DINOSAURS, MUSEUMS, AND THE MODERNIZATION OF AMERICAN FOSSIL PREPARATION AT THE TURN OF THE 20TH CENTURY

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Abstract

By the turn of the 20th century, the institutional setting for American vertebrate paleontology had shifted from private collections into large, well-funded, urban museums, including the American Museum in New York, Pittsburgh's Carnegie Museum, and the Field Columbian Museum in Chicago. This shift ignited a fierce competition among museum paleontologists to display fossil vertebrates—especially gigantic Jurassic sauropods from the American West. Museums launched ambitious expeditions aimed at collecting exhibit-quality dinosaurs. The net result was an enormous influx of unprepared fossils. Getting these fossils into shape for study and display posed a number of novel challenges for fossil preparators. New material arriving from the field required room for temporary storage and dedicated laboratory space in which to prepare it. Adapting a basic fossil preparation lab to the needs of dinosaur paleontology often involved considerable extra investment in equipment and space. Finding, training and retaining skilled fossil preparators could be very expensive, also. The sheer volume of work, and its unique demands, led to increased specialization and professionalization among the science support staff. This in turn, drove higher standards for the work, leading to important lab innovations. Preparators developed new techniques to handle the workload, some of which required expensive new machinery, entirely new systems (e. g., electricity, or pneumatic apparatus) or new spaces in which to operate the equipment, some of which produced particularly noxious dust, noise, or smells. The essential task of fossil preparation, usually performed in backroom or basement labs by low-paid minions working in relative obscurity, was a vital prerequisite for the higher profile work of publishing original research and putting fossils on display.

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Introduction

By the turn of the 20th century, the institutional setting for American vertebrate paleontology had settled into large, well-funded, urban museums. Prominent among them were the American Museum of Natural History in New York, Pittsburgh's Carnegie Museum, and the Field Columbian Museum in Chicago. A fierce competition to display mounted fossil vertebrates, especially gigantic Jurassic sauropods, then broke out among museum paleontologists. In turn, this contest – the second American Jurassic dinosaur rush – ultimately led to the modernization of American fossil preparation.

During this period, these museums launched ambitious expeditions aimed at collecting exhibit-quality dinosaurs, which netted an enormous quantity of unprepared fossils. Getting these fossils into suitable shape for study and display posed a number of novel challenges for fossil preparators. New material arriving from the field required room for temporary storage and dedicated laboratory space in which to prepare it. Adapting a basic fossil preparation lab to the needs of dinosaur paleontology often involved considerable extra investment in equipment and space. Finding, training and retaining skilled fossil preparators became increasingly expensive. The sheer volume of work, and its unique demands, led to increased specialization and professionalization among the science support staff. This, in turn, drove higher standards for the work, leading to important lab innovations. Preparators developed new techniques to handle the workload, some of which required expensive new machinery, entirely new systems (e.g., electricity, or pneumatic apparatus) or new spaces in which to operate the equipment, some of which produced particularly noxious dust, noise, or smells. Nevertheless, the essential task of fossil preparation, usually performed in backroom or basement labs by low-paid minions working in relative obscurity, was a vital prerequisite for the higher profile work of publishing original research and putting fossils on display.[1]

Making room for dinosaurs

Developing an efficient system for storing and preparing fossils was an essential first step in building a museum program in dinosaur paleontology. At New York's American Museum, a flourishing program in mammalian paleontology, established in 1891, lent the Department of Vertebrate Paleontology (DVP) a considerable advantage over upstart programs at the new museums in Pittsburgh and Chicago. Even so, the influx of Jurassic dinosaur specimens, beginning in 1897, quickly overtaxed the DVP's ability to handle fossils. Fortunately, Curator Henry Fairfield Osborn, who was wealthy and very well connected, had the clout to get what he wanted from museum administrators. His program began in humble quarters, cramped and confined in the museum's basement. By 1898, its three storerooms were filled to capacity with fossils. Osborn used this fact to leverage some new space. Late in 1899, the museum completely remodeled his department, assigning it to new offices on the uppermost floor of the east wing. Osborn was understandably pleased with his "very roomy" accommodations.[2]

The remodeled workspace for the DVP was a boon for fossil preparation. Better lighting and ventilation in the new top-floor fossil preparation lab made the work more pleasant, and elevated its visibility and prestige (Fig. 1). Rooms were retained in the basement, however, both for long-term storage of inferior fossils, and to provide room for the dirtiest and noisiest lab work, which Osborn preferred to keep out of sight. The opportunity to upgrade the lab's systems and appliances was available in 1899, and it was probably taken, although it seems likely that improvements were continuously being made in

[1] Peter J. Whybrow notes that, "the methods and techniques employed in the [paleontological] laboratory … are seldom clear and sometimes not even mentioned! Vertebrate paleontology must be one of the few "sciences" where the techniques used to establish the facts appear to be of little consequence." See Peter J. Whybrow, "A History of Fossil Collecting and Preparation Techniques," *Curator* 28, no. 1(1985): 5-26, on p. 5.

[2] On cramped quarters and planned improvements, see Ronald Rainger, *An Agenda for Antiquity: Henry Fairfield Osborn and Vertebrate Paleontology at the American Museum of Natural History, 1890-1935* (Tuscaloosa and London: The University of Alabama Press, 1991): 90; and, DVP annual reports for 1898 and 1899. See also letters, H. F. Osborn to J. Wortman (on the commodious new office spaces), 10 November 1899, H. F. Osborn to B. Brown (on basement storage), 25 July 1902, and A. Hermann to H. F. Osborn (on basement lab work), 22 December 1903, DVP Arch., AMNH.

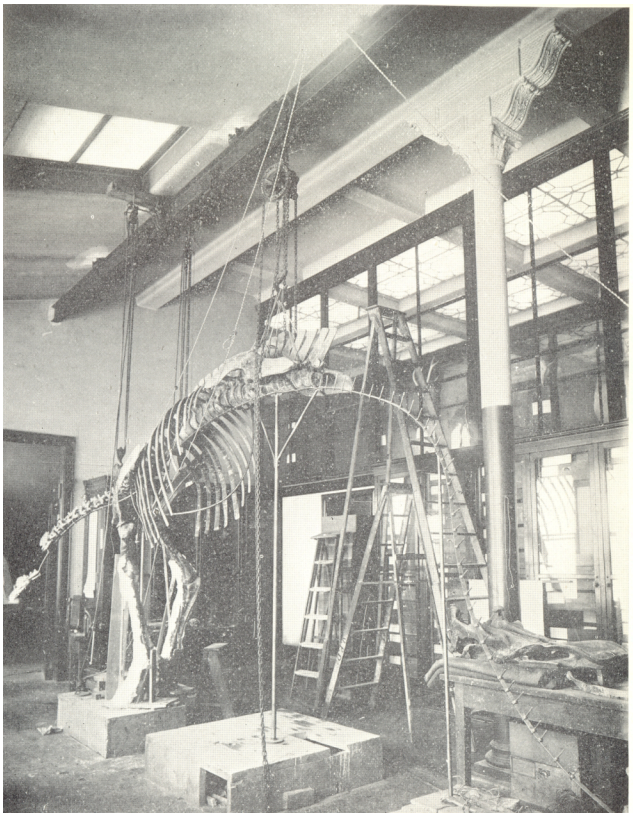

FIGURE 1: The new, top-floor preparation lab at the American Museum of Natural History. (From Hermann, 1909.)

the lab to keep it state-of-the-art. The lab featured an overhead trolley system, with chains and movable hoisting blocks attached to steel rails, which was used both to lift and move heavy blocks, and to suspend specimens while they were being fitted for mounting. The lab was wired for electricity, which provided power for reliable indoor illumination, and to run certain tools, including the "indispensable" portable electric drill. Small electric motors were useful for operating a multitude of essential tools (Fig. 2). A two horse power motor operated a large lathe, which drove a rotary diamond saw used for cutting stone and fossil bone, wheels for grinding and sharpening hand tools, a drill for boring specimens, and a small saw for cutting and splitting metal. A smaller motor ran the blower on a miniature gas-blast furnace used for heating and shaping metal armatures for mounting specimens, or for tempering or re-shaping metal tools (Fig 3).[3]

The generous new quarters acquired in 1899 were insufficient to ward off a storage crisis that occurred in 1903. It was brought about inevitably by the influx of oversized Jurassic dinosaurs, especially from Bone Cabin Quarry (Wyoming), opened in 1897. Assistant Curator William Diller Matthew described the deplorably crowded conditions in the several DVP storerooms, and Osborn conveyed this information to the museum president in his annual report. To make his point, Matthew counted 106 stacks of trays filled with fossils, averaging fifteen trays per stack, for which no racks were available, all despite the most diligent economizing of storage space. In order to access fossils, it was necessary to un-pile and then re-pile the stacks, which was difficult, inconvenient, and, worst of all, injurious to the specimens. Also, floor space for tables to store oversized specimens was completely taken up, so that tables had to be stacked as many as three high, the limit of safety. Finally, boxes as yet unpacked were piled "as high as is practicable and higher than is convenient." There was simply no way to fit additional fossil material into the storage space then allotted to the DVP. Osborn recommended that the osteological collections belonging to another department be removed from the east wing of the museum to make more room for his growing collection of fossils.[4]

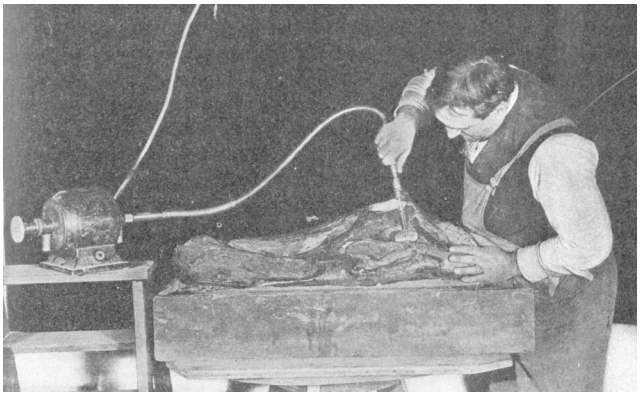

FIGURE 2: A preparator uses a small electric motor to drive a wire brush. (From Hermann, 1909.)

[3] See Adam Hermann, "Modern Methods of Excavating, Preparing and Mounting Fossil Skeletons," *The American Naturalist* 42, no. 493(1908): 46-47; and, Adam Hermann, "Modern Laboratory Methods in Vertebrate Paleontology," *Bulletin of the American Museum of Natural History* 26(1909): 330-331. There are very few records in the DVP Archives on the fossil preparation lab.

[4] DVP annual report for 1903.

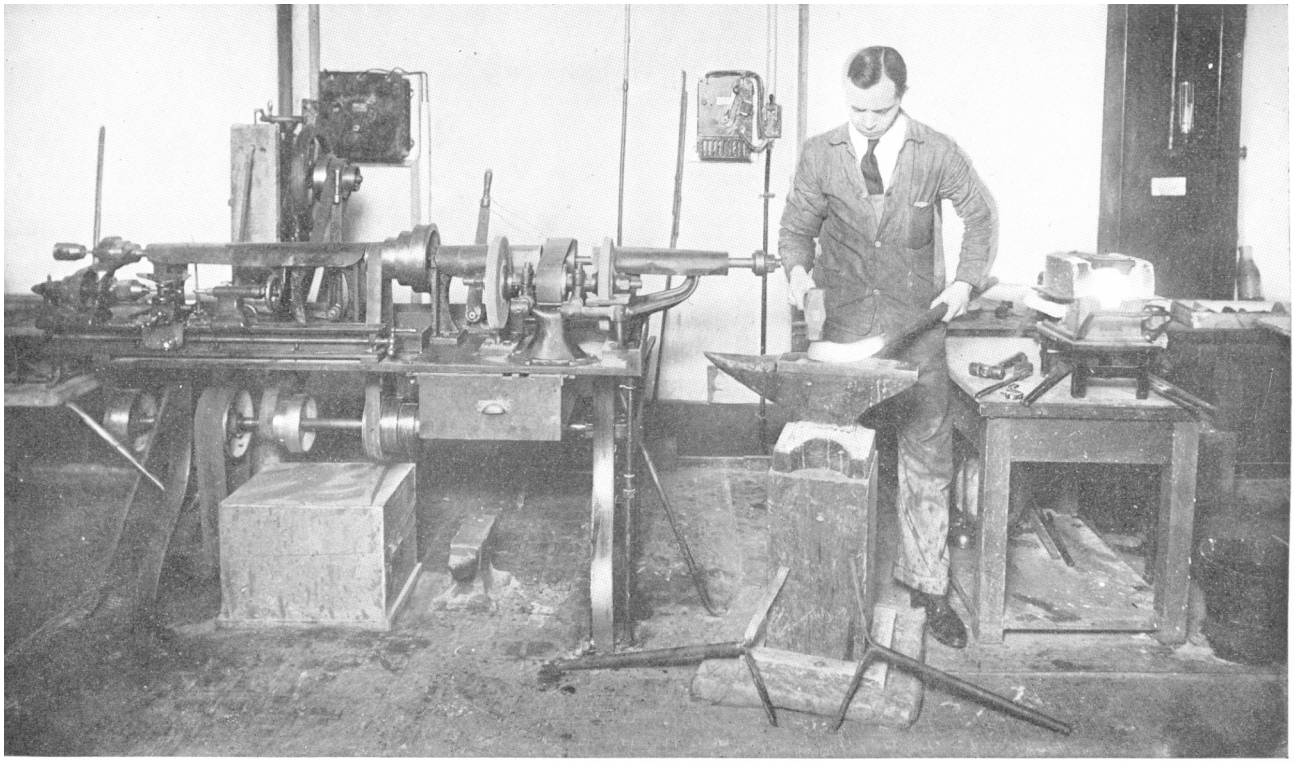

FIGURE 3: A preparator shapes metal at an anvil. On the left is a lathe with appliances for turning, boring, grinding and section cutting. On the right is a gas-blast furnace. (From Hermann, 1909.)

At Pittsburgh's Carnegie Museum, Director William J. Holland was a newcomer to vertebrate paleontology who sometimes failed to anticipate fully the needs of this department. Holland was especially keen to please his patron, Andrew Carnegie, who took a personal interest in mounting a sauropod dinosaur in his new museum. Nevertheless, it was not until October 1899, when collectors were already returning to Pittsburgh with an abundance of specimens from their inaugural field season, that Holland appealed to the Committee on Buildings for space in the museum to establish a laboratory for fossil preparation and an office for Jacob L. Wortman, his new curator. The lab took shape rather quickly, with only a few start-up troubles (Fig. 4). Preparators began slowly turning out specimens in early November. By January, Wortman was well satisfied with progress in the lab. He was less pleased, however, with his overbearing superior, and was forced to resign his position after a heated exchange with Holland. The director hired John Bell Hatcher – recently returned from Patagonia – to replace him. Following Hatcher's first field season in 1900, Holland provided a new, larger space for the preparation lab and storeroom. Hatcher and his staff spent a week arranging these rooms for maximum efficiency. Nevertheless, a growing preparation staff and a steady accumulation of Jurassic dinosaur fossils ultimately overwhelmed the available space. In 1906, preparators fitted up temporary quarters in the basement of the new museum building, which was still under construction. But a lack of adequate space and proper appliances hampered their work. Until the new building was completed, and a permanent lab established, finding room for fossil storage and preparation would continue to be a problem that occasioned considerable inconvenience and loss of time.[5]

[5] See William J. Holland, "The Carnegie Museum Pittsburgh: Annual Report of the Director for the Year Ending March 31, 1904," *Publications of the Carnegie Museum* Serial No. 28(1904): 24; William J. Holland, "The Carnegie Museum Pittsburgh: Annual Report of the Director for the Year Ending March 31, 1906," *Publications of the Carnegie Museum* Serial No. 43(1906): 29; and, letters, W. J. Holland to T. G. McClure, 10 October 1899, Holland Papers, CMNH; J. B. Hatcher to W. J. Holland, 8 November 1900, Hatcher Papers, CMNH; and J. Wortman to H. F. Osborn, 4 November 1899, and 6 January [1900], DVP Arch., AMNH. For more on the

Money, staff, space, and other resources for paleontology would be comparatively difficult to come by at Chicago's Field Columbian Museum, where no patron had as yet shown any particular interest in dinosaurs. There, Curator Oliver C. Farrington took an *ad hoc* approach to assimilating the new vertebrate paleontology program within the structure of his Geology Department. Following the museum's inaugural paleontology expedition in 1898, space for fossils had to be improvised somewhere in the West Pavilion, without adversely affecting Geology's space. And Farrington, a hard-rock geologist by training, was loathe to give over any of the space devoted to rocks, minerals, ores, etc., in order to accommodate paleontology. Accordingly, Farrington and his new paleontologist, Elmer S. Riggs, found a means to compress the departmental library, in Hall 74, to half its original size. Once fitted with tables and a rack of storage trays, the space gained was just barely large enough to serve as the museum's first fossil preparation laboratory and storeroom (Fig. 5). But when dinosaurs first arrived in 1899, the makeshift lab proved too small for the work. Extra space was afforded by removing the remaining books and bookcases to the increasingly crowded curatorial office in Hall 73. The preparation lab, expanded to fill all of Hall 74, gained a turning lathe, a workbench, and a sink with running water. This, too, proved inadequate once work commenced on a mother lode of Jurassic dinosaurs collected from western Colorado in 1900-1901. To provide more room, Farrington agreed, in the spring of 1902, to swap his spacious corner office in Hall 73 with the undersized preparation lab. The new lab included all the trappings of the old, and added a closet, revolving worktables, and a skylight with sliding overhead curtains. About 300 square feet of additional space for fossil vertebrate storage was found in 1905 by discarding two exhibit cases full of "duplicate specimens of kerosene" from some adjacent space in Hall 71, which was partitioned off and connected to the preparation lab.[6]

Finding good help

At all three museums, a staff of skilled and experienced technicians was the most vital ingredient for operating an efficient fossil preparation lab, but finding the right preparators and retaining their services for the long term could be a difficult proposition. Luring dissatisfied staffers from other institutions became a common practice. Osborn acquired his chief preparator, Adam Hermann, from Yale. Holland, in turn, took Arthur Coggeshall from Osborn. Riggs bagged Harold W. Menke from the American Museum after Osborn turned him away, but then failed to entice Albert Thomson or Charles Christman from the same institution, Charles W. Gilmore from the Carnegie Museum, or even Charles Bunker from the University of Kansas.[7] Few men, it seems, were willing to work for peanuts in Chicago.

history of dinosaur paleontology at the Carnegie Museum, see Helen J. McGinnis, *Carnegie's Dinosaurs: A Comprehensive Guide to Dinosaur Hall at Carnegie Museum of Natural History, Carnegie Institute* (Pittsburgh: Carnegie Institute, 1982); and, Tom Rea, *Bone Wars: The Excavation and Celebrity of Andrew Carnegie's Dinosaur* (Pittsburgh: University of Pittsburgh Press, 1999).

[6] See Field Columbian Museum, "Annual Report of the Director to the Board of Trustees for the Year 1899-1900," *Publications of the Field Columbian Museum, Report Series* 1, no. 6(1900): 447 and 449; Field Columbian Museum, "Annual Report of the Director to the Board of Trustees for the Year 1901-1902," *Publications of the Field Columbian Museum, Report Series* 2, no. 2(1902): 104; and Field Columbian Museum, "Annual Report for 1904-1905," 360. For more on the early history of vertebrate paleontology at the Field Columbian Museum, see Paul Brinkman, "Establishing Vertebrate Paleontology at Chicago's Field Columbian Museum, 1893-1898," *Archives of Natural History* 27, no. 1 (2000): 81-114. (Note, however, that Brinkman (p. 105) was mistaken in identifying Hall 75 as the museum's first fossil preparation lab.) When the Field Columbian Museum was first established as a memorial of the 1893 world's fair it acquired massive numbers of economic geology specimens including, for instance, "coal from every developed coal field in the United States." Many of these specimens were later regarded as duplicates when the museum switched to a natural history format. See Paul Brinkman (in press), "Frederic Ward Putnam, Chicago's Cultural Philanthropists, and the Founding of the Field Museum," *Museum History Journal*.

[7] Letters, O. C. Farrington to F. J. V. Skiff, 11 November 1905, DGC, FMA; and, A. Thomson to E. S. Riggs, 11 January 1906, Riggs Correspondence, Geol. Dept. Arch., FM.

FIGURE 4: An early fossil preparation lab at the Carnegie Museum of Natural History. Courtesy of Carnegie Museum of natural History, Pittsburgh, Pennsylvania.

Seducing another institution's valued staff members was most often interpreted as a hostile act, however. Osborn, for example, remarked bitterly about Hatcher's "absence of a clear feeling of right or wrong," when the latter allegedly (according to Osborn) co-opted his own brother-in-law, Olaf A. Peterson, who was then working for the DVP, to accompany him on the Princeton Patagonian Expedition of 1896. However, less than one month later, Osborn asked a Princeton collector in Hatcher's employ to make a special search for certain fossil mammal desiderata on his behalf. Osborn declined to hire the Princeton collector outright, though, claiming that "no man's heart can be in two places at the same time."[8] When Peterson returned from the last of the Princeton Patagonian Expeditions, Osborn wanted him back, but he chose to go to the Carnegie Museum, instead. Early in 1900, Wortman, who wanted to return to work in New York and needed to stay in Osborn's good graces, wrote a letter to his former boss disavowing any role in bringing Peterson from Princeton to Pittsburgh.[9] And Samuel W. Williston felt he owed Hatcher an apology and an explanation when Riggs tried to tempt Sydney Prentice, the Carnegie Museum's talented scientific illustrator, with a similar position at the Field Columbian Museum.[10]

A higher salary, better working conditions, and greater opportunities to do certain kinds of preferred work, like research or fieldwork, were the chief inducements used to lure preparators to switch allegiances. The same were also sometimes used to try to persuade them to stay. Osborn was sometimes proactive in lobbying for his preparators. In 1900, for example, after instituting a new rule requiring his staff to work eight hours per day (instead of seven), he felt they deserved a raise. "I think they all should be encouraged by a *slight* advance of salary [emphasis added]," he wrote in his annual report. Preparators and other support staff also had their own reasons for staying or leaving. Many of these men worked anonymously, and some resented it. Peterson quit the American Museum because of a perceived lack of due credit. On the other hand, those who stayed and did good work could sometimes negotiate for greater official acknowledgement of their efforts. Arthur W. Slocum, for example, wanted a position title "of sufficient merit to warrant publishing the name of its holder in the Annual Reports as a member of the Scientific Staff [of the Field Columbian Museum]." Some preparators used job offers at rival institutions to bargain for better terms. Still others, like Norman Boss of the Carnegie Museum, tried this tactic and were sent packing. Curators and administrators very much resented this practice, and worked to suppress it. Some, including Osborn, seemed to think that the gentlemanly thing to do was to deal preparators among themselves like baseball trading cards.[11]

Osborn expected unflagging loyalty from his subordinates, especially collectors and preparators, although he was sometimes reluctant or even unwilling

[8] The quotations come from two letters, H. F. Osborn to W. B. Scott, 15 February 1896; and, H. F. Osborn to J. W. Gidley, 9 March 1896, DVP Arch., AMNH.

[9] Letter, J. Wortman to H. F. Osborn, 6 January [1900], DVP Arch., AMNH.

[10] Letter, S. W. Williston to J. B. Hatcher, 25 February 1903, Hatcher Papers, CMNH.

[11] Osborn's quotation comes from DVP annual report for 1900. On A. W. Slocum, see letter, O. C. Farrington to F. J. V. Skiff, 9 January 1906, DGC, FMA. On N. Boss, see letter, J. B. Hatcher to W. J. Holland, 16 January 1904, Hatcher Papers, CMNH. Farrington wrote a letter to C. Christman [26 January 1906, DGC, FMA] warning that his museum "would not care to have its offer used to compel the payment of higher wages by a sister institution." For an example of Osborn dealing a preparator, see letter, H. F. Osborn to W. B. Scott, 12 January 1900, DVP Arch., AMNH.

FIGURE 5: Hall 74, the first fossil preparation lab at the Field Columbian Museum. (The Field Museum, negative #CS 3243.

to meet the demands of workers who asked for more rewards, financial or otherwise, in return for their faithful service. He denied Princeton's James W. Gidley a long-term opportunity with the DVP, for instance, because he felt it would be better to "train someone in [the work] whose sole interest is in the American Museum." Gidley stayed for years, anyway, always on a temporary basis, but he grew increasingly frustrated with his lot. In 1899 he complained, "It seems rather hard after all my years of experience … that I should be out here in the field working like a slave for … $50 per month, less than I was getting before I went to college."[12] Barnum Brown pleaded for years for a permanent position under Osborn, but did not get one until sometime after his return from Patagonia in 1900. He negotiated repeatedly for better pay, also, but Osborn was exceedingly slow to raise his salary. Osborn seemed to think that the experience Brown was getting under his tutelage, the reputation he was winning, and the opportunity to publish some of his own results "ought to be sufficient reward" for the persistent low pay and lack of commitment on Osborn's part.[13] Riggs probably fell into permanent disfavor with Osborn after he cancelled a miserable arrangement he had made to work for the DVP for half pay, in order to take a seemingly much more promising position at the Field Columbian Museum.[14] After Wortman quit the DVP and joined

[12] On Gidley, see letters, H. F. Osborn to J. W. Gidley, 18 March 1896; and, J. W. Gidley to H. F. Osborn, 1 August 1899, DVP Arch., AMNH.

[13] Letter, H. F. Osborn to B. Brown, n.d., [May 1899], DVP Arch., AMNH. Other letters express the same ideas. See especially H. F. Osborn to B. Brown, 12 January 1900, DVP Arch., AMNH.

[14] See Brinkman, "Establishing," 94-96.

the Carnegie Museum, taking Coggeshall with him, Osborn feared he would try to lure away more of his collectors. Osborn expected them to feel honor-bound to remain, writing in a thinly veiled warning to his new field foreman Walter Granger that "it would be a decided breach of faith for any man to leave the party before the close of the season."[15] Many of Osborn's subordinates, perhaps surprisingly, did remain loyal to the DVP. Historian Ronald Rainger lists fourteen employees who stayed with Osborn for more than twenty years.[16]

Finding capable young men, with little or no experience with fossils, but with reasonably good mechanical skills, and then training them to be excellent preparators, was another common approach to staffing the preparation lab. Holland and Hatcher were especially keen to find and train their own preparators for the Carnegie Museum. But what were the qualities that suited a person for such a position? Hatcher felt that willing, interested, and modest young men were the best candidates to become well-trained workers. He also insisted on finding someone who would be agreeable, although he seemed to get along with any man who respected him. Holland, on the other hand, seemed not to get along well with anybody. He valued obedience most, and sought men who appeared to be pliant, modest, and willing to obey orders. He preferred to find a "college-bred" man "who has his way to work in the world." But he could be picky. He turned one young man away for being "too sullen." Another was "too raw." Nor did he want a man with too much experience who might come at a high price. "We would do better to try and get a young man and bring him up after our own fashion," he wrote to Hatcher.[17]

Osborn valued loyalty in his subordinates above all other virtues. He also seemed to take particularly well to men from the rural West. Over the long term, he seemed to get along much better with men who earned their reputations entirely under his watch with the DVP, men who owed him their careers. He had much poorer luck with Cope and Marsh cast-offs like Hatcher, Peterson, and Wortman. Hermann, however, was an important exception to this rule.[18] Wortman, who served as Osborn's field foreman for almost ten years, was a poor judge of character. He seemed to have an early flush of enthusiasm for all men, which often wore off at the first sign of adversity. He adored Brown in 1896, for example, but absolutely despised him in 1897. He seemed not to value college experience in his subordinates, claiming, "a little learning is a dangerous thing."[19]

Yet at the height of the second Jurassic dinosaur rush, when the workload in the lab reached its zenith, no museum could afford to be too choosy about its preparators. Men of various skill-levels and experience swelled the ranks of the fossil preparation staffs at all three museums in the first few years of the twentieth century. Indeed, by 1900, the crush of dinosaurs coming in from the field created a terrible fossil preparation bottleneck in the DVP, despite efforts (described below) to mechanize and otherwise streamline the work. Osborn griped that his preparation staff of seven men was too small. "I wish without injustice to other departments," he wrote in his annual report, "that [the preparation staff] were larger because a very careful estimate of materials now in the department shows that without any additions whatever it will occupy 7 men for a period of 10 years to prepare and mount the specimens [which] are worthy of exhibition [emphasis original]." But this report left him vulnerable, such that in his next report he was more careful to state that to cease collecting was simply not an option.

[15] Letter, H. F. Osborn to W. Granger, 5 June 1899, DVP Arch., AMNH.

[16] Rainger, *Agenda*, 80.

[17] See letters, W. J. Holland to J. B. Hatcher, 12 June, 6 July, and 17 July 1900, Holland Papers, CMNH.

[18] More on Osborn's working relationships appears in Ronald Rainger, "Collectors and Entrepreneurs: Hatcher, Wortman, and the Structure of American Vertebrate Paleontology Circa 1900," *Earth Sciences History*, 9, no. 1(1990): 14-21. Insightful firsthand accounts of Osborn's imperiousness can be found in George G. Simpson, *Concession to the Improbable: An Unconventional Autobiography* (New Haven and London: Yale University Press, 1978), 40; and, Edwin H. Colbert, *Digging into the Past: An Autobiography* (New York: Dembner Books, 1989), 168-171. See Robert W. Howard, *The Dawnseekers: The First History of American Paleontology* (New York and London: Harcourt Brace Jovanovich, 1975), 270-271, for some less sympathetic accounts.

[19] Letter, J. Wortman to H. F. Osborn, 26 August 1898, DVP Arch., AMNH.

"Although a large force [of preparators] is employed," he explained, "we are still very much in arrears, and were it not for the very rapid and energetic work of other Museums in beds which will soon be exhausted, I would recommend a diminution of field work until we might gain headway [emphasis original]." Osborn added more and more men, and by 1903, the DVP boasted a preparation staff of fifteen.[20]

When a similar fossil preparation crisis arrived at the Carnegie Museum, in 1903, Hatcher responded by contracting field operations. He kept Peterson in Pittsburgh for the summer to work on the backlog of unprepared fossil mammals. Later, in September, he recalled collector Earl Douglass from the field one month early, both because of a sudden and surprising drain of fieldwork funds, and because of the abundance of work to do back at the lab.[21] Farrington urged the Field Columbian Museum to hire additional preparators in 1902, in order to keep abreast of the mounting workload. His request was denied, not because there was no need for help or no money to cover the cost, but merely because the Geology Department already had seven employees.[22]

Putting preparators to work

The high volume of work to be done during the second Jurassic dinosaur rush led to some increase in specialization and a sharper division of labor in museum paleontology departments. Osborn hired dedicated collectors and preparators from the very start. He would orchestrate the work of the department and reap most of the credit for its accomplishments, but he left the lower status labor to his staff of subordinates. He rarely participated in fieldwork, and seldom, if ever, involved himself with the dirty work of fossil preparation. So large was Osborn's preparation staff that it led to extremes of specialization. Christman, for example, specialized in repairing broken specimens, while Otto Falkenbach excelled at making casts and doing fossil restoration. Rainger has detailed how effectively the division of labor worked in the DVP, and how Osborn profited by it. But it was sometimes a source of discord. Hatcher, for one, was particularly critical of Osborn's brand of fireside natural history. He wrote: "It seems to me that if some of the older workers in vertebrate paleontology [Osborn] would go to the trouble to go out into the field, do their own collecting, and familiarize themselves with the laboratory work, they would have a greater appreciation for the work and efforts of others."[23]

Hermann was the DVP's chief preparator during the second American Jurassic dinosaur rush. Hermann ran the departmental lab, supervised the other preparators, and, at Osborn's urging, developed new techniques for preparing and mounting fossils for display. He hardly ever participated in other departmental activities, however. Coggeshall, who trained under Hermann at the American Museum, later filled the same role of chief preparator for the Carnegie Museum. At the Field Columbian Museum, which had a much smaller paleontology staff than its eastern rivals, the situation was very different. Riggs played the part of collector, chief preparator, researcher, and exhibit developer, and was the only vertebrate paleontologist of his era to make significant contributions in all four of these areas. He was repairing a chair with wire and glue, when a young man with an interest in paleontology turned up in his office, looking for career advice. He explained, "Son, in this field you have to be able to do everything."[24]

Often the men who did fieldwork in the summer spent the winter months working in the fossil preparation lab. Many of these men were particularly keen to prepare the specimens that they had collected. Valuable experience gained in the lab was later applied in the field, often yielding better results and higher standards for fieldwork. Collectors who learned about the capabilities of modern lab work usually made better judgments about which fossils to

[20] DVP annual reports for 1900, 1901, 1903 and 1904.

[21] Letters, J. B. Hatcher to O. A. Peterson, 26 May 1903; and, J. B. Hatcher to E. Douglass, 4 September 1903, Hatcher Papers, CMNH.

[22] Letters, O. C. Farrington to F. J. V. Skiff, 14 November 1902; and, H. N. Higinbotham to F. J. V. Skiff, 29 November 1902, DGC, FMA.

[23] Letter, J. B. Hatcher to T. W. Stanton, 6 January [1904], Hatcher Papers, CMNH. See also Rainger, *Agenda*, especially Chapter 4. On specialization in the preparation lab, see DVP annual report for 1903.

[24] William Turnbull, [Remarks upon Receiving an Honorary Membership in SVP], *Society of Vertebrate Paleontology New Bulletin* no. 172(1997): 42-43.

collect, and what to leave behind. They also learned firsthand the value of keeping careful field notes, drawing accurate quarry diagrams, and carefully packing and labeling all packages from the field – making a special effort to preserve a record of any field associations of bones or fragments that might be useful back in the lab. Preparators also advised fieldworkers on better collecting techniques. At the American Museum, Osborn often acted as the heavy in these interactions. In 1900, for example, he advised George R. Wieland and Granger to be sure to apply a separating layer of linen or paper between the bone and the protective plaster jacket – plaster applied directly to friable specimens had a tendency to pull off pieces of bone when the jacket was removed in the lab. In 1902 he admonished Granger to provide a complete packing list when shipping fossils back from the field, in order that preparators might find pieces in the order in which they were required. This was already a standard practice, so what could Granger say in reply? "I will look after this listing with special care this fall [emphasis original]," he wrote.[25]

Osborn sent a letter to Brown that was very critical of some of the latter's fieldwork. "You will be very much disappointed," he wrote,

> "that the Dinosaur which you collected with so much care and labor has proved almost valueless. We have developed block after block in the hope of finding something of value; but in vain. I have directed Mr. Hermann to abandon work on the specimen, and to move the block down to the basement, although it is hardly worth keeping at all. …This seems to warn us that we should certainly examine material a little more carefully in the field before taking it up…. I know you sent the specimen to us after the best possible methods; but it should have received a more careful examination. I therefore request you to examine all your prospects and bones pretty carefully, so as to make yourself absolutely sure that we are not bringing on material that will not pay the shipment much less the heavy expense of collection."[26]

Brown responded diplomatically, claiming, "I greatly appreciate your criticism." Of course, as Osborn himself pointed out, he had done his best. The specimen had simply not turned out as well as expected, which is a risk inherent in fieldwork. Brown continued to placate his superior, explaining, "every pound of matrix that we can possibly remove … will come off." But this procedure flatly contradicted Hermann's advice "that it is a great fault on the part of some fossil collectors to free the bones too much from the matrix, for this weakens the specimens and makes them more difficult to transport." Brown also pointed out that developing specimens in the field "takes a great deal of valuable time from prospecting," which was inconsistent with Osborn's policy that collectors should spend the majority of their time prospecting, rather than excavating.[27] This exchange of letters seems to lend support to Hatcher's claim (made later in 1904 and mentioned above) that Osborn had become too far removed from fieldwork and fossil preparation to appreciate the efforts of others. Nor was he able to offer very useful criticism or direction, despite Brown's politic reply.

Dedicated preparators also ventured occasionally into the field, sometimes with useful results, often not. Coggeshall joined Wortman at Sheep Creek in 1899, and kept detailed notes about the quarry conditions, which were later very useful for reconstructing the skeleton of *Diplodocus*.[28] But he seems not to have participated in fieldwork thereafter. Hermann joined the DVP field crew at Bone Cabin Quarry in 1899, but he only stayed a week. Camp life, according to Granger, was a "trifle too rough for him."[29]

Asher Van Kirk, an apprentice preparator for the Carnegie Museum, gave fieldwork a try in the

[25] Letter, W. Granger to H. F. Osborn, 15 September 1902; see also letters, H. F. Osborn to G. R. Wieland, 27 September 1900; and, H. F. Osborn to W. Granger, 3 December 1900, and 9 September 1902, DVP Arch., AMNH.

[26] Letter, H. F. Osborn to B. Brown, 25 July 1902, DVP Arch., AMNH.

[27] See letter, B. Brown to H. F. Osborn, 12 August 1902, DVP Arch., AMNH; and Hermann, "Modern Laboratory," 286. See also letter, H. F. Osborn to B. Brown, 25 July 1905, DVP Arch., AMNH.

[28] William J. Holland, "The Vertebral Formula in *Diplodocus*, Marsh," *Science* n.s. 11, no. 282(May 25, 1900): 817, footnote.

[28] Letter, W. Granger to H. F. Osborn, 19 August 1899, DVP Arch., AMNH.

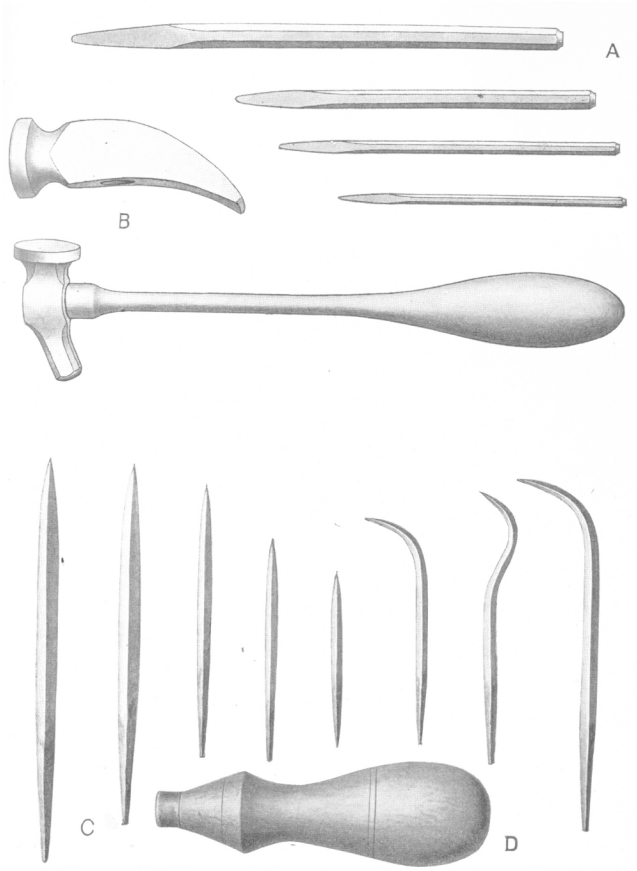

FIGURE 6: Hand tools, including hammer, chisels and awls. (From Hermann, 1909.)

summer of 1902, but he had a beef with the expedition cook and made "such a complete fool of himself" that he fled home to Pittsburgh, leaving Peterson shorthanded in the field.[30] And Hatcher, a brilliant fieldworker, was famously ill suited for work in the preparation lab.[31]

Developing newer, faster, and more accurate techniques

The need for greater speed and accuracy drove the development of a number of innovative fossil preparation techniques. Prior to the second Jurassic dinosaur rush, when the high volume of work first began to demand greater efficiency, fossil preparators worked exclusively with hand tools, especially awls and chisels (Fig. 6). Bones were set-up on sandbags for protection in a position favorable for working, and held firmly in place by means of several additional sandbags. A rotating stand or table was useful for keeping the working surface of the bone turned toward the light from a window. Preparators removed the hard matrix from the bones by chipping it away with a tedious, repetitive tapping of light shoemaker's hammers on hardened steel chisels or awls for finer work (Fig. 7). The work was exhausting for the preparator, and sometimes too hard on the specimens. The constant vibration often caused pain or numbness in the chisel hand, and soreness in the arms. The jar from the repeated blows caused much unwanted breakage in soft or brittle specimens, especially when the hardness of the matrix required a heavier hammer stroke to break it. A hardening agent of shellac or gum arabic prevented some breakage, but, other than exercising extreme caution, little could be done to protect thin edges or other delicate structures. Worse still, a wide range of motion was required for wielding a hammer and chisel. On complicated bones with deep and intricate cavities, it was often impossible to find a place of purchase for the chisel, or room to swing the hammer. Sometimes it was necessary to smash a complicated bone to pieces in order to work out the matrix. But the greatest disadvantage of using hand tools was the slowness of the work.[32]

Preparators derived new techniques for speeding the work by adapting the technologies of other, more lucrative industries to fossil preparation. Hermann introduced the electric dental lathe and dental engine at the DVP laboratory. Hatcher, likewise, showed an interest in introducing electric mallets and lathes in the preparation lab at the Carnegie Museum. Both were useful for operating small corundum grinding wheels, dental burs, or small rotary brushes (wire or bristle). A flexible arm attachment provided a greater range of motion and better access to cavities that could not be reached with ordinary hand tools (Fig 2). Hermann also had an extra large dental mallet custom-built for his lab to do very delicate chiseling on smaller specimens.

[30] Letter, O. A. Peterson to J. B. Hatcher, 30 August 1902, Hatcher Papers, CMNH.

[31] Charles Schuchert and Clara M. LeVene, *O. C. Marsh: Pioneer in Paleontology* (New Haven: Yale University Press, 1940), 219-220.

[32] Elmer S. Riggs, "The Use of Pneumatic Tools in the Preparation of Fossils," *Science* n.s. 17, no. 436(1903): 747-749; and, Elmer S. Riggs, [MS] "Hunting Fossils, Grand Valley, Colo.," Riggs Collection, Colorado National Monument.

Ideally suited for working on extremely delicate skulls or teeth, dental appliances were almost useless for the heavier work involved in dinosaur paleontology. For matrix that was too hard to work effectively with metal tools, Hermann experimented with acid preparation. He had some success using hydrochloric acid and potash, both of which were useful for softening hard carbonate matrix. The great disadvantages of this technique were the noxious fumes and the care involved in assuring that the acid dissolved the matrix and not the fossils. In 1903, when the backlog of unprepared specimens grew to overwhelming proportions, Hermann began experimenting with labor-saving tools in earnest. He had his greatest success using sandblasting equipment, which in trials was found to be very practical for cleaning matrix from large bone surfaces, but only where the matrix was considerably softer than the bone. Late in December of that year he urged Osborn to invest in some expensive new equipment and systems in order to modernize the lab for greater efficiency.[33]

Osborn read a paper about Hermann's new technique before a meeting of the (short-lived) Society of the Vertebrate Paleontologists of America. "The writer," he boasted, "has recently been experimenting with a sandblast, driven by a compressed air engine, with admirable results." It is difficult to take this claim literally, however, as it was Hermann who developed and tested the new sandblast. In December, 1907, Hermann gave a talk before the same organization on modern methods of excavating, preparing and mounting fossil vertebrates. He published a short paper on the same subject in the *American Naturalist*. Osborn

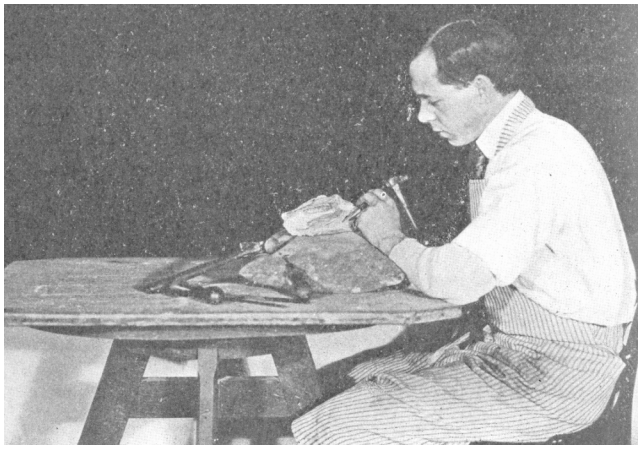

FIGURE 7: A preparator working with hand tools, sand bags and a rotating table. (From Hermann, 1909.)

encouraged him to publish an even longer and more comprehensive article on modern laboratory methods in vertebrate paleontology for the *Bulletin of the American Museum of Natural History*, in 1909.[34]

The introduction of pneumatic tools, especially the pneumatic hammer / chisel, was the most important innovation made in fossil preparation during the second Jurassic dinosaur rush. Riggs developed this technique at the Field Columbian Museum early in 1903. He tried ordinary stone cutting tools at first, but found them to be brutal instruments ill adapted to fossil preparation. He then spent two months making and trying various modifications. To obtain a more controlled stroke, he experimented with a special chisel holding attachment that threaded onto the end of the pneumatic hammer. The attachment served to soften the blows of the hammer by means of a coil spring, which absorbed some on the impact. Its square fitting also prevented the rotation of the chisel. Finally, an air escape vent directed forward blew dust and fragments away from the working surface.[35]

The complete pneumatic apparatus consisted of an air compressor with an engine to run it, air tank, pressure gauge, piping and fixtures, and a suite of air tools, including pneumatic hammers and drills. The entire outfit cost between $800-$1000, and could

[33] Hermann, "Modern Laboratory;" letter, A. Hermann to H. F. Osborn, 22 December 1903, DVP Arch., AMNH; and, letter, P. Russell to J. B. Hatcher, 14 March 1902, Hatcher Papers, CMNH. Francis A. Bather, a British paleontologist, had also been experimenting with acid preparation at about the same time. Hermann, "Modern Laboratory," quotes from Bather's work extensively. Henry M. Bernard, meanwhile, had used a sand-blasting device to prepare trilobites, although it is not clear that Hermann knew about this work. See Francis A. Bather, "The Preparation and Preservation of Fossils," *Museums Journal* (1908): 76-90; and, Henry M. Bernard, "On the Application of the Sand-blast for the Development of Trilobites," *Geological Magazine* 1(1894): 553-557.

[34] See Henry F. Osborn, "[Abstract] On the Use of the Sandblast in Cleaning Fossils," *Science* n.s., 19, no. 476(1904): 256; Hermann, "Modern Methods;" and, Hermann, "Modern Laboratory."

[35] Riggs, "Pneumatic Tools."

supply pressure for up to eight air tools at one time. The basic tool was the pneumatic hammer / chisel, which was adapted from tools designed for stone cutting or riveting metal. This hand-held, cylindrical device housed a hollow chamber where an air-driven hammer played lightly upon the head of a chisel at a rate of at least 3000 strokes per minute. This succession of blows caused the chisel to vibrate rapidly. When the operator pressed the tip of the chisel to rock, the rock tended to shatter at a remarkable rate. Work with the pneumatic hammer was faster, more accurate, more versatile, and easier on the fossils and the men who prepared them.[36]

Once past the experimental phase, Riggs was quick to share specifications of this important new technique with colleagues at other institutions. He published a detailed article on the pneumatic hammer in the May 8th, 1903 issue of *Science*. He was also eager to demonstrate it to visitors who stopped in Chicago on their way to or from the field. Brown was astonished at its cutting capacity, and he urged Osborn to introduce it at the American Museum. Osborn saw it for himself later that same year. Riggs also wrote letters to Hermann, at the DVP, and Alban Stewart, at the National Museum in Washington, DC, singing its praises, and encouraging them to adopt the technique in their own labs. Stewart began using pneumatic tools for fossil preparation late in 1903 with great success. Hermann recommended the introduction of air tools and sand blasting equipment, both of which required a compressed air plant, in December 1903. He warned that both systems would best be confined to the basement, because of excessive noise and dust. Consequently, new and better lighting would also be required. Strangely, Osborn was slow to approve this change. Hermann hoped to get a complete pneumatic set up by the spring of 1905, when his lab was upgraded with a new power plant and other new machinery. Riggs claimed that a man could turn out twice as much work using the pneumatic hammer. The noise was annoying at first, and intolerable to anyone trying to read or write in the same room. But the men who operated the equipment quickly grew accustomed to the noise, and indeed, spoiled by the relative speed and ease of the work.[37]

Conclusion

By 1908, the second American Jurassic dinosaur rush was essentially over. Giant sauropod dinosaurs had been mounted for display in New York, Pittsburgh and Chicago, and more would quickly follow. Mounted dinosaur skeletons proliferated widely in the aftermath of the rush. Another, less visible, but just as lasting legacy of the rush was the modernization of American fossil preparation. Large public museums ultimately provided ample, dedicated lab space, along with the requisite money, equipment and labor to do fossil preparation properly. Likewise, the demand in museums for a large number of cutting-edge, mounted dinosaur exhibits created a mandate for innovation, and for newer, better, and more efficient techniques for streamlining the work while improving the results. Larger staffs and a finer division of labor brought increasing specialization. This, coupled with prolonged, steady employment at ambitious museums provided certain preparators with the opportunity to hone their skills. Presentations on fossil preparation at professional meeting, and technical papers published in scientific journals spread information about the best new materials, tools and procedures from one museum to another. Publications by Riggs, Hermann and others, were the first, tenuous steps in the professionalization of American fossil preparation. Other, informal vectors for the spread of new techniques included personal correspondence, courtesy calls at rival museums, and the swapping of lab personnel.

Most important were the critical lab innovations that dramatically improved the speed and quality of fossil preparation, including acid preparation, sand-blasting, and especially pneumatic hammers and chisels. A century later, these same tools and techniques are still the mainstays of modern fossil preparation.

[36] Riggs, "Pneumatic Tools;" and, letter [draft], E. S. Riggs to A. Hermann, 30 June 1903, Riggs Correspondence, Geol. Dept. Arch., FM.

[37] See letters, E. S. Riggs to A. Hermann, 30 June 1903; B. Brown to H. F. Osborn, 31 May 1903; A. Hermann to H. F. Osborn, 22 December 1903, DVP Arch., AMNH; A. Stewart to E. S. Riggs, 29 August 1903, and A. Hermann to E. S. Riggs, 16 December 1904, Riggs Correspondence, Geol. Dept. Arch., FM; and, Riggs, "Pneumatic Tools."

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