4-2020

The Bare Bones of Paleontology

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May 1, 2019

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History 490

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Picture a scientist digging in the blazing sun when suddenly, he hits something. He digs faster and discovers it's the fossil of a *Stegosaurus*, this is paleontology. Paleontology is the study of life on Earth before and sometimes during the era of Earth's lifetime called the Holocene Epoch[1]. This includes the most ancient species to appear on Earth over 3 billion years ago, to some species that went extinct at the dawn of man roughly 12,000 years ago. While the life forms studied in paleontology are millions of years old, the study itself is fairly new, with the earliest studies being done around the 18th century. One of the ancient Greek philosophers, Xenophanes, could be considered an early paleontologist since he concluded by examining fossilized sea shells that some areas of land were once under water[2]. Paleontology has been used in pop culture for the past century, and especially since it became popularized. It then became officially part of the modern evolutionary synthesis in 1944, and was considered a true science that could affect humans today. Paleontology and dinosaurs themselves have been used as a plot in novels, video games, and of course film. The oldest film to feature a dinosaur is the 1914 film by D.W. Griffith, "Brute Force", which features cavemen and dinosaurs together. By this point paleontology had not yet proven humans and dinosaurs didn't coexist in the past. Of course, the most famous film to have themes involving paleontology and dinosaurs is the 1992 Steven

[1] The Holocene Epoch is the past 11,700 years of life on Earth.
[2] Martin J.S. Rudwick. *The Meaning of Fossils* (2nd ed.). (The University of Chicago Press, 1985), 39.

Spielberg film, “Jurassic Park”, which was based on a novel of the same name from 1990 by Michael Crichton, who originally starting writing it back in 1983. By this point, paleontology had been a massive interest in America for nearly 40 years.

On it’s way to becoming a beloved science that piqued the interest of young boys and girls everywhere, paleontology had to go through some growing pains as it developed from a niche study by natural scientists in the late 1700s and early 1800s. The professionalism of paleontology was challenged many times before it became a legitimate study, especially in the mid to late 1800s. One such challenge was The Bone Wars, a part of the Great American Dinosaur Rush. The Bone Wars took place from 1877-1892 and featured two main combatants throughout the period; Othniel Charles Marsh and Edward Drinker Cope. Throughout the Bone Wars, Marsh and Cope did do many things to outdo each other that would question the moral integrity of paleontology and the professionalism of the study itself. From spying, to bribery, to even potential sabotage; Marsh and Cope left a bad taste in the mouth of scientists everywhere who were interested in the new field of paleontology. But, they also left a pretty low bar for those who did end up studying paleontology to excel in the field as professional and ethical scientists. The strife caused by the Bone Wars helped paleontologists understand what level of professionalism was needed to do what they needed in order to make discoveries.

To understand the impact the Bone Wars left, we must look back at what the study of paleontology was before Marsh and Cope lowered the bar in morality and professionalism. As stated before, the earliest study of paleontology was back in the 6th century B.C.E. when Xenophanes in Greece determined that some land used to be underwater based on fossilized sea shells he found. Another early paleontologist before the study truly began was Shen Kuo, a

Chinese naturalist from the 11th century C.E. that determined, based on marine fossils found in the Taihang Mountains, that over many years the land and the sea shores shifted[3]. Even Leonardo da Vinci around 1500 used ichnofossils[4] to back his hypothesis concerning the biogenic nature of body fossils. Another early paleontologist to backup the early stages of the study was Robert Hooke, an English natural philosopher from the 1600s who concluded in his book, "Micrographia", that petrified wood formed from wood soaked in mineral-rich water, and fossils such as Ammonite shells were produced the same way. This caused debate within the natural science community over the organic origin of fossils and the possibility of extinction. These four early paleontologists became the building blocks for future paleontologists as they determined how everything on Earth fit together.

Thomas Jefferson was one of the founding fathers of the United States and had many achievements politically, but many do not know that he was a huge advocate for the natural sciences. Originally, he only wanted to compile a list of animals found in the wilderness of North America but eventually this led to an interest in the extinct animals as well as the current animals found in North America. In 1796, Jefferson came to discover what he believed to be an extinct species of cat that he named *Megalonyx* or "the Great Claw" due to the creatures massive claws. In his memoir about the discovery published in *Transactions of the American Philosophical Society*, *A Memoir on the Discovery of Certain Bones of a Quadruped of the Clawed Kind in the Western Parts of Virginia*, Jefferson states, "The movements of nature are in a never ending circle. The animal species which has once been put into a train of motion, is still probably

[3] Joseph Needham. Science and Civilization in China: Volume 3, Mathematics and the Sciences of the Heavens and the Earth (Caves Books Ltd. 1986), 614.
[4] Ichnofossils are traces of ancient life that are not actual organism parts such as tracks or imprints.

moving in that train[5]". In 1797 he soon discovered that he had made an error when reading an article by Georges Cuvier about an extinct sloth species named *Megatherium* which was nearly identical to his *Megalonyx*. This was one of the first of many discrepancies during the early stages of paleontology. Jefferson eventually came to study natural history during his time in the White House according to *Thomas Jefferson as a Paleontologist* which states, "These studies of the mammoth were carried on mostly in an unfurnished room of the White House itself during the trying political time of 1800… Jefferson retreated from the storm to contemplate the mysteries of nature[6]". Jefferson was criticized by his political adversaries for his passion for science as many of them believed it was clouding his judgement as president of the United States. Despite so much opposition, Jefferson was not deterred, this can be seen in a letter Jefferson wrote to Charles F. Welles in 1809 in which he states, "Of all the charges brought against me by my political adversaries, that of possessing some science has probably done them the least credit. Our countrymen are too enlightened themselves to believe that ignorance is the best qualification for their service[7]". By this point in paleontology's history, many people weren't convinced it was a true science, especially with the rise of evangelicalism in the American Republic. After retiring from the presidency in 1809, Jefferson settled down in Monticello and set up his own private collection of fossils, turning his home into one of the first natural history museums. In Monticello, Jefferson placed fossil bones including those of

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[5] Thomas Jefferson. "A Memoir on the Discovery of Certain Bones of a Quadruped of the Clawed Kind in the Western Parts of Virginia" pg. 255. *Transactions of the American Philosophical Society*, Vol. 4 (1799)
[6] Henry Fairfield Osborn. *Thomas Jefferson as a Paleontologist*. *Science* 82, no. 2136 (1935): 533-38. http://www.jstor.org/stable/1662361.
[7] "Thomas Jefferson to Charles F. Welles, 3 December 1809," *Founders Online,* National Archives, version of January 18, 2019, https://founders.archives.gov/documents/Jefferson/03-02-02-0033. [Original source: *The Papers of Thomas Jefferson*, Retirement Series, vol. 2, *16 November 1809 to 11 August 1810*, ed. J. Jefferson Looney. Princeton: Princeton University Press, 2005, pp. 51–52.]

mammoths and *Megalonyx* which were prominently displayed in the entrance hall of Monticello along with antlers of deer and bison heads.

With the president of the United States backing the study, young paleontologists from around the world began digging in hopes of making new discoveries. Unfortunately nothing of major significance happened in the United States for paleontology for the next 13 years. Then, in 1822, the editor of the French journal, *Journal de Phisique*, Henri Marie Ducrotay de Blainville, invented the word "paleontologie" for the reconstruction of ancient animals and plants from fossils and thus the study finally had a name of its own and could be seperate from the umbrella term, “natural sciences”. In 1836, an American geologist named Edward Hitchcock described some footprints he found of giant birds from Jurassic formations in Connecticut, which would eventually be recognized as ichnofossils of dinosaur tracks. For the next 50 years, paleontology rapidly evolved as a study with many different decisions made and discoveries. These include the creation of a new order of reptiles in 1841, dinosauria, for fossils discovered while digging; the first global geologic timescale in 1841 which is defined by John Phillips based on the type of fossils found in strata of the Earth; the first actual dinosaur skeleton found in the United States, *Hadrosaurus*, which was excavated and described by Joseph Leidy in 1858; and the publishing of *On the Origin of Species* in 1859 by Charles Darwin.

The first ever fossils found in America were discovered in 1739 when French military general, Charles LeMoyne de Longueui, found the fossilized remains of a wooly mammoth in what became Big Bone Lick, Kentucky. This discovery piqued the interest of some people, but it wouldn’t become full on paleontology until almost 100 years later. Two individuals in particular became interested thanks to this discovery, Georges Cuvier, and Thomas Jefferson. Cuvier went

on to be named the founding father of paleontology, while Jefferson went on to have many names including the father of American vertebrate paleontology. Georges Cuvier was a French naturalist and zoologist who made large strides in bringing paleontology into the public eye. Cuvier was primarily based in France but helped make discoveries in the Americas including presenting a paper in 1796 on living and fossil elephants that shows that mammoths were a different species from any living elephant based on the mammoth bones found in Big Bone Lick. In this paper he argued that this proved the reality of extinction, which he claims was caused by a geological catastrophe[8]. This theory wouldn't be improved upon until the 1970s when geologist Walter Alvarez introduced the theory that a giant meteor crashed into Earth, killing the dinosaurs. He created this theory when he found two dark layers of rock sandwiching a lighter, half-inch-thick seam made of iridium that was laid down around the exact same time that the dinosaurs went extinct. Cuvier was intelligent beyond his years and went on to discover many other fossilized species including *Pterodactylus*, *Mosasaurus*, and *Megatherium*.

Based on everything in the past, one could tell there wasn't exactly a lot of structure in the study of ancient life on Earth. With this lack of structure, there was also a lack of professionalism. Professionalism is the competence or skill expected of a professional. This means that a person should be able to conduct themselves in a professional manner in their career. Allowing themselves and others in their career to make advances. In early paleontology there was a distinct lack of professionalism because no one really knew what was considered professional and what wasn't. This especially applied to the two major combatants in the Bone Wars, Othniel Charles Marsh and Edward Drinker Cope.

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[8] Martin J.S. Rudwick. *The Meaning of Fossils* (2nd ed.). (The University of Chicago Press, 1985), 101–109.

Othniel Charles Marsh was born on October 29, 1831 in Lockport, NY to a somewhat well off family. His parents were farmers but thanks to his rich uncle George Peabody, he was able to receive a high education than most in his position. Marsh graduated from Phillips Academy, Andover in 1856 and Yale College with his bachelor of arts degree with honors in 1860[9]. He then received a Berkeley Scholarship from Yale and studied geology, mineralogy and chemistry at Yale's Sheffield Scientific School and graduated with an MA in 1863. With his background in geology, and a passion for learning, Marsh traveled to Berlin to study paleontology and anatomy for the next three years. While in Berlin, Marsh met a fellow young paleontologist named Edward Drinker Cope and the two became great friends as they discussed their passion for the new study. When he returned to the United States in 1866, Marsh was appointed professor of vertebrate paleontology at Yale University making him the first professor of paleontology in the United States[10]. After receiving a $100,000 inheritance from his uncle George Peabody, Marsh began his hunt for fossils that led him to the start of the Bone Wars. His first stop was the Yale Expedition of 1870, the expedition took Marsh and a group of fossil hunters from New Haven, Connecticut to North Platte, Nebraska over the course of six months. On this expedition, Marsh and his troops travelled to new territories such as Wyoming, Colorado, Salt Lake City, and San Francisco with the help of the military. In *Harper's New Monthly Magazine Vol. 43*, an article written by one of the fossil hunters states, "The search for fossils met with great success and remains of cretaceous reptiles and fishes were collected in great quantities. One trophy was the skeleton of a sea-serpent, nearly complete and so large that

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[9] "Professor Marsh is Dead. The World-Famous Geologist Succumbs to Pneumonia. Chair of Paleontology Founded for Him. Caused the Establishment of Peabody Museum". *New York Times*. March 19, 1899.

[10] Lowell Dingus. *King of the Dinosaur Hunters: The life of John Bell Hatcher and the discoveries that shaped paleontology*. (Pegasus Books. 2018)

we spent four days in digging out and carrying it back to camp[11]". By the end of the expedition, Marsh and his team discovered two kinds of rhinoceroses, fossil turtles, a few birds and rodents, the remains of several brontotheres, several mosasaurs, and a wing finger of a pterosaur. His first big discovery though, was made a year later in 1871 when Marsh discovered the first American pterosaur fossils. This expedition and discovery gave Marsh a huge boost in his importance in the study of paleontology making his downfall during the Bone Wars all the worse for his legacy.

Edward Drinker Cope was born on July 28, 1840 in Philadelphia, Pennsylvania to a wealthy Quaker family. Unfortunately, his mother died when he was only three years old, leaving his stepmother to fill the maternal role. As the eldest child in the family, Cope was given the best education. He distinguished himself from his siblings and step siblings as a child prodigy interested in science; he published his first scientific paper at the age of 19. Despite his clear attunement to science, Cope actually didn't have much formal education past 16 as he hated the education he received at boarding schools, leading Cope to educate himself[12]. Cope eventually attended the University of Pennsylvania in 1861 studying comparative anatomy under Joseph Leidy, one of the most influential anatomists and paleontologists at the time. From 1863 to 1864, Cope travelled throughout Europe, visiting as many museums as he could to learn more about anatomy and paleontology, as many fossils that were discussed in paleontology at the time were found in Europe. While in Germany, Cope met Othniel Marsh who was studying in Berlin at the time; the two became good friends who saw themselves as equals despite Cope having published

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[11] C.W. Betts "Searching for Dinosaur and Other Prehistoric Animal Fossils." *Harper's New Monthly Magazine*. 43 (257): 663-671, October 1871.
[12] Jane Davidson. *The Bone Sharp: The Life of Edward Drinker Cope*. (Academy of Natural Sciences. 1997)

37 scientific papers and Marsh only having published two[13]. After Cope left Europe and returned to the United States, his father helped him secure a job as the Professor of Zoology at Haverford College. After several years of teaching, Cope decided to travel around the United States to further his scientific career. His first stop in 1868 was the marl pits of New Jersey where he would in time discover some of the first dinosaurs in America. On this trip were Cope, and several of his mentors including Joseph Leidy, James Ellsworth DeKay, Christian Erich Hermann von Meyer, and Richard Owen from Haverford College. According to Cope's article in *The American Naturalist*,

> In huge reptiles the region has been especially prolific. Through the care of Superintendent Voorhees, the remains of seven of the larger species have been exposed and preserved during the excavations. Four of these belonged to the group of Crocodiles; namely *Thoracosaurus Neocæsariensis, Thoracosaurus obscurus, Bottosaurus Harlani, Macrosaurus lævis, Hyposaurus Rodgersi*[14].

These discoveries gave Cope a huge boost in credibility in the following year.

During his travels in the 1870s, Cope published around 25 reports and preliminary observations each year. The hurried publications led to errors in interpretation and naming leaving Cope with a reputation he had to fix. One such error was his interpretation of an *Elasmosaurus* skeleton in which he placed the head of the dinosaur on the wrong end[15]. Marsh pointed this out later on, damaging their relationship and fueling what became the Bone Wars. Marsh pointing out the mistake in Cope's interpretation of the *Elasmosaurus* is seen as the first

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[13] Mark Jaffe. *The Gilded Dinosaur: The Fossil War Between E. D. Cope and O. C. Marsh and the Rise of American Science*. (New York: Crown Publishing Group. 2000)
[14] Edward D. Cope "The Fossil Reptiles of New Jersey, Part One." The American Naturalist, Vol. 1, 23-30, 1868.
[15] "The Fossil Reptiles of New Jersey." *American Naturalist* Vol 3. Num. 2, April 1869, pp. 84-91

spark of the Bone Wars. The way he went about pointing out the mistake is what adds to this theory, when Cope first realized the mistake, her bought every copy of *American Naturalist* he could to make sure his mistake wasn't publicized. Unfortunately, Marsh kept his copy and released the information. In a letter to the *New York Herald* in 1890, Marsh pointed out the issue of Cope's error when he wrote, "Later he issued a second edition of the volume, containing a new restoration, with the head in the proper position, but there was nothing to show that a previous edition of the work had been published"[16]. While this act of aggression was the spark needed to create a feud between Marsh and Cope, the time that has been dubbed the Bone Wars wouldn't truly begin until 1877.

The Bone Wars were a time of great turmoil in the study of paleontology. The science was fairly new and not many people considered themselves paleontologists so there was not a lot of precedent for how to go about your work. Despite the somewhat questionable methods used during the Bone Wars, some paleontologists believe the result was a massive amount of discoveries that sent paleontology far further than the original scientists envisioned. According to the book *Dinosaurs: A Concise Natural History*,

> Their rivalry resulted in what has been called the 'Golden Age of Paleontology,' a time when the richness of the dinosaur faunas from western North America first became apparent – when the likes of Allosaurus, Apatosaurus,and Stegosaurus were first uncovered and brought to the world's attention[17].

On the other side, many paleontologists believe that the Bone Wars may have actually harmed paleontology as a science due to the methods used and things that came of it. For example, in

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[16] "Othniel Charles Marsh to New York Herald, 12 January 1890" *New York Herald*
[17] David Fastovsky and David Weishampel. "*Dinosaurs: A Concise Natural History*." Pg. 298. (Cambridge University Press; 2 edition, 2012)

Cope versus Marsh, the author states, "The Cope-Marsh feud was a bitter one. Both contenders lost by it, and the study of vertebrate paleontology is hampered by the confusion of names and the plethora of hasy description caused by this rivalry"[18]. The confusion of names in *Cope versus Marsh* is referring to a discovery made by Marsh when in a rush to outdo Edward Drinker Cope put out an article in 1879 about a "new" dinosaur he called Brontosaurus which he formed from multiple inconclusive bones, unfortunately the bones of the same dinosaur had already been discovered in 1877 and named Apatosaurus, this is considered one of the big issues with the Bone Wars. This specific issue of misnaming is still persistent and was discussed recently in a 2008 article titled *Fossil Quality and Naming Dinosaurs* in which the author states, "Among dinosaurs, Benton (2008) found that 726 (51.8%) of the 1401 species named up to the end of 2004 are currently regarded as invalid"[19].

What could be considered the first "strike" of the Bone Wars was a series of events that happened in 1877. In 1877, Marsh received a letter from a man, named Arthur Lakes in Morrison, Colorado informing him of several fossils he had found embedded in rock while hiking in the nearby mountains. Marsh informed Lakes to keep the findings a secret in exchange for $100 but unfortunately Marsh was slow to reply so Lakes shipped some bones to both him and Cope[20]. When Marsh discovered that some of the bones were being shipped to Cope, he sent his field collector, Benjamin Mudge to Colorado to ensure that Lakes continued to work with them. Marsh published a description of the discoveries in the *American Journal of Science* on

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[18] Alfred S. Romer "Cope versus Marsh." *Systematic Zoology* 13, no. 4 (1964): 201-07. doi:10.2307/2411780.
[19] Michael J. Benton "Fossil Quality and Naming Dinosaurs." (Biology Letters Vol. 4 Issue 6. 2008)
[20] John Noble Wilford. *The Riddle of the Dinosaur*. Pg. 106 (New York: Knopf Publishing. 1985)

July 1, 1877[21], and before Cope could publish his own interpretation of the finds, Lakes wrote to him that the bones should be shipped to Marsh instead. Along with this, according to *Smithsonian Magazine*, "Lakes spent four field seasons chiseling the most easily reached bones out of the fossil beds. Before he left the area, he allegedly blew up one of the most productive sites— 'Quarry 10'—to prevent Cope from digging there"[22]. Cope took this as a great insult to him and thus, the Bone Wars began.

So already at the very start of the war we see a lack of professionalism from one side in particular involving bribery. A modern day paleontologist would never stoop that low and would allow other scientists to have a look and interpret together rather than hogging the glory to themselves. Unfortunately, this was the early stages of paleontology as a professional career so there weren't many rules in place to keep things like this from happening. It was quite literally the lawless West we see today in modern interpretations of the American West in film and on TV. From here, things get less and less professional. This lack of professionalism continued that same year when Cope received a letter from naturalist O.W. Lucas who informed Cope of large fossils he found near Cañon City, Colorado; this letter also came with several samples. Cope concluded from the samples he was given that the dinosaurs they found were herbivores, possibly the largest discovered, even larger than the organisms Marsh found in Morrison. With this information in hand and a chance to outdo his rival within his grasp, Cope struck at the opportunity and raced to Cañon to begin digging for more. Word of these finds reached Marsh who sent Mudge and a former student, Samuel Wendell Williston, to Cañon to set up a quarry and begin digging for fossils. Marsh soon learned from Williston that Lucas was finding the best

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[21] "Principle Characteristics of the Coryphodontidæ" *American Journal of Science* Vol. 14 Art. 11 Pg. 81-89

[22] Genevieve Rajewski. "Where Dinosaurs Roamed." Smithsonian 39.2 (2008): 20.

fossils and refused to quit Cope to come work for Marsh. With this unfortunate news, Marsh ordered Williston and Mudge back to Morrison, where Marsh's small quarry collapsed and nearly killed his assistants. With the two rivals tied with one "victory" each, Marsh began to worry that he might have to admit defeat to Cope if it wasn't for another letter he received that year.

The letter that Marsh received led him to what became the biggest "battleground" of the Bone Wars. The letter mentioned large quantities of bones found in Como Bluff, Wyoming and groups of men snooping around the area. Marsh sent Williston to investigate as soon as he returned from the quarry collapse and they soon discovered that it was Cope's men snooping around the Como Bluff in search of fossils. Marsh quickly sent money to the two new bone hunters that sent him the letter, Carlin and Reed, and urged them to send additional fossils in hopes of avoiding the same situation he dealt with with Lakes. One of the men went to deal with Marsh directly to get a better deal in exchange for their service but unfortunately left feeling bullied by Marsh, this came back to bite Marsh later on. Despite his future misfortune, Marsh's investment in Como Bluff led to great rewards for his research. With all of the information gathered at the bluff in the first year, Marsh described and named dinosaurs including Stegosaurus, Allosaurus, and Apatosaurus in the December 1877 issue of the *American Journal of Science*[23]. To get back at Marsh for stiffing them on a better deal, Carlin and Reed began to spread the word of his new discoveries. Word of his discoveries quickly spread and soon there were more paleontologists hunting bones at Como Bluff.

[23] "Principle Characteristics of the Coryphodontidæ" *American Journal of Science* Vol. 14 Art. 11 Pg. 81-89

Of course, one of the first paleontologists on the scene to collect rare fossils was Edward Drinker Cope. Before he actually went himself, Cope sent "dinosaur rustlers" to the area in an attempt to quietly steal fossils from Marsh's camp. During the winter of 1878, Carlin, dissatisfied with Marsh's inconsistent payment and began working for Cope instead. Cope took this opportunity to hire more people who were dissatisfied with Marsh and began digging at Como Bluff. Both Marsh and Cope's workers suffered hardships while digging due to the weather, sabotage, and obstruction from each other's camps. One example of this was when Carlin locked Reed out of the Como train station, forcing Reed to haul the bones down the bluff and crate the specimens by himself on the train platform in the bitter cold. Another example was when Cope ordered Carlin to set up his own quarry in Como Bluff, while Marsh sent Reed to spy on his former friend. A third example of this is when the scientists' rival teams fought each other by throwing stones. Spying and sabotage became a consistent issue at the Como Bluff between Marsh and Cope's camps. This continued for the next 15 years at Como Bluff.

Both Marsh and Cope used their personal wealth to fund expeditions in Como Bluff during the summers, then spent the winters publishing their discoveries in their respective magazines[24]. In June of 1879, Marsh decided to finally visit Como Bluff himself after having Lakes join the digging earlier that year. New quarries were constantly opening as both Marsh and Cope dried up their fossil reserves quickly to try and outdo each other. While Marsh's camp kept opening up new quarries to discover more fossils, relations between Lakes and Reed soured and eventually both men chose to resign from Marsh's excavation in 1880 despite everything Marsh tried to keep them on at Como Bluff. Reed ended up staying for 4 more years to help his old

[24] Robin Bates (series producer), Terri Chesmar and Rich Baniewicz (associate producers); Barbara Feldon(narrator) (1992). *The Dinosaurs! Episode 1: "The Monsters Emerge"* (TV-series). PBS Video, WHYY-TV.

friend Marsh as long as he could. With the loss of Reed and Lakes, Marsh's other men began to become uneasy and dissatisfied with the dig. Marsh ended up sending Williston's brother Frank Williston to the dig to try and keep morale up and keep everyone satisfied. Eventually Frank ended up leaving Marsh's employ and taking up residence with Carlin who in turn left Cope's employ to start a business with Frank. With the loss of Carlin, Lakes, and Frank both men began to lose faith in Como Bluff but kept digging for the next 12 years as it was a sort of gold mine of fossils. Despite all of his misfortune, Marsh did find a friend with great scientific credibility stick around, Charles Darwin. In an 1880 letter to Marsh, Darwin stated,

> I received some time ago your very kind note of July 28th, and yesterday the magnificent volume. I have looked with renewed admiration at the plates, and will soon read the text. Your work on these old birds on the many fossil animals of N. America has afforded the best support to the theory of evolution, which has appeared within the last 20 years. The general appearance of the copy which you have sent me is worthy of its contents, and I can say nothing stronger than this[25].

So despite slowly losing his workers at Como Bluff, Marsh still believed he was in the lead over Cope in the Bone Wars.

Another paleontologist at the time was Professor Alexander Emanuel Agassiz of Harvard who sent his own team of bone hunters to Como Bluff to try and make his own discoveries and prevent Marsh and Cope from doing any more harm to their reputations as the feud began making national headlines. At the same time, Carlin and Frank formed a bone company to sell

[25] Charles Darwin to Othniel Marsh, August 31, 1880, in American Experience: Dinosaur Wars http://www.pbs.org/wgbh/americanexperience/features/primary-resources/dinosaur-letter/

fossils to the highest bidder after stealing some fossils from both scientists camps[26]. Reed left in 1884 to become a sheep herder, leaving Marsh with very little left to find at Como Bluff. Despite the loss of Reed and the lack of bones being found, Marsh had more operational quarries than Cope in 1884; Cope, who in the early 1880s had more bones than he could fit in a single house, had fallen behind in the Great Dinosaur Rush. By the late 1880s, the media sensationalization of the Bone Wars had begun to die down due to international stories of the time and both men wanted to escape the spotlight. Marsh was placed at the head of the consolidated government survey by his friends in Washington to help him get out of the spotlight. Cope unfortunately didn't have friends in high places and had to dig his way out of the spotlight. He began investing in gold and silver prospects in the West, and braved malarial mosquitoes and harsh weather to search for fossils himself as many people refused to work for him because they were on Marsh's payroll. Both men began to falter in their studies and loyalties as Cope began to run out of money and Marsh alienated his allies due to being very secretive about his findings from the digs. Cope's would find his chance to strike at Marsh in 1884, when Congress began to investigate the proceedings of the consolidated geological survey.

Cope kept a journal of Marsh and the consolidated geological survey's misdeeds for several years. Cope eventually used his journal to create an exposé on Marsh as a critical blow to his career. The original plan for this was to create a series of newspaper debates between Marsh and Cope; as the public already knew a little bit about the feud, while the scientific community knew all about the feud. Unfortunately, before the articles could be published, the

[26] David Rains Wallace . *The Bonehunters' Revenge: Dinosaurs, Greed, and the Greatest Scientific Feud of the Gilded Age*. (Houghton Mifflin Books. 2000)

New York Herald released an article titled “Scientists Wage Bitter Warfare". This article shocked the general public and according to “The Fossil Feud Between E. D. Cope and O. C. Marsh”, “Most scientists of the day recoiled to find that Cope's feud with Marsh had become front-page news. Those closest to the scientific fields under discussion, geology and vertebrate paleontology, certainly winced, particularly as they found themselves quoted, mentioned, or misspelled. The feud was not news to them, for it had lurked at their scientific meetings for two decades. Most of them had already taken sides”[27]. This article began a war in the presses between Cope and Marsh, with Cope accusing Marsh of plagiarism and misspening of government funds. Marsh and the consolidated geological survey fired back by publishing their own articles and filing charges against Cope. Cope had to defend himself in the press as the articles written about the feud were poorly written and under-researched. At one point, Cope was asked to step down from his teaching position at the University of Pennsylvania unless he could provide proof of his claims against Marsh. Marsh himself kept the *New York Herald* story alive by constantly firing at Cope, but by the end of January 1884 the story had disappeared from newspapers due to other more interesting stories happening at the time.

While there were no official charges or trial against Marsh, Congress demanded that the budget of the consolidated geological survey be itemized just in case anyone did end up misusing government funds. In 1892, Marsh resigned from the consolidated geological survey at the demand of his superior who nearly went down with Marsh for their crimes. At the same time, many of Marsh's allies were retiring or had died, making him a less significant figure in the field of paleontology. As Marsh began to fade into obscurity due to his reduced wealth,

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[27] Elizabeth Shor. *The Fossil Feud Between E. D. Cope and O. C. Marsh*. Detroit, (Michigan: Exposition Press. 1974)

Cope received a position on the Texas Geological Survey. Cope's luck just kept on coming throughout the early 1890s, as he was promoted to Leidy's former position as Professor of Zoology and was elected President of the American Association for the Advancement of Science the same year that Marsh stepped down as head of the Academy of Sciences. Later in the 1890s, Marsh won the Cuvier Medal, the highest paleontological award, giving him more credit in the scientific community. Cope and Marsh were at each other's throats until 1897 when Cope died at the age of 56 with an astounding 1,200 papers written in his lifetime. But before Cope died, he issued Marsh a final challenge. He donated his skull to science so that his brain could be measured, hoping that his brain was larger than Marsh's; at the time, brain size was thought to be a measure of intelligence. Marsh never accepted the challenge, and Cope's skull is still in the archives at the University of Pennsylvania to this day[28]. Marsh later died two years later in 1899 at the age of 67 after falling into financial ruin due to his exploits throughout the years. Based on pure numbers, Marsh "won" the Bone Wars. Both scientists made incredible discoveries throughout the years, but while Cope discovered a total of 56 new dinosaur species, Marsh discovered 80[29]. The legacies both men left behind left a mark on paleontology as a study for years to come.

After the Bone Wars subsided and Marsh and Cope passed away, the scientific community began to rebuild its reputation. Many scientists who worked for Marsh and Cope began trying to build careers for themselves, including a former Marsh employee, J.B. Hatcher. In 1893, Hatcher arrived at Princeton University searching for work. Between 1896 and 1899, Hatcher and O.A. Peterson went on three expeditions to Patagonia in South America,

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[28] Dodson, Peters, Bakker, Robert (interviewees) (1992). *The Dinosaurs! Episode 1: "The Monsters Emerge"* (TV-series). PBS Video, WHYY-TV.
[29] Edwin Colbert. *The Great Dinosaur Hunters and Their Discoveries*. (Courier Dover Publications. 1984)

accompanied at different times by A.E. Colburn and Barnum Brown. The collection of fossils the scientists discovered, mainly comprised of fossil mammals, birds and reptiles, were some of the most diverse fossil finds discovered thus far. Soon after his last trip to Patagonia, Hatcher took a job at the Carnegie Museum of Natural History in Pittsburgh[30]. The vacuum Marsh and Cope left was soon be filled with both their former employees and admirers from their heyday.

Many of the future paleontologists who grew up watching the Marsh and Cope feud unfold began to realize they didn't want to have the same reputation as those two. Two of which were Thomas R. Overton (1862-1935) and Handel T. Martin (1862-1931), products of the Gilded Age Bone Wars. In 1895 Overton and Martin helped excavate the 12 Mile Creek Paleoindian site in Folsom, New Mexico and according to *The Gilded Age "Bone Wars" and the Birth of Paleoindian Archaeology: Williston, Martin, Overton & the 12 Mile Creek Site*, "One consequence of the Folsom investigations was to establish standards of evidence involving interdisciplinary studies of the site and its setting conducted by or under the watchful eye of established professionals"[31]. This excavation was one of the first after the Bone Wars unofficially ended in 1892 so there was plenty of pressure on these new paleontologists to show professionalism. The discoveries made at the 12 Creek site were published in 1906 featuring a reconstruction of a bison found at the site. This was the beginning of the rebuilding of paleontology's reputation in the eyes of the scientific community.

From here on, paleontology began to rebuild itself as a profession in the eyes of the scientific community. With many of the fossils beds in the midwest dug out by Marsh and Cope,

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[30] *History of Vertebrate Paleontology at Princeton*. Yale Peabody Museum of Natural History http://peabody.yale.edu/collections/vertebrate-paleontology/history

[31] Marlin F. Hawley "The Gilded Age 'Bone Wars' And The Birth of Paleoindian Archaeology: Williston, Marton, Overton, And The 12 Mile Creek Site". NORTH AMERICAN ARCHAEOLOGIST, Vol. 30(2) pg. 107, 2009

many paleontologists headed even further west to the Pacific Coast. In 1901, Petroleum geologist William Warren Orcutt recovered first fossils from the La Brea Tar Pits in Southern California in what is today Los Angeles, a rich source of ice age mammal remains including mammoths, smilodons, and ground sloths[32]. Between 1906 and 1916 hundreds of thousands of Pleistocene fossils were uncovered in central Los Angeles after the discovery of the La Brea Tar Pits. The La Brea tar pits later become a huge tourist attraction and a big inspiration for future young paleontologists. Then, in 1905 another huge attraction for paleontology was discovered. Barnum Brown discovered and described Tyrannosaurus Rex (T-Rex) for the first time in Wyoming. When he discovered it, Brown wrote, "Quarry No. 1 contains the femur, pubes, humerus, three vertebrae and two undetermined bones of a large Carnivorous Dinosaur not described by Marsh.... I have never seen anything like it from the Cretaceous"[33]. The T-Rex was one of the largest dinosaurs ever discovered and while it wouldn't gain major prominence in paleontology at the time, it became the dinosaur every child knows when they find out about dinosaurs.

In 1909, Massachusetts paleontologist Mignon Talbot became the first female paleontologist elected to the Paleontological Society[34]. In 1912, Alfred Wegener proposed the theory of Continental Drift, leading to plate tectonics, which explained many patterns of ancient biogeography revealed by the fossil record[35]. This is a major advancement in paleontology as it gave more legitimacy to the idea that the Earth was as old as the fossils stated. Also in 1912,

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[32] "Orcutt Ranch Horticultural Center Rancho Sombra del Roble". Los Angeles Department of Recreation and Parks.
[33] Lowell Dingus; Mark Norell. *Barnum Brown: The Man Who Discovered* Tyrannosaurus rex. (University of California Press. 2010) 90, 124.
[34] Eleanor S. Elder. "WOMEN IN EARLY GEOLOGY". (*Journal of Geological Education*. 30 (5) 2016) 287–293.
[35] W. R. Jacoby . "Modern concepts of earth dynamics anticipated by Alfred Wegener in 1912". (*Geology*. 9: 1981) 25–27.

Charles Dawson announced the discovery of Piltdown Man in England[36], this was one of the first of many hoaxes in paleontology, setting back the credibility of the science despite years of rebuilding. Piltdown Man confused paleoanthropologists until the fossils were revealed as fakes in 1953[37]. Much later in 1938, several moonshiners in Texas discovered dinosaur tracks which prompted Barnum Brown of the American Museum of Natural History to send Roland T. Bird to Texas in search of dinosaur trackways[38].

Finally, in 1944, paleontology was recognized as a true professional study to undertake. For years the study was considered a career but never a true profession, there were university departments and majors in paleontology but it was never a true profession. In 1944, George Gaylord Simpson published "Tempo and Mode in Evolution", a crucial contribution to the evolutionary synthesis, which integrated the facts of paleontology with those of genetics and natural selection. Paleontology was finally viewed as a legitimate profession that could help us understand the history of the Earth. Simpson argued that the microevolution of population genetics was a valid way to explain the patterns of macroevolution observed by paleontology[39]. "Tempo and Mode in Evolution" earned Simpson the Daniel Giraud Elliot Medal from the National Academy of Sciences in 1944. This solidified paleontology as a professional science that was recognized by the scientific community.

Despite the impact left by the Bone Wars on the history of paleontology, very few historians actually know anything about the Bone Wars. This is due in part to the many

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[36] Frank Spencer. "Dawson, Charles (1864–1916)". *Oxford Dictionary of National Biography*. (Oxford University Press. 2004)
[37] Roger Lewin, *Bones of Contention*, (Trustees of Clark University 1987)
[38] L. L. Jacobs III. "Home on the Range" Pg. 4-5 Lone Star Dinosaurs. (Texas A&M University Press. 1995)
[39] George Simpson, *Tempo and Mode in Evolution*, (New York, Columbia University Press 1944)

discoveries made since then and the effort by the scientific community to cover up this blemish. After the Bone Wars, many publications that were friends with both men put out biographies in the hopes of saving the reputation of both men so they do not fade into obscurity. Unfortunately many of these biographies and books about the Bone Wars are either dry or just a cliffnote among other facts in a book about the history of paleontology. The book *The Bonehunter's Revenge: Dinosaurs, Greed, and the Greatest Scientific Feud of the Gilded Age* states,

"The bone war crept into my consciousness much the same way it entered history. I kept coming across it while reading about paleontology, and it gradually evolved from a diversion to a fascination… Their rivalry was virtually unrestrained, without the checks and balances that cultures usually put on such disagreements"[40].

The Bone Wars are described here as a fun fact one comes across while doing other research that evolves into a full on research topic itself. Much like how I came to want to research the Bone Wars. The Bone Wars almost comes off as an anomaly that is so unique that it's both incredibly obscure and yet well known.

Without the Bone Wars, paleontology would not be the way we know it today. The Bone Wars gave us an example of scientists using unrestricted attacks on fellow scientists in order to outdo each other. Paleontologists may have figured out not to attack each other on their own, but the Bone Wars sped up the process to help paleontology become a true professional career. It was a necessary evil. Paleontology today is professional and the scientists who study it have mutual respect for one another rather than constantly trying to outdo each other in the public forum. Marsh and Cope paved the way for future paleontologists such as Mignon Talbot,

[40] David R. Wallace "The Bonehunter's Revenge: Dinosaurs, Greed, and the Greatest Scientific Feud of the Gilded Age". (Houghton Mifflin Harcourt, 2000)

Thomas R. Overton, Handel T. Brown, and Barnum Brown to become professionals in their field without having to pay spies or other people to sabotage one another.

Marsh and Cope were by no means professional in their activity while digging for fossils. This isn't to say they didn't leave a major impact on the profession of paleontology. In the end, Marsh and Cope were left in financial ruin with the amount of money they spent trying to one-up each other over the course of nearly 30 years. Despite that, together they ended up discovering over 130 new species of dinosaurs across the American West. Cope died in 1897 after having written over 1,200 papers in his lifetime. Marsh died in 1899 being claimed the victor of the Bone Wars having discovered over 80 species by himself. In *The Bone Hunters* the author states,

> Finally, there is durable, intelligent, well-focused hatred, a long-range creative force as powerful as love. Here Cope and Marsh truly excelled. Even though dragging fantastic loads of what are generally called 'human frailties', they managed to create on the way a new understanding of the earth and its life. No higher human achievement is possible[41].

This quote shows that while Cope and Marsh did plenty of harm to both each other and their study, they did happen to discover a new way of looking at the history of our Earth and that impact is far greater than any harm they did to the history of paleontology. The Bone Wars left a massive impact on the paleontology community and that impact did plenty of harm but was overall good for the study of life on our planet. The strife caused by the Bone Wars helped paleontologists understand what level of professionalism was needed to do what they needed in order to make discoveries.

[41] Url Lanham. "The Bone Hunters" Pg. 271. (1918). Columbia University Press. (1973)

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