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Alcide d'Orbigny and American micropaleontology

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Abstract – Alcide d'Orbigny's foraminiferal work appeared almost 100 years before serious studies of Foraminifera began in America. Americans both under- and well-appreciated d'Orbigny, but he was rejected by the British, who believed most Foraminifera were variations on a few long-lived types. The American pioneer J.A. Cushman mostly ignored d'Orbigny, but Galloway and Loeblich and Tappan praised d'Orbigny and recognized more of his genera than previous workers. In America, d'Orbigny-type models of Foraminifera became an effective teaching tool. Americans now consider d'Orbigny as the 'father of micropaleontology' for his descriptive and geologic studies that were so influential in starting the comprehensive study of Foraminifera. ***To cite this article: J.H. Lipps, C. R. Palevol 1 (2002) 461–469.*** © 2002 Académie des sciences / Éditions scientifiques et médicales Elsevier SAS

d'Orbigny / Foraminifera / micropalaeontology / United States

Résumé – Alcide d'Orbigny et la micropaléontologie américaine. Le travail d'Alcide d'Orbigny sur les Foraminifères a devancé de presque 100 ans les premières études réalisées en Amérique sur ce sujet. Selon les auteurs, les Américains ont diversement apprécié le travail de d'Orbigny, mais ce dernier a été rejeté par les Anglais, qui pensaient que la plupart des espèces de Foraminifères n'étaient que des variétés de quelques taxons connus sur de longues périodes. J.A. Cushman, pionnier américain de la micropaléontologie, a souvent ignoré d'Orbigny, mais ce ne fut pas le cas de Galloway ou de Loeblich et Tappan, qui ont loué le travail de d'Orbigny et reconnu la validité d'un grand nombre de ses genres. En Amérique, les modèles de Foraminifères de d'Orbigny ont été considérés comme outil d'enseignement. Les Américains reconnaissent maintenant d'Orbigny comme « le père de la micropaléontologie » pour l'importance de ses études descriptives et géologiques, qui sont les fondements des travaux sur les Foraminifères. ***Pour citer cet article : J.H. Lipps, C. R. Palevol 1 (2002) 461–469.*** © 2002 Académie des sciences / Éditions scientifiques et médicales Elsevier SAS

d'Orbigny / Foraminifères / micropaléontologie / États-Unis

1. Introduction

Alcide d'Orbigny, renowned for his paleontological, geological and biological work in the early 1800s, is especially well remembered by micropaleontologists for his descriptions and understanding of Foraminifera. He began his career in science at an early age by describing the order and many species. Because of the huge amount of descriptive systematic and stratigraphic work he did with Foraminifera [29], he is sometimes referred to as the "father of micropaleontology" [18]. He could probably be legitimately considered the 'father' of several other subdisciplines as well [15, 27, 30]. Here I examine his influence on both American and British micropaleontology of Foraminifera, since these two are linked by a common language and literature.

The so-called British school of foraminiferology arose soon after d'Orbigny's death in 1857 with the publication of Williamson's monograph on the Recent Foraminifera of Great Britain [32]. The British approach was characterized by conservatism in species recognition and geological longevity of those few species that were recognized. American micropaleontology began much later with the initial work of Chapman, Cushman, and a few oil company paleontologists working on

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Foraminifera before 1915 [20]. Cushman's early work was largely modeled on the English school, Brady's *Challenger* Report in particular [1]. Later as he examined his own material, especially from oil fields, he began to develop his own characteristic views [3, 28]. While Cushman was certainly the most dominant and influential American foraminiferal worker, he was not alone. Others began to study Foraminifera, and these workers commonly disagreed with Cushman [28]. Hence no real American school of micropaleontology existed; instead many workers tried to understand and develop the field. Alcide d'Orbigny had enormous impact on both British and American micropaleontologists, as witnessed by the continued interest in his work, his taxa, his collections including models, and his localities.

2. Alcide d'Orbigny (1802–1857)

By the time Alcide d'Orbigny was born in 1802, Foraminifera had already been known for more than 2500 years [20]. Herodotus, in the 5th century BC, thought the larger Foraminifera (*Nummulites*) weathering from the Egyptian pyramids were lentils dropped by the pyramids' construction workers that had turned to stone. Pliney the Elder repeated this story in 76 AD, and noted that they occurred throughout the region. Indeed nummulitic limestones are common throughout the Mediterranean region and are easily recognizable because of the coin-like foraminiferal tests. Clusius in 1550 knew this too, but he had a different interpretation—*Nummulites* were coins scattered by retreating Tartars which King Ladislaus turned to stone to prevent his troops from stopping to pick them up. Smaller Foraminifera, of course, remained unknown.

All of this changed and set the stage for Alcide d'Orbigny when Robert Hooke turned his microscope on beach sand. He found a foraminiferan and realized that it was an organism; indeed he called it a "tiny water snail" [16]. Antony van Leeuwenhoek also found Foraminifera, which he illustrated, in the stomachs of shrimp [11, 17]. Like Hooke, he called these "very little snail shells". For the next century and a half, various workers found Foraminifera and always referred them to metazoan groups, like cephalopods, snails or worms. In 1758, Linné included 15 species of Foraminifera, assigned to two genera (*Nautilus, Serpula*) that also included metazoans, in his *Systema Naturae* [19]. Others, like Fichtel and Moll, Montagu, Walker and Boys, de Montfort, Lamarck and Defrance, soon after Linné proposed new species and genera of Foraminifera [3]. By the time Alcide d'Orbigny published his own work in 1826 [23], 87 genera and hundreds of species of Foraminifera had been formally described and referred to metazoan groups. D'Orbigny entered the study of Foraminifera just as it was about to blossom into its own discipline.

Alcide d'Orbigny, born in Couëron, France, in 1802 to Marie-Anne and Charles d'Orbigny, worked with his father studying Foraminifera from the local beaches near their home [18, 29–31]. At age 11, Alcide drew and described Foraminifera for his father. Later the family moved to Esnandes, near La Rochelle, when Alcide was 13, and to La Rochelle itself when he was 18. In this vicinity, which Heron Allen [15] considered a most superb place to learn about Foraminifera because of the huge estuary and the molluscan trade there, Alcide began his own studies of Foraminifera under his father's guidance. He and his father examined the nearby marine and estuarine sediments finding numerous Foraminifera in them. As La Rochelle was also a major port for sea-going vessels, Charles arranged for seamen and captains to bring back samples of sediment from far parts of the world's oceans, which Alcide also studied. In the d'Orbigny sample collections in Paris, bottles and vials are labeled with the names of exotic places – Bourbon, Madagascar, Otahyte and so on. Heron Allen [15] devoted 105 pages to Alcide d'Orbigny's life and times with foraminifera; to cover d'Orbigny's other accomplishments in the same detail would require 10-fold or more pages. Much of d'Orbigny's materials, both of Foraminifera and of other sorts, is preserved in the 'Muséum national d'histoire naturelle' in Paris.

Like all workers before them, the d'Orbignys considered foraminiferal tests to be the shells of metazoans, mostly cephalopods. Although this conclusion seems peculiar by today's standards, the degree of knowledge of these and other organisms was rudimentary at best, microorganisms being a prime example. Many foraminiferal tests certainly do look remarkably like tiny cephalopods, and small ammonites even grade in size down to that of some Foraminifera. They are commonly found together in the same rocks as well. To consider Foraminifera as cephalopods therefore seemed logical and not unusual at all in the early 1800's. D'Orbigny's father, who had great influence on Alcide, had already described living Foraminifera as though they were truly cephalopods having little arms or tentacles.

Between 1823 and 1826 d'Orbigny issued 100 plaster models of Foraminifera that could be purchased in four sets of 25 each for 20 Fr. He made the models by sculpting them in gypsum and then molding those. The molds were filled with plaster of Paris, so that many copies could be made. Most sets of the plaster models

seem to have been lost, although sets exist at the Natural History Museums in Paris, London and Washington, DC, as well as a few elsewhere. These models were constructed to illustrate Foraminifera to the interested person who might be without a microscope, and because the methods of publication of figures were not well developed.

Alcide d'Orbigny published his first work on Foraminifera in 1826 [23] as an introduction to Foraminifera to accompany his models. In this, his *Tableau méthodique*, he laid out the first classification for Foraminifera and proposed that they be placed in his new Order Foraminifères in the Cephalopoda. He included in it 64 genera grouped in five families based on the plan of growth. The presumption that Foraminifera were tiny cephalopods by Alcide and his father surely prompted d'Orbigny's diagnosis of his Order:

> "The Cephalopoda of this Order have a bursiform body, in the posterior portion of which the shell is enclosed; this body is sometimes of great volume compared with that of the head, to which it serves as a refuge in moments of danger, enclosing it almost entirely in the anterior folds of the skin. This head is very small, slightly, or not at all, distinct from the body, and terminated by numerous tentacles, which are disposed in several rows around the mouth, which is central."

Heron Allen [15 (p. 25)] thought this description to be "absolutely staggering". He added: "At such a description of a Foraminifer as this the brain of the modern Rhizopodist reels, and his senses gape!" While d'Orbigny's diagnosis is indeed weird in light of the subsequent knowledge of Foraminifera, it seems less strange in the context of the times and in view of how some living Foraminifera dispose their protoplasm and pseudopodia. If d'Orbigny sought to see the body parts of a cephalopod in Foraminifera, a living specimen would amply provide the arrangements that could be so interpreted with a poor microscope and a predisposed mind.

Although d'Orbigny clearly named the Foraminifera for the first time in the *Tableau*, he is not given credit for the systematic use of the name, for he used the French vernacular rather than a Latin term, as required by the International Commission on Zoological Nomenclature. Instead, the honor goes to Eichwald when in 1830 he Latinized the name [21].

The *Tableau* was an introduction to the Foraminifera, with the models and over 150 plates intended for publication, with the *Tableau* providing details. The *Tableau* thus was an incomplete work, hurriedly published, so d'Orbigny could set sail as the "voyageur naturaliste du Muséum d'histoire naturelle" to South America [3]. He was appointed to this position in November, 1825, just as he was working on the *Tableau*. The preparations for the voyage and its departure on July 29, 1826, took much of d'Orbigny's attention. This led to later nomenclatural problems with the 552 species listed in the *Tableau*, most of which remained undescribed and not illustrated. Thus, d'Orbigny was not credited with many of these names, except in cases where later publication of his figures validated his work [3].

D'Orbigny left Paris for South America the same year that the *Tableau* was published and did not return until 1834. During this time, d'Orbigny busied himself with zoological, botanical and anthropological descriptions of Argentina, Brazil, Uruguay, Chile, Peru and Bolivia. For this work, he is deservedly famous [15, 27] and his name remains associated with a huge number of taxa and discoveries. When d'Orbigny returned to Paris, he discovered that Dujardin had recognized that Foraminifera were not metazoans at all, but some "lowest forms" of life that he named 'Rhizopoda' [12, 13]. D'Orbigny seemed unphased by this, and declared that he also had discovered these facts while he was in South America. Even though d'Orbigny's classification was assailed by a number of other workers, he continued his studies, publishing nine works on Foraminifera among the many other volumes and papers he wrote. In these, d'Orbigny described well over 1500 species of Foraminifera [29, 31]. His 1826 classification included 64 genera, 51 newly described [3], and he continued to add genera and adjust his classification until 1852 when he had 72 genera, 53 named by himself previously [3], in nine families grouped into seven orders [26]. He also recognized that Dujardin was correct and that Foraminifera were not cephalopods; he elevated them to a Class. In his Tertiary Vienna Basin paper on Foraminifera, he stated that foraminiferal species were very numerous, had restricted geographic ranges, and were specially created 27 different times [25]. These views were reinforced by his other work in paleontology throughout France.

3. D'Orbigny attacked

Other workers did not readily accept much of what d'Orbigny wrote about Foraminifera [15]. Even his countryman, Deshayes, in a particularly unfriendly attack on d'Orbigny's foraminiferal classification called it a "vicious", "unnatural" and "defective" system [10 (p. 224)]. D'Orbigny claimed that Deshayes failed to understand his models of Foraminifera, and he never forgave him for his harsh words. However, as Heron Allen [15] notes, eventually Deshayes's classification of Foraminifera became more accepted than did d'Orbigny's. Alcide d'Orbigny passed away at age 55, disappointed at the reception his work received. He was

passed over several times for election to the French Academy of Sciences and other micropaleontologists scorned his work. Yet his stature today in France and elsewhere as a chronicler of life through time is outstanding.

The emerging British school of foraminiferology found little in d'Orbigny's work to admire. Williamson, Carpenter, Parker and Jones all believed that d'Orbigny made far too many genera and species for such "simple organisms" as Foraminifera. William C. Williamson, for example, thought d'Orbigny had made "species with reckless indifference to the innumerable inosculating forms" [32]. William B. Carpenter in his famous, coauthored Ray Society publication "Introduction to the Study of Foraminifera" [2], on the first page, second sentence of the Preface, justifies much of what follows by attacking d'Orbigny: "With the progress of my own researches, however, I came more and more strongly to feel how unsatisfactory are the results of the method pursued by M. d'Orbigny and by those who have followed his lead, both as regards the multiplication of *species*, the distinction of *genera*, and the grouping of these genera into *families* and *orders*." He then wrote that he and his colleagues (and coauthors) William K. Parker and T. Rupert Jones had come to the same conclusions that "*. . . sharply defined divisions* —whether between species, genera, families, or orders—*do not exist among Foraminifera*." Thus, the British school, represented by these men, was in clear opposition to d'Orbigny's views concerning Foraminifera. Carpenter, Parker and Jones [12] recognized only 18 of d'Orbigny's genera (Table 1), although nearly all others were discussed, mostly in disparaging terms, in the descriptions of other genera. Carpenter elaborated this view with eight "general propositions" about Foraminifera in his Preface to the *Introduction*:

I. "The range of variation is so great among *Foraminifera*, as to include not merely the differential characters which systematists proceeding upon the ordinary methods have accounted *specific*, but also those upon which the greater part of the *genera* of this group have been founded, and even in some instances those of its *orders*."

II. "The ordinary notion of *species*, as assemblages of individuals marked out from each other by definite characters that have been genetically transmitted from original prototypes similarly distinguished, is quite inapplicable to this group, since even if the limits of such assemblages were extended so as to include what would elsewhere be accounted genera, they would still be found so intimately connected by gradational links, that definite lines of demarcation could not be drawn between them."

III. "The only natural classification of the vast aggregate of diversified forms which this group contains, will be one which ranges them according to their direction and degree of divergence from a small number of principal family-types...

IV. "Even in regard to these family-types, it may be fairly questioned whether analogical evidence does not rather favor [...] their derivation from a common original, than that of their primitive distinctness."

V. "The genetic continuity between the *Foraminifera* of successive geological periods is as complete as the nature of the case admits."

VI. "There is no evidence of any fundamental modification or advance in the Foraminiferous type from the Paleozoic period to the present time. [...] There is no indication of any tendency to elevation towards a higher type."

VII. Here Carpenter urges that the general principles deduced from Foraminifera should be applied to all "those great types of Animal and Vegetable forms".

VIII. Carpenter suggests that the aim of the "Philosophic Naturalist should be to determine how small a number of primitive types may reasonably be supposed to have given origin by the ordinary course of 'descent with modification' to the vast multitude of diversified forms that have peopled the globe..."

These views had great impact on the English-speaking world. Even Charles Darwin was influenced by Carpenter, and he addressed the problem of geologic longevity in Foraminifera in the 4th edition of the *Origin of Species*: 'It is not an insuperable difficulty that Foraminifera have not, as insisted on by Dr. Carpenter, progressed in organization since even the Laurentian epoch; for some organisms would have to remain fitted for simple conditions of life, and what could be better fitted for this end than these lowly organized Protozoa" [9 (p. 402)]. These views remained in place among the British, but not on the Continent, where studies of microfossils included much description of species and genera and reclassification, as well as stratigraphic documentation of Foraminifera [3].

The British views changed with Henry B. Brady and his publication of the Foraminifera dredged by H.M.S. *Challenger* [1]. Brady must have found himself in a quandary, for he praised his friends, Carpenter, Parker, Jones, and Williamson, yet rejected their views of generic and species systematics. He notes in the *Challenger Report* (p. v) that: "There is little in d'Orbigny's classification or in his definition of the Order that commends itself to the student of the present day..." Then he goes on to write that Carpenter and colleagues' views concerning the recognition of genera and species "are for the most part incontestable, but they embody

Table 1. D'Orbigny genera recognized as valid in each of seven major British and American foraminiferal classifications. Page numbers are indicated for the description of each genus. A dash indicates the name was considered a synonym or was not referred to in the systematic section. Total number of valid d'Orbigny genera is listed below each publication.

Tableau 1. Genres de d'Orbigny reconnus comme valides dans chacune des sept principales classifications de Foraminifères britanniques et américaines. Les numéros de page correspondant à la description de chaque genre sont indiqués. Un trait indique que le nom était considéré comme un synonyme ou n'était pas mentionné dans le chapitre de systématique. Le nombre total de genres de d'Orbigny est indiqué sous chaque publication.

D'Orbigny's genera & date published	Carpenter 1862	Brady 1884	Cushman 1928, 1948	Galloway 1933	Loeblich & Tappan 1964, 1987
Total of the 66 genera recognized	18	43	51, 52	54	54, 59
Adelosina, 1826	—	—	—, —	—	—, 328
Alveolina, 1826	99	221	—, —	—	—, 361
Amphistegina, 1826	241	739	281, 302	315	C685, 609
Anomalina, 1826	—	671	315, 332	287	C754, —
Articulina, 1826	—	182	150, 180	130	C478, 350
Assilina, 1839	—	76	212, 239	420	—, 682
Asterigerina, 1839	—	—	281, 301	314	C592, 609
Bigenerina, 1826	—	368	118, 116	228	254, 172
Biloculina, 1826	—	139	—, —	—	—, —
Bolivina, 1839	—	416	221, 268	351	C549, 498
Bulimina, 1826	194	397	247, 266	362	C559, 521
Calcarina, 1826	216	711	282, 303	312	C628, 671
Candeina, 1839	—	622	310, 327	332	C675, 482
Cassidulina, 1826	197	427	292, 313	368	C737, 504
Chrysalidina, 1839	193	387	253, 132	360	C279, 185
Citharina, 1839	—	—	—, —	—	C514, 412
Clavulina, 1826	—	393	127, 130	217	C279, 182
Cruciloculina, 1839	—	—	—, —	—	C458, 338
Cuneolina, 1839	193	67	116, 135	227	C285, 148
Cyclolina, 1846	—	—	104, 111	137	C301, 94
Dendritina, 1826	—	—	217, 243	136	C482, 370
Dentalina, 1826	—	—	187, 215	246	—, —
Dimorphina, 1826	—	580	198, 226	260	C516, 404
Faujasina, 1839	—	732	208, 236	270	C640, 678
Flabellina, 1839	—	70	193, —	240	—, —
Gaudryina, 1839	—	377	126, 123	216	C269, 136
Gemmulina, 1939	—	—	—, —		—, 701
Glandulina, 1839	—	—	188, 228	244	C537, 432
Globigerina, 1826	181	589	303, 322	329	C669, 389
Globulina, 1839	—	—	—, 226	—	C530, 419
Guttulina, 1839	—	—	196, 224	258	C531, 419
Gyroidina, 1826	—	—	272, 290	284	C750, 638
Hauerina, 1839	—	190	150, 183	128	C470, 334
Heterostegina, 1826	288	745	213, 240	421	C650, 684
Lingulina, 1826	—	517	192, 218	252	C528, 399
Marginulina, 1826	—	526	187, 214	243	C520, 411
Nonionina, 1826	—	724	—, —	—	—, —
Oolina, 1839	—	—	—, —	245	C540, 427
Operculina, 1826	247	742	213, 239	420	—, 686
Orbitoides, 1848	298	76	337, 246	430	C710, 646
Orbitolina, 1850	—	—	182, 210	206	C309, 166
Orbulina, 1839	176	606	306, 326	333	C675, 494
Pavonina, 1826	—	374	230, 272	349	C563, 529
Placopsilina, 1850	—	314	176, 207	190	C247, 80
Planorbulina, 1826	206	655	326, 340	297	C693, 588
Planulina, 1826	—	—	318, 334	292	C686, 580
Polymorphina, 1826	166	557	198, 229	257	C530, 420
Pyrulina, 1839	—	—	—, 228	—	C533, 421
Quinqueloculina, 1826	—	—	146, 177	119	C458, 336

Table 1. Suite.
Tableau 1. Suite.

D'Orbigny's genera & date published	Carpenter 1862	Brady 1884	Cushman 1928, 1948	Galloway 1933	Loeblich & Tappan 1964, 1987
Rimulina, 1826	—	70	—, —	251	C529, 399
Robertina, 1846	—	—	246, 265	368	C777, 451
Rosalina, 1826	—	—	—, —	—	C584, 561
Sagrina, 1839	—	—	—, —	348	C569, 519
Sphaeroidina, 1826	185	619	300, 321	325	C547, 564
Spiroloculina, 1826	—	147	149, 178	111	C453, 331
Triloculina, 1826	—	—	151, 184	123	C466, 344
Trochulina, 1839	—	—	—, —	—	—, 559
Truncatulina, 1826	—	658	—, —	—	—, —
Uvigerina, 1826	169	573	256, 273	373	C565, 525
Vaginulina, 1826	—	529	192, 218	238	C524, 414
Valvulina, 1826	146	391	128, 129	212	C279, 183
Verneuilina, 1839	—	382	126, 122	215	C268, 136
Vertibralina, 1826	72	186	168, 196	130	C456, 319
Virgulina, 1826	—	413	248, 268	364	—, —
Vulvulina, 1826	—	—	118, 117	228	C241, 113
Webbina, 1839	—	348	324, 339	296	C448, 323

only one aspect of the subject" (p. vi), and: "Thus, whilst recognizing fully the value of the plan introduced by my friends [...] of grouping the almost endless varieties of the Foraminifera round a small number of typical and subtypical species, as a method of study. [...] I have been unable to follow them so far as to make it a basis of nomenclature" (p. vii). Brady thus frees himself to develop his own methods of recognizing species and genera while he tried to understand the huge diversity of Foraminifera discovered on the *Challenger* expedition. In that report, he utilized 43 d'Orbigny genera (Table 1).

4. D'Orbigny and American micropaleontology

American micropaleontology developed more slowly [20]. Micropaleontology started in oil company laboratories set up between 1914 and 1921. During this same time, the pioneer American foraminiferologist, Joseph A. Cushman (Fig. 1), started his intensive studies of Foraminifera, although he had already published 50 papers in botany, paleontology, invertebrate zoology, and protozoology (including foraminifera). After 1910, he wrote only about Foraminifera, establishing himself as the expert on the group. In 1922, he consulted for an oil company in Mexico, earning enough money to construct a laboratory in Sharon, Massachusetts [28]. Cushman founded his own journal, the *Contributions from the Cushman Laboratory for Foraminiferal Research*, where he published numerous papers on new species, stratigraphic occurrences, distribution, and classification of Foraminifera. Cushman initially followed Brady's *Challenger* classification [4, 28], but later developed his own different ideas, concluding that species were distinctive, commonly short in geologic range, and hence useful in biostratigraphy. His organizing principals were based on the idea that the earliest parts of the test showed relationships more clearly than the adult forms because those were commonly modified [3]. Cushman wanted a classification that would show the natural relationships of Foraminifera, at least as he envisioned them. He revised his 1925 outline [5], rejecting Brady's scheme, and then published a more detailed discussion in his book *Foraminifera – Their Classification and Economic Use* [6]. In this book and its subsequent editions, Cushman did not discuss previous workers much devoting only a sentence or two to d'Orbigny and Brady. Cushman was well aware of the importance of priority in nomenclature, and he was careful to attribute his taxa to their original describers. In 1928, he recognized 51 d'Orbigny genera, and in the last edition of his book, he listed 52 [8]. In addition to d'Orbigny's genera, Cushman thought he should understand d'Orbignian species as well, and obtained original material and examined specimens in the original collections in France [7].

Joseph Cushman was not alone in studying Foraminifera in America. At the same time, J.J. Galloway (Fig. 2) ran an oil company laboratory and was later professor at Columbia University. He developed his classification of Foraminifera and he discussed it with Cushman in 1926 [3, 28]. Galloway accused Cushman

Fig. 1. Joseph A. Cushman and his students, Frances Parker (standing) and Margaret Moore at the 'Naturhistorisches Staatsmuseum' in Vienna, July 1932 (courtesy of the Todd Library, Smithsonian Institution).

Fig. 1. Joseph A. Cushman et ses étudiantes, Frances Parker (debout) et Margaret Moore au Naturhistorisches Staatsmuseum (Muséum national d'histoire naturelle) de Vienne, en juillet 1932 (reproduit avec l'aimable autorisation de la bibliothèque Todd, Smithsonian Institution).

of taking his ideas [14 (p. vii)] for Cushman's own book published two years later. In 1933, Galloway finally was able to get his own *Manual of Foraminifera* published [14]. Whatever the case with Cushman, and it was complicated [3, 28], Galloway's book is remarkable in three matters regarding d'Orbigny. First, Galloway included as the frontispiece of his *Manual* an engraving of Alcide d'Orbigny that appeared in d'Orbigny's *Voyage* in 1836 [24]. Galloway entitled this illustration "ALCIDE D'ORBIGNY, GREATEST STUDENT OF FORAMINIFERA". Second, his section on classification of Foraminifera included an excellent summary of d'Orbigny's work, with a lesser number of words devoted to d'Orbigny's critics, the British in particular. In fact, Galloway says little about Carpenter, Parker and Jones while calling Brady "the most brilliant student of Foraminifera since d'Orbigny" (p.10). Third, the *Manual* contained 54 of

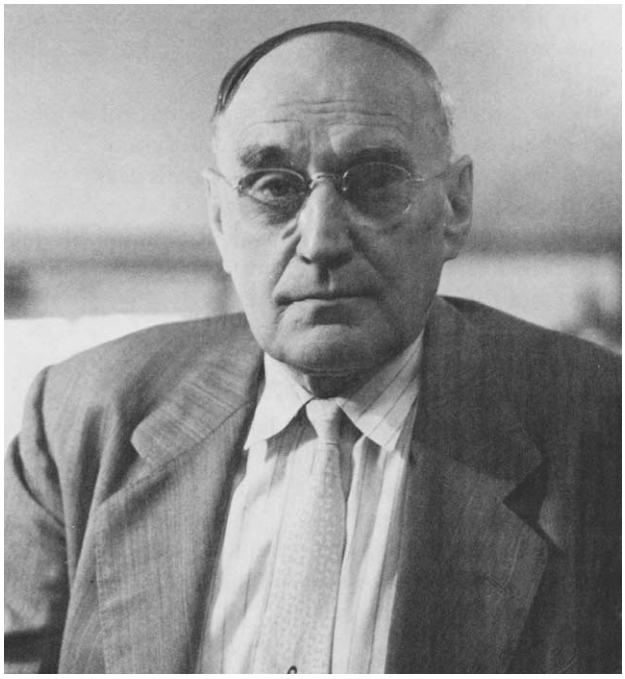

Fig. 2. Jesse J. Galloway (courtesy of the Department of Geology, Indiana University).

Fig. 2. Jesse J. Galloway (reproduit avec l'aimable autorisation du département de géologie de l'université d'Indiana).

d'Orbigny's genera, two more than Cushman's last edition (Table 1), and the same or just five fewer than Loeblich and Tappan's comprehensive works 31 and 54 years later [21, 22].

The last great American systematic treatments were by A. R. Loeblich and H. Tappan (Fig. 3) [21, 22]. In these works, they considered all the known generic descriptions of Foraminifera from any place in the world. In general, these works recognize far more genera than ever before in more suprageneric categories. This should not be surprising as genera keep on being described, especially after compendia are published. Both their 1964 [21] and 1987 [22] books are most likely the most cited foraminiferal works in history.

Like Galloway, Loeblich and Tappan held d'Orbigny in high regard. They had traveled to Paris in the 1950's and studied d'Orbigny's material there and collected from his localities. From this, they concluded that he was a very careful and reliable observer [21, p. C56]. Loeblich and Tappan thus accepted 54 and 59 of d'Orbigny's genera (Table 1) in their books [21, 22].

D'Orbigny had influence on the way Foraminifera were taught in the United States as well. The idea of using large-scale models to demonstrate features of Foraminifera, as d'Orbigny had, caught on in American universities and colleges, where they made the study of Foraminifera much easier. His models were emulated on several occasions by the American Museum of Natural History and other manufacturers. Such models can still be purchased for classroom and other use.

Fig. 3. Helen Tappan (Loeblich) and Alfred R. Loeblich, Jr., in 1982, when both shared the Paleontological Society Medal.

Fig. 3. Helen Tappan (Loeblich) et Alfred R. Loeblich Jr., en 1982, lorsqu'ils partagèrent la médaille de la Société de paléontologie.

5. Summary

Most American foraminiferal workers regard Alcide d'Orbigny as one of the outstanding figures in the history of the field. Not only did he start the systematic study of them, but the descriptive work he did in the first half of the 1800s remains of value in present-day classifications and studies. His ideas of the relationships of the Foraminifera to other groups followed the tradition of the time, but when Foraminifera were demonstrated to be single-celled organisms rather than metazoans, he readily accepted it. Although the early British school generally disagreed with most of what d'Orbigny did, American (and later British) workers came to appreciate his initial efforts. Indeed, many of his validly described genera are included in the American systematic treatments, and his method of using models to instruct about Foraminifera became widely used in courses. His collections and publications remain a valuable resource for all micropaleontologists!

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