CHAPTER I: Newton -v- Leibniz

Section 3: Controversy

In the previous two sections and their related readings, we learned of the important contributions made by Newton and Leibniz respectively towards the development of the calculus. It is easy now 350 years after the fact to look back and give equal credit for this achievement to both men, but in real time things were not so clear.

As we saw, Isaac Newton was reluctant to publish many of his findings. Whether it was insecurity, unwillingness to be scrutinized, or simple rebellion against authority, he kept many of his results to himself or communicated them only to select people. The essentials of his version of the calculus, his fluxions, were developed around 1669 and communicated to his friend and mentor Isaac Barrow. Newton's *Method of Fluxions* in which he outlined most of his results was written in 1671, but not published until 1736, nine years after his death. Similarly, Newton developed many other results that would eventually become a part of calculus and analysis (such as the binomial theorem, infinite series, elementary differentiation and integration) and in 1669 he wrote *De analysi per aequationes numero terminorum infinitas* (*On Analysis by Equations with an Infinite Number of Terms*) in which he included many of these topics, although not published until 1711. Infinite analysis had long troubled mathematicians, to the point that many avoided infinite expressions altogether. This was one of the many obstacles that hindered the development of the calculus for years. Infinity and infinitesimals (and indivisibles) were perplexing to mathematicians going back to ancient Greece. In fact, we will see in our next several chapters that the trajectory of the development of the calculus truly originates with Zeno, Eudoxus, and Archimedes, travels through Cavalieri and Fermat, Wallis and Barrow, and reaches its culmination with Newton and Leibniz. Newton and Leibniz are considered the founders of the calculus not because they were the first to consider the topics and issues, or even because they were the first to solve specific problems. Rather, they were the first to coalesce a wide variety of individual problems into a system. Also, it was in *De Analysi* (as it became known) that for the first time in the history of mathematics an area was found through the inverse of differentiation. Here we see the beginning of the fundamental theorem of calculus, also discovered by Leibniz.

Newton's epic work *Principia*, which was to become perhaps the most influential scientific work of all time, included many of his results on the calculus and the acclaim and notoriety of this impressive work influenced many to support Newton as the father of calculus. Leibniz however has an impressive list of accomplishments that gives credence to at least equal credit. As we saw in Section 2, Leibniz published his results before Newton, and more importantly with superior notation and cohesiveness. There is significant evidence that Leibniz recognized the fundamental inverse relationship between differentiation and integration, perhaps even before Newton did. His affinity for knowledge and his appreciation of clear notation and order supports the view that Leibniz would have pursued and developed this beautiful relationship. His voluminous correspondences with mathematicians on the European continent as well as in England can be seen as a two-edged sword. On the one hand, there is ample evidence that Leibniz knew of the pre-calculus progress made by others, and his advancements in notation and synthesis into a coherent system of rules was impressive. But it is this same exposure to the work of others that caused (and still causes) some to doubt his originality.

Newton began corresponding with Leibniz (through Henry Oldenburg, the secretary of the Royal Society of London) in the mid 1670's. In his first letter, Newton outlined many of his results without detailing his methods. Unfortunately for history, this letter took some time to reach Leibniz, and so although Leibniz replied immediately, Newton believed he had taken six weeks or more to formulate his reply and an aura of distrust was born. Newton wrote a second letter that took eight months to reach Leibniz in which he communicated clearly but politely his suspicions that Leibniz has essentially plagiarized his work. Leibniz again replied immediately with a detailed accounting of his methods.

In 1711, Leibniz read a report by British mathematician John Keill in which he makes the accusation that Leibniz had stolen from Newton. Leibniz denied Keill's claims and stated that he did not learn of the fluxional calculus from Newton. Keill countered with the two letters sent from Newton to Leibniz and the Royal Society formed a committee to resolve the dispute over priority. The proceedings of the committee were heavily biased towards their countryman. In their hearings, they never asked Leibniz for his account and the final report was even written by Newton himself, not surprisingly finding in his favor.

As a result, Leibniz had a long feud with Keill, refusing to even communicate with him and ignoring letters from him. Eventually Newton wrote Leibniz directly, and Leibniz replied with a complete description of his version of the calculus and how he developed it. In the end, British mathematicians ended up supporting Newton while many on the European continent believed Leibniz. As a result, mathematics in England fell behind the rest of Europe, and when the movement began in the late 18th century to solidify the foundation of the subject and even add rigor, it was led by continental mathematicians.

Today, many people still support Newton and some support Leibniz. It is safe to say that most support the view that they should share equal credit. The gathering of 2,000 years worth of progress and methods into a coherent system and essentially seeing the order through the chaos was a remarkable achievement. It paved the way for the following 350 plus years of rapid advancements in the mathematical and scientific communities. In the next few chapters we will discuss the prior work that paved the way for Newton and Leibniz.