throughout. First known as the Highland Society’s Veterinary School, its graduates received their certificate from the Highland Society stating they were “qualified to practise the veterinary art.”

Dick’s thriving practice was incorporated into his school, and during the next decade both prospered as a clinic for treating lame and sick horses. A new school building was constructed in 1833 that included more space and a miniature version of the traditional medical amphitheater, wherein students looked directly down on Dick in action. Later, as Professor Dick, he was credited with the ability to sit in his second-floor office and diagnose lameness by listening to the claps of a horse trotted on cobblestones in the street below.

The importance of all this is that at the time of William Dick, English veterinarians were emigrating to North America, and many of them were poorly educated in London. Turns out, the inspiration for American veterinary education and science came not from London but from the back room of a forge in Scotland. In his long career, Dick mentored and bequeathed seven extraordinary men who would found veterinary schools throughout the world—including three in North America: Andrew Smith in Toronto, Duncan McEachran in Montreal, and James Law at Cornell University in New York—each bearing the gift of Dick’s extraordinary clinical skill, his knowledge of science, and his talent skill as an educator.

4. THE SCIENCE GIANTS OF 1860: PASTEUR, VIRCHOW, AND DARWIN

In the 1860s there were three European giants in the fields of biology and medicine. Their discoveries had been made in a short five-year span just before the American Civil War: in France, the chemist Louis Pasteur discovered alcoholic fermentation, microbial spoilage of wine and milk, and pasteurization (1857); in Germany, the medical pathologist Rudolf Virchow established the cell as the basic unit of life and disease in his book *Cellular Pathology* (1858); and in England, Charles Darwin changed science forever with his *On the Origin of Species* (1859). Late in their careers, all three had astonishing impacts on science through investigating animals—their experiments were veterinary science, and veterinarians contributed to and capitalized on their discoveries.
Charles Darwin created a new discipline, evolutionary biology; he also gave rise to creationism, a term he first used in an 1856 letter to describe people who objected to the emerging science of evolution. Darwin was referring to their belief that life originated from specific acts of divine creation rather than through natural processes. It was creationism that carried the burden of European anti-science to America.

Rudolf Ludwig Karl Virchow, the world’s preeminent physician for forty years, was a rebel from the start. Established as a young—and progressive—pathologist in Berlin, he declared himself a Democrat during the political upheavals of 1848 and was forced to leave for a position as professor in Würzburg. At the persistent interposition of medical organizations, he was recalled to Berlin in 1856. Active politically, Virchow was one of the founders of the Progressive Party and served on the Berlin City Council, the Landtag, and the Reichstag. A true comparative pathologist, he used his fame and political influence to promote the education and licensure of veterinarians as a means to reduce human disease in rural Germany. His work gained worldwide distribution in scientific journals and helped make German veterinary science preeminent.

Physicians and medical pathologists from North America, Scandinavia, Turkey, and Russia traveled to Berlin to study in Virchow’s laboratory. For veterinarians, study with former Virchow pupils Wilhelm Schütz and Robert Ostertag at the Berlin Veterinary College was obligatory. For three generations, American veterinarians were taught from German textbooks or from translations of them. Ostertag’s text on meat and sanitary inspection promoted a new discipline.

Late in his career, Virchow offered his expertise to train veterinarians in pathology and used his political influence to promote licensure of veterinarians as a means to prevent the spread of zoonotic diseases to humans. On the farm he saw no separation of human and veterinary public health.

Virchow never lost his sense of justice. To debunk racist poppycock appearing in the medical press that data from studies on the skulls of native American tribes was evidence of inferiority, he published *Crania ethnica Americana* (1892), writing that a “cephalic index, calculated on length and breadth of the cranial vault” had no bearing as a measure in human populations. Virchow died in 1902 in Berlin, his failing health attributed to a streetcar accident.
Louis Pasteur gained world fame late in his career for his studies on immunity in animals. He produced and tested vaccines for fowl cholera in chickens, anthrax in cattle, swine erysipelas, and rabies in dogs and humans. His veterinary and medical colleagues had actually done the work for three of his greatest vaccine successes: veterinarian Jean Toussaint had developed the fowl cholera and anthrax vaccines and physician Émile Roux had first used dried nerve tissue as a vaccine for rabies. The original rabies vaccinations in cattle, done by the French veterinarian Pierre Galtier, professor of pathology in Lyon (and on which Pasteur had based some of his studies), was never noted.

From Pasteur’s papers released in the 1970s, it was clear that although his fame had been gained legitimately, he had been a successful self-promoter and entrepreneur and had sometimes padded his results. At the time, a little fabrication and plagiarism here and there didn’t seem to dent Pasteur’s fame in medicine.

After his early successes on alcoholic fermentation and during the final stages of his silkworm disease studies, Pasteur had shifted to work with infections of animals. Perhaps the change was a consequence of his stroke in 1868 that paralyzed the left side of his body. The government’s disarray and overthrow of Louis Napoleon after the Prussian defeat in 1870 may also have been a factor. But more likely, Pasteur was drawn to veterinary science by the astonishing discoveries being made in bacteriology.

In 1880, an epidemic of fowl cholera destroyed 10 percent of the fowls in France. Chickens, turkeys, and waterfowl died suddenly—some having said to have dropped during flight. Signs of disease were inflammation of the face, cyanotic wattles, and swollen joints. At autopsy there was evidence of sepsis: scattered hemorrhages about the heart and inflammation throughout the body—lungs, liver, and other organs red and swollen.

Pasteur, asked to investigate fowl cholera, traveled to hard-hit southwestern France. At the Toulouse Veterinary School, Professor Toussaint had already isolated the fowl cholera bacillus in 1879 and produced a vaccine for chickens; in honor of his scientific idol, he had named his new bacillus Pasteurella. Toussaint was also working on anthrax: on July 12, 1880, he presented his data on tests of his anthrax vaccine in sheep and dogs to the French Academy of Sciences (Académie des Sciences).

Toussaint gave Pasteur broth cultures of his fowl cholera bacilli (and, most likely, his thoughts on anthrax). Returning to his laboratory at Arbois, Pasteur maintained the virulent fowl cholera bacteria in chickens by feeding them...
breadcrumbs containing a few drops of infective culture; when they died, he fed cultures from their blood to a new group of chickens. Leaving for vacation in the hot summer, he instructed his assistant, Charles Chamberlain, to maintain the cultures. Chamberlain failed to do that and left on a holiday of his own; the bacterial cultures remained stored on the shelf.

Returning from vacation, Pasteur used these aged cultures to feed susceptible chickens to maintain the bacteria; the birds sickened slightly but survived. Reusing the surviving chickens, he again injected virulent bacteria; this time the chickens did not sicken. The resistance of the chickens was noted and, remembering Edward Jenner’s vaccination discovery, Pasteur suspected the aged culture had in some way reduced the virulence of the fowl cholera bacteria—that it had been attenuated. Recognizing the potential importance of using aged cultures to diminish virulence, Pasteur shifted his studies to diminishing the virulence of anthrax bacilli using heat. Toussaint had used the antiseptic potassium dichromate to damage the bacteria for his vaccine, and Pasteur did the same.

French veterinarian Hippolyte Rossignol, the editor of *La presse vétérinaire* (The veterinary press), attending a lecture by Pasteur, challenged him to test his anthrax vaccine in a public demonstration. Pasteur agreed, and on May 5 and again on May 17, 1881, twenty-four sheep, one goat, and six cows were given Pasteur’s heat-attenuated anthrax bacilli at the test site in Pouilly-le-Fort. Two weeks later, on May 31, these animals, as well as controls of nearly the same numbers, were injected with virulent anthrax. Three days later when Pasteur arrived to inspect the animals, the gathered crowd greeted him with applause. The vaccinated animals were all alive; of the controls, unvaccinated, the sheep and the goat were dead and the cows sick.

Pasteur did not reveal the nature of his vaccine, but his papers showed he had used heat and potassium dichromate (growing bacilli at forty-two degrees Celsius made them unable to form spores)—never crediting Toussaint for his anthrax vaccine. Adrien Loir, Pasteur’s nephew, revealed the story in his 1938 book *A l’ombre de Pasteur* (In the shadow of Pasteur). The truth was that W. S. Greenfield, working at the Brown Animal Sanitary Institution in London, had developed and tested a vaccine against anthrax months before Pasteur’s experiments at Pouilly-le-Fort. But Pasteur had the fame to attract attention, the creativity to improve on the work of others, the courage to risk his vaccines in public, the power of the press to publicize his successes, and the financial base to take advantage of them.
Pasteur’s greatest achievement was a vaccine for human rabies: on July 6, 1885, the first treatment of a young boy bitten by a rabid dog was done; the boy’s survival spread the Pasteur name worldwide. In France, the Institut Pasteur opened in 1888 and was dedicated to producing rabies vaccine and to investigating other infectious diseases; it continues today as Sanofi Pasteur. Copycat Pasteur Institutes offering rabies vaccinations opened in Chicago in 1890, New York City in 1891, and Baltimore in 1897; they were short-lived. The New York City Pasteur Institute closed in 1918.

5. ROBERT KOCH: GAME CHANGE

When new light microscopes with improved resolution could detect small particles, a new field of study was born. Botanists began to investigate algae, protozoa, and other large one-celled organisms. Physicians were slow to use the new instruments. An exception, Pierre François Olive Rayer investigated animal diseases and identified glanders as a new disease in horses in France—he was dean of the Faculty of Medicine in Paris and was elected to the American Academy of Arts and Sciences in 1855. Rayer and Casimir Davaine, using a primitive microscope, found anthrax bodies in blood smears of sheep dead of anthrax sepsis; they transmitted the disease to mice, and pathologist Rayer published a description of their anthrax bodies.

The small field of microscopic botany was soon dwarfed by astounding investigations in Germany that revealed something entirely new. Robert Koch’s report on the anthrax bacillus, published in a German botany journal, was the first to unequivocally prove the link of a specific microorganism to a single disease, rejecting the idea of spontaneous generation and supporting the emerging germ theory of disease.

Hermann Robert Koch had an MD degree from Göttingen and had worked in research laboratories as a student. The issues of the day were spontaneous generation and contagion, and his mentor, the anatomist Jacob Henle, had published a theory that tiny living particles, unable to be seen by the naked eye, might cause disease. After passing his examination for practice and serving briefly in the Franco-Prussian war, Koch began work as district surgeon in rural Wollstein in Prussia (now Wolsztyn, Poland) in 1880. Aware that contagious diseases of livestock were a source of human disease, the Prussian government