By far the most oft-cited example of the power of animal experimentation against human disease is the discovery of insulin. Insulin revolutionized the treatment of diabetes when it was first used at the University of Toronto in the 1920s. The traditional story of the discovery of insulin, told over and over again in textbooks, films, tapes and television programs, goes roughly like this:

By the early years of the twentieth century it was understood that the disease named diabetes mellitus involves the body's inability to metabolize or utilize its food, especially carbohydrates. It was also understood that the pancreas holds the key to carbohydrate metabolism. When experimental animals had their pancreases removed, they immediately lost the ability to utilize carbohydrates, the amount of sugar in their blood and urine rose sharply, and they soon died from severe diabetes. Various researchers speculated that the pancreas, which secretes digestive enzymes into the gut (its external secretion), must also produce another kind of secretion, one enabling the body to utilize its fuel. The search for the internal secretion of the pancreas had occupied a number of physiologists throughout the world, but by 1920 it had not produced any practical results.

In the autumn of 1920 Frederick Banting, a young surgeon in London, Ontario, happened to be reading an article about the pancreas. Banting began thinking about the problem of the internal secretion, and late that night jotted down an idea for an experimental procedure—ligating the pancreatic ducts — that might be a way of isolating an internal secretion. He took his idea to his alma mater, the University of Toronto, where the Professor of Physiology, J.J.R. Macleod, was an internationally known expert in carbohydrate metabolism. Macleod was at first skeptical of Banting's suggestion, but reluctantly agreed to give him a lab and some dogs for a few weeks during the coming summer. He assigned him a young science student, Charles Best, to do the chemical tests necessary for the work, and then went off to Scotland for his summer holidays.

Banting and Best experienced a number of problems with their work in that summer of 1921, the story goes, but soon found that their approach was yielding remarkable results. With the extract of pancreas they had made from duct-ligated dogs they were able time after time to lower the blood sugar and remove other symptoms from diabetic dogs. Prof. Macleod came home to a pair of excited researchers who, by the autumn of 1921, were keeping a severely diabetic dog, Marjorie, alive with their extracts. Marjorie eventually lived for seventy days before being sacrificed; until then diabetic dogs had died within a week or two of their pancreas being removed.

By the winter of 1921-22 Banting and Best were giving their first papers on the internal secretion of the pancreas. They were also ready to test their extract on humans. In Toronto General Hospital a young boy, Leonard Thompson, became the first diabetic to receive insulin. His life was miraculously saved.[1]

Nonetheless, new historical evidence unearthed by medical historian Michael Bliss for his new book on the discovery of insulin reveals that virtually every step in the traditional account is highly questionable, if not outright false. While Bliss did not explicitly analyze the historical data to assess the importance of animal experimentation, it is clear from the factual evidence presented in Bliss' book that the animal experimentation which preceded the discovery of insulin was not part of the *scientific* process that led to the discovery of insulin. While the various dog experiments conducted by von Mering and Minkowski in 1882 and by Banting and Best in the early 1900s were undoubtedly useful for convincing skeptics that insulin exists, all of the hard scientific information which allowed researchers to discover insulin consisted of clinical data: observations of actual human patients.

Physiologists themselves began to criticize Banting and Best's dog experiments as far back as the 1920s when the experiments were performed. In fact, in the December 16, 1922 issue of the *British Medical Journal*, Dr. Ffrangcon Roberts published a devastating critique of the animal experiments. After studying Banting and Best's major scientific papers in the *Journal of Laboratory and Clinical Medicine*, Roberts reviewed the steps leading up to the discovery of insulin in Toronto. Roberts explains that the animal experiments were based upon Banting's hypothesis that it was necessary to protect the "internal secretion" of the pancreas (insulin) from being destroyed by the "external secretion" of the pancreas: the enzyme trypsin.

Banting maintained that the most effective way to destroy the trypsin in the animal body to prevent it from breaking down insulin would be to tie off the ducts that secrete trypsin, causing the trypsin-producing cells to deteriorate or atrophy. Banting insisted that all previous attempts to isolate insulin (the "internal secretion" of the pan-

[1]***Bliss, M.* The Discovery of Insulin *(Chicago: The University of Chicago Press, 1982), pp. 11-12.***