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
kept astonishing records. For the period April 1, 1877, through March 31, 1878, anthrax was reported to have killed 70 horses, 1,203 cattle, 1,313 sheep, and 204 hogs. Glanders was diagnosed in 2,953 horses (138 died and 2,499 were killed peremptorily), and in one family of 6 men infected, 3 died of glanders. Rabies killed 571 dogs, 6 horses, 132 cows, 33 sheep, 16 hogs, and 6 humans—137 roaming dogs and 1,098 dogs suspected of rabies had been killed. It was a dangerous time in the countryside.59

In his office, Koch set up a laboratory with a homemade incubator, a microscope, and a crude microtome to cut slices of tissue. Beginning a study on algae, he soon switched to anthrax. Examining glass slides bearing drops of serum from infected blood with his new microscope, Koch found the large anthrax bacilli. He then investigated ways to grow these bacteria by incubating them in broth, then in gelatin, and finally in household agar, which did not melt at incubation temperatures. Each tiny bacillus would form a colony that in a few days he could see without using his microscope.

Koch inoculated mice with slivers of wood containing anthrax bacilli from the spleen of a cow dead of anthrax; the mice died in a few days. For control mice he used normal spleen tissue on wood slivers, and they remained healthy. Koch then repeated this experiment by using his pure cultures of the anthrax bacillus he had grown on agar. His results were the same. When he smeared old bacterial cultures that had been deprived of oxygen and moisture onto glass slides, stained them with one of the new German dyes, and examined them in his microscope, he noted that the large box-shaped anthrax bacilli had transformed into small dense round spores. In these old cultures the anthrax bacilli died, but the spores did not. They would survive dormant until activated by moisture and oxygen to form new bacilli, a discovery that explained the persistence of anthrax in animals put in pastures that had not been grazed for years.

Working alone, Koch studied a large spore-forming bacillus he had isolated from animals and that he believed might cause anthrax, a dangerous and rapid killer of cattle and sheep as well as humans. To consult with the expert on spores, Koch traveled the short distance to the University of Breslau (now Wrocław, in Poland) to demonstrate his findings to Ferdinand Cohn, an eminent botanist, algae expert, and fledgling bacteriologist.

Cohn invited two colleagues to view Koch’s demonstration: Julius Cohnheim, the pathologist who had just been hired from Virchow’s institute in Berlin (where he had discovered inflammation was due to white blood cells
passing through swollen capillaries), and a young American visiting pathologist working in Cohnheim's laboratory, William Welch, who would become his own giant of American medicine as one of the founders of Johns Hopkins School of Medicine and the first director of the Rockefeller Institute for Medical Research in New York in 1901. All three scientists in Breslau recognized the astonishing value of Koch's findings. Cohn helped Koch with engravings for his paper and expedited its publication in the botany journal he edited. What followed was a cascading series of discoveries of bacterial causes of tuberculosis, tetanus, and other infectious diseases.

In universities, the discipline of bacteriology moved from its academic home in botany to medicine and veterinary science. Veterinary medicine rapidly emerged as a new discipline. Veterinarians had played important roles in the birth of bacteriology and immunology, and their efforts were leading to modern concepts of animal health care. In the American Veterinary Review's News and Sundries section, there was a note that in 1882 physician Friedrich Loeffler and veterinarian Wilhelm Schütz had isolated the glanders bacillus and named it Bacillus mallei. Later there were notices that Pasteur, working with fowl cholera and anthrax, had discovered that living bacteria modified by allowing their cultures to age or be treated with heat could induce immunity against virulent infection.

And America too was on the cusp of an astonishing era of scientific progress. Northwestern University’s Robert Gordon, a stagnation economist, points to the period of 1840–1970 as one of striking innovation and growth in all areas: agriculture, medicine, transportation, energy, and communication. It was also the period when veterinary medicine evolved in North America from farriers and itinerant cow leeches to science-based veterinarians; its progress would grow in spurts, enhanced or retarded by change in the economy, by demands of war, and by idiosyncrasies of political culture—elements of society that are linked together.

For forty years of that remarkable century and a quarter, Robert Koch was the world’s most celebrated medical scientist. His discoveries that bacteria caused anthrax and tuberculosis led to a half-century when bacteriologists anywhere could make discoveries using Koch’s innovative use of the light microscope, dyes for staining bacteria, and agar-based solid media to grow these new germs. As his fame spread, Koch was offered a position in Berlin to head a research institute on infectious diseases. His discovery of the tuberculosis bacillus, made in
Robert Koch was the most celebrated medical scientist in the Western world at the turn of the century. His last trip to the U.S. was for a reunion in Iowa. Here: The Koch brothers in Keystone, Iowa, in 1908. Left to right: Arnold Koch (brother, St. Louis, Mo.), Mrs. Robert Koch (Berlin), Adolph Koch (brother, Keystone, Iowa), Mrs. Adolph Koch (sitting), and Professor Robert Koch (Berlin). (COURTESY OF THE WALTER BIERRING PAPERS, STATE HISTORICAL SOCIETY OF IOWA, DES MOINES.)

a building close to the Berlin Veterinary College, was presented at a conference in Berlin and quickly published in the *Berliner Klinische Wochenschrift* in April 1882; it won Koch the Nobel Prize in Medicine in 1905. The bacteriologic techniques Koch developed and the laws of proof he devised to make his discoveries changed science. Thereafter, Koch’s postulates were required to prove that specific bacteria were the cause of a single disease.

Two years before he died in 1910, Koch made a trip to the U.S. with his new wife. They stopped once in New York for a dinner at the Waldorf Astoria Hotel with Andrew Carnegie, who was supporting his research institute, and then traveled on to the Midwest to visit his brothers. His older brother, Adolph — also a graduate (in agriculture) from the University of Göttingen — was a farmer in Keystone, Iowa.