discussion of that problem I was never quite sure whether Cushman's ignoring of that difficulty was based on hunch or doubt or whether fate played favorites with him.

The taxonomic nomenclature of the Foraminifera was greatly confused by numerous infractions of the principles of zoological nomenclature. Cushman's manual of 1928 embodied corrections (new or already published in his briefer papers) of most of the irregularities. Consequently, the nomenclature is now largely consistent with the International Rules. This manual is now in its fourth revised edition. Though the classification contains points on which differences of opinion may fairly arise, it placed teaching and use of Foraminifera on a firm footing. As Cushman stated in the first edition, he was not satisfied that he had found the final answers. Until his last days, he continued to restudy and revise the classifications of the families in a series of monographs. The fact that his classification is regarded as the *point of departure* by those who differ with it indicates the scope of its influence on the students and specialists of the world. If the author of this manual had made no other contribution to paleontology, it alone would have earned him an outstanding position in the history of his special field of work.

Cushman rejoined the U. S. Geological Survey in 1930. The rather nominal salary that he received almost equalled his expenses in operating the Laboratory. This however seemed not to have given him much concern because his membership on the Survey staff was advantageous to all concerned. His productivity of work for the Survey was exceptionally large and the threefold cooperation between his Laboratory, the Survey and the Smithsonian Institution was made much closer. He also continued independent publication of monographs and papers in his Laboratory series. In 1932 with Mrs. Cushman, an artist, and an assistant he again visited collections in Europe to get additional first hand knowledge and illustrations of type specimens. The results of this study were incorporated in the revised second edition of his manual in 1933.

Cushman worked with a dispatch and efficiency that never seemed to fag. His brevity, somewhat categorical style, and failure to worry over or to get mired down in problems or scientific dilemmas were not always understood whenever all aspects of his contribution to science were not weighed. These traits were connected with his ability to take an involved problem and emerge on short notice with a workable solution. His manner of passing by or through a problem or a difficulty was often superficial, but time and again he returned, when opportunity and his schedule allowed, to attack the problem or parts of it in more detail. Evidently his strategy was not to lose sight of his program or his major objectives. His reports were usually finished in advance of the date he set.

When Cushman entered the scene, philosophical endeavor in paleontology had outrun its resources of basic knowledge of the classification and of the stratigraphic and geographic distribution of faunas. The knowledge of the Foraminifera was not only inadequate but was confused as to classification, evolution, history, and use in historical geology. Cushman pioneered in reversing certain aspects of that situation. His reconnaissance methods in taxonomy and faunal description enabled him to make far more nomenclatural corrections and to place on record far more faunas, genera, and species of Foraminifera than any other person. He thereby broadened the base of observations on which philosophical endeavor may renew its efforts to discover the larger principles of dynamic biology. All this was done with amazing consistency, considering the size and complexity of the field covered.

The story of Cushman's career does not represent merely the history of an individual—it is the history of the family of which he was the head. Mrs. Frieda Billings Cushman made it her life work to maintain a favorable environment for the Laboratory work and to perform the odds and ends of duties needed to keep the institution operating on schedule. Her cultural interests and hospitality furnished visitors, students, and associates at the Laboratory with diversions that they can always recall with pleasure. Alice E. Cushman acted in various capacities as treasurer, editor, secretary, and keeper of publications. Both she and Mrs. Cushman performed a thousand and one odd

duties that would have dissipated the energy of the Director of the Laboratory. A relative of Mrs. Frieda Cushman, Miss Susan Minns, and various members of the immediate family made large contributions of money to aid research and to bear the cost of special publications. Acknowledgments for those appear in various monographs.

After Cushman's death, Mrs. Cushman and Robert W. Cushman gave important aid and co-operation in transferring the collections and library to the National Museum. Robert, Alice, and Ruth Cushman (Mrs. Eric Hill) and Mrs. Cushman joined a group of paleontologists in organizing the Cushman Foundation for Foraminiferal Research. A gift from Mrs. Cushman enabled this Foundation to start immediately in serving its purpose of promoting and publishing the results of research on the Foraminifera.

The activities of the family and of the Laboratory were scheduled and integrated in a remarkable way, yet the schedule seemed natural and not grinding to the spirit. Each visiting scientist and research student pitched in with the Laboratory Staff to clean house and to perform special tasks that were required to keep the Laboratory in working order. Work and research proceeded in an orderly fashion without the titular director seeming to employ authority or outright direction.

Many of those who worked or studied at the Laboratory were invited to join the family in hiking, camping, and seeing the New England scenery in all seasons. Cushman enjoyed fishing and sketching landscapes, and he displayed exceptionally good taste in photographing landscapes and fall colors in Kodachrome. He practised his hobbies with energy and dispatch.

The New England thrift in running the institution was itself an interesting study in ways of conserving resources. At an early stage in his career, Cushman studied methods of investment. He kept abreast of political and economic trends for their bearing on investment by regularly reading the newspapers and two or more financial journals. Every afternoon he listened to the radio report on the stock exchange while labeling slides or doing other work, or using the interval as a brief period of rest. His skill and success in investment, even during the economic depression of the 1930's, caused a member of a well-known brokerage firm in Boston to inquire half seriously if he would work for them.

Cushman was a Unitarian, an Odd Fellow, and a Mason. He and the family regarded their participation in community and civic affairs and voting as obligations that a citizen could not shirk. For over 20 years Cushman received advanced students from Harvard and Radcliffe and provided instruction without compensation. He was generous with his time and knowledge. If the costs of operating the Laboratory and if the time he gave on his own means to research, teaching, and scientific aid to other micropaleontologists were figured in terms of equivalent effort in commercial paleontology, those gifts to science would amount to a fortune.

At the end of his life Cushman alone or as senior author had published 536 articles, reports, monographs, and his manual *Foraminifera, their classification and economic use.* He left eight completed and nine partly completed works mostly of larger proportions which have subsequently been or will be published. He was responsible for an impressive share of the fossil and Recent faunas so far described. The new genera and species he described constitute a large proportion of those so far known. Because of his systematic methods of working and keeping records his work perpetrated incredibly few taxonomic homonyms or absolute synonyms. His card catalogue of the species and genera of Foraminifera contains nearly 100,000 cards. Incidental to his work and world-wide reputation and connection with the U.S. Geological Survey and the U.S. National Museum, he assembled the most impressive single collection anywhere of the smaller Foraminifera of the world. At the time of his death the collection contained slightly more than 12,000 primary and secondary type specimens. His own collections and library on Foraminifera were bequeathed to the Smithsonian Institution. These, with extensive collections of the U.S. Geological Survey that were in his care, will be preserved as a unit in the National Museum.

Cushman's work, more than that of any other person, was responsible for introducing the contemporary epoch in micropaleontology. For three decades he was its leading figure as a

teacher, as the founder and director of its most famous Laboratory, and as the leader, in volume and significance of work. Cushman received several high honors and belonged to a number of outstanding American and foreign scientific societies. Although his work was appreciated during his life time, the honors that came to him scarcely seem to warrant mention in a brief account of a man whose accomplishments were so extraordinary.

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