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AND THE GREAT PLAGUES

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How Microbes, War, and Public Health Shaped Animal Health

Norman F. CHEVILLE

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Cover photo: Veterinary Pathology class, Iowa State College, 1929.
From author's collection.

CONTENTS

PREFACE

Animal health care in North America evolved from farriers and itinerant cow leeches to science-based veterinary medicine in one century, from 1860 to 1960. This history focuses on the scientists and institutions that pioneered veterinary education and research. It memorializes the events and ideas that propelled science forward and those that blocked progress. An important part of the story is how cycles of discovery were enhanced or retarded by viability of the economy, by demands of war, and by idiosyncrasies of political culture—elements of society that are linked together.

Veterinary science in the rural Midwest arose from agriculture, but in urban Philadelphia it came from medicine; similar differences occurred in Canada between Toronto and Montreal. The Iowa Agricultural College was the first to establish a state-supported school of veterinary medicine in the United States that survived; its first scientists were agriculturalists and its graduates founded colleges and departments of veterinary medicine in the Midwest, Great Plains, Atlantic Seaboard, South, and the Palouse of the Northwest. In contrast, the University of Pennsylvania veterinary school was established as a cooperative venture with the medical school; its first science faculty were physicians who brought home the medical sciences from Europe.

As land grant colleges were established after the American Civil War, individual states followed divergent pathways in supporting veterinary science: one, a trade school curriculum that taught agriculturalists to empirically treat animal diseases; the other, a curriculum tied to science. The relevance of this, a pattern continued for a century, is that today some institutions have moved back to the trade school philosophy. Avoiding lessons of the 1910 Flexner Report on medical education reform, university-associated veterinary schools are being approved that do not have control of their own veterinary hospitals, diagnostic laboratories, and research institutes, components that are critical for training students in science. Underlying this change were twin idiosyncrasies of culture—disbelief in science and distrust of government—that spawned scientology, creationism, anti-vaccination movements, and other anti-science scams. All of these scalawags had destructive impacts on science in general and in veterinary medicine in particular. And there were other bogeymen within science: fraudulent scientists that stole the work of others, dishonest entrepreneurs, and latter-day snake oil salesmen.

The most recent impact on veterinary science has been the ascendance of women. Not permitted to study for the profession in early times, female students exploded after World War II, from near 0 in 1960 to nearly 90 percent of all veterinary school graduates in 2000. Women continue to play an increasing role in scientific research in the great plagues: veterinarian Amy Vincent, a scientist at the National Animal Disease Center, was awarded membership in the National Academy of Medicine in 2020 for her work on surveillance, vaccines, and the pandemic potential of swine influenza models.

THIS BOOK COVERS THE CENTURY when the infectious diseases anthrax, tuberculosis, smallpox, tetanus, plague, and polio were conquered and illuminates the important role that veterinary research played in that battle. The narrative is driven by astonishing events that centered on animal disease: the influenza pandemic of 1872, discovery of the causes of anthrax and tuberculosis in 1880s, the conquest of Texas cattle fever and then yellow fever, the German anthrax attacks on the U.S. during World War I, the tuberculin war of 1931, Japanese biological warfare in the 1940s, and today's bioterror dangers. These events illustrate how progress in biomedical science comes and goes in cycles. From 1860 to 1960, new investigative techniques appeared, shined brightly, and were replaced by technologies that were more advanced. When seminal discoveries were made, each generation of scientists was presented with new opportunities that lasted decades. This is the story of how pioneer veterinary scientists contributed to and capitalized on those discoveries for one century.

Norman Cheville
January 2021

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Four books by midwestern authors were critical for historical accuracy: *History of Veterinary Medicine at Iowa State College*, C. H. Stange, 1929, Iowa; *Veterinary Military History of the United States*, Louis Merillat and Delwin Campbell, Illinois, 1935; *A Short History of Veterinary Medicine in America*,

B. W. Bierer, Missouri, 1955; and *The American Veterinary Profession*, J. F. Smithcors, Michigan, 1963.

Regional books of exceptional value were *The Cary Legacy*, Sam Hendrix, Alabama, 2018; *Chronicles of Faith*, Frederick Patterson, Alabama, 1991; *A Century of Excellence*, Ronnie Elmore and Howard Erickson, Kansas, 2005; *History of the School of Veterinary Medicine of the University of Pennsylvania, 1884–1934*, Louis Klein et al.,1935; and *A Cornell Heritage: Veterinary Medicine 1868–1908*, E. P. Leonard, 1979.

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PART I

PROLOGUE

A Science Heritage

The Puritan ship *Mayflower* landed on Cape Cod in 1620, bringing Dorking chickens, Tamworth pigs, and two dogs, an English mastiff and an English spaniel. All sturdy breeds, they had been healthy when leaving England and survived in Plymouth Colony freed from European plagues. Their risk of disease in the New World may also have been diminished by a reduction in the population density of both native humans and animals from a catastrophic plague that had swept through eastern Massachusetts the previous decade.[1]

The "Indian disease" had devastated tribes prior to the *Mayflower*'s arrival; it had also killed muskrats, mink, and raccoons. Tribal members developed high fevers, headaches, and skin rashes and, near death, bleeding from the nose. Historians believed the disease to have been leptospirosis,[2] acquired from rats leaving the ships of previous French explorers.[3] The bacteria that cause leptospirosis—spirochetes similar to those of syphilis—attack the liver, kidney, and red blood cells; harbored in the kidney tubules, they are released with urine into aquatic environments like the marshes and cranberry bogs frequented by the agrarian native tribes of eastern Massachusetts and Rhode Island. Tisquatum—called Squanto—was a native American interpreter for the Puritans; kidnapped and taken to Spain and England, he returned to find his Pawtuxet tribe no longer existed.

There was no cow on the *Mayflower*—and no cow's milk, cheese, or butter. Three years after arrival, on September 10, 1623, the English commercial cargo ship *Anne* left the struggling Plymouth Colony with a load of clapboards and beaver hides for England. Aboard was Edward Winslow, returning to England as an agent for the colony with instructions to bring back healthy cattle. Arriving in London, Winslow purchased three red Devon heifers and one bull—all free of rinderpest, cowpox, and other diseases that afflicted European cattle. He accompanied them home on the ship *Charity*, arriving at Plymouth in March of the next year. Short and sturdy, the red Devon was a multipurpose breed that not only provided milk and meat but could be readily trained as obedient draft oxen. In four years the colony's herd grew to sixteen with the arrival of four black Kerry cows from England. The red Devon survived to become the draft oxen and foundation stock of New England cattle for two centuries.[4]

At the time there was no concept of a veterinarian—no science or education to support animal health care and no government agency to call or blame when disease appeared. There *were* homemade remedies. In the 1672 book *New England Rarities Discovered*, author John Josselyn described cranberries as "excellent against scurvy" and "also good to allay the fervor of hoof diseases." The *Mayflower* had carried a copy of *The Surgeon's Mate* by John Woodall, the first surgeon general of England; written at the behest of the East India Company's navy, its only treatments were herbalism, phlebotomy, and prayer. Medicine, like governance in Plymouth Colony, adhered to biblical mandates; science was not used for analysis or logic in solving problems of health, thievery, or fornication. For animal health care in England there had been only untrained cow leeches. Control of the great animal plagues that periodically swept through the countryside was limited to feeble attempts by local agriculturalists to persuade herdsmen and drovers to segregate and remove sick and dying animals.[5]

History does not record the arrival of the horse in the early American colonies.[6] Heavy forests made horseback travel difficult and there was less need for the horse. But in Europe horses were transportation, the means for war, and a bedrock of the economy, and it was the unschooled farrier who cared for common horses. On wealthy royal estates and in cavalry stables and equitation academies, horse masters had developed an art for the care of the lame and sick. Their diagnoses, arrived at by experience, were tainted by superstition, hindered by religious dogma, and unproven by experiment, and they were frequently wrong.

In the mid-1600s, skills of the horse master began to appear in books. The first classic, *Le parfiat maréchal* (The complete horseman), was published in Paris in 1664 and appeared in German and English translations. The author, horse master Jacques Labessie de Solleysel, included a chapter on disease, complaining that in France, the veterinary art was too much in the hands of the farrier.[7]

1. THE VETERINARY SCHOOLS OF EUROPE

The Seven Years' War from 1756 to 1763 put European states on the side of either France or Britain in a debacle that cost nearly a million lives. Horses of both sides died in catastrophic epidemics of infectious diseases. Tetanus, glanders, and rabies killed military horses and also infected and killed horsemen. Tetanus, an ever-present danger, arose from contaminated wounds. Before streets were paved and hooves protected from nails and debris by horseshoes, tetanus took a terrible toll. The painful unremitting muscle contraction of tetanus—called lockjaw in humans—led slowly and relentlessly to excruciating paralysis of muscles in the jaw, diaphragm, and rib cage. Dying was prolonged and painful. In the 1757 Battle of Prague, four thousand wounded soldiers died of tetanus and deaths in horses were correspondingly high—the astonishing losses forced cavalry horse masters to seek answers in science.

A highly infectious plague was equally catastrophic for cattle in the same century. Three devastating outbreaks of rinderpest—German for cattle plague—hit Europe in 1709–1720, 1742–1760, and 1768–1786. Affected cattle stopped eating and rapidly developed high fevers, diarrhea, and ulcers in the mouth; mortality rates were often 100 percent in newly infected herds. Losses were so great that production of milk and meat seriously declined. During the first epidemic, the public's belief of rinderpest as divine punishment with its mandate to bear the burden was overridden by practical agriculturalists who imposed trade barriers—the rinderpest decrees—to avoid contact between local herds and caravans of cattle traveling on military sorties or on the overland oxen trade routes. Cull-and-slaughter programs were devised that proved ineffective. By the last rinderpest epidemic, both royals and politicians had taken notice of a need for veterinary science and education to combat diseases of cattle. The message had been clear: animal plagues could destroy the growing prosperity.

By the mid-1700s, France's population and economy had doubled, and Louis XV's finance minister had stabilized coins. Rising prices for agricultural products were highly profitable for large landowners who introduced changes from Britain—fertilizers, crop rotations, and the planting of new-world maize and potatoes. The Industrial Revolution was being fueled by trade with America and the steam engine of a Scottish engineer. With some irony, agricultural economic success brought dangers of both war and animal disease. In the countryside, the growth of livestock populations had increased the likelihood of serious and recurring infectious diseases in cattle and sheep—anthrax, sheep pox, scabies, blackleg, and rinderpest—all diseases that could destroy food production and, along with it, the French economy. Losses from disease were forcing science into workaday animal husbandry.

As new knowledge about contagious diseases emerged, facts began to be objectively verified. In the next century, primitive scientific experimentation provided data that created experts in animal health. When the mechanical movable type printing press introduced mass communication with unrestricted circulation of information and ideas to the masses, there was a sharp increase in literacy that overwhelmed the monopoly of the learned elite, broke Latin's status as the lingua franca, and extended into agriculture to give birth to veterinary medicine. Scientists organized academies and meetings where papers were read and from which reports were published. In the new British journal *The Veterinarian*, an English veterinarian reported the first subtle signs of muscle rigidity in a horse with tetanus acquired from a nail injury to the hoof while being shod by a careless farrier: "Head more elevated than usual, ears erect and pointed forward, membrana nictitans protruding in part over the eye, nose thrown out, nostrils dilated, his tail a little elevated, he straddled in his gait . . ."[8]

The free exchange of views was a powerful stimulus to discovery, and by the end of the nineteenth century, veterinarians could explain that tetanus was caused by a bacterium. Scientists named it *Clostridium tetani* and discovered that it thrived in the dead tissue of wounds, releasing its toxin to spread through the body, causing lethal muscle contraction. Pioneer veterinarians were contributing to and capitalizing on the new scientific discoveries. Anti-science clerics and superstitious magicians were still forces, but education was becoming garlic to society's anti-science vampires, who were blind to natural science—or so it seemed.

THE FIRST FORMAL SCHOOLS to educate veterinarians were established in France—one in Lyon, the other outside Paris in Alfort. Claude Bourgelat, the founder of both, was born and educated in Lyon, where he was admitted to the bar, succeeding his father, a prominent attorney, in the practice of law. Biographers write of him as a lazy youth of high intelligence and a superior and widely admired horseman. He was connected socially and as a young man was appointed *écuyer* (horse master) of the Academy of Equitation in Lyon in 1740.

Bourgelat's wealth and his position as a director of the Lyon city library had given him access to books. The ancient Roman and Arabic veterinary texts, destroyed in Medieval Europe, had been rediscovered and translated into English, French, and German. Available to only the wealthy, they were sequestered in great city and personal libraries in England and France. Among the Roman works that had been translated into European languages was *Epitoma rei militaris*, a book on cavalry and military tactics written in Latin in the fourth century by the eastern Roman citizen Flavius Vegetius; George Washington owned a copy and used Vegetius's "Let him who desires peace, prepare for war" in his first inaugural address. Vegetius wrote one other important book, *Digesta artis mulomedicinae*, a collection of equine anatomy, disease, and clinical care—and Bourgelat had a copy.

As he matured and traveled, Bourgelat gained an appreciation of biology and science. In Lyon he published a three-volume tome, *Élémens d'hippiatrique, ou, Nouveaux principes sur la connoissance et sur la médecine des chevaux* (Elements of hippiatry and new knowledge of equine medicine). Strongly advocating for veterinary education, Bourgelat operated a private school in Lyon for several years. In 1761 he was named inspector of the library of Lyon, in which role he was accused by Voltaire of preventing entry into France a consignment of books containing the historic *La tolerance*. But his connections and position among the elite horsemen were unassailable. He had furnished excellent remounts for cavalry regiments of the King and had eradicated glanders as a scourge of military horses.

Bourgelat was supported by another native of Lyon with a close relationship to its Academy of Equitation: Henri Bertin, the comptroller of finances under Louis XV. A lieutenant general of the Paris police, Bertin was a favorite of the king's mistress Madame de Pompadour and used this influence to obtain a Royal Charter for Lyon. King Louis XV gave the new school the title of the Royal Veterinary College when it opened to students in January 1762. Two years later, using his political power to override opposition from local farriers, Bertin called Bourgelat to Paris to found the second French school, l'École Vétérinaire Nationale d'Alfort.

In the next decade the French schools prospered and were visited by influential veterinarians from other European countries who returned home to establish veterinary schools in Vienna, Copenhagen, London, Edinburgh,

The Cow-Doctor depicts the high status of veterinarians in Europe in the mid-1880s. (CHARLES COUSEN, ENGLISH ENGRAVER, 1854; AFTER A PAINTING BY EDMOND TSCHAGGENY, BELGIAN, 1845. © WELLCOME IMAGES.)

Skara (Sweden), and Brussels. In Germany there were new schools in Berlin, Hannover, Munich, and Stuttgart, and Russia founded schools in Kharkov (now Ukraine), Dorpat (now Tartu, Estonia), and Kazan—all dedicated to veterinary science, some making astounding discoveries. In France, rinderpest led the government to create a third veterinary school in Toulouse directed toward diseases of cattle.[9] The first veterinary school in the United States was a direct legacy from Toulouse; the first in Britain was from Lyon.

In England, successful farmers and "gentlemen of rank, fortune, and ingenuity" assembled in Odiham's George Tavern on May 16, 1783, to discuss how to encourage agriculture and industry in Hampshire. Establishing the Odiham Agricultural Society, they resolved to reform farriery and animal care by establishing a school to teach veterinary science. Granville Penn, a leader of the group—and grandson of William Penn—was sent to London to seek out the immigrant Lyon veterinary school graduate Charles Benoit Vial de Saint-Bel. The expatriate Frenchman had taught in the veterinary school at Alfort but, quarreling with Bourgelat, he returned to Lyon as head of the

Academy of Equitation and to serve as one of the horse masters of Louis XVI. Failing to be appointed at Alfort when Bourgelat died and tainted by connections to nobility—Bourgelat is alleged to have contributed to the charge that Vial was an enemy of the government—Charles Vial fled revolutionary France for England with ideas of starting his own school for veterinarians. Planning together, he and Penn established a London committee of the Odiham Agricultural Society to secure funds for a veterinary school.

Notoriety for their cause occurred in 1789 when the Western world's most famous racehorse, a tall English thoroughbred named Eclipse, died of colic. Eclipse had dominated the racing seasons of 1769 and 1770 and stood at stud for nineteen years. To find the cause of death and to explain his extraordinary athleticism, the owners found only one qualified veterinarian for the task: Charles Vial; his autopsy of Eclipse revealed a massively enlarged heart. The publicity of Vial's report was an important assist in the birth of a London veterinary school.[10]

Financial support for the new London school came from livestock organizations and fifty guineas from the Duke of Northumberland. Perhaps more important, there was strong encouragement from London medical scientists, including the famed anatomist/surgeon John Hunter—he had discovered the circulation of blood in the body—and in the end, from Parliament. The veterinary school building was constructed in 1791 in Camden Town of St. Pancras Parish, close to stables that served the London transport system. The next January it opened as the Veterinary College, London, with four students studying toward a veterinary certificate. Successful in the first decade, the school was granted a Royal Charter and christened the Royal Veterinary College.

Two years later, Charles Vial was dead of glanders. He had suffered in great pain for seventeen days with boils and buboes in different parts of his body—the same massive and disseminated lymph node swellings in the horse he had treated and from which he had acquired the disease. Vial died on August 21, 1793. John Hunter also died that year; he had been the leading surgeon and medical scientist of the eighteenth century and had strongly supported the college, arranging for veterinary students to attend his medical lectures.

Losing Vial's leadership and Hunter's scientific support, science in the Royal Veterinary College declined, and with it the competency and luster it had accrued. Edward Coleman, its new principal, seemed to lack inquisitiveness for science and creativity, as well as enthusiasm for change. The journal *The Veterinarian* was founded in London in 1828; in the second volume (1829), editors Percival and Youatt, both veterinary surgeons, condemned the weaknesses of the college in London, accusing the two faculty—Professor Coleman and his assistant—of "*abuses* and *mismanagement*" and writing that the school should "correct the existing evils, and establish our claims to respectability." Other damning editorials soon appeared, one stating that "many valuable horses have been destroyed by the ignorance of men who have been pupils at the Royal Veterinary College for a short period."[11] What was needed, they said, were longer months of study, more anatomical demonstrations, and practice in techniques of surgery, laboratory work, and the forge. All agreed on the need for a committee to contact Parliament to enact a law to restrict farriers from practicing as veterinarians.

Farriers responded in the journal. An anonymous retort signed only by "A Farrier" maintained that farriers provided better horse care than that provided by the Royal Veterinary College. But farriers knew nothing of the diseases of food-producing livestock that were a major concern of educated veterinarians. There were cattle plagues other than rinderpest in the English countryside, some of them contagious to humans, making it dangerous to be a cow doctor. Diseases killing animals were not only killing farmers and veterinarians, they were being passed through meat and milk into the cities.

Raw milk, with its contaminants of disease-causing bacteria, could be hazardous, especially if it came from cows with tuberculosis. Increasing in the 1700s because human urban populations were growing, tuberculosis, known as the white plague, was killing hundreds of citizens. The disease most often insidiously attacked the lungs but could also settle in the bones, intestines, brain, or any other organ. Many cases of tuberculosis were caused not by the human bacillus but from the bovine tuberculosis bacillus, gotten through impure raw milk. In Germany one farm family, all "herculean in stature and boastful of strength and health," had been stricken when they purchased a group of Simmental cattle, all infected with bovine tuberculosis. Within a year, the thirteen-year-old daughter and eighteen-year-old son developed pulmonary tuberculosis and died. The next year a twenty-three-year-old son died. The year after that the mother, remaining daughter, father, and finally the third son died.[12]

Pesky skin diseases moved from cow to herdsmen and milkmaids. There were scabies parasites that crawled into the skin just where they readily jumped to humans, and ringworm that when brushed onto the arms grew in nasty inflammatory rings until treated with turpentine. And there was cowpox. Teats of milk cows developed painful pocks that spread to the hands of milkers. Starting as small vesicles, they progressed to pustules and then to scabs that peeled away in a week or two; there was no fatality, and milkers with cowpox recovered without developing serious illness. There was even an old wives' tale that cowpox was beneficial—milkers having had cowpox were not susceptible to the plague of smallpox. The tale was true. It was the impetus for the greatest medical discovery of the century—and perhaps ever—which was reported in London in 1798 and had begun with a disease of cattle.

2. EDWARD JENNER: ZOOLOGIST, PHYSICIAN, PIONEER

In the mid-1700s, human smallpox was a horrific and disfiguring lethal disease that decimated global human populations. Called by physicians variola (from the Latin *varius*, for speckled), smallpox spread from patient to patient through the mouth and nose. Physicians called it a contagion—a disease caused by contact. No one knew about the cause or that, after silently multiplying locally in the tonsils for a week or so, massive amounts of variola virus were released into the bloodstream. As it spread throughout the body, there was debilitating fever, headaches, and collapse; lodging in the skin, smallpox virus speckled the victim with ugly vesicles, pustules, and scabs, if the patient survived that long.[13]

To lessen the mortality, physicians offered a risky preventative, variolation—scraping a tiny piece of scab from a sick smallpox patient into the skin of the forearm of a healthy person.[14] A local smallpox pustule would develop on the variolated arm and the variolated patient would sicken but survive; the peripheral site of infection would bypass massive viral replication in the tonsils, providing time for an immune response that could prevent disease from being fatal; but not always—variolation still carried a risk of serious disease and death from smallpox.

In the dairy farming country of Southwest England, cows carried their own pox virus. Cowpox appeared on the teats and udder of milk cows as vesicles, then pustules, and finally scabs that healed within a few weeks. The pustules would "degenerate into phagedenic ulcers, which prove extremely troublesome. The animals become indisposed, and the secretion of milk is much lessened."[15] The problem was, cowpox was a zoonotic disease—transmissible to people.

Milkmaids and male servants assisting with milking developed cowpox—with identical vesicles, pustules, and ulcers on their hands; the "system becomes affected" with headache, muscle pain, fever, and swelling of axillary nodes, yet humans, like cows, recovered. Local folk knowledge was that milkers, drovers, and other cow handlers that had developed cowpox would not "take the smallpox." It was common opinion that milkmaids having had cowpox could safely nurse smallpox patients without fear.

In the Dorset village of Yetminster—far removed from the sophisticates in London—farmer Benjamin Jesty and his two servants became infected with cowpox. In 1774, impressed that all had passed through the next smallpox epidemic untouched, Jesty took his wife and two sons to a cowpox-infected dairy farm nearby and, making skin abrasions with a darning needle, inoculated them with purulent material from cowpox scabs. When the cowpox lesions healed, they too passed through smallpox episodes without taking the disease. Yet the citizens of Dorset saw farmer Jesty's act as unnatural. Rather than attracting fame, he was ridiculed by friends and vilified by gentry for having violated the laws of nature.

In the next two decades, other creative people in England, Denmark, and Germany used cowpox to protect against smallpox. John Fewster, an apothecary in Thornbury, Gloucestershire, inoculated children with cowpox, suggesting that it protected against smallpox. In 1791 the German teacher Peter Plett inoculated three children with cowpox exudate fluid, and he too saw them protected. Turns out, experienced physicians in the dairy farming areas were aware that cowpox could be used for protection, but these were anecdotal cases, unpublished, unpopular, and disbelieved by the medical establishment. But that changed when a scientist in Gloucestershire went at the problem systematically.

In the English dairy country of Gloucestershire smallpox was common, and in the village of Berkeley physician Edward Jenner used variolation in his medical practice.[16] This was the flat fertile valley of the River Severn, home of the Gloucestershire Old Spots pigs and Gloucestershire cows—large black-brown animals with white underlines, a white stripe along the spine that extended over the tail, and curved white horns with black tips that rivaled those of Ayrshire cattle. Their milk was high in butterfat and protein—good for making Double Gloucestershire cheese.

In 1770 Jenner left Gloucestershire to serve an apprenticeship in anatomy and surgery with John Hunter, the famed Scottish surgeon in St. George's Hospital in London. Hunter taught him the scientific method, passing on

William Harvey's advice: "Don't think, try." An inquisitive naturalist, Jenner pursued lifelong studies in zoology and was elected a Fellow of the Royal Society in 1788, an honor based on his paper about the nesting habits and parasites of the common cuckoo; with observation, dissection, and experiment he had proven that newly hatched cuckoos, not adults, pushed competing eggs and fledglings out of the nest.

In his medical practice in Berkeley, Jenner noted that milking servants having had cowpox were resistant to variolation; no pustule would develop on the forearm where the smallpox material had been scraped into the skin. Attentive to the folktales and anecdotes of his medical colleagues, he began collecting information on his patients. Within one year his case records were surprisingly clear. Milkmaids who had suffered cowpox were resistant when exposed to smallpox; others, having had smallpox as children, would not develop pustules of cowpox.

By 1796 Jenner had accumulated sufficient evidence to attempt an experimental inoculation. In the spring, vesicle fluid from a cowpox lesion on the hand of a milkmaid was scraped into the arm of a healthy eight-year-old boy, James Phillips, the son of his gardener. The boy developed lesions of cowpox that regressed as expected, and six weeks later material from a smallpox pustule was scraped into a small spot on his arm—no pustule, no fever, and no smallpox. In his garden hut, Jenner began scratching cowpox scabs into the local villagers free of charge.

Presenting his views to the county medical society, Jenner was ridiculed and told that if he persisted, he would be requested to resign. Perhaps there was a cultural basis for the society's stance. Gloucestershire's most famous citizen was William Tyndale, an Oxford scholar of the Protestant Reformation who first translated the Bible into English; for his efforts, he had been strangled and burned at the stake by orders of Henry VIII.

Publishing his book on his own in 1798, Jenner included case descriptions that documented the cross-protection observed in his practice and that by deliberately pricking cowpox scabs into the skin of the arms of healthy people he could induce protection against smallpox.[17] It was a new way to think about disease prevention. The Royal Society advised that he should be cautious and prudent and not risk his reputation by presenting evidence so much at variance with established knowledge.

Perhaps the medical authorities in London were concerned about Jenner's unlikely proposal that a horse disease was also connected to smallpox. In his book, Jenner had described twenty-three case studies of animal diseases and their role in human smallpox; eleven cases involved horses and their pox-like disease of the heels that was transmitted to humans and, Jenner believed, to cows. He begins with a description of "grease," an "inflammation and swelling in the heel" that when transmitted to horse handlers and farriers causes a disease that "bears so strong a resemblance to the smallpox that I think it highly probable it may be the source of the disease." Jenner proposed that the horse handlers who assisted in milking transmitted the equine disease to the teats of cows and that cows infected humans—"although I have not been able to prove it from actual experiments." He notes in support that attempts to variolate farriers were frequently "foiled" and that in Ireland, where men do not milk cows, cowpox was not known.[18]

To a worried populace the process of using cowpox for protection seemed worth the risk. It was being called vaccination—derived from *vacca*, Latin for

The Cow Pock—or—the Wonderful Effects of the New Inoculation! The political cartoon arose from the anti-science zealots of the anti-vaccination movement. At left, the poor are enticed in with free food, then inoculated. Jenner, the doctor, holds the right arm of a woman and slashes it with a knife as blood is collected by a boy. At right, those inoculated have sprouted miniature cow parts on their limbs and body. (ORIGINALLY PUBLISHED BY H. HUMPHREY, ST. JAMES'S ST., LONDON, JUNE 12, 1802. JAMES GILLRAY, ARTIST. COURTESY OF THE LIBRARY OF CONGRESS PRINTS AND PHOTOGRAPHS DIVISION, WASHINGTON, D.C.)

cow. As Jenner's method became widespread, critics called him a criminal and money grabber who had duped both the medical community and Parliament. Scratching smallpox scabs into a healthy person was seen as a way to cause disease, not prevent it. Sanitarianism, the "atmospheric" and "vapors" theories of disease causation, made it clear that the removal of "filth" was the way to prevent disease. There was no concept of specific causes for disease.

There *were* serious drawbacks to vaccination. The small vaccination scarifications, if not kept clean, could harbor bacteria that caused tetanus that killed the patient. Syphilis was another concern. In early vaccinations, it was the custom to use scab material from the arm of a recently vaccinated person to vaccinate another, and there were rumors that syphilis had been transferred at the same time.

Public fears that this new "vaccination" would cause bad things was driven by an anti-intellectual culture and anti-science prejudice. Gossip expressed in the press led to panic and fear of unfounded dangers. Anti-vaccination societies formed in both Britain and France. Developing hostility on the basis of misinformation, they dissipated their anger in caustic ways. Panic was promoted by anti-vaccination zealots. The anti-vaccination movement would be alive for nearly a century.[19]

3. WILLIAM DICK: FROM FARRIER TO VETERINARIAN IN EDINBURGH

As improbable as it seems, much of North America's early heritage in veterinary medicine originated from the knurled hands of Scotsman John Dick, an extraordinary farrier in Edinburgh. The earliest British farriers were both blacksmith and horseshoer; using cast iron, they built the shoe and shod the horse. Some also served as veterinary nurses, providing amateur diagnoses and dispensing crude treatments. In the British Army, farriers were responsible for euthanasia and keeping records of horses put down, a duty little changed from that of the farriers of the English Crusaders in the twelfth century. In today's ceremonial parades, the British Army farrier marches behind bearing the symbol of his trade, the farrier's ax, an instrument with a spiked end used to produce a lethal blow to the head and a blade to cut off the foot of the dead horse for military records.

As iron horseshoes became commercially available, the art of the farrier shifted from blacksmith to focus on correcting lameness and putting down horses that could not survive. Good farriers had the skill to pinpoint the cause of abnormal gaits and the ability to see that horses were shod correctly. A prime attribute was the ability to provide corrective shoeing for lameness and diseases of the hoof. Diagnosis of abnormal gaits required the skill to see and hear subtle defects in real time and the analytical ability to provide proper horseshoes.

As was the custom in Scotland, farrier John Dick gave advice on diseases of the horse. He was blacksmith, farrier, and amateur veterinarian, even doing minor surgery such as tenotomy—and he passed his skills to his young son William. An inquisitive boy, William Dick attended night classes at the University of Edinburgh in chemistry, physics, and anatomy. He received permission to attend anatomy lectures in the Edinburgh medical school at No. 10 Surgeons' Square. The professor of anatomy, John Barclay, MD, was impressed with young William and invited him into his lectures on anatomy. Perhaps he was also interested in William's knowledge of horses—Barclay was a comparative anatomist with a strong interest in horses and agriculture and a director of a Scottish agricultural organization, the Highland Society. Medical students in Barclay's class, disgruntled at the attention given to Dick, complained that he was "but a common blacksmith." Barclay's response was, "Well, well . . . all I can say is, that whether he be a blacksmith or whitesmith, he's the cleverest chap among you."[20] Finishing the Barclay lectures, Dick took the "lang road coach to London" to attend the lectures of Professor Edward Coleman, principal of the London Veterinary College. In London for only three months, he was granted a veterinary diploma in January 1818 and returned to Edinburgh.

Dick began a series of lectures in veterinary science at the School of Arts of Edinburgh Monday through Thursday. The initial lecture was given in the presence of the Veterinary Committee of the Highland Society. There was no salary. In the first lectures of 1821, seventeen farriers attended. In the next season of forty-six lectures there were twenty-five students, and by 1832–1833 there were fifty students.

Supported by Barclay, Dick started his own school for veterinarians in a building near his father's forge on Clyde Street. Rudimentary and scattered with anatomical specimens, it seemed to one visitor to be a cluttered "appendage of a forge" with "skeletons of all descriptions . . . standing higgelty-piggelty" 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."[21]

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.[22]

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.[23]

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[24] 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.[25] 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.[26]

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).[27]

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.[28] 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 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.[29]

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.

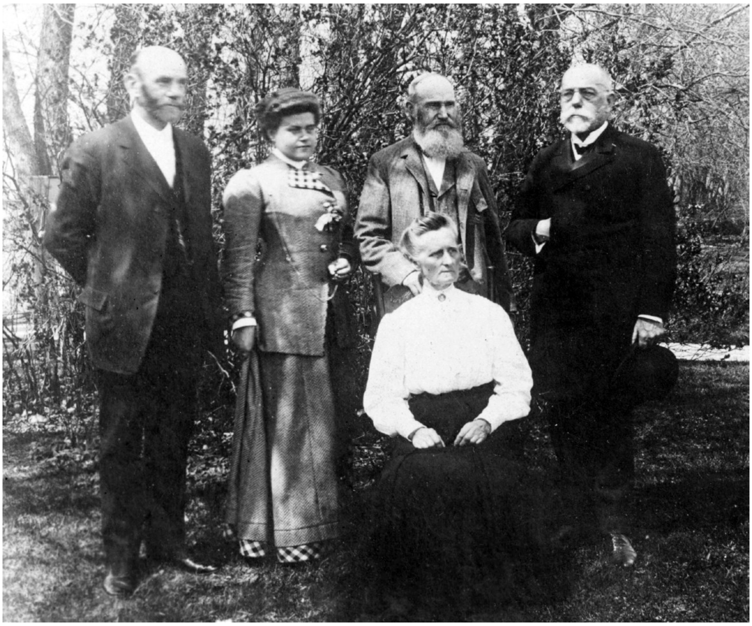
Working alone, Koch studied a large spore-forming bacillus he had isolated from animals and that he believed might cause anthrax, a dangerous and rapid killer of cattle and sheep as well as humans. To consult with the expert on spores, Koch traveled the short distance to the University of Breslau (now 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.[30]

PART II

FARRIER TO VETERINARIAN

Science in the Heartland

General George Washington issued an order on December 16, 1776, that a farrier be included in the roster of each mounted regiment of the Continental Army.[1] Farriers made their own iron horseshoes and kept the Army mobile; they had experience with equine behavior, lameness, and injuries to teeth and limbs but knew little of contagion. Tetanus and glanders were their two bugaboos: both killed horses—and farriers as well.

Pamphlets and books on the farrier's art printed in the Atlantic coastal cities of revolutionary America contained cursory information on diseases of the horse. *Gentleman Farrier's Repository* by J. Bartlet in Philadelphia came out in 1775 and was followed by *Every Man His Own Farrier* by Francis Clater and *The Bite of Dogs* by James Mease—all dedicated to educating farriers. There is no record of a veterinarian in the Revolutionary Army. Unlike Europe, revolutionary America had no educated veterinarians.

The Philadelphia Society for Promoting Agriculture offered a medal in 1806 for the "best essay and plan for promoting veterinary knowledge."[2] The winner was Benjamin Rush, a physician who had signed the Declaration of Independence and was on the faculty of the Medical School of the University of Philadelphia. Addressing his medical students "On the Duty and Advantages of Studying the Diseases of Domestic Animals, and the Remedies Proper to Remove Them," he promoted the establishment of a veterinary chair as a component of the medical college: "Should the subject of the diseases of domestic animals be connected with instruction upon the principles of agriculture . . . it would form a still more useful branch of education."[3] Few seemed interested in attending a school for veterinarians. Although there were nearly thirty thriving formal veterinary schools in Europe in 1850, there were none in North America.

As agriculture prospered in North America, livestock populations increased and so did infectious diseases. With added income, farmers began subscribing to the new agricultural periodicals in which accounts of plagues in farm animals painted a scary picture, reinforcing a need for veterinary science. The *American Farmer*, started in 1819 by J. S. Skinner in Baltimore, had a veterinary section that offered advice on animal diseases. *Farm and Fireside*, an agricultural weekly distributed throughout the Midwest from Chicago, had a veterinary department.

Roving the countryside were self-trained charlatans often claiming to have been "veterinaries in the Army." Many were quacks offering fake diagnoses and phony surgical procedures. Most were itinerants, staying but a day or a week in a town and advertising their specialties as "cow leeches" or "horse doctors" with expertise in dental treatments, gelding, and blistering or firing of the feet. Income was mostly derived from the sale of medicines of their own concoction. Amateur "surgery" often did serious damage; firing, the savage application of red-hot pokers to horses' feet to induce "curative inflammation," injured more horses than it saved. Diagnoses were improbable—hollow horn in cattle, wolf teeth in horse's mouths, and other superstitious names tied to phases of the moon and signs of the zodiac. Since the horns of cattle are naturally hollow, diagnosing an ailment as hollow horn was always successful; a small hole drilled into the horn confirmed the diagnosis for an astonished and gullible farmer.

6. EMIGRANTS WEST: OHIO COUNTRY, IOWA TERRITORY, AND TEJAS

The first feeble attempts to initiate formal veterinary education might have succeeded had the presidential election of Clay vs. Polk in 1844 turned out differently. James K. Polk, a dark horse who came out of nowhere to win the 1844 Democratic nomination, had beaten Henry Clay by a whisper in the election: a change of only five thousand votes in New York would have made Clay president and veterinary education would have been different.[4] In a letter to George Dadd dated November 25, 1849, Clay wrote: "There is no department in the medical world in which there is such a lamentable want of knowledge as that of the proper treatment of Horses and Cattle. Whoever shall supply this deficiency ought to be regarded as a great benefactor, and I shall be very glad if your exertions entitle you to that merit."

Westward expansion was usurping national energy. In the next four years under President Polk the United States doubled in size: Texas was welcomed into the Union, Polk bluffed the British out of half of Oregon, and the U.S. went to war with Mexico to grab California and the Southwest. Frontiersman and their politicians had little interest and less time to support academic matters. Animal health care in America was dependent upon European immigrants.

In Boston, amateur agriculturalist George Dadd persisted in his campaign for a school of veterinary medicine—publishing *The Modern Horse Doctor*, *The American Cattle Doctor*, and *The Advocate of Veterinary Reform and Outlines of Anatomy and Physiology of the Horse*. Starting the periodical the *American Veterinary Journal* in 1851, he thought it too scientific and dumbed down the content; readership declined and the magazine collapsed. The Boston Veterinary Institute was incorporated during May 1855 with Dadd on the faculty; although it closed after five years, its graduates played a role in American veterinary medicine.[5]

VETERINARIANS FORMALLY EDUCATED in Europe were slow to emigrate to North America. By the mid-1800s the few veterinarians practicing in the United States included only twenty graduates of London's Royal Veterinary School and a few from German colleges.[6] Their only avenue for keeping abreast of science was through the new English scientific journals *The Veterinarian* and the *Veterinary Record*, and for newer immigrants the German veterinary journals.

On a visit to America in 1853, the Scottish veterinarian J. Horsburgh from Dalkeith stopped in New York, Philadelphia, and several cities in Ohio and Kentucky. He carried the title Member of the Royal College of Veterinary Surgeons—MRCVS—a diploma granted by the official British licensing committee. On his return Horsburgh published his impressions: "In all of these places, and surrounding countries for a distance of 1,200 miles, there was not a qualified veterinary surgeon. . . . Here there is ample room for our superabundant veterinary surgeons." Horsburgh writes that in his hometown of six thousand in Scotland there were thirteen practicing veterinary surgeons who had graduated from a veterinary school.[7] His message was the stimulus for an important group of emigrating graduates from the Highland Society's Veterinary School in Scotland who laid the groundwork for veterinary education in rural North America. It was time. Livestock moving into the frontiers of the West—the Ohio Country, the Midwest, and Great Plains—were encountering new hazards not known in Europe.

FRONTIERSMEN OF THE MIDWEST had first begun moving west through the Cumberland Gap to settle Ohio Country, the vast unsettled region north of the Ohio River that included Ohio, western Pennsylvania, northwestern West Virginia, and southeastern Indiana. The National Road—the Cumberland Pike—had reached Zanesville and central Ohio by 1830. Outfitting in Cumberland, the terminus of the Chesapeake and Ohio Canal, new settlers pushed past the Appalachians. Early farmsteads, built along riparian streams close to wood and water, had little quality pastureland so that cattle were turned out to browse in the woods.

Farmers in Ohio Country began to encounter a new disease in their cattle and sheep that they called trembles.[8] Signs of trembles began with lethargy, trembling, and pungent breath and quickly ended in prostration and death. In some areas, cattle died by the hundreds, whole herds being found dead in the woods. In 1839, Ohio farmer John Rowe suspected a link between trembles and white snakeroot, a common shady woodland plant in the daisy family. Feeding the plant to cows, he reproduced trembles and then sickened young calves by giving them milk from the poisoned cows—perhaps one of the first animal disease experiments in North America.

About the time trembles first appeared in livestock, humans were afflicted with a new disease that frontier physicians named milk sickness. Patients suffered nausea, muscle weakness, thirst, and constipation, and they too had foul breath that smelled like turpentine or acetone. Although the disease was at first confused with malaria, these patients did not have fever. In Madison County, Ohio, a quarter of the population died. In Dubois County, Indiana, half the deaths in the early 1800s were due to milk sickness; one year the death toll neared one out of every two people, striking children most often.[9] In Danville, Indiana, one-tenth of the population died of milk sickness in a single year. In the Little Pidgeon Creek settlement, one of the victims was Abraham Lincoln's mother, Nancy Hanks Lincoln.

Milk sickness also came from consumption of contaminated butter and meat. It was not seen in populous areas but claimed victims from pioneers carving their homesteads out of the forests. In the 1830s, Anna Pierce Hobbs was concerned about milk sickness. Her mother and sister-in-law had died of the disease. After some brief training in midwifery and dentistry in Philadelphia, Hobbs had returned home to be the first physician in Rock Creek, Hardin County, Illinois. Quizzing patients about their disease, she was taken by a Shawnee woman into the forest; pointing to white snakeroot as the plant she used to treat snakebite, the woman said it was the cause of milk sickness. Feeding white snakeroot to a calf, Hobbs reproduced the toxic disease.

Contagious diseases of livestock were always a threat to survival—strangles in horses, lung parasites of cattle, and abortion in hogs and cows—but isolation and the low density of animals kept the catastrophic plagues at bay. In the Ohio Valley of the 1830s, a new killer disease of pigs had appeared. Farmers called it hog cholera but were not attentive to its slow but insidious spread into the territory. The disease moved slowly through small farms of the Midwest. As hog populations increased, so did hog cholera, and within fifty years the disease would spread through the country.

CROSSING THE MISSISSIPPI RIVER INTO IOWA, settlers heading west were confronted with what seemed to be an endless sea, the tallgrass prairie. Journals of early arrivers told of "a sea of waving grass" and of riding from Oskaloosa to Des Moines without seeing a single tree.[10] Grass got taller the further west they went. Lieutenant Colonel Stephen Kearney, riding west with a troop of soldiers, had noted in his diary that the grass was so high it covered their stirrups; then in central Iowa the men could tie it in knots over the backs of their horses. In early summer, wild strawberries stained horses' hooves red.[11] Tallgrass prairies made travel difficult and carried the danger of fire—burning their animals and their families; settlers sought wooded areas along streams and creeks.

There was little white snakeroot west of the Mississippi River, but immigrant farmers had to deal with locoism. The leaves and seeds of the purple locoweed and other *Crotalaria* plant species were tasty to livestock but drove them to all sorts of abnormal behavior. Locoweed killed not only cattle but horses, pigs, and chickens. Crotalaria toxin damaged the liver and brain—hence *loco*, the Spanish word for crazy. Common in the western Midwest, Great Plains, and grasslands of Canada, purple locoweed is still the most common poisonous plant for American livestock.

As the Great Plains opened to settlers, the grasslands of Kansas and the Nebraska Territory were plowed and sewn to wheat, rye, and other grains. In wet summers, the harvests of rye and wheat were sometimes speckled by swollen black grains. After several weeks of eating the speckled grain, cattle lost weight and developed rough hair coats, painful feet, and ulcers in the mouth and around the hooves. If they continued to eat contaminated grain, gangrene appeared and cattle began to behave abnormally and even to suffer convulsions. Turns out, a parasitic fungus, *Claviceps purpurea*, had attacked the seeds of rye, wheat, and other grasses, transforming their seeds into a black mass and producing toxins that caused an ancient human disease, ergotism. Ergot's alkaloid toxin constricted arteries so severely it caused gangrene in the ear tips, tails, and lower legs.[12]

Steamboats moving up the Missouri River carried old plagues into the Great Plains. The American Fur Company's S.S. *St. Peter* left St. Louis bound for Fort Union in 1836. It carried supplies for the Missouri River ports in Kansas, the Dakotas, and Montana. It also carried smallpox. The Great Plains smallpox epidemic lasted five years, from 1836 through 1840. Although many immigrants died, there were massive death loses of Native Americans all along the Missouri Valley. The Indian Vaccination Act of 1832, passed to save native peoples in the U.S., had excluded the Mandans, Hidatsas, and Arikaras from the program.

As the U.S. Cavalry moved westward to protect the frontier, regimental farriers came with them. Endurance of the military horse was compromised by any defect in gait, and the inspection and re-shodding of cavalry horses at six-week intervals was essential. Faults in the gait of the horse were stumbling, forging, and interfering (where a foot in flight strikes the opposite leg). The farrier decided whether these were caused by improper shoes, unbalanced feet, poor conformation, or debility due to sickness. Was the wall of the front feet at the toe too long or the heels too low? Were the shoes of unsuitable weight or fitted too pointed at the toe? All of these would lead to forging, a fault of the gait in which the toe of the hind foot overtakes and strikes the bottom of the front foot on the same side at the moment the front foot is starting in flight.[13] No trivial matter; a forging horse would fall, injuring the rider. Forging was even more disastrous when it tipped a carriage, killing the passengers.

Horses of the U.S. Cavalry moving westward into the Midwest carried strangles with them. A worldwide disease of horses, strangles was a streptococcal infection of the throat and upper respiratory tract. Seldom lethal, it could persist to become chronic, causing horses to develop bastard strangles—nasty abscesses that formed in lymph nodes throughout the body. The disease "followed the trail of the Army and bivouacked in its corrals from the days of the pioneers."[14]

The Black Hawk War of 1832 was a turning point in American veterinary care. War began when several tribes, led by Sauk chief Black Hawk, left their Indian homelands in Iowa, crossing the Mississippi River into Illinois. Misled by invading pioneers, Black Hawk deliberately violated the treaty, leading his tribe east across the Mississippi. The frontier battle that ensued left several hundred dead and caused the needless loss of many cavalry mounts. It was clear that too many horses were in a weakened condition and that the infantry and the current mounted rangers could not cope with the mobile mounted Indians of the forest.

When the Black Hawk War was over, the corps of mounted rangers equipped to serve the war was reorganized as the First Dragoons and, led by Colonel Kearney, was dispatched to Missouri. For fifteen years they lived and fought in pioneer posts in the Great Plains, exploring repeatedly the headwaters of the Mississippi, the Canadian border, and Texas. Twice they were assigned to the Rocky Mountains and once to the Pacific Coast. Throughout these duties, equine mortality to contagious disease remained high. Horses of the United States mounted forces had fought in the Revolution, the War of 1812, and the Indian Wars without adequate veterinary care. The Army quartermaster general in 1853 petitioned Congress to establish an Army veterinary corps with a school for military veterinarians. Request denied.

IN THE 1830S AMERICAN IMMIGRANTS moved into Mexican territory, crossing the Sabine River and settling to the Brazos and beyond. Traveling along the Old San Antonio Trail to the land grants of Stephen Austin along the Brazos, the Anglos in the Mexican territory of Tejas soon outnumbered the Spanish-speaking Tejanos four to one. On March 2, 1836, Texas declared itself independent. As tensions increased, a Mexican army of over three thousand, led by President Antonio López de Santa Anna, moved north to assert Mexico's international right to ownership of Tejas. Holding out in the adobe walls of a century-old mission at the edge of the dusty village of San Antonio, a ragged band of two hundred men—including American legends Davy Crockett and James Bowie—blocked the northward advance of the Mexican army for twelve days. The infantry and cavalry were repelled in two charges of a blood-stained battle. On March 6, 1836, the third Mexican charge, emboldened by the blaring strains of the chilling *degüello*, swept through the Alamo, killing all except Lieutenant Dickenson's wife and infant child and a servant.

The significance of the Texas Revolution to veterinarians is that in the long and difficult marches from and to Mexico City, Santa Anna's army had been plagued by poor nutrition and weakened by disease. It had been ill-equipped, and the damage done to the cavalry played a major role in the war. It was too late, but nearly two decades later, President Santa Anna established the first veterinary school in the Americas on August 17, 1853, in the San Jacinto Hospice. The school changed name, affiliation, and location several times in the next decades. Its science underpinning was weak, and the Spanish language barrier, the culture, and hostility from the Mexican-American War prevented any impact on veterinary education north of the Rio Grande. But it was the first on the continent. Today, Santa Anna's school is the College of Veterinary Medicine at the National Autonomous University of Mexico.

AS SETTLERS MOVED INTO OPEN Nebraska Territory, they needed additional protection against attacks by Sioux Indians. The U.S. Army had manned posts along the Platte River in Nebraska and the Big Sioux River in Iowa, and as settlers moved northwest, a new post was established at Fort Randall (now South Dakota). Located on the right bank of the Missouri River in remote hills bordering the endless prairie, Fort Randall was opposite the camps of Sioux and Mandan Indians. Cavalry units from posts along the Platte and Big Sioux Rivers were moved north and west to Fort Randall. Four companies of the Second Dragoons and their horses assembled at Fort Randall in August 1856, camping in a dry ravine. Unlike cavalry of the British and French, who had military veterinarians, the American cavalry had none—its military horsemen were notoriously slovenly in their care of their horses. Superior riders were not always good horsemen. No hay or grain had accompanied the troop to Fort Randall, and horses had been forced to forage in the weedy ravine on their own.

About the twentieth of August, ten days after they arrived, an outbreak of a slowly progressing fatal disease appeared in the cavalry horses, beginning in all four companies simultaneously. The dying horses became lame and coughed incessantly, and thick yellow mucus ran from their noses. Swelling of the throat and abscesses pressing upon the pharynx and trachea made it difficult to breath. Striking signs of the disease included rough hair coat with loss of hair, especially of the mane and tail, and pus around the coronary band of the feet (where the hoof joins the skin), which led to painful sloughing of the hooves.

At first, the signs seemed to be typical of strangles, but none of the horses developed disseminated bastard strangles. Strangles was seldom fatal and this new disease was relentlessly lethal, killing over half the cavalry horses at Fort Randall. A farrier suggested there might be something damaging in the soil where the horses foraged. One officer wrote a summary of the disease, which a compatriot mailed to a veterinary journal in Germany.[15] Reading it decades later, reviewers agreed that although the horses probably had persistent strangles, they were being killed by selenium toxicity—later called alkali disease. The element selenium is plentiful in the soils of South Dakota, and some plants that survive in the dry autumn concentrate it in their leaves. Milk vetch and purple locoweed—selenium-accumulating plants—had been prevalent in the weedy ravine. When hay and grass were provided to the affected horses, the disease disappeared.

The lack of military veterinary expertise in the cavalry was noted by American captain George Brinton McClellan, who had just returned from Europe—he had been officially dispatched to observe the organization and equipment of allied armies in the Crimean War of 1853–1856. McClellan, the son and brother of distinguished Philadelphia physicians, had recognized the dangers of infectious glanders spreading in military horses and riders. Outbreaks of glanders had been devastating to British horses in the Siege of Sevastopol, and by 1860 it had appeared in McClellan's cavalry horses. He had no counterpart to the British Veterinary Corps and no one in the U.S. Cavalry knew about how the disease might be controlled or prevented. Glanders, from the Old French *glandres* (glands), was a chronic unremitting bacterial infection that damaged the respiratory tract and lymphoid tissues. Appearing first as weakness, nasal discharge of pus and mucus, and swollen lymph nodes, glanders progressed to debility, with erosions in the respiratory tract, nodules in the lungs, and pustules in the skin called farcy buds; it was uniformly fatal in two to three weeks. Resembling slow and insidious tuberculosis, glanders was fatal in horses; it also infected and killed soldiers. It had been a terrifying disease in Europe and now it was here.

By the 1870s, glanders was widespread in the U.S. Cavalry. The hotspot was Benicia Barracks in the North Bay area of San Francisco. First occupied in 1849 during the California Gold Rush, Benicia was the Army's ordnance supply facility for the West Coast: it also stabled the Army's only Camel Corps for the deserts of the Southwest. Recently graduated, veterinarian Samuel G. Going entered the Army and was assigned to the 1st Cavalry at Benicia Barracks. He and his brother, also an Army veterinarian, had been born in New York but educated at the Highland Society's Veterinary School in Edinburgh, Scotland. Going had a solution to the problem at Bernicia Barracks. Out of 180 horses stationed there, he killed all but 10. Blankets, halters, and cinches were burned and the stables destroyed.

Seeking improved conditions and facilities, Going proposed a commissioned rank for Army veterinarians. His petition to the U.S. Congress dated October 11, 1878, was ignored; it was the first military report made by a qualified veterinarian recorded in the War Department. Going remained with the 1st

Cavalry and was killed in action when he and ten men in a scouting detachment were ambushed during the Nez Percés War. His body was recovered and today lies in Fort Walla Walla Cemetery in Washington state.

The episodes of inferior horse husbandry and outbreaks of glanders—coupled with criminality in the Quartermaster Corps's procurement of remounts—continued to cause astonishing noncombat deaths of horses. General McClellan, familiar with the superior horse care and veterinary services of the British and French armies, recommended that "a veterinary school should be attached to the establishment, for the instruction of officers and veterinaries."[16] The U.S. surgeon general did not act on the request. Army General Orders of 1879 mandated that veterinary surgeons in the cavalry be graduates of "an established and reputable veterinary school" and imposed the first standards for veterinary education in the United States. The French were at the forefront again; they had established a postgraduate school for military veterinarians, the École d'application du service veterinaire, at their army cavalry school in Saumur.

7. THE CANADIAN MIDWEST: DIVERGENCE OF LOWER AND UPPER CANADA

The Grand Trunk Railway, Canada's first major railroad, was completed from its headquarters in Montreal west to Sarnia in 1856. Tracks ran through Toronto, Guelph, and Upper Canada's agricultural lands, completing a connection to Port Huron in Michigan and a rail line connection to Chicago. Four years later the Grand Trunk extended south to the cold-water port in Portland, Maine. Funded by London banks and promoted by new Canadian immigration programs, the railroad was a major economic stimulus to agriculture and livestock production. It also had an indirect but astonishing impact on veterinary medicine in North America.

Aware of the economic importance of animal diseases, the Upper Canada Board of Agriculture voted to establish a training school for veterinary surgeons and hired a local veterinarian, Scottish immigrant Andrew Smith, to teach a course in veterinary science. In 1861, Smith gave his first lectures to a small group in Toronto. The next years, more lectures, and in 1866 the first graduates of a formal course were awarded a diploma after being examined by veterinary surgeons appointed by the Board of Agriculture.

The new veterinary school was funded only in part by the provincial government. Operated as a private enterprise by Smith, it was known until 1869 as the Upper Canada Veterinary School—Upper in the St. Lawrence River, as opposed to Lower Canada of French Quebec. It offered the V.S. degree (for Veterinary Science). Smith, using his own money, constructed the first Canadian veterinary college building in Toronto in 1870.

Renamed the Ontario Veterinary College, it was from its origins in agriculture and the nature of Andrew Smith a practical school to deal with diseases of horses and livestock. It was the first successful school for veterinarians that survived in North America—started in the fledgling capital of Upper Canada by a Scotsman from Professor Dick's school in Edinburgh.[17] In running the school, Smith was aided by a fellow Edinburgh graduate, Duncan McEachran. The two published a textbook for farmers, *The Canadian Horse and His Diseases*. During the last quarter of the nineteenth century, the Ontario Veterinary College instructed more students and graduated more veterinarians than all other veterinary colleges in North America combined. Many of its students were from the United States, to which they returned to practice—and some to start veterinary schools.

After working three years at the Upper Canada Veterinary School in Toronto as professor of materia medica, McEachran, dissatisfied with what he believed to be faulty standards for admission and inadequate requirements for graduation, left for Montreal. The limiting factor for entrance had been only that the student must be able to read and write; even that could be waived for one year if the student was doing well.

In Montreal, McEachran established the Montreal Veterinary College in 1866—starting with higher standards for admission and a more rigorous scientific curriculum.[18] To teach botany, chemistry, and physiology, Principal McEachran invited professors from McGill University to include veterinary students in the classes. Physician William Osler accepted the offer to teach parasitology and physiology, admitting veterinary students to his lectures at the medical school. Osler, newly returned from a European tour of study, had just been appointed lecturer at Montreal Medical School. One year later he was advanced to professor and appointed chief of pathology at Montreal General Hospital.[19]

Osler's interest in parasitology had developed when he was a student at Toronto Medical School, where his professor of medicine, James Bovell, was an enthusiastic naturalist. Bovell developed Osler's early love of comparative medicine—and his first contact with veterinary medicine, advising him to study internal parasites in the dissecting room of the Ontario Veterinary College. When Bovell left Canada, Osler moved to Montreal and continued his medical studies at the more prestigious McGill University, graduating in 1872.

One of Osler's lifelong friends was a veterinary officer in the Royal Artillery, Griffith Evans (who discovered *Trypanosoma evansi*, the cause of equine surra, while his unit was stationed in Montreal). Osler had just returned from European studies in Britain and Germany. He had absorbed Rudolf Virchow's thoughts on comparative medicine and political drive to license veterinarians for public health purposes. After periods at the University of Pennsylvania, Johns Hopkins University, and Oxford University, Osler would be the most famous physician in North America, a reputation achieved through his revolutionary teaching—incorporating clinical patients into the medical curriculum and using autopsy material to teach pathology.

Osler introduced the microscope and clinical chemistry to the hospital and, from his own funds, purchased a dozen Hartnack microscopes from abroad. He began teaching parasitology at the Montreal Veterinary College in 1876, bringing his famous bedside teaching to the stables. An advertisement in a national journal for the introductory lecture at the Montreal Veterinary College for the 1882–1883 season lists Prof. William Osler, M.D., M.R.C.V.S.—Osler was not a licensed veterinarian; perhaps this was a deliberate error of McEachran.

Through careful postmortem work, Osler established the cause of a chronic respiratory condition in foxhounds at the Montreal Kennel Club as parasitic bronchitis.[20] Continuing his legacy from Virchow, Osler investigated the origins of human echinococcosis—sending his veterinary student Albert Clement to the Montreal abattoir (he examined 1,037 hogs and found 76 animals affected).[21] Osler recognized the intelligence of Clement and put him to work assisting on several projects. Studying an outbreak of hog cholera near Quebec,[22] Osler provided the first good description of gross and microscopic pathology of that disease and recognized that bacteria were not involved: "Bacteria and micrococci were occasionally met with, but not in situations or numbers to be of great pathologic importance."[23] Louis Pasteur, Theobald Smith, D. E. Salmon, and others were ascribing hog cholera to a bacterium; they should have been listening to Osler. Bacteria as a cause of hog cholera was a notion not dispelled until the virus was identified in Iowa in 1903.[24]

Osler was acclaimed father of Canadian comparative pathology, having used animal specimens for medical students and human tissues for his veterinary students. Osler successfully proposed the incorporation of the Montreal Veterinary College into McGill University as the Faculty of Comparative Medicine and Veterinary Science. Leaving Montreal for the University of Pennsylvania, he served on the board of veterinary journals and contributed translations of German articles for the *American Veterinary Review*. He had been elected president of the Montreal Veterinary Association and contributed heavily to the veterinary literature of the day, publishing papers on verminous bronchitis of dogs, trichinosis, and cysticercosis in the meat supply of Montreal; he distinguished anthrax from human typhoid fever when European experts were confusing the two.

ALBERT W. CLEMENT WAS A Massachusetts native educated at Harvard and Montreal Veterinary College.[25] Recognizing his intellect, Osler awarded Clement with a residency in his medical school department of pathology. After three years under Osler, Clement spent two years in Europe. He spent periods at the Royal Veterinary College in London, the National Veterinary School in Alfort, France, and the pathological institute under Rudolf Virchow at the University of Berlin and with the veterinary pathologist Wilhelm Schütz at the Berlin Veterinary College (working sometimes at the Berlin central slaughterhouse). His great admiration for Berlin was in contrast with the absence of teaching in pathology in both London and Alfort. Clement's first paper as sole author (and the first on pathology by a veterinarian in North America) was a study of kidney lesions of equine azoturia, now a model for rhabdomyolysis and capture myopathy of wild cervids.

Returning to Montreal, Clement left shortly for his career as a scientist, following Osler to the Johns Hopkins Hospital laboratory. In Baltimore, Clement published an article with Johns Hopkins medical pathologist William H. Welch on hog cholera and, in 1900,[26] with W. G. MacCallum, Welch's successor at Hopkins, on tuberculosis in a lion. Serving as a consultant to the Bureau of Animal Industry on pleuropneumonia, Clement was known for his textbook *Veterinary Post-Mortem Examinations*, for important national changes as president of the American Veterinary Medical Association, and for establishing sanitary laws in Maryland. He died of cardiac failure the next year in the Johns Hopkins Hospital, where William Osler was still physician-in-chief.

THERE WAS NO FRENCH LANGUAGE veterinary school in Canada until May 29, 1866, when the Quebec Provincial Parliament approved an act to provide $300 to establish a French language veterinary school in Montreal; the act specified that it be under the auspices of the Chamber of Agriculture of Lower Canada and that Duncan McEachran be director. The new French section in the Montreal Veterinary College of English-language McGill University began the next year, using faculty from Victoria University to teach basic sciences in French; its first class of two graduated in 1869.[27]

In 1876, when wheat became a dominant product in western Canada, the Quebec government began to induce farmers to establish dairy operations, offering to provide francophones with access to veterinary courses. One of the beneficiaries was an extraordinary immigrant, Victor-Théodule Daubigny. Daubigny had emigrated from France in 1872—like H. J. Detmers, to escape the consequences of the Franco-Prussian War.[28] He did not speak English and Canada did not recognize his training as a notary clerk in France. He began farming and, when the opportunity came, enrolled in the French section of the veterinary school at McGill University in January of 1877.

McEachran, noting his farm experience and communication skills, hired Daubigny after graduation to head the French section. Leaving that position in 1877, Daubigny opened a French-speaking veterinary school, École Vétérinaire Français de Montréal, which took its first students on September 30, 1886; courses in chemistry, histology, and physiology were taught by the French-language Université Laval science faculty.[29]

Paul Paquin, a native of St. Andrews, Quebec, graduated from the French section of Montreal Veterinary College in 1883. Leaving for Missouri to organize a sanitary department, he was in the next year delegated to the Institut Pasteur for experience in the laboratories of Cornil and Ranvoir. Returning to the University of Missouri in 1884, Paquin established the Laboratory of Bacteriology, Pathology and Hygiene, billed as the first in the West. The next year Paquin was made state veterinarian in Missouri and was awarded an MD degree at the university in Columbia. Throughout his career, he was a major force for public health in Missouri.

Daubigny's son, François-Théodule Daubigny, emigrated to Canada in 1882, earned his veterinary diploma in 1889, and stayed on as faculty, assuming much of the teaching (the school was renamed École de Médecine Comparée et de Science Vétérinaire de Montréal). He succeeded his father as director in 1909 and successfully guided the school into the new age, with peak enrollments of sixty-two in 1916–1917 and a move to a new building on the Université Laval campus in 1914.

In the post–World War I era, enrollments dropped—to sixteen in 1920—and the school's mounting debt drove the Université Laval/University of Montreal to establish a committee for change. The result was that the school was moved to the Institut Agricole d'Oka in 1928—placing the school under Trappist monks—with the new name École de Médecine Vétérinaire de la Province de Québec. Daubigny resigned the same year. The school was taken over by the Quebec Department of Agriculture in 1947 and moved to its present location at the University of Montreal campus in Saint-Hyacinthe. Today, a large multi-specialist clinic, the private Centre Vétérinaire Daubigny, serves the companion animal population of Quebec City.

THE DIFFERENT CURRICULA, STANDARDS, and connections to livestock diseases of the two English-speaking Canadian veterinary schools allowed Toronto to survive and Montreal to fail. Toronto's Smith recognized what McGill's McEachran did not, that nineteenth-century veterinary education should follow the practical dictates of the livestock industry. Their lessons left a similar pattern in the United States: Harvard failed, and Iowa survived. And in Canada, the practical French-speaking School of Veterinary Medicine, founded by farm boy Daubigny, survived and prospered.

8. PIONEERS IN THE MIDWEST FRONTIER: PHYSICIANS IN VETERINARY PRACTICE

The earliest cultural fabric of the midwestern American territories was created by English-speaking eastern Americans moving west. The language of the first rural settlers, earthier and less cultured than in the East, came from a unique North Midland English dialect carried through Ohio, Indiana, and Illinois, absorbing dialects and changing as it moved west. Migrating New Englanders carried along New Jersey English, the biblical language of the Quakers, and the Low German (Plattdeutsch) from Pennsylvania and the Maryland Hessian Barracks. There was also some West Country English with its curious use of the verb *be*—not "*We are . . .*" but "*We be* movin' west."[30]

The language was changing. Within two decades, the early settlements of the Midwest and Great Plains were being infiltrated by old-world immigrants who were not speaking English and not Congregationalist, Methodist, or Anglican. Germans, the Dutch, Scandinavians, Danes, and even the Swiss and Luxembourgers were immigrating to the Midwest and Great Plains, soaking into the gauze of early American settlements and changing place names to Holstein, Schleswig, New Prague, New Glarus, and Guttenberg. They spoke broken English and wrote, if at all, poorly. Historical novels of the region written by early eastern authors created characters that spoke in the author's style, and the patois and character of the earliest midwestern frontier language seemed to be lost. But it can be found in Hamlin Garland's book *Main-Travelled Roads*.[31] With his family, author Garland had moved continually westward in search of a better life—from Wisconsin, to Iowa, and then to Nebraska Territory. In Iowa he lived in Osage during his formative years, and his books were an anti-idyllic snapshot on the nature and misery of farm life, which was closely tied to populist revolts of the time.

As Garland described the midwestern farmer in the nineteenth century, he "put in the storms as well as the sun. I included the mud and the manure as well as the wild roses and the clover." But however accurate that was, his descriptions of settlers communicating with their neighbors and with their animals were flawless. Here a farmer, "sitting bent and cold but cheery under a slough hat," talks and encourages his team of four horses: "Come round there, boys!—Round agin! We got t' finish this land. Come in there, Dan! *Stiddy* Kate,—stiddy! None o' y'r tantrums, Kittie. It's purty tuff, but got a be did. *Tchk! tchk!* Step along, Pete! Don't let Kate git y'r single-tree on the wheel. *Once* more!"

Although regional factions no longer exist in veterinary medicine, when ignored, the words of Garland do apply to urban populist-driven resentments in the South, Great Plains, and Midwest that erupt now and then with scary implications. Translated into modern and republican terms, the words of Garland's characters in their groping for a fairer society should still be menacing to modern politicians who forget: "A man like me is helpless. . . . Just like a fly in a pan of molasses. There ain't any escape for him. The more he tears around the more liable he is to rip his legs off."

AS IMMIGRANTS MOVED INTO the Midwest and Great Plains, farriers and unschooled, apprentice-trained veterinarians came with them to serve the livestock industry. After spending a few months apprenticed to a practitioner with an established reputation and trained only by observation and oral instruction but with no further education or formal training, a budding horse doctor typically started business as a "veterinary" in the town livery stable. There had been no classes, no textbooks, and no graduation—only a letter stating he had trained for nine months under the eyes of a "veterinary." Veterinarians could do that in the 1870s. They had to know how to treat abscesses, bad teeth, inflamed sores, intestinal colic, and disease caused by poisonous plants. Surgical skills for traumatic injuries, especially for those acquired during birthing, were needed. Dominating surgical procedures were the castrations of stallions, mares (called spaying), and ridglings, males with undescended testicles that remained in the abdomen.

Harrison Shaw Titus, a pioneer "vetinary" (or vitin'ry, as the new Yorkshire immigrants in Eden Township called him), had been born in Sheboygan County, Wisconsin, and moved with his family to a Mississippi River town, where he learned the farrier trade. After a monthlong apprenticeship to a practitioner, Titus moved again to central Iowa—following the railroad as it laid track westward.

Much of the history of the early American veterinary profession has been lost despite the need for preservation.[32] Apprentice-trained veterinary practitioners often advertised as veterinary surgeons. Many were located in livery stables that provided daily rental horses and buggies—early versions of rent-a-car businesses, they were close to railroad stations and hotels.

RURAL POPULATIONS BEYOND the Appalachians had been mired in superstition and cared for by midwives, patent medicines, and traveling salesmen. People treated their wounds and fevers with home remedies of whiskey, turpentine, and bag balm that were good "for man or beast." Cattle were another matter; their loss meant disaster for the frontier family. In small rural villages without a veterinarian or experienced farrier it was not uncommon for a physician to derive much of his income from the practice of veterinary medicine. Three of them—David Fairchild, William Mayo, and Sesco Stewart—would play roles in midwestern medical and veterinary sciences.

In 1853 there were nearly two hundred physicians in the United States, graduates of eastern American medical schools, that practiced veterinary medicine.[33] In Olmstead County, Minnesota, two remarkable physicians treated animals in the first years of their medical practices. David Fairchild and William Mayo had been exposed to critical science in their early years and they shared an intense curiosity and, unusual for the time, had microscopes that enhanced the scientific basis and reputation of their practices. Fairchild would become dean of a medical school, a historian of pioneer medicine, and a founding scientist of the first state veterinary school; Mayo gave birth to one of the great medical hospitals in the nation. Both had practiced briefly as a veterinarian.

David Sturgis Fairchild, for his medical training, attended lectures at the University of Michigan in 1866–1867; the next year, to finish his MD degree, he moved to Albany Medical College of Union University, at the time one of the country's prominent medical schools.[34] The New England Fairchilds were descendants of the puritan Thomas Fairchild, whose offspring included an astonishing number of academic educators. After practicing in his hometown for a year, Fairchild moved west to begin his own practice in the small village of High Forest in Olmsted County, Minnesota. Human patients were few, and he was called on to treat animals. Outgoing, robust, and handsome, Fairchild soon was appointed to the Olmsted County Board of Commissioners.

Ten miles, as the crow flies, from High Forest was the practice of William Mayo. Mayo had emigrated from England, where he had trained as a chemist under the Quaker John Dalton, who promoted the new idea that all matter was composed of atoms. Emigrating to America, he worked as a chemist in Bellevue Hospital in New York City and then moved west, teaching chemistry and obtaining his MD degree from the itinerant Indiana Medical College, a primitive medical school that moved west to Iowa as the Keokuk Medical College.

Mayo was short, wiry, and formal; a grandson described him as "strange, ferocious, striving and restless." To avoid the malarial swamps in Indiana, William Mayo moved his family from his short-lived medical practice in Lafayette, Indiana, to Minnesota.[35] As with Fairchild in High Forest, patent medicine, midwifery, and home remedies were in vogue, and farm families in La Sueur did not need or trust him for their own health care but did bring him their livestock. For several years, William Mayo survived as a veterinarian. In 1862, as Civil War recruiting began in the Midwest, he had obtained an appointment as an examining physician for a regional military enrollment board in Rochester, Minnesota.[36]

UNLIKE SOME OF THE SCIENCE-BASED medical schools in the East, those in the Midwest in the mid-1800s were rudimentary; they played little role in creating veterinary science. Frontier physicians, like veterinarians, were often apprentice-trained. As cities grew along the Mississippi River, private medical schools moved in. The Indiana Medical College began as a tiny, unstable, and short-lived school—from 1842 to 1850—in La Porte. William Mayo graduated in its last class and taught chemistry during his short time in Indiana. The school was unsuccessful and moved to Iowa to become the College of Physicians and Surgeons of the Upper Mississippi in Davenport. It graduated fifteen physicians before it again moved south on the river to join a medical group in Keokuk.

In the winter of 1850–1851, the Iowa State Legislature recognized the Keokuk Medical College as the official Medical Department of the State University of Iowa. The arrangement in Keokuk would operate in a new building as the College of Physicians and Surgeons of the State University of Iowa and would continue as the state-sponsored medical college for another twenty years, when the medical school moved to Iowa City.

A medical department for the university in Iowa City was approved as the university's medical college in 1870. It opened for its first class in September with a dean and eight faculty; thirty-seven students enrolled, eight of them women. The curriculum was a mere two-week course of lectures followed by sixteen weeks of clinical training. In Keokuk the medical school would continue to operate as an independent institution until it closed in 1908 and transferred its records to Drake University in Des Moines.

The early lack of support and vision for medicine in the Midwest led to medical quacks, worthless patent medicines, and the appearance of quasi-medical businesses: the Palmer Chiropractic operation in Davenport, Still Osteopathic School in Des Moines, and the Iowa Homeopathic College of Medicine in Iowa City. The University of Iowa had two medical schools operating simultaneously: the allopathic medical school, the one operating today, and the Iowa Homeopathic College of Medicine. Started in 1876 as the Homeopathic Medical Department, the Board of Regents allocated funds for a homeopathic school building and hospital, which opened at the corner of Jefferson and Dubuque Streets in Iowa City in 1895.

Homeopathy attempted to cure sickness by stimulating the body to recover itself using a loopy belief, the law of similars and the infinitesimal dose. Instead of looking at symptoms as the unwanted evidence of disease, it viewed them as signs the body was healing itself—giving remedies that would cause the same symptoms in a normal person. Treatments were plant and chemical extracts diluted to one part per million. The lack of science caught up to the scam and the homeopathic school and hospital closed in 1919.[37]

Veterinary homeopathy had first been formalized when a German veterinarian named F. A. Gunther published his *Homeopathic Veterinary Medicine* in about 1840. It appeared on the American scene when a second edition was translated into English and published in the U.S. in 1853. The book was publicized big-time by Dr. F. Humphreys, a prominent physician in Philadelphia, who took up veterinary work treating horses with dilute suspensions of belladonna (one part in a trillion of water), which had "the horse on his feet in two hours. Ten doses at 12-hour intervals 'perfected the cure.'" Humphreys printed pamphlets and books on homeopathy that flooded the eastern markets.[38]

Humphreys's remedies cost less than a penny per dose, which he prophesized that "any sensible, faithful man of ordinary intelligence can master without difficulty."[39] But like human homeopathy, science caught up with veterinary homeopathy and it was gone. J. F. Smithcors, in noting the frequent brutal treatments delivered by veterinarians in those days, wrote that "at a time when both men and animals literally died of the doctor, homeopathy at least gave them the opportunity to die of disease—or recover with the aid of Nature, perhaps assisted by homeopathic nursing care."[40]

9. NEW PLAGUES, CIVIL WAR, AND THE UNITED STATES DEPARTMENT OF AGRICULTURE

A rapidly spreading respiratory disease of cattle entered Massachusetts on July 23, 1859, with four Dutch cows imported by Winthrop Chenery of Belmont, near Boston. The cows, shipped from Rotterdam, had high fevers, labored breathing, and frothy noses. They were all so sick when they arrived in Boston that only two were able to walk from the boat to Mr. Chenery's farm.[41] When the carcasses were examined, the lungs were heavy and inflamed and the lining of the rib cage was rough and carpeted with tags of clotted serum. The disease was recognized immediately as contagious pleuropneumonia, but not before it had begun to spread through the area. Within the next four years the disease had appeared in twenty townships in Massachusetts. The potential for massive outbreaks in eastern states and the need to prevent contagious pleuropneumonia from spreading westward into the cattle country of the open plains and South Texas was an important factor spurring Congress to establish a U.S. Department of Agriculture.[42]

WHEN THE AMERICAN CIVIL WAR BEGAN, the absence of veterinary care in the U.S. Army made it dangerous to be a military horse. Remount purchases of sickly horses from corrupt contractors used by the Army Quartermaster Corps led to enormous death losses. Cavalry horses, weakened by poor nutrition and husbandry, could not withstand long military sorties and were susceptible to strangles and glanders. The Civil War was notorious for quartermaster kickbacks.

Army Quartermaster Corps officer McKinstry was court-martialed for paying $119 for horses that sold on the market for $80. Contaminated meat was supplied to the Army at high prices. Wool material knitted from cheap shoddy—yarn constructed of scraps or old clothing—was sold to the government by New England mills at the price of high-grade wool; uniforms disintegrated after the first rain.

No qualified veterinarians were available: Europe had thirty formal veterinary colleges; North America, none. The Army quickly created the position of veterinary sergeant, a noncommissioned officer, for each battalion. No veterinarian applied, and in 1862 the position was eliminated. Joseph Bushman, a graduate of London's Royal Veterinary College practicing in Washington, D.C., was asked by the Lincoln administration to serve in the U.S. Army as a veterinary sergeant. Bushman declined since in England military veterinarians were commissioned officers; he was later recruited to supervise the critical horse and mule recruitment center, the Remount Station along the Potomac River.[43]

The next year, the U.S. War Department ordered each cavalry unit to have a veterinary surgeon at $75/month (four times the pay of a veterinary sergeant) but failed to provide instructions or qualifications for selection by any responsible regimental officer. Army line officers ignored the order. One state militia did have a qualified veterinarian: the 7th Pennsylvania Cavalry had a Boston Veterinary Institute graduate, George F. Parry, probably the first schooled veterinarian to enter military service in the United States.[44]

General McClellan, head of the Army of the Potomac, knew about modern veterinary care and continued as a strong proponent of veterinary education. Replaced with Ulysses S. Grant, he ran unsuccessfully against Abraham Lincoln in the general election for president in 1864. Had he won, there may have been a national veterinary school at West Point. Grant, although a superb horseman—he had been the best rider in the Cadet Corp at West Point—knew little of the modern veterinary schools of Europe. He dignified quackery by persuading Congress to allocate $10,000 per year for a know-nothing charlatan named Dunbar to teach horseshoeing and lameness care for Army cavalry.[45]

AFTER THE CIVIL WAR, as animals were imported and numbers increased, so did infectious diseases. Animal plagues were destroying the livestock industry beyond the capacity of cities and states to deal with them. Texas cattle fever and bovine tuberculosis were serious problems, and contagious pleuropneumonia, trichinosis, and hog cholera were closing European markets to exports of pork. It was the federal government and its fledgling U.S. Department of Agriculture that stepped in to save the animal industry.

Despite the energy consumed by the Civil War, three major developments of the period set the stage for veterinary science in the rural Midwest: the immediate success of the Bureau of Animal Industry in combating the infectious plagues, the establishment of the National Academy of Sciences to provide scientific advice to Congress, and westward expansion of the railroads and the ensuing growth of the livestock industry. In the Midwest, the Northwestern Railroad crossed the Mississippi River and connected to the Union Pacific in Omaha in the 1860s, and the Kansas Pacific extended through Denver to the Union Pacific in Cheyenne. In contrast, the Texas and Pacific Railroad moving west from New Orleans and Shreveport reached Fort Worth only in 1876. The Civil War had stopped railroad construction throughout the South. Still lacking stockyards, railroad stock cars, and access to the Chicago markets, Texas cattle continued to use trails to Kansas for another decade (see appendix I).

TEXAS CATTLE FEVER (called southern cattle fever in the eastern states) appeared during the summer months in the western plains as cattle were driven north to the railheads in eastern Kansas, Missouri, and Illinois. The disease killed quickly—it destroyed red blood cells but left few other signs of disease except for red urine and striking pallor from anemia. The disease occurred in native cattle but was limited to those that had contact with longhorn cattle driven north by South Texas ranchers—causing observers to call it Texas fever, or redwater (because of the bloody urine), and later, when the disease was better understood, hemoglobinuric fever.

The sturdy Texas Longhorn cattle had originated from Iberian lineages, direct descendants of the Spanish breeds Barrenda, Retinto, and Grande Pieto. They had been moved north by Mexican ranchers but abandoned when Texas was settled and became independent. Feral for nearly two centuries, the Texas Longhorns had evolved to be highly tolerant of feed and drought stress. They could withstand the grueling cattle drives to the Kansas railheads.

Before the Civil War, cattle were driven from Texas northward to markets in Missouri and Illinois on the Shawnee Trail via Austin, Waco, and Dallas. Closed during the Civil War—both Union and Confederate soldiers used the Shawnee Trail—routes shifted to the Chisholm Trail after the war, to new railheads in Kansas. The buildup of cattle in Texas during the war promoted huge cattle drives to the North. The price of cattle in Texas in 1866 was $4 per head; in Kansas City, $40 per head. In spring 1866 an estimated 250,000 longhorns headed north. As the Kansas Pacific Railroad arrived in Abilene, stockyards were built that attracted cattle drives; the terminus for the Chisholm Trail was Abilene from 1867 to 1871, when the Santa Fe Railroad moved south toward Wichita.

As the Union Pacific moved into western Nebraska, a Texas Trail was established that led to Ogallala, Fort Scott, and other western cities. A strict law against moving cattle into the state was enacted by the General Assembly of the State of Iowa: moving cattle "in such condition as to infect with or to communicate to other cattle . . . Texas fever . . ." would be fined up to $1,000 and "any person injured or damaged by such an act may bring action to recover the damages."

Days after the longhorns had passed through, local cattle began dying in large numbers. In Missouri, angry farmers started turning back the herds at the border. State legislatures created a hodgepodge of laws to keep southern cattle from passing through their states to market. The first legislation against the movement of Texas cattle had been an act by the Kansas Territory in 1859 prohibiting the driving of cattle from Texas or Arkansas through the four eastern counties between June and November. Missouri, Colorado, Nebraska, and the Dakota Territory soon passed similar laws. Challenged, the U.S. Supreme Court ruled these laws unconstitutional on the grounds that they discriminated against all Texas cattle and constituted a restraint of trade. Nonetheless, gangs of concerned citizens were formed in the trail states to prevent passage of cattle. Arriving at the outskirts of Kansas City on the Chisholm Trail, many drovers were turned back by organized groups of angry Kansas stockmen. Reactivated from Civil War antislavery vigilantes, they called themselves Jayhawkers, and the task of bullying Texas drovers "jayhawking." Loss of passage through Missouri and Illinois shifted cattle trails westward to the Chisholm Trail to connect to railheads of the Kansas Pacific Railroad being pushed westward to Denver. The drives had to start in early June since the grasslands would be dry by midsummer.

Horace Capron, a livestock breeder in Illinois, was appointed in 1867 as commissioner of the U.S. Department of Agriculture—USDA for short. His immediate problem was Texas cattle fever, and he proposed that this disease receive the most attention. An article in *The Veterinarian* had notified its readers that "a very subtle and terribly fatal disease" had broken out among cattle in Illinois. Southern cattle moving overland to northern markets were bringing the debilitating and deadly fever throughout the Midwest, especially into Illinois, Indiana, and Ohio. In the East the disease was called southern cattle fever, but the spread northward was similar; cattle shipped north from Florida were bringing the fever to the Mid-Atlantic states.

Commissioner of Agriculture Capron, in his first annual report in 1868, pointed to the need for funds for research on Texas cattle fever and went further—he recommended the "creation of a division of veterinary surgery for the investigation and prevention of diseases of domestic animals." There was no response from the U.S. Congress. States were paralyzed by the problem and no useful research was underway. "Out west," John H. Rauch, MD, the Chicago health commissioner, recorded over two thousand autopsies on cattle with Texas fever from 1868 to 1869, including lesions and organ weights, but the information didn't explain what was going on.

State commissioners of agriculture from the Midwest assembled in Springfield, Illinois, in December 1868 to deal with Texas cattle fever. They were divided as to who should undertake investigations of the disease. Should it be Congress and the Treasury Department, or the War Department with its installations and network of veterinarians, or the fledgling U.S. Department of Agriculture? The states settled on USDA commissioner Capron's request for funds, which allowed him to expand his current work with livestock. The state commissioners also recommended to Congress that there be the establishment of a veterinary division within the USDA. No response.

The new commissioner of agriculture, George Loring, asked veterinarian H. J. Detmers to undertake a study of southern cattle fever. After he spent several months on the ranges of Texas talking with ranchers and farmers about the disease, his 1885 report *Investigation of Southern Cattle Fever* dealt with cocci and bacilli recovered from the livers and spleens of dead animals as potential causal agents, but he knew that his study had failed to find the real cause of the disease.[46] At the end of his sixth year with the Bureau of Animal Industry, a disgruntled Detmers resigned to become the professor of veterinary science at The Ohio State University.

Investigations into the *cause* of Texas cattle fever seemed to be stymied. But the discoveries in its geographic spread and seasonal occurrence had been the beginnings of a new discipline, veterinary epidemiology. A Texas cattle fever quarantine line was established at approximately the thirty-seventh parallel of latitude that turned northward in the Atlantic Coastal Plains. Veterinarians in the new state departments of veterinary science made important contributions—Mark Francis in Texas, Frank Billings in Nebraska, R. H. Dinwiddie in Arkansas, and Paul Paquin in Missouri. Francis shipped eighteen Texas Longhorns to Paquin to investigate how ticks were involved in the disease spread. Although barren as to cause, these scientists laid the groundwork for a surprising discovery of the new agent that was destroying red blood cells in the dying cattle.

EQUINE INFLUENZA, A RAPIDLY SPREADING and sometimes fatal respiratory disease, decimated horses in New York City, Boston, Washington, and Chicago in 1872.[47] Transport in the cities stopped. The *New York Times* of October 30 reported that twelve thousand horses were down with influenza. In Boston, mail, groceries, and freight sat on docks undelivered; a fire that broke out in November could not be contained as fire wagons pulled by men, not horses, could not keep up with a fire spreading through the town. Much of Boston—776 buildings—burned. In Chicago, hundreds of sick and dying animals lay unable to function. Today, when transportation problems center on where to park one's car, it is hard to imagine a time when business in most large American cities was paralyzed because horsepower was incapacitated by disease.

Equine influenza had originated in Markham, Ontario, Canada, in the last few days of September 1872 and had spread along railroad lines and hubs, canals, and stagecoach lines throughout North America. The route of a traveling circus was traced by new centers of disease; even its mules and zebras were afflicted. Influenza was reported in Washington State in May 1873 and had rapidly spread throughout the Midwest and southward into Central America and the Caribbean. In one frontier skirmish the U.S. Cavalry and Apache Indians fought on foot—horses on both sides were too sick to ride into battle.

The first sign of influenza in horses was a rapidly developing fever, often increasing to 107 degrees within twelve hours. Horses coughed unproductively and respiration became labored and pulse rate accelerated. There were chills with trembling and shivering, first in the flanks, then progressing to all muscles of the body. Pregnant mares aborted. Rush Shippen Huidekoper described the fine points of the disease in Philadelphia: "hairs become dry and rough and stand more or less erect" and there is swelling of the eyelids, underbelly, and penis sheath. Mucous membranes of the mouth and other orifices were violet-red or even saffron-colored. Horses became stupid (the horseman's language for unresponsive), standing immobile with head hanging, ears listless with puffy and swollen eyes, and paying little attention to the stablemates or surrounding attendants. Stupor increased: "The horse stands limp, as if excessively fatigued, staggers, and falls."[48]

Mortality was low, 2 to 10 percent, but recovery of horses required several weeks. Viral influenza was complicated by secondary bacterial infections of strangles; the virulent streptococci of strangles infected the throat and lungs, leading to fatal pneumonia. Weakened horses that recovered were useless for weeks so that business dependent upon cartage was suspended where oxen could not be procured to make deliveries. Glanders strewn by the Civil War was a factor in this influenza outbreak, complicating the diagnosis and confusing self-taught "veterinarians" who were called into the scene.

In the stables of the Washington streetcar line in the District of Columbia, the ravaging influenza epizootic of 1871–1872 paralyzed streetcars and general traffic. In the nation's capital that year there was no veterinarian able to diagnose and deal with the problem, no government veterinary agency to call, and no veterinary diagnostic laboratory with experts to examine tissue specimens from an emergency animal disease. In their absence, the disease at the streetcar stables was investigated and identified by a military medical pathologist.

Joseph Woodward, MD, had done autopsies on two American presidents, Abraham Lincoln and James Garfield. The first pathologist at the Army Medical

Museum, the forerunner of the Armed Forces Institute of Pathology, he had founded the Division of Comparative Pathology. Woodward was called the father of veterinary pathology in America due to his studies on the pathology of the great cattle plague raging in the eastern United States during the 1860s; he had published his report on contagious pleuropneumonia in 1870, the first on microscopic changes in the lungs of cattle.[49]

Around the nation's capital during the influenza outbreak, the lack of veterinary science expertise was clear to everyone, including the Army, the USDA, and the city's Sanitary Department. There were too few educated veterinarians around to deal with serious animal plagues.

HOG CHOLERA, A NEW DISEASE, was first encountered in the Ohio Valley in the 1830s. Today named classical swine fever, it had moved rapidly through the Midwest. As hog populations increased, so did hog cholera and, in fifty years, the disease had spread through the country, often coming in waves of terrible death loss. It killed pigs quickly. Attacking blood vessels, it caused massive hemorrhages and swollen fluid-filled tissues. Piles of dead pigs were common in the rural Midwest when hog cholera attacked.

In 1878, U.S. commissioner of agriculture Le Duc, a Minnesotan, asked nine veterinarians to investigate hog cholera in different parts of the country and report on the status and treatments used in various regions: H. J. Detmers, for Illinois; James Law, New York; D. W. Voyles, Indiana; D. E. Salmon, North Carolina; Albert Dunlap, Iowa; H. F. Dyer, Illinois; A. S. Payne, Virginia; J. N. McNutt, Missouri; and C. M. Hines, Kansas. At the time, Salmon and even Pasteur were writing that the cause of hog cholera was a bacillus to which they gave the name *Bacillus suis*. Theobald Smith concurred but was calling it *Bacillus cholera-suis*.[50]

Reports submitted by Law and Salmon were general and vague and contributed little; worse, they supported the hypothesis that bacteria caused hog cholera. In contrast, the report by Detmers made it clear that the bacterial cause of hog cholera was far from settled and that, in the facts known, the cause was most likely not bacterial. Using his pathology training from Berlin, Detmers cautioned rightly that the science behind this assumption was incomplete, that there were some cases where bacilli could not be cultured from dead animals, and that no bacillus had yet been proven to cause hog cholera; none had fulfilled Koch's postulates. This was the start of an antagonism with Salmon that persisted for two decades. Twenty years later, when Salmon wrote his history of veterinary research of the time, he did not mention Detmers.[51]

10. AGRICULTURE AND VETERINARY SCIENCE IN THE MIDWEST

Farmers College of Ohio was built on College Hill in the outskirts of Cincinnati in 1848. One of the first institutions of higher culture beyond the Appalachian Mountains, it was dedicated to the "practical character of its course of instruction." Cincinnati, the first major inland city, was populated by Americans going west; it lacked the immigrants ballooning eastern cities. It was the boomtown of mid-America, the sixth largest city from 1840 to 1860. Known as "Porkopolis," its agricultural and meatpacking industries flourished before being replaced by Chicago and St. Louis.

In 1848, two years after statehood was granted, the Iowa Legislature petitioned the U.S. Congress to grant the state Fort Atkinson—buildings and two sections of land in Winneshiek County—for an agricultural college. Completed only four years previously to protect the Winnebago Indians in their migration from Wisconsin to Nebraska, Fort Atkinson had been disenfranchised. But the fort was assigned to the Iowa Volunteers military unit, not for an agricultural college.[52] It was officially abandoned on February 14, 1849, at the start of the Mexican-American War.

By mid-century, several states began to see the enormity of agriculture's economic impact and a need for encouragement. In 1855, state legislatures chartered the Agricultural College of the State of Michigan and the Farmers' High School of Pennsylvania. Opened under a new name in May 1857, Michigan Agricultural College was a model of success.[53] In Iowa, a bill founding a state agricultural college was signed by Governor Ralph P. Lowe on March 22, 1858, the charter being for an "Iowa Agricultural College and Model Farm."[54] Story County was selected as the site the next year, and the first building, Farm House, was completed in 1861. Then came the passage of one of the most effective acts ever passed by the U.S. Congress.

To address agricultural issues, the Land-Grant College Act, written by Justin S. Morrill of Vermont, chairman of the U.S. House Agriculture Committee, included provisions for teaching veterinary science as part of agricultural education. The bill, after passing both houses of Congress, had been vetoed by President Buchanan. The same bill was reintroduced in 1862 and by July 2 became law when signed by President Lincoln. The Act granted huge tracts of federal land to develop agricultural colleges. It was an astonishing stimulus for higher education in all states and territories, but it was the expanding agricultural lands that reaped the greatest benefit. The tallgrass prairies of Iowa, the Great Plains of Kansas and the Nebraska Territory, the Southern Seaboard, and the Palouse lands spreading south from Spokane had rapidly expanding livestock industries and took advantage of the bill's provisions for teaching science to agriculture students. Five years later, twenty-two colleges and universities were offering instruction in agriculture.

The Iowa Legislature was one of the first to accept the land grant provisions. Approved in 1862, the Iowa Agricultural College and Model Farm became an operating land grant institution two years later when the General Assembly awarded it the state's land grant charter. The Land Grant Act provided 240,000 acres of federal lands in Iowa for the college; rented, the lands earned 8 percent on an appraised valuation of $1.50–$3.00/acre—income that went to the college. An effort to repeal the state law that established an agricultural college failed and was followed, in 1864, by a proposal to divert the granted lands from the Iowa Agricultural College to increase the endowment of the state university with conditions that would satisfy the Land Grant Act—that the university establish a department of agriculture, an experimental farm, and an agriculture course. The proposal did not succeed.[55]

In 1867, the new Iowa Agricultural College Board of Trustees' Committee on Organization and Selection of Faculty traveled east to evaluate a dozen of the "best schools of agriculture" and to solicit names for president and professors.[56] To the committee, Michigan Agricultural College had the most appropriate curriculum, with a balance of science and practice. President Williams cautioned that his college suffered a conflict with Michigan state legislators about whether the school should emphasize cultural education as well as practical labor. He recommended Adonijah Welch, teaching in Ypsilanti, as a presidential candidate who could defend science and education in Iowa.

There were no provisions for veterinary science in Michigan Agricultural College's curriculum, but the plan did include a future course for agriculture students in animal physiology with anatomical dissections and microscopic examination of tissues. The committee noted that the college was three miles east of Lansing on 676 acres of dense forest and believed its "isolated, natural wilderness a serious misfortune."

The next stops had programs that resembled Michigan: Pennsylvania Agricultural College, which opened February 1859, and Massachusetts Agricultural College close to Amherst College, which had been organized the previous October. The committee was much impressed with plans for the Agricultural College at Cornell, which was not fully organized yet had an excellent design with a high chance of success given its gift of over $500,000 from Ezra Cornell.

The board also visited—but disapproved of greatly—the Sheffield Scientific School of Yale College. Yale had received large agricultural college land grants but ignored agriculture: "they make no pretensions to having an agricultural college; the faculty are unbelievers in the idea of manual labor in connection with acquiring a college education"; there was "no attempt to give the student any of the practical application of the theories taught." Decades later, the Connecticut Legislature stripped Yale of its land grant status and gave it to the state's university.

At later stops, Harvard University, Columbia University, the Smithsonian Institution, Lehigh University, and Farmers' College in Ohio fared little better with the committee. Before returning home, the committee met with Horace Capron, commissioner of agriculture, in Washington, D.C., the president of the Ohio Pomological Society, and editors of *Prairie Farmer* and other farm journals.

Returning home, the board selected Adonijah S. Welch as president of Iowa Agricultural College. Then principal of Michigan Normal School, he left for Ames—transported from train station to the college farm in a mule-drawn wagon. Within a month, Welch took the train east to "buy a library" and to hire Norton S. Townshend as professor of practical agriculture. Norton, a physician turned farmer and agriculturalist, was the director of the Ohio State Board of Agriculture.

The new College Building at Iowa Agricultural College was dedicated on March 17, 1869. The first official class of twenty-four men and two women entered the four-year course of study that year. The inaugural speech by President Welch was devoted to the need for education of women, and the response by Professor Townshend echoed the importance of women: ". . . the feet of our pupils are not to be tortured or dwarfed by the Chinese shoe of sectarian limitations."[57]

Charles Bessey, a specialist in poisonous plants, was hired that year as professor of botany, zoology, and horticulture. A prosperous farmer from Mount Pleasant, Iowa, Isaac Phillips Roberts, was appointed farm manager. Roberts turned out to be an extraordinary agriculturalist and, despite no academic degree, was appointed professor of agriculture when Townshend resigned the next year. Roberts moved as a young man to Cornell University where, as head of a newly formed Department of Agriculture, he oversaw the veterinary work of James Law.[58]

Turns out, both Adonijah Welch and Norton Townshend were strong proponents of science, and their influence was critical in driving a college of veterinary medicine in Iowa. History does not make clear whether Welch convinced Townshend of the merits of science for veterinarians, the influence went in the other direction, or their stance was arrived at independently—nor does it explain why Townshend left Iowa after one year to return to Ohio Agricultural and Mechanical College as the professor who would engineer a college of veterinary medicine in Ohio.

OTHER NEW LAND GRANT COLLEGES began a scramble seeking formally educated veterinarians to teach veterinary science to their agriculture students; funds for a professor of veterinary sciences were added to the college budgets. Between 1868 and 1873, the agricultural colleges of Iowa, Kansas, Illinois, Ohio, and Massachusetts established veterinary departments in which veterinary science was taught to agriculture students by veterinarians.

In the next decade, agricultural interests often worked against professional veterinary medicine in several states. Veterinary departments established in agricultural colleges in Maryland, Connecticut, and Pennsylvania were dedicated solely to the education of agriculture students; the goal was to make every agriculturalist their own animal doctor, even counseling them to seek a state veterinary license. Some states—Nebraska, Illinois, and North Carolina—even amended their veterinary practice act to include agriculture graduates that had taken veterinary science courses in college. But in the heart of the Midwest livestock belt, legislatures in Iowa, Ohio, Michigan, and Kansas moved to create schools dedicated to veterinary medicine.

In the first years few students would enroll in the agriculture curriculum, and there was criticism of the new college from politicians and agricultural writers who tried to make it appear that agriculture was discouraged by college administrators who, they wrote, were attempting to transform agricultural studies into a liberal education. The truth was that few farmers had faith in a need for scientific agriculture and home economics for survival in farm and home; they would not send their children to college to study what they viewed as manual labor.

What the criticizing politicians and editorialists did not see was that farm people *would* send their children to seek the kind of broad education that would enhance their value and earning power and give them greater opportunities. It was fortunate that Iowa Agricultural College president Welch had the greater vision for the future of agriculture and veterinary science and that he was supported strongly by the governors of the state of Iowa. Theologian Welch, New York farmer Ezra Cornell, and Philadelphia publisher Joshua B. Lippincott are too often overlooked as visionaries in the founding of veterinary medicine.

The original bill founding the Iowa Agricultural College had included provisions for teaching courses in veterinary science to agriculture students. President Welch reported in 1871 that "the seniors of the agricultural course will need a professor . . . who will give lectures on comparative anatomy and physiology and veterinary science."[59] One year later, Dr. H. J. Detmers was appointed as the first professor of veterinary science in the Agriculture Division at the Iowa Agricultural College.

THE STIMULUS FOR FORMAL VETERINARY schools that arose in the Midwest came from a feisty German immigrant, Heinrich Janssen Detmers, who scattered seeds of European animal husbandry and veterinary science throughout Illinois, Missouri, Kansas, Iowa, and Ohio. The son of a farmer from rural Oldenburg, Detmers had matriculated at the nearby Royal Veterinary College in Hannover, then one of the best veterinary schools in Europe. He spent two years there and a final year at the Royal Berlin Veterinary College, graduating in 1859.[60] In Berlin, veterinary professors Schütz and Ostertag had worked and studied under Virchow, and Detmers was exposed to the best German veterinary science.[61]

In the scientific milieu of Berlin, the medical pathologist Rudolf Virchow, viewed as the greatest physician for three decades, had turned his attention to disease control on the farm as the means to stop bovine tuberculosis, anthrax, and other dreaded diseases of livestock that were transmissible to humans. Virchow recognized that many of the contagious diseases in rural Prussia could be reduced by having competent veterinarians that were responsible under law to control animal disease on the farm. He was a political force in licensing of veterinarians and veterinary inspection of meat. He also pushed for on-farm control of disease by mandating that autopsies on animals be done by licensed veterinarians trained in pathology. It was this fertile science ambience created by Virchow's precision and skill that formed Detmers into the extraordinary analytical scientist he was. Perhaps it was also the dogmatic academic climate in Berlin that made him arrogant and unwilling to suffer laggards.

Detmers passed the state veterinary examination in his native Oldenburg and practiced veterinary medicine in his home village of Stumpens for three years. Accepting the chair of stock breeding and veterinary science in Neuenberg, in the Grand Duchy of Oldenburg—the salary was small—he soon asked to be relieved of his position to return to practice. The request was denied. There was turmoil in the rural areas. Kaiser Wilhelm and the new Prussian prime minister, Otto von Bismarck, were on their way to reunify Germany and had just forced Oldenburg into a North German Confederation, and it appeared that a Franco-Prussian conflict was in the works—it was a dangerous time for a young man in Oldenburg. There were extraordinary opportunities for graduate veterinarians in America, but it was a dangerous time there too.

When the American Civil War ended in 1865, Detmers emigrated with his three children, establishing himself as a veterinarian in Dixon and then Quincy in Illinois. Both towns had railroads that would take Detmers to Chicago and back. His formal degree and German scientific background gave him prominence in the Midwest. While practicing veterinary medicine he also wrote about animal disease and science for the *Chicago Tribune* and edited the veterinary department of *Farm and Fireside*, an agricultural weekly. Detmers had already had that experience in Neuenberg and, connecting in 1869 with the Industrial College of Illinois, now the University of Illinois, he taught veterinary science and stock breeding for two years.[62] He also lectured at the University of Missouri.

On March 8, 1872, Detmers was appointed to the chairs of veterinary science and German at Kansas State Agricultural College—the first veterinarian on the faculty.[63] The 1871–1872 Kansas State catalog lists eleven faculty including President Denison and one "Professor of Veterinary Science and Animal

Husbandry, H. J. Detmers, V.S." Detmers proposed that his daughter, Jenny, could teach German and chemistry the next fall and winter at his expense, provided that he was granted a leave of absence from July to November 1872 to deliver lectures at the Iowa State Agricultural College; his offer was accepted by the Kansas State Agricultural College Board of Trustees.

On the Manhattan campus Detmers taught anatomy and physiology to freshman agriculture students and taught breeds of horses and other animals to sophomores, pathology to juniors, and veterinary jurisprudence and pharmacology to seniors. He also ordered the first workable microscope from Germany. Astonishingly, Detmers had developed a curriculum for a veterinary school but no one seemed interested.

The Kansas State Agricultural College president at the time was focused on the move to the new one-hundred-acre site of its present campus and constructing the first building (it was called Farm Machinery Hall). The college was under fire from legislators in Topeka for not fulfilling its mandate for agriculture and mechanical education and for deviating from its trade school mission. In the spring of 1873 a new Board of Regents appointed by the governor removed the Kansas State president and appointed John A. Anderson to the office. There was a delay since, by the rules, the new Board of Regents for Kansas could not be confirmed until January 1874. In the meantime, Detmers and two other faculty who opposed the board and disagreed with Anderson's trade school ideas on education went to Topeka to oppose the confirmation. They were not successful. When the Board of Regents was confirmed, Detmers and the two other faculty members were dismissed for "insubordination and gross misconduct"—and not even permitted to complete the work of the college year. From 1874 to 1888 there was no veterinarian on the Kansas State Agricultural College faculty.

In May of 1872, Detmers moved to Ames to teach agriculture students beginning in the fall term. He agreed to teach seniors pathology, comparative anatomy, and physiology. Two of his students, Cessna and Dietz, left descriptions of Detmers's instruction: "It was of the highest type and lectures were precise and scholarly." Detmers was a short, stocky man with poor vision. Cessna's notes tell us that he "was a typical German with all the personal qualities such a man is supposed to have—officially gruff, positive, intolerant of opinions different from his, even somewhat quarrelsome, socially pleasant, accommodating, a good fellow generally." His English was broken. Discussing a certain disease of the bones he had said about the animals, "Und dey die shust like de vlies" and their bones "vould prake shust like izzigles."[64] With students, Detmers was genial and friendly and his hearty laugh and cordial manner made students "feel at home" in his lectures. But he was gruff, and harsh on students who did not perform. He was even more outspoken and harsh to college administrators who did not support science. Detmers had a tendency to be irascible and snarky—characteristics that caused him grief several times and probably was responsible for his many moves. Teaching at Iowa Agricultural College for only a short time, he left an astounding science legacy in one of his agriculture students, Millikan Stalker.[65] Detmers moved on to work for the Bureau of Animal Industry and to be the founding dean of the veterinary school at Ohio University.

OLOF SCHWARZKOPF, A GRADUATE OF the Imperial Veterinary College in Berlin, followed Detmers's wanderlust. Arriving in New York City in 1885 as an assistant to Frank Billings, he enlisted in the Army the next summer when Billings left for Nebraska. Assigned to 8th Cavalry, he was on the overland march from Texas to South Dakota. In 1889, Schwarzkopf was hired as professor of veterinary science at the University of Minnesota; a veterinary curriculum was established with twenty-one students enrolled in a three-year program that was abandoned in 1892 "due to high costs."[66] Schwarzkopf moved to Chicago as dean of McKillip College of Veterinary Medicine and in 1897 to New York City as professor at the American Veterinary College. In 1900 he reenlisted in the 3rd Cavalry, rising in rank and playing a major role in attempts to control infectious diseases that ravished the Army horses. Assigned to the Philippines during the Spanish-American War, he spent the last years of his career in Fort Riley, Kansas. Schwarzkopf had the most index citations in the *American Veterinary Review*—excepting editors Liautard and McEachran—many of them translations of German scientific papers. He retired in Germany and died on June 3, 1923, in Wiesbaden.[67]

PART III

PIONEERING VETERINARY EDUCATION

1860–1900

In the United States, the annual loss of livestock from disease was computed to be $100 million in 1870, a huge sum. Self-trained quacks abounded and there were few educated veterinarians available for farmers or the Army. An editorial in the *Philadelphia Press* promoted a federal military veterinary school, suggesting that there be "the establishment of a professor at West Point and educating a class of veterinarians, one of whom shall be attached to each regiment of the cavalry." In the inaugural issue of the *American Veterinary Review* in April 1877, Cornell's Professor James Law promoted a national veterinary college as more effective than the many small departments of veterinary science in each state that had been created by the Land Grant Act.[1]

Offerings of fraudulent degrees in veterinary medicine were still common. The *American Veterinary Review*'s correspondence section in the first volume carried an exposure of the Philadelphia Veterinary College and its companion for medicine, the Philadelphia University of Medicine (neither to be confused with the University of Pennsylvania). Both were diploma mills offering bogus degrees on parchment for a large fee—no classrooms, no faculty, no clinics, just mail in the fee and get a diploma by return mail. "Professor McClure," the principal of the Philadelphia Veterinary College, was arrested after a police sting operation and received nine months in the penitentiary and a $2,000 fine.

The first nationwide moves to seriously affect the lack of education for veterinarians came not from the livestock industry or academia but from two federal agencies with mandates to protect the public: the U.S. Department of Agriculture's Bureau of Animal Industry, which needed competent veterinarians for its research and inspection services, and the Department of War's U.S.

Army, whose operation depended on healthy horsepower. The disastrous loss of horses in the Indian and Civil Wars had not been addressed, and in post-war military maneuvers, incompetent veterinary care had brought great risks of disease. Army General Orders of 1879 mandating that veterinary surgeons in the cavalry be graduates of a veterinary school began to weed out amateur farriers and agriculturalist quacks. The Orders also provided funds for fourteen veterinary surgeons for the Army. The message was clear: you could not be a military veterinarian without a formal education in a veterinary school.[2]

11. URBAN EAST VERSUS RURAL WEST: MONTREAL AND NEW YORK DISS TORONTO AND IOWA

The New York State Legislature in Albany had authorized the New York College of Veterinary Surgeons in 1857. Legislators chose as director a new French immigrant, Alexandre Liautard, who had been in the country for only five years. The new school began classes on November 23, 1864, by using Liautard's clinic and practice at 205 Lexington Avenue in New York City for instruction—it was the first successful veterinary school in the United States. Alexandre François Liautard, VS, was a Parisian who had begun his studies at the veterinary school in Alfort before moving south to graduate from the new National Veterinary School in Toulouse. A literate and scholarly veterinarian, Liautard earned an MD degree from the New York School of Medicine.

In 1863, veterinarians in seven states had met in New York City to organize a national society. Coming from New York, Massachusetts, New Jersey, Pennsylvania, Maine, Delaware, and Ohio, the forty delegates founded the U.S. Veterinary Medical Association and selected Liautard as the first president and New York City as the headquarters. Formed from only states on the Eastern Seaboard, the association proved to be more metropolitan than regional or national and was giving public credence only to eastern institutions. The semiannual meetings moved between New York and Boston with little participation by veterinarians west of the Appalachians. Within the group there was the charge that the president evinces little interest in veterinary matters west of Philadelphia.

Liautard started and edited the continent's first successful veterinary journal, the *American Veterinary Review*. Sponsored by the U.S. Veterinary Medical

Association, the new journal relied heavily on European articles for advances in veterinary science; in the first volume there were six German issues translated by Frank Billings, a German-trained veterinarian working in Boston. A prolific writer, Liautard published the *Manual of Operative Veterinary Surgery* and was a leading author for the fledgling veterinary journal.

Liautard left the New York College of Veterinary Surgeons over a squabble with faculty in 1875. Taking most of the student body, he established the new American Veterinary College that opened for clinical instruction at 139 West Fifty-Fourth Street. Quarrels continued, and two years later another group withdrew from the original school and established a third school, the Columbia Veterinary College (which folded seven years later).

All the time, Liautard was campaigning in his journal for higher standards but did not practice what he preached, keeping his new American Veterinary College a two-year school. Later, when higher entrance standards were forced on him, he returned to France. Liautard had prospered with his private veterinary colleges; he retired to his summer home, Le Chateau, a private mansion in Bois-Jérôme-Saint-Ouen, north of Paris.

Instability and quarreling engendered by Liautard's leadership led slowly to the destruction of veterinary schools in New York City. His two veterinary colleges merged in 1899 to form the New York-American College of Veterinary Surgeons (1899–1913). That amalgam moved under an academic umbrella in 1913 to become the New York State College of Veterinary Medicine at New York University. But that school folded and veterinary education ceased in New York City in 1922.[3]

The U.S. Veterinary Medical Association was marred by internal political bickering and provincial views. It was not until the 1877 meeting, held in the veterinary department of the University of Pennsylvania, that the association got to the business of education, establishing a feeble committee that proposed a three-year term of six months each year and a common examination for all graduates. None accepted the plan.[4] At the first annual meeting west of the Appalachians in 1884—in Cincinnati, Ohio—H. J. Detmers, then dean at The Ohio State University, proposed the creation of a western branch of the association. Detmers's proposal was unsuccessful, and the meetings returned to New York.

Public health officials carried the plight of the universities onto the national scene, pushing the politicized machine of the U.S. Veterinary Medical Association to act more effectively on the need to educate veterinarians. The inattention of the eastern veterinary establishments to the needs of midwestern veterinary science continued for several decades, when it boiled to the surface at their annual meetings. Veterinarians in the Midwest continued to propose a western division of the association—its annual meeting remained in the Boston-Philadelphia-New York corridor until 1890, when it was first held in Chicago; in 1895, the annual meeting went to Des Moines. Change came through public demands for improvements in veterinary education, from new opportunities provided by the Land Grant Act and from the Army's need for horse care. In the Midwest, the major stimulus for veterinary education was the push by agriculturalists to control or even prevent the great plagues of cattle and swine that were destroying the animal industry and the export of meat.

THE RURAL MIDWEST HAD NO veterinary schools, journals, or organizations in the Civil War decade. At the new Iowa Agricultural College, the second class to graduate included a young Quaker farm boy with a bent to science and interests in animal welfare and education. Millikan Stalker had been born in Plainfield, Indiana, of pioneers who moved west to a farm in Iowa. After finishing school in Richland, he attended the Quaker Spring Creek Academy, the precursor of William Penn College, training to become a district schoolteacher. Inquisitive but unsatisfied, he enrolled at the new Iowa Agricultural College in a general science course and graduated with a Bachelor of Science degree in the Class of 1873.[5]

Two professors of agriculture played critical roles in Stalker's education: botanist Charles Bessey and professor of agriculture Isaac P. Roberts.[6] In November 1873, Cornell University's Vice President Russell traveled to Ames to interview Roberts, offering him a position in Ithaca; he accepted. When Roberts resigned, Stalker, despite his youth, was appointed professor in charge of agriculture. The next year, having attended Detmers's lectures on veterinary science and attentive to President Welch's mandate for a course in veterinary science, Stalker took a leave of absence to acquire a formal degree in veterinary science. He chose to study under the most prominent veterinarian in the United States, Alexandre Liautard, in New York City.

Stalker arrived at the American Veterinary College in December 1875, several weeks after the term had started. He was advised by Liautard that his late arrival would not interfere with his graduating the following year and, considering his degree in science, he could omit some of the lectures in the remaining term. Stalker finished the term and left for Iowa for summer vacation. Even though he had stood apart as a "westerner," Stalker fondly remembers "former associates and classmates in the American Veterinary College."[7]

In autumn 1876, Stalker planned his return to New York by way of Toronto and Montreal. So impressed after spending one day in Toronto, he elected to remain there for his final year. Ontario Veterinary College was North America's first and most diverse clinical faculty. The surrounding area would closely mimic that of Iowa, not only in agriculture and topography but in swine production. The curriculum was devoted to practical clinical training under the careful eyes of the Scotsman from Edinburgh, Andrew Smith. The Toronto school remained in session six weeks longer than American Veterinary College, providing more time for study. Perhaps the program in Ontario was a better fit for Quaker Millikan Stalker. Smith was a gentle man and was both practical and persistent; he lacked the flamboyance and self-promotion that Stalker had found in Liautard.

In April 1877, Stalker graduated from the Ontario Veterinary College with the VS degree and returned to Ames to find he had been promoted in November of the previous year as professor of agriculture and veterinary science. Once home, Stalker published a note on tuberculosis in a cow in the Case Reports section of the *American Veterinary Review* in 1877. The paper was, he wrote, more "experiences of the western practitioner" than a scientific paper. He tells of his diagnosis of tuberculosis that "did not suit the farmer . . ." So a neighborhood "cow leech" was called in, who, of course, diagnosed hollow horn. The gimlet was produced and hollow horn confirmed. Cow leech No. 2 was called in and diagnosed a clear case of "loss of cud." In the end, Stalker was called back to do a postmortem examination on the cow, which confirmed tuberculosis.

At the Iowa Agricultural College in Ames, the catalog of 1879 listed a new veterinary school, stating that the course occupied two years: sessions to begin in March and finish at the end of November. In May of the next year the Board of Trustees approved a building for "Veterinary, Agriculture and Botany," which was labeled "North Hall." The first announcement in the catalog stated that "students having completed the two years' course of study and fulfilled all requirements for graduation, will be entitled to the diploma of the College, with the degree of Bachelor of Veterinary Medicine, B.V.M. Students who have graduated from any of the courses of the Agricultural College with the degree of

B.S., or who may have completed an equivalent course of study in any well recognized College or University, and who shall subsequently complete the course of study in the School of Veterinary Medicine, will be entitled to the degree, Doctor of Veterinary Medicine, D.V.M."

The new veterinary school in Iowa had only two professors: Millikan Stalker, VS, whose background was agriculture, and David Fairchild, MD, who came from medicine. For nearly ten years, they would be the only instructors—one a veterinarian and the other a physician. Lectures on chemistry, poisonous plants, insects, and parasites came from faculty in agriculture. It was a fusion of the sciences of agriculture and medicine that created the unique discipline that would become veterinary medicine in the Midwest.

As Stalker was finishing his veterinary degree in Toronto, the inaugural issue of the *American Veterinary Review* came off the press in New York City. The journal's first issue, published in 1877, had five papers—including one each by Liautard, McEachran, and Law.[8] McEachran's paper on veterinary education belittled Smith's school in Toronto and denigrated Cornell for teaching agriculture students the in-depth courses in veterinary science without having a veterinary school.[9]

In issue No. 2 there were twelve citations from Liautard and six from McEachran. There was one each from Law at Cornell and Smith in Toronto—both in the correspondence section doing combat with McEachran. Law responded that "Cornell University does not attempt to make veterinarians of her agricultural students" and that he wanted a veterinary school at Cornell but that it would be delayed until they had the high-quality faculty to meet Cornellian standards.

McEachran's article on education had started a conflict between Ontario Veterinary College and the Montreal Veterinary College. Writing that Toronto had greater numbers of applicants and students because it had lax standards and little science and taught only practical clinical work, he seemed to be mean-spirited. Fighting back from Toronto, Smith writes that McEachran had ignored his paper's title and written an unjust tirade about rivals of the Montreal Veterinary College, stating that the paper's "chief import" was "attacks on the Veterinary College at Toronto, misrepresentations respecting a conversation between Mr. Coleman and their writer, assaults on Mr. Stalker and Mr. Duncan, and puffs of a rival institution."

But the worst was yet to come. On reading the news of the new school in Iowa, McEachran had been incensed at this upstart on the prairie and its connection to Toronto. Being no friend of his competitor, Andrew Smith in

Toronto, McEachran, fueled by Liautard, placed a blistering anonymous editorial in the third volume of *American Veterinary Review* in 1880, signed only as "A Veterinarian."

Belittling the new Iowa school, McEachran damned Stalker, Toronto, and the "University of Iowa" [*sic*], writing that ". . . Mr. Stalker's knowledge of veterinary science is as limited as his respect for the profession, which if true, renders him utterly unfit to fill the position to which he has been assigned. In the name of an honorable profession, of which I am a member, I protest against this making of veterinary surgeons by institutions that employ as teachers men who have in justice no claim to the degree they assume and who have done much to degrade the profession. . . . I protest against Toronto, or any other recognized school, granting diplomas to men who have in no wise complied with the requirements of their course as set forth in their annual announcements."[10]

Stalker's response, appearing later in the same volume, explained his Toronto legacy of the importance of knowledge of the farming industry. Stalker called McEachran's diatribe "feeble" and "coarse and ungentlemanly" and said that it "springs from jealousy;"[11] he added, "I have a personal acquaintance with nearly every prominent breeder in the State; have mingled with them in their conventions. . . . The rapidity with which Iowa has come to the front rank as a stock-growing State, shows these men to be intelligent and energetic." Not leaving "well enough" alone, Liautard followed with a limpid editorial supporting McEachran. Perhaps the European's disdain for Stalker's Quaker heritage had been part of the attack.

Liautard and McEachran had been compatriots. They were both literate, prolific writers, which allowed them to control the printed word about veterinary medicine and thus the public's view of what the profession was. Liautard's journal, the *American Veterinary Review*, was an enormous contribution to veterinary science, but the emphasis of the editors on their own veterinary schools and denigration of others excluded the developing schools of the Midwest—Iowa State and Ohio State. They had viewed Stalker as some funky westerner. And they carried a grudge: fifteen years later, during the opening of the school year of 1895, the *American Veterinary Review* published a list of veterinary colleges with data on deans, faculty, courses, and fees—Iowa State College, which then had perhaps the best veterinary hospital, was omitted from the list.[12]

The self-replicating history of veterinary medicine, begun with distortions and deletions promoted by Liautard and McEachran, is still replicated. Astonishingly, one of the worst examples was published on the hundredth anniversary of the American Veterinary Medical Association. A historian at the National Library of Medicine improperly credited McEachran for creating the "model for the veterinary curriculum." The truth is that McEachran, by failing to see the needs of the livestock industry, had devised a model for failure. More importantly, the article ignored the Ontario Veterinary College, the most impressive school of the time, and made no reference to pioneering American veterinary schools in Iowa, Ohio, and Kansas, or the dozen or more departments of veterinary science in midwestern and southern colleges of agriculture that were teaching impressive veterinary science courses on Detmers's German model, several of them on the cusp of creating new formal veterinary schools. Both McEachran and Liautard, in their praise of Harvard, had failed to see the emerging potential of the land grant colleges and their astonishing impact on animal health.

The ultimate models for formal, science-based veterinary education in America came not from the private schools but from state-supported veterinary colleges which, under a university umbrella, gave them access to the best in science. Experts in chemistry, zoology, parasitology, botany, and, finally, microbiology were available that had profound impacts on the quality of education. Science faculties had direct effects through teaching veterinary students and indirect effects through stimulation of faculty to improve. Five university-affiliated colleges took the lead: Ontario Veterinary College, Iowa State College, University of Pennsylvania, The Ohio State University, and New York State Veterinary College at Cornell; without them, the veterinary profession might never have developed so firmly in science and into such a contributing force for good in society.

12. THE PIONEER STATE COLLEGES: IOWA, OHIO, PENNSYLVANIA, AND CORNELL

In 1884, Frank Billings, director of the new Pathobiologic Laboratory at the University of Nebraska, referred to the United States as "a country where there are very few well-educated veterinary surgeons, where there is no true value of veterinary science; . . . a country where quacks and empirics of every form are nourished and appreciated before the well-educated practitioners, in only too many instances; . . . where there is no official examination of the products from food-producing animals, and where there are neither laws nor regulations for the suppressions of animal diseases; . . . where there is no well-organized veterinary school."[13] Billings should have noted the changes going on next door.

Iowa Agricultural College had its first veterinary school graduate in 1879—George Faville. Dean Millikan Stalker, recently returned from Canada with his VS earned at Ontario Veterinary College, was teaching all clinical courses. He was lauded as a great lecturer—students agreed that "no one at the time had the ability to express himself in better and clearer English and could present his subject more effectively . . ."[14] His expertise was in toxic plants, especially ergotism and crotalism. In the biennial reports to the governor, Stalker documented contagious diseases most important in the economy of the Midwest: bovine tuberculosis, Texas cattle fever, and glanders in horses.[15]

Glanders was "alarmingly prevalent" in horses of Iowa. It was a heritage of the Civil War—military horses returning home brought glanders to the Midwest, causing the first state regulatory services to be organized and the first state veterinarians to be appointed. Worse for the horseman was that glanders was communicable to humans with the same fatalities as in the horse. Stalker notes four human deaths that occurred on farms where he had treated equine glanders. In one, "a poor German living about seventeen miles northwest of Denison was engaged in breaking prairie." He had purchased a horse with a "cold" that had spread to other horses. One had died and "the owner concluded to make a post mortem examination. . . . Five days later the man was attacked with glanders, and died on the fifteenth day." In 1881, Governor Geer commissioned a veterinary surgeon to visit different districts of Iowa affected by glanders with the power to "take steps as he deemed necessary to secure protection."[16]

Anthrax was a special problem in wet years when the natural bogs and undrained marshes in the Midwest promoted activation of latent anthrax spores in the soil. Cattle died suddenly—often thought to have been hit by a lightning strike. But it was sepsis: *Bacillus anthracis* spores entered their body and transformed into aggressive, capsule-bearing virulent bacteria that grew rapidly and uncontrollably to massive numbers in the bloodstream. In 1880, Joseph Boggs, a farmer in Mills County, Iowa, skinned one of his cows that had died suddenly and threw the carcass into a pen of nine pigs; the next morning all nine were dead.

In the first veterinary school class, Stalker taught about "contagion," unaware that bacteria were specific causes of disease. As to the cause of glanders, he wrote that it most likely was of "spontaneous origin" and that any protracted debilitating disease might eventually develop into glanders, even though the patient may not have been exposed to the disease. But then Stalker continued with, "Contagion is the chief, if not the only, cause of glanders in this country."[17] How he defined contagion is a bit mysterious, and how a disease arising spontaneously could become contagious was more so.

Stalker was an avid reader and learned quickly of the discoveries in Europe. By the end of the decade he was leading the state in understanding the dangers of these new bacteria, writing in his annual report of 1885: "The fact that the milk of tuberculous cows is charged with poison germs should cause it to be rejected in every instance as an article of food. Tuberculosis has been experimentally developed in the lower animals by feeding the milk of cows affected with the disease. As tubercle in man and in the bovine species is identical, the conclusion is inevitable that a similar experiment on man could be followed by a similar result. The fact that consumption prevails to an alarming extent in this country, and the same disease is frequently seen in cows that contribute to the milk and beef supply of our people, renders the subject worthy of the most careful investigation by sanitarians."[18]

One of Stalker's targets was the state commissioner of dairy, who for the next twenty years—with the support of hostile farmers, shippers, and transport businesses—objected to culling cows with tuberculosis. Stalker persisted and was responsible for the first veterinary practice act in Iowa, establishing the Office of the State Veterinarian and quarantine laws on tuberculosis, anthrax, and glanders. His task had not been easy.

Horse dealers, cow salesmen, and hatchery businesses worked against veterinary science. Veterinarians certified the health status for animals to be sold and were an obstacle to free trade in diseased livestock. In Illinois, powerful agricultural politicians prevented effective disease control—a new Illinois Stallion Registration Act, which formerly required veterinary inspection of stallions for public service, allowed each owner to certify as to the health of his own stallion. There were similar acts regarding self-policing in the poultry industry.

TEACHING BASIC SCIENCES OF ANATOMY, physiology, and pathology in the new veterinary school in Iowa was assigned to David Sturgis Fairchild, an Ames physician who in 1872 had moved his practice from Minnesota to Iowa.[19] Fairchild's notice card in the *Ames Intelligencer* of July 4, 1879, states: "D. S. Fairchild, PHYSICIAN AND SURGEON, Ames, Iowa. Offices in Bradley's

Brick Block, over Thomas & McLain's drug store, Office hours from 10 AM to 12 N, from 2 PM to 6 PM; from 7 PM to 8 PM." During his first years in Ames, Fairchild organized the Story County Medical Society and later became its president. He was also surgeon for the Northwestern and Milwaukee Railroads. Surgeon for a transcontinental railway system was a prestigious position in the late 1800s and gave Fairchild access to hospitals and medical equipment along the rail line that made him well-known in Iowa and provided surgical experiences for the medical reports he wrote. He also had the authority to stop any passenger train to pick up a patient for transport.

The physician of choice for influential people in the county, Fairchild was officially appointed in 1878 to be the college health officer at the Iowa State Agricultural College for an annual salary of $100 with the understanding that he could continue his private practice. He was also hired to teach chemistry. In 1880, Fairchild was appointed professor of histology and pathology at the new veterinary school at Iowa Agricultural College. That same year he was elected professor at the short-lived College of Physicians and Surgeons in Des Moines and for two years, prior to its incorporation into Drake University, served as a president of the medical school.[20]

In those early days, facilities in the veterinary school were spartan. Fairchild acknowledged that the quality of instruction was not up to par since he had little equipment and scarcely any room, writing of Dr. Herbert Osborn, the professor of entomology who lectured to veterinary students: "We have a feeling even to this day, that the professor . . . was somewhat amused at the course of instruction. . . . We had no apparatus, not even a chart. The best we could do was to make some drawings on a blackboard."[21] But Fairchild's microscope, a Schrourer with one-quarter and one-sixth lenses, and four Beck student microscopes left over from Bessey's botany laboratory were invaluable for the study of blood, muscle, and other tissues.

The Iowa Agricultural College was mandated by the legislature to educate people for work in agriculture and engineering. Some legislators inclined to a trade school mentality rather than the scholarly environment that was required for a university. At the time there was a great outcry among politicians and agricultural editors that the college was drifting away from the original intent of the founders and was becoming a scientific and literary institution. President Adonijah Welch was held responsible for this "failure" of the agricultural department.

Fairchild writes of this controversy between faculty and the Iowa State Board of Trustees, which he thought typical of new colleges west of the Mississippi: "The utilitarian idea was predominant. The faculty never lost sight, however, of the cultural value of a college education; the members of the Board of Trustees were generally of a different mind. They estimate the value of an education from the standpoint of its efficiency in earning a living in the workshop or the farm assuming many times a degree of contempt for the cultural side of a medical training."[22]

Believing agriculture to be purely a manual employment, it was assumed there would be no career for a scientifically trained agriculturist. Fairchild writes that these were bitter years for President Welch, who "for many years . . . looked forward with apprehension to the annual meeting of the Board of Trustees, who had from year to year warned the faculty to keep their satchels packed for sudden removal . . ."[23]

Outbreaks of infectious diseases among students on campus led President Welch to request funds in 1883 for a college student hospital building. The matter was not taken seriously by the Board of Trustees, who favored construction of a veterinary hospital and suggested that "if the college physician would waive all claims to an appropriation for a college hospital and would join the veterinary department in securing a liberal appropriation for a veterinary hospital," the old veterinary hospital (a barn) would be vacated and remodeled for use for the care of sick students.[24] President Welch declined the proposal. He continued to push for science and culture in the curriculum over manual training. For his transgressions, Welch was fired by the Board of Trustees the next spring.

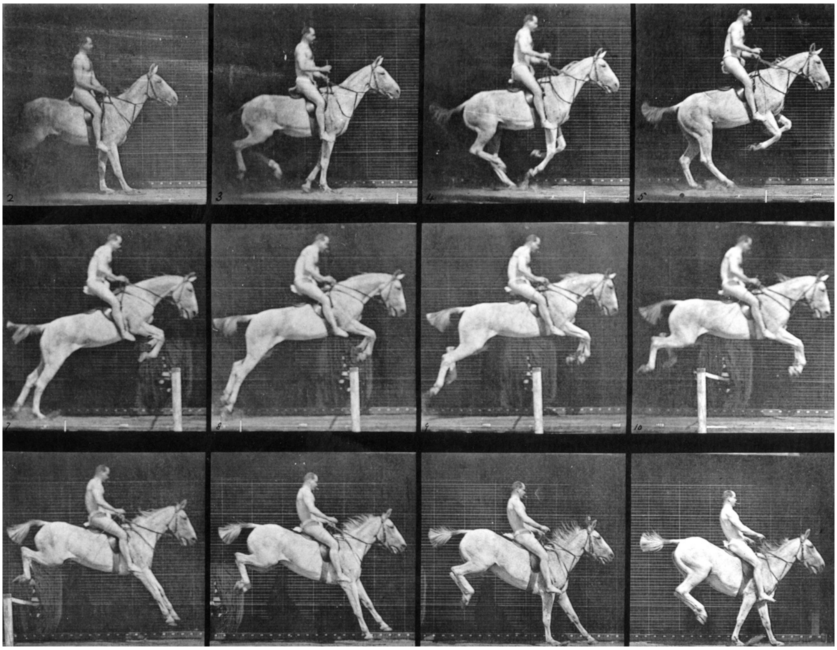
Despite efforts of the board, there were science faculty insisting on rigor and quality who played pivotal roles by bringing the best science into the veterinary school. For students, the curriculum included courses in botany, entomology, and parasitology—topics covered by professors outside the veterinary faculty. Herbert Osborn, the entomologist at the Iowa Agricultural Experiment Station, known worldwide for parasites of animals, lectured on flies, fleas, and ticks that attacked animals. Charles Edwin Bessey lectured on poisonous plants—toxicity was common in animals grazing timbered pastures. Bessey was the first chair of a Department of Botany, Zoology, and Horticulture in the new Iowa Agricultural College faculty; he was critical in educating the first veterinary students as scientists.[25] Bessey and Stalker authored a paper on the toxicity of rattlebox, *Crotalaria sagittalis*, one of the toxic plants of the Missouri River bottomlands. Poisonous plant toxicity in animals grazing timbered pastures was common in the Midwest and the topic was prominent in the veterinary curriculum. When the tallgrass prairies had been plowed, new invasive plants moved in. Some were toxic and others carried fungi that produced toxins.

AN URBAN CONTRAST TO RURAL Iowa Agricultural College, the veterinary school at the University of Pennsylvania had grown from medicine, not agriculture, and its faculty was more connected with the upper social class.[26] The veterinary school was established by Rush Shippen Huidekoper (MD, Penn; VS, Alfort), who belonged to an old and distinguished family in Philadelphia that had long been part of the medical school.[27] Huidekoper practiced medicine for fifteen years, during which he was chief medical officer and lieutenant colonel of the Pennsylvania National Guard and was in charge of medical activities with civil authorities during the Johnstown Flood and the Homestead riots.

An excellent horseman and member of the local Rose Tree Hunt Club, Huidekoper laid the groundwork for establishing the Department of Veterinary Medicine at the University of Pennsylvania. With comfortable means—and no obligation on the university—he went to France at his own expense for two years' study at Alfort. Due to his degree in medicine he was admitted to advanced standing and in 1882 received the VS degree. Following graduation at Alfort, he spent six months as an itinerant student in the laboratories of Virchow, Koch, Nocard, Ercolani, Chauveau, and Pasteur.

Returning to America in 1883, Huidekoper was appointed dean of the new School of Veterinary Medicine (with no salary), then under construction. He spent the year organizing a three-year curriculum of study. The school opened with a dedicatory service in October 1884; twenty-nine students were admitted for a rigorous curriculum patterned after the French schools. The first class graduated in June of 1887, receiving the VMD degree—from the Latin *Veterinariae Medicinae Doctoris*. Huidekoper's social connections to the publisher J. B. Lippincott resulted in a large initial endowment that enabled him to maintain the school and achieve academic success. Huidekoper delivered eight lectures each week, directed the dissection room work, and conducted clinics in mornings, and yet had general administrative direction of the school and hospital.

Between 1884 and 1897, photographer and inventor Eadweard Muybridge worked at the veterinary school producing hundreds of photographs of animals in motion, proving that at one point in the gallop, all four feet were off the



Body movements of horse and rider during jumping. Eadweard Muybridge photographs of a cigar-smoking veterinary school dean Rush Shippen Huidekoper on his horse Pandora. (COURTESY OF THE UNIVERSITY ARCHIVES AND RECORDS CENTER, UNIVERSITY OF PENNSYLVANIA.)

ground; he also photographed the human body in motion, many of his subjects discretely naked. Muybridge's work included injured horses to assist in understanding lameness. Huidekoper appeared in some of Muybridge's photographs on his favorite mare, Pandora.

Huidekoper had never been paid a salary and there were no funds for his successor. The school's existence was fragile and its annual deficit made survival seem doubtful. The circle of men important in founding the school had dispersed: Rogers moved abroad, philanthropist Lippincott died in 1884, and Provost Pepper's attention was divided among medicine and other schools. Officials of the University of Pennsylvania were not inclined to support veterinary medicine.

In 1887, Huidekoper petitioned the state legislature for an annual financial support, requesting $100,000 each year; the legislature approved $50,000 but mandated that it go for a building and for free tuition for residents of

Pennsylvania. William Osler, a faculty member at the medical school, wrote a letter of strong support to the *Journal of Comparative Medicine and Surgery* in 1888; privately, like Huidekoper, Osler felt the school could not continue. Huidekoper's relationships with politicians became acrimonious and he resigned as dean in 1889. The following year he abruptly quit his faculty position and moved to New York.

In New York City, Huidekoper maintained a veterinary practice; he lectured at the veterinary colleges, served two 2-year terms as president of the American Veterinary Medical Association (1887–1889 and 1890–1892), and kept on as the chief medical officer of the Pennsylvania National Guard.[28] When the Spanish-American War broke out, Huidekoper received a commission in the Medical Corps; he was made chief surgeon of the First Army Corps and went with troops to Puerto Rico. His appointment was criticized by ranking medical officers. Some enterprising war correspondent discovered that Huidekoper had practiced veterinary medicine in New York City and thought that an unpardonable offense for a physician. New York daily newspapers printed nasty headlines: "Huidekoper a Horse-Doctor—Was Known Only as a Vet" and "Huidekoper Doctored Mules and Cats—He Now Kills Uncle Sam's Heroes." Huidekoper was not deterred. When the war was over he moved to Washington, spending two years promoting the Army Veterinary Service.

John Marshall, the physician who replaced Huidekoper, was the fourth generation of physicians in his family. Marshall had trained in Germany—in Göttingen, and earned a NatScD degree from Tübingen—and he carried home the German traditions in medicine to the veterinary school. When he retired in 1897, Marshall was replaced by Leonard Pearson, a truly remarkable veterinary educator. South Carolinian M. P. Ravenol, MD, was the first bacteriologist at the University of Pennsylvania; he and Pearson organized the state laboratory in 1896, the first of its kind, an integral part of the veterinary school, and a critical facility for animal disease research—including advances in the knowledge of tuberculosis, glanders, hog cholera, Johne's disease, and forage poisoning.

THE PIONEER FORCE FOR SCIENTIFIC veterinary education in Ohio was Norton Strange Townshend—farmer, agriculturalist, physician, Ohio state senator, and head of the original Department of Agriculture and Botany at the Ohio Agricultural and Mechanical College. The college's Board of Trustees—Townshend was one of its first members—established a veterinary science course in the new Department of Zoology and Veterinary Science. The discipline was transferred to the School of Agriculture in 1876 as the Department of Agriculture, Botany, and Veterinary Science, with Townshend and zoology professor Albert H. Tuttle teaching animal diseases.

Townshend had joined with Oberlin College and Cleveland University to establish a college of agriculture in Ohio. He was the director of the Ohio State Board of Agriculture (1858–1869).[29] For the school year of 1869–1870, Norton accepted President Welch's offer of a professorship at Iowa Agricultural College and Model Farm and left Columbus for Ames.[30] At Iowa Agricultural College, the Board of Trustees hired him as college physician with instructions to charge twenty-five cents per visit, the money accruing to the board. Returning to Ohio after one year, Townshend continued his interests in veterinary medicine and published papers in the *American Veterinary Review*, including a report on mortality in colts in central Ohio in 1882.

In Ohio, the provisions of the Land Grant Act had been accepted in 1868 and the state received 630,000 acres of land to establish the Ohio Agricultural and Mechanical College on the Neil farm north of Columbus. Ten years later it was renamed The Ohio State University. The curriculum had been skewed to liberal arts, a shift that angered the agricultural community. To heal the rift, a new experiment station, the Ohio Agricultural Experiment Station, was incorporated within the university and built on the farm, which produced food for the college dorms.

A vigorous campaign was mounted by the editor of an agricultural magazine, *Farm and Fireside*, to separate the Experimental Station from the university—an attempt to convince the university to offer more agriculture and mechanical courses rather than liberal arts. Five years after funds from the Hatch Act of 1887 were received, the Ohio Agricultural Experiment Station moved from Columbus to Wooster in Wayne County, and with it, the research program for livestock diseases. Renamed the Ohio Agricultural Research and Development Center in 1965, it is today Ohio's livestock disease research center as part of OARDC's Food Animal Health Research Program.

When Detmers resigned from the Bureau of Animal Industry, he had moved to the Illinois Industrial College in Champaign. He was a wise choice for professor at the Ohio Agricultural and Mechanical College. In Columbus, Detmers developed a curriculum for several years and, given Townshend's and the university's support, began teaching veterinary medicine in the fall of 1884;

he added helminthology and bacteriology to the curriculum, one of the earliest presentations of these subjects to veterinary students in the U.S.

The program opened to students for the DVM degree in 1885 and graduated its first class two years later. In 1889 the program became the School of Veterinary Medicine, with Detmers as director, and the first veterinary hospital was built on campus in 1891. Detmers was also appointed veterinarian at the new Ohio Agriculture Experiment Station on campus (until it moved to Wooster in 1892), where he continued his work on hog cholera.

The Ohio State University's veterinary college continued to grow as one of the seminal institutions of veterinary science in the United States. Detmers kept abreast of what was going on in Europe. Every few years he would spend the summer in Germany visiting the laboratories of Koch and Ehrlich and in September would return with the latest ideas of these scientists. Mark Francis writes that "every time he returned from Europe he brought with him some optical apparatus, usually microscopic lenses and immersion objectives."[31]

Within a decade, perpetual arguments with administrators at Ohio State led them to reduce Detmers's salary. A surly Detmers resigned. His protégé, Mark Francis, writes that Detmers was an impulsive man who in anger "said and did things that he regretted later."[32] After resigning, he would write and live off royalty income. Working with Bausch and Lomb, microscope manufacturers in Rochester, New York, Detmers and an engineer had made improvements in a hypodermic syringe in 1890 that permitted the instrument to be sterilized without damaging the plunger.

Two of Detmers's first students, the benefactors of his understanding of science and pathology, were David White, the succeeding dean of the veterinary college in Ohio, and Mark Francis, who would become dean of the Texas A&M College of Veterinary Medicine and one of the outstanding veterinarians of the century. Francis played a major role in the control of Texas cattle fever and would become a national leader in the science of veterinary medicine.

Detmers died in Columbus in December 1906. By the end of his career he had become an important national figure, and his services to veterinary science were recognized by the Saddle and Sirloin Club of Chicago, where his portrait hung among noteworthy persons who have contributed to the livestock industry. His legacy included a daughter, Freda, who became a distinguished botanist at the University of Southern California.

IN THE EAST, EZRA CORNELL, a successful businessman, inventor, and strong proponent of agriculture, donated his farm in the Finger Lakes region of New York to establish a university. Working with legislative colleagues and first president Andrew Dickson White, the New York State Legislature was persuaded to locate the state's land grant university in Ithaca. Cornell University hired George Caldwell in 1867 as the first professor, to teach agricultural chemistry; professors of botany (Albert Prentice), entomology (Henry Comstock), and veterinary science (James Law) were added, and Cornell University opened in 1868. A professor of agriculture was added in 1874 when Isaac P. Roberts left Iowa State for Ithaca. None of the faculty were agriculturalists and, for farmers, Roberts brought credibility to the Agriculture program at Cornell.

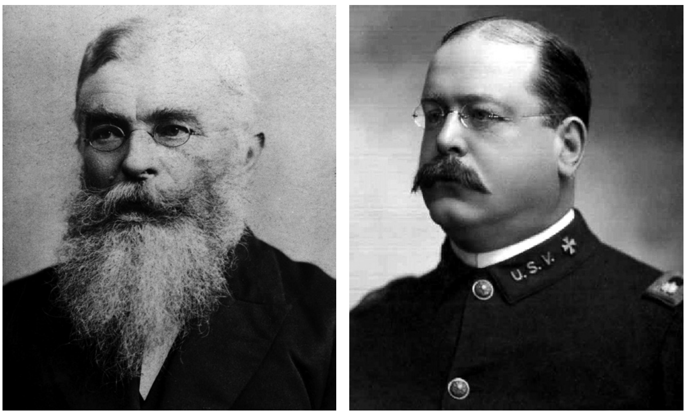
Veterinary professor James Law was a graduate of the Veterinary College of Edinburgh in 1857 and had qualified for licensure with the title of Member of the Royal College of Veterinary Surgeons (MRCVS) in 1863.[33] He had visited the French schools in Alfort and Lyon, been an instructor in John Gamgee's New Veterinary School in Edinburgh, and moved with it to London, where Gamgee established the short-lived Albert Veterinary College. When it closed, Law began a practice in Belfast, Ireland. Receiving a strong letter of recommendation from Gamgee, Law was hired to teach veterinary science at Cornell.

At Cornell, Law was a champion of higher education for veterinarians and started a school at Cornell that was abandoned for lack of students, most unwilling to undertake the long period of study. Only four men graduated from the veterinary department in the next twenty-seven years (when the New York State Veterinary College at Cornell was established). The first graduate, Myron Kasson in 1871, was awarded the BVS degree (for Bachelor of Veterinary Science) after four years at Cornell. The second graduate, Daniel Salmon, entered Cornell in 1868. Influenced by Law to study veterinary medicine, he was given special arrangements for a four-year course. Part of the deal was that he would attend the veterinary school in Alfort, France, for clinical experience, after which Cornell would grant the DVM degree. A. M. Farrington (in 1879) and Fred L. Kilbourne (in 1885) graduated with the BVS degree. Subsequent degrees for veterinary study at Cornell were the BS.

In June 1888 the loosely associated Departments of Agriculture, Agricultural Chemistry, Veterinary Medicine, Botany, and Entomology at Cornell were combined to form the College of Agriculture with Isaac Roberts named dean.

He retained his chair in the Department of Agriculture and was appointed the director of the Agricultural Experiment Station. Liberty Hyde Bailey, teaching at Michigan Agricultural College, was hired to teach horticulture.

The first class to enter the New York State Veterinary College at Cornell started in 1896, two years after the school had been organized with state support. Dean James Law was at the peak of his national prestige and had hired an impressive faculty that was influenced by the high quality of the faculty in other biological sciences at Cornell. For the next decade they were leaders in the tiny but growing discipline of veterinary medicine.



The two pioneer veterinary educators who had the greatest impact on early American veterinary education. One was an itinerant frontier German immigrant veterinarian, the other a sophisticated early American physician. Both were innovative, irreverent, and ferocious and had earned veterinary degrees from Europe—and both suffered from their insistence that science be the basis of veterinary school curricula. *Left:* Heinrich Janssen Detmers, who stimulated veterinary science in five rural midwestern states and the Bureau of Animal Industry. *Right:* Rush Shippen Huidekoper, who founded veterinary education in Pennsylvania and was responsible for establishing the rank and rights of the Army Veterinary Corps; he wears the Army uniform of the Spanish-American War with collar insignia of the U.S. Volunteers and the Maltese Cross of the Medical Corps. (PHOTOGRAPH OF DETMERS COURTESY OF THE OHIO STATE UNIVERSITY ARCHIVES. PHOTOGRAPH OF HUIDEKOPER COURTESY OF THE UNIVERSITY ARCHIVES AND RECORDS CENTER, UNIVERSITY OF PENNSYLVANIA.)

THE FOUR UNIVERSITY VETERINARY COLLEGES struggled but had two essential elements of survival: access to high science through other disciplines in academia and at least one astonishing godfatherly supporter. At Penn it was the philanthropist publisher J. B. Lippincott; for Ohio it was agriculturalist Norton Townshend and for Iowa, President Adonijah Welch. Cornell would prosper in the academic world because of its extraordinary ideological support from Ezra Cornell and his endowment. Each of these institutions also benefited from a progressive component of rural areas. Ezra Cornell prospered in the Finger Lakes region of New York. Unencumbered by the trade school mandates of many of the rural pioneer legislatures of the Midwest, Cornell would seek and retain astonishing men, not men with brilliant academic pedigrees but those who had proven their worth on the world of the frontier. Neither Cornell's pioneering agriculturalist Isaac Roberts nor surgeon Walter Williams had earned academic degrees, yet they were brilliant men who rose to the top of the university world by their hard work and their extraordinary knowledge, skills, and abilities.

13. PLAGUES AND THE BUREAU OF ANIMAL INDUSTRY

In 1880 there was widespread criticism of the U.S. Veterinary Medical Association from the pioneers in the field—from Law at Cornell, Huidekoper at Penn, and even from Liautard, director of the New York College of Veterinary Surgeons—that the organization was not effective in bringing about the federal regulations that were needed to control infectious diseases of livestock. At the annual meeting, state veterinarians from Nebraska, Minnesota, and the Dakotas complained. The territorial veterinarian of Wyoming was dismayed at the "apathy displayed by the association at the last annual meeting, as well as the lack of interest of veterinarians, in regard to . . . the necessity of wholesome sanitary laws and their enforcement."[34]

It had taken over a decade since agriculturalists in midwestern states proposed a federal agency to deal with the destructive plagues that were destroying the livestock industry, but in 1881 the U.S. Congress created a new Cattle Commission, placing it in the Department of Treasury. Historically, Treasury's Patent Office had evolved as the source of governmental information on agriculture; a report by the commissioner in 1837 noted rapid improvements in agricultural implements and suggested the Patent Office deal with livestock matters. When the Department of Interior was established ten years later, the Patent Office, including its agricultural work, was transferred there, and in 1861 the commissioner of patents had asked Congress to create a separate department to deal with agricultural matters.[35] After two years in the Patent Office, the Cattle Commission was moved as the Veterinary Division into to the new U.S. Department of Agriculture—the USDA.

IN EARLY MARCH OF 1884 there was hysteria among ranchers in Coffey County, Kansas, when a report was publicized that a foot-and-mouth disease outbreak had occurred. Local cattle were developing ugly ulcerative lesions in the tongue and mouth and around the fetlock, pastern, and hoof areas of the lower leg. It had been a cold, wet spring followed by a very hot early summer. The cattle had lost weight, had rough hair coats, and preferred to stand in water or in the shade when available on the Kansas plains. The hysteria might have been justified. Any diagnosis of foot-and-mouth disease would surely lead farmers to financial ruin with livestock deaths, quarantine of Kansas cattle, loss of export markets, and drop in market prices. Area stockmen and veterinarians from Leavenworth and Emporia traveled by train to Neosho Falls, convening to inspect the disease in Coffey and Woodson Counties. In their report the disease was pronounced to be the contagious foot and mouth disease.

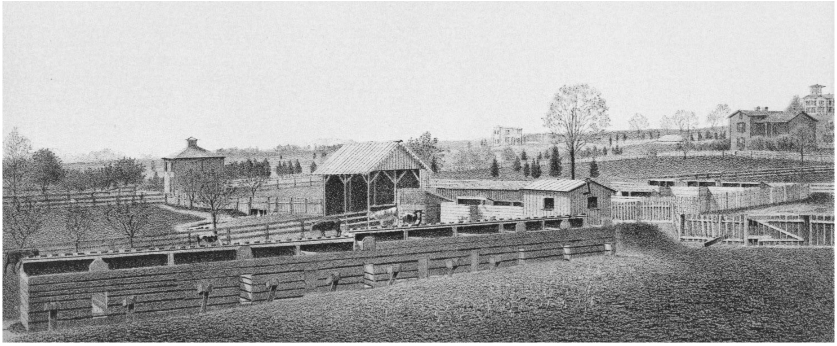
The U.S. Department of Agriculture and the Army Veterinary Service were activated. The USDA commissioner, George Loring, sent emissary M. R. Trumbower from Illinois to investigate but he failed to confirm the diagnosis. Loring then sent Daniel Salmon, who also wasn't certain that this was foot-and-mouth disease. Salmon asked national leaders to convene in Kansas—state veterinarians and professors of veterinary science (including Iowan Stalker, Paul Paquin from Missouri, George Faville from Colorado, and James Law all the way from Cornell). Of this large group, only two could rule out foot-and-mouth disease. Millikan Stalker and George Faville recognized the disease immediately; it was ergotism. There were no fevers or ulcers of the mouth. Cattle were being poisoned from a fungus growing on wheat and rye grass. Returning home, Salmon would take credit for the discovery, writing that "his team" had solved the problem, noting in the popular press—the *Northwestern Live Stock Journal*—that "Prof. Stalker of the Iowa University [*sic*], and Prof. Faville of the

Colorado Agricultural College have seen similar cases . . . and concurred in the opinion." Trumbower's official report never mentioned that it was Stalker and Faville who had made the diagnosis.[36]

The foot-and-mouth disease scare seemed to have spurred politicians into action. Two months later, in a bill signed by President Chester Arthur on May 29, 1884, the Veterinary Division became the Bureau of Animal Industry. Daniel E. Salmon, the first head of the BAI, had been one of the first graduates of the DVM-granting department at Cornell University. Salmon's assistant director was Theobald Smith, a PhB graduate of Cornell holding the MD degree from the Albany Medical College. Under their guidance, the BAI began dealing scientifically with the serious infectious diseases afflicting livestock. It was facing some serious plagues.

Texas cattle fever persisted as the major plague of cattlemen. BAI director Salmon mapped the flow of disease from south to north. In Nebraska, Frank Billings recorded the peculiar spread of Texas cattle fever in 1887 and published a report that ticks were responsible for perpetuating the disease, writing: "No ticks, no Texas fever." English veterinarians noted Billings's conclusions but Americans did not.[37] H. J. Detmers and Theobald Smith, following current dogma that arthropods did not cause disease, discredited the idea that ticks were involved in Texas cattle fever.

In 1889 the BAI assigned three scientists to investigate the disease: Theobald Smith; Cooper Curtice, a physician in charge of the BAI's zoology department;



Veterinary Station, USDA, ca 1883: seven acres on Benning Road, a quarter mile from the northeast boundary of Washington, D.C. Main buildings at far right, background. At this site, director Fred Kilbourne planned the experiments that established ticks as the purveyor of Texas cattle fever. (U.S. DEPARTMENT OF AGRICULTURE DRAWING.)

and veterinarian Fred Kilbourne, head of its Experiment Station at Benning Road just outside the District of Columbia.

Working with blood from infected cattle, Theobald Smith soon discovered the protozoan parasite that destroyed red blood cells; he named it *Pyrosoma bigeminum* (now *Babesia bigemina*). It was a protozoan species that invaded, grew inside, and severely damaged the red blood cells which—misshapen and bearing "eat me" signals on their damaged surfaces—were removed by resident scavenger macrophages as they passed through the tortuous vascular passages through spleen and liver. Red blood cell destruction was so severe it led to lethal anemia. But how did this new protozoan parasite survive outside the cow host and how did it move from one cow to another?

Studying field cases, Fred Kilbourne was listening to western stockmen who were calling the disease tick fever, and it was his insistence that convinced Salmon and Smith that ticks were somehow associated with the disease. Kilbourne planned and carried out the experiments that proved ticks were transmitting and perpetuating the disease in cattle. It was soon shown that a tick—it was named *Boophilus annulatus*—was the carrier. Kilbourne also discovered that newborn calves growing in an infected herd were resistant as adults because they developed immunity from their mother. The newborn calf would be infected but survive because of antibodies in its mother's milk and would be solidly immune as an adult. Smith, senior to Kilbourne, took the lion's share of the credit for the discovery of ticks in the disease.

Then the BAI research team discovered something entirely new—a tick was not simply a mechanical bearer of the cause but was required as an *intermediate host* for the perpetuation of the disease in cattle. Curtice worked out the life cycle of the tick and revealed that the protozoan parasite, after being sucked into the tick from an infected cow, not only replicated in the tick but passed its protozoan pathogen to its tick offspring. The next spring, when invading a new uninfected cow, the parasite caused the disease all over again. The study explained why Texas cattle fever occurred only in summer months and how it overwintered in the South.

This new discovery had a remarkable impact on medical science, opening the way for others to follow on insect-borne global diseases such as yellow fever, malaria, and typhus. Yellow fever, first documented in seventeenth-century Latin America, was a mosquito-borne disease of the Atlantic trade routes, causing disastrous outbreaks in the U.S., Brazil, and Spain. In U.S. outbreaks it would kill thousands—in 1793, Philadelphia, still the U.S. capital, lost 10 percent of its population. Other large metropolitan areas had similar outbreaks—Washington, Baltimore, Memphis, and New Orleans. The disease would travel northward with steamboats. Shreveport, Louisiana, lost a quarter of its population to yellow fever in 1873. After his discovery that female *Aedes aegypti* spread the virus as an intermediate host, the Army physician Walter Reed made it clear that his studies were predicated on the studies on Texas cattle fever.

"Our knowledge of yellow fever would in all likelihood have been delayed if the work of the Bureau of Animal Industry of the USDA on Texas fever had not been done," so said Simon Flexner, MD, of the Rockefeller Institute of Medical Research in 1920.[38] The discovery of the role of the cattle tick as an intermediate host in the epidemics of Texas cattle fever was one of the most notable medical achievements of the nineteenth century and made possible the methods of sanitary science that allowed the building of the Panama Canal.

HOG CHOLERA RESEARCH AT THE BAI was headed by Director Salmon; investigations were run by Theobald Smith, head of the Pathological Division, and Emil De Schweinitz, head of the Biochemic Division. From Washington, D.C., in 1885, they announced the isolation of the hog cholera bacillus, which Smith named *Salmonella cholera-suis* in honor of his boss. When injected into pigs, the newly discovered bacillus produced hemorrhagic disease and death.[39]

At the time, two similar bacterial diseases of pigs were sweeping the country: swine erysipelas and hemorrhagic septicemia, which both caused death with hemorrhages and other signs similar to those caused by the hog cholera bacillus. And all three were confounding investigations into hog cholera. Adding to the confusion were the experiments on the hog cholera bacillus of Smith, which he published as a BAI *Special Report of the Cause and Prevention of Swine Plague*—Smith was actually describing hemorrhagic septicemia.[40] Salmon finally recognized the dilemma and reported, not admitting any failure, that there were actually two diseases that "are sometimes found to exist at the same time in the same herd."

Detmers and Billings were at odds with Salmon over etiology; Detmers claimed that his *Bacillus suis*, reported years earlier, was the same bacterium reported by Salmon but could not prove the claim. From Nebraska, Billings claimed that Salmon had been wrong all along and that his own research had discovered the bacteria that caused swine plague. A native of Massachusetts, Billings was an exceptional, energetic, and intelligent scientist with great powers of persuasive speech. He had enrolled at the Imperial Veterinary College of Berlin and, although unable to speak German well, graduated in 1878 with honors—the first American graduate of a German veterinary school. Returning to the U.S. to practice for a few years, he again went to Germany to visit Rudolf Virchow's laboratory and tour German science faculties.

Billings was also an egocentric and snarky fellow, and he sent off a barrage of letters to the editor of the *American Veterinary Review* disparaging any scientist who disagreed with his findings. His prime targets were scientists of the BAI, especially Salmon, and a battle between the two of them would go on from 1886 to 1892.[41] Perhaps Billings's ferocity was stoked by Salmon's rejection in 1886 of Billings's application to work for the BAI. To defend his position on hog cholera, Billings produced a foolhardy four-hundred-page bulletin—an official publication of the University of Nebraska Experiment Station—denouncing the work of the BAI. Read worldwide, it produced controversy that some approved, especially Detmers.

Billings went at Salmon with a vengeance. In the correspondence section of the *American Veterinary Review* for May 1887 Billings ridiculed Salmon's report, and in the editorial section of the following January's issue Salmon countered that Billings's writings were the "product of a disordered brain" and that "he has proved nothing that was not previously reported from results of experiments in this Bureau." Salmon complained to the commissioner of agriculture, asking him to appoint a board of disinterested scientists to investigate the epidemic disease of swine. The board was appointed and visited Billings in Nebraska, Detmers in Ohio, and the BAI. An equivocal response was issued and the situation was unchanged.[42]

Billings and Salmon continued the fight at meetings of the U.S. Veterinary Medical Association. Billings continued to be the big bad wolf of the era, and his eloquence seemed to frighten others from doing combat with him. But his reputation was badly mangled in 1887 by a letter to the editor that denigrated the BAI and claimed that he had discovered a bacterium that caused Texas cattle fever. Salmon's final retort was, "Unfortunately, the greater part of the bacteriological researches which are published . . . are absolutely valueless, and are a check to progress rather than an aid to it, because some one must disprove the conclusions which follow from them, and, even then, other workers must remain in doubt as to which observer is correct."[43] But Billings's criticism had been valuable in wading through the complex of the diseases that were killing pigs.

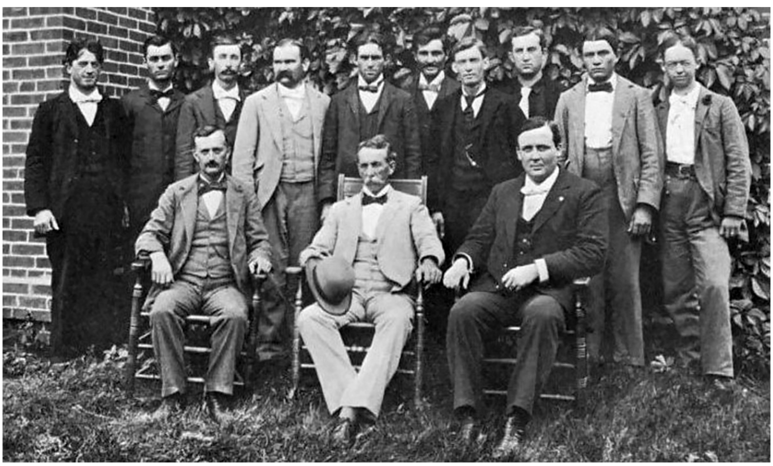
IN 1887 THE U.S. CONGRESS passed the Hatch Act, which gave $15,000 per year to each state land grant college to create agricultural experiment stations. Named for William Hatch, the chairman of the House Committee on Agriculture, it had been pushed strongly by Seaman Knapp, president of Iowa Agricultural College, who had written the first draft. One of the provisions of the Hatch Act of 1887 providing funds to establish agricultural experiment stations was that "it shall be the object and duty of said Experiment Stations to conduct original researches or verify experiments on the physiology of plants and animals." Another provision was that annual reports be submitted to Congress.

As the century closed, eleven of the agricultural experiment stations had veterinarians attached to them. All reported work "in progress." In those with official veterinary sections, few were involved in research. Most were overloaded with teaching or duties as state veterinarian. Half of the experiment station veterinarians were examining specimens for diagnostic purposes or answering letters of inquiry regarding treatment. Some were manufacturing vaccines for anthrax and blackleg, or producing tuberculin used in the diagnosis of tuberculosis in cattle. The bulletins they produced only rarely contained "original researches." Billings's comment was that it was wasting money on petty salaries or equally petty experiments—"a sheer waste of money with no adequate results."[44] That was not quite true: Hatch Act money did have an impact on state veterinarians and college diagnostic programs. Some of them were discovering new plagues.

In France, a venereal disease of horses named dourine, or *maladie du coit*, was being eliminated by a law that compelled veterinary officials to permanently brand affected horses with DN. Known as equine syphilis and covering sickness, the disease was passed during mating and began with chronic swelling of the genitals and progressed to silver-dollar-sized skin swellings and inflammation of the nerves that led to hindquarter paralysis. There was no cure or vaccine, and condemned horses were to be destroyed. Dourine had not been reported in the United States, but in 1885 an imported Percheron stallion carrying the unmistakable condemnation brand DN had been found by Illinois assistant state veterinarian W. L. Williams to have spread dourine throughout DeWitt County. In 1888, Williams's extensive report in the *American Veterinary Review* led to the development of a test for antibodies in horse sera and a program to destroy affected horses with indemnity paid to owners.[45] The cause was identified as a protozoan parasite, *Trypanosoma equiperdum*. It took a half-century, but dourine was eliminated from the U.S. in the 1940s.

14. BACTERIOLOGY IN THE HEARTLAND

The catalog from Iowa Agricultural College that came in the mail listed the requirements for the two-year veterinary course; they were simple: "Candidates for admission must be at least sixteen years of age. Before entering the classes, they must pass an examination in reading, orthography, geography, grammar, and arithmetic." William Benjamin Niles, a teacher in a country school, applied. He had finished grade school in the one-room country schoolhouse in Edenville and began work on the farm. In the winter of 1882–1883,



The Veterinary Society, a student-faculty club at Iowa Agricultural College, 1898. Front row (three faculty sitting, one standing, *left to right*): William Niles, DVM, professor of surgery; Millikan Stalker, VS, dean; W. E. Harriman, MD, professor of pathology. Harry Titus, DVM, house surgeon, stands between Stalker and Harriman. Back row: nine veterinary students. Niles and Titus came to Iowa Agricultural College from Edenville, Iowa. Photo is taken in front of the new Veterinary Medical Hospital.

a country school in Eden Township had employed him as a teacher. The next year, he took the morning train to Ames and enrolled in veterinary school.[46]

Niles graduated from veterinary school as an honor student in the Class of 1885. His senior thesis had been on lumpy jaw, a chronic tumorlike growth on the jaw of cows. He had isolated the fungus causing the lesion—now called actinomycosis. After graduating, Niles was hired as house surgeon in the veterinary clinic and continued working in bacteriology with Professor Halsted in botany. Starting a private practice in Webster City during the fall of 1886, he continued until July 1887, when he was offered a position in South Carolina.

John M. McBryde, a native South Carolinian and professor of agriculture and horticulture at the University of South Carolina in Columbia, hired Niles as professor of veterinary science and veterinarian for the State Agricultural Experiment Station. McBryde had developed a strong program in agriculture, one of the first to teach bacteriology, and had been appointed president of the University of South Carolina that year. South Carolina was to offer the DVM degree, like the PhD, as a graduate degree. The program ran headlong into politics and was short-lived; there was only one graduate who began his practice in rural South Carolina.

Niles had stepped into a bitter battle in higher education. President McBryde and the university in Columbia were taking flak over what was perceived as ignoring the needs of the state's "white trash poor and colored." Governor Ben Tillman led the battle, saying the university was catering to the upper social crust and "not to the poor farmer and the common man who needed it most of all."[47] He was promising to build a new agriculture school in honor of Thomas G. Clemson, superintendent of agricultural affairs at the U.S. Patent Office, who was a strong promoter of agricultural education in South Carolina. President McBryde was soon forced out at the university and moved to Blacksburg, Virginia, to be the fifth president of Virginia Polytechnic Institute, where he successfully developed another outstanding agricultural college.

The new Clemson Agricultural and Mechanical College was built, much of it with convict labor, in the country on the site of an abandoned Cherokee Indian settlement on the banks of the Seneca River. It opened for students in July 1893. Not wanting to move to the isolated village created as Clemson College, Niles accepted Stalker's open position in Iowa. South Carolina's bacteriologist, Meade Bolton, left for Washington to work for the Bureau of Animal Industry. Charles McBryde, former president McBryde's son, who had earned the MD degree, moved in the next decade to Ames to work with Niles on hog cholera.

The new veterinary department at Clemson College was headed by W. E. A. Wyman, a successful equine specialist whose alma mater was the New York College of Veterinary Surgeons and School of Comparative Medicine. In 1893 Wyman published *The Clinical Diagnosis of Lameness in the Horse*, a marvelous book with elegant woodcuts of lame horses in action. The professorship of veterinary science at Clemson seemed to be a rotating chair. Wyman left after five years and was replaced by George Nesom, an Iowa State classmate of Niles, who had some success in expanding the department. Quitting in 1903, Nesom was replaced in turn by Louis Amos Klein from the faculty at Iowa State College. Klein left after six years to be dean at the University of Pennsylvania; he retired in 1930 and was replaced at Penn by Harold E. Bemis from Iowa State.

WILLIAM NILES'S SCHOOLMATES WERE seeding the faculties of land grant colleges. Niles's classmates in 1885 were astonishingly successful: Sesco Stewart, a Canadian who entered veterinary school with an MD degree from Wooster University in Ohio and medical practice experience in Oakland, Iowa, ended as the dean of the Kansas City Veterinary College and the force behind the Missouri Valley Veterinary Association; George Glover, after inspecting cattle on the National Cattle Trail and working in Montana, was the first dean of the Division of Veterinary Medicine at Colorado State Agricultural College; C. A. Carey was state veterinarian of Alabama for many years and the founding dean of the Veterinary Division of the Alabama Polytechnic Institute (now Auburn University).[48] All were national leaders who increased the geographic diversity of the veterinary profession as presidents of the American Veterinary Medical Association: Sesco in the 1902–1903 meeting in Minneapolis; Glover in 1910–1911 in San Francisco; and Carey in 1919–1920 in New Orleans. Carey, through his appointment as chairman of the USDA's Committee on Eradication of Texas Cattle Fever, had a major role in the elimination of that disease.

Edwin Preston Niles, five years younger than William, left Edenville for veterinary school and graduated in the Iowa State Class of 1886, one year after his brother. He was hired by President John McBryde to be professor of veterinary science at Virginia Polytechnic College in Blacksburg. S. B. Nelson, a graduate of the Iowa State College Class of 1889, was the founding dean of the veterinary school at Washington State College. As new centers of veterinary medicine were created, the influence of Stalker and Fairchild spread throughout the Midwest, South, and West. R. A. Craig, Class of 1897, took a position at Purdue University, taking house surgeon Harry Titus with him the next year.

THE NEW BUILDING FOR THE veterinary hospital at Iowa Agricultural College was a two-story brick building constructed for the "Veterinary Department" on a hill south of the campus; described as "the best infirmary in the United States," it opened for business on June 1, 1885.[49] Field investigations, headed by Dean Stalker, were done in the Iowa Agriculture Experiment Station. But, there was little time to seriously study animal disease. When the Hatch Act of 1887 dedicated federal money for research at land grant collages, Stalker requested that "a well-trained veterinarian should be added to the present corps of instructors";[50] the request was approved. Mandating the field investigations combined with duties of teaching surgery, $1,600 was appropriated for the position. William Niles, then at the University of South Carolina, accepted an assistant professorship in Ames to begin on March 1, 1891.

The position gave him travel experience and time for his investigations on the use of tuberculin as a test for tuberculosis in cattle and mallein in the diagnosis of glanders in horses. Niles's senior thesis at Iowa Agricultural College had been on actinomycosis. In Iowa he was back into the new discipline of bacteriology, using his experience he had gained from Meade Bolton in South Carolina.

Veterinary bacteriology was being added to departments of agriculture in the land grant colleges. In 1897, Kansas State College hired Paul Fischer as professor of veterinary science and college veterinarian. Fischer developed and taught bacteriology in the Department of Veterinary Science for three years before leaving for The Ohio State University.[51]

IN 1893, WILLIAM FAIRCHILD, the professor for basic sciences since the veterinary school opened, resigned and was replaced by another physician, Irving W. Smith, MD. Smith had graduated from Iowa Agricultural College in 1872 and attended medical classes at the University of Iowa; probably on advice from Fairchild, Smith went east for a better medical education, an MD degree from Jefferson Medical College in Philadelphia. Smith had married Sally Stalker, Dean Stalker's sister. Entering medical practice in his hometown of Charles City, he left for Ames in 1893 when he was appointed college physician and professor of pathology in the Division of Veterinary Medicine.

Smith also followed Fairchild as dean of the Drake University Medical School. In his history of that school, Smith wrote that "in the year 1879 there was in operation at the Iowa Agricultural College at Ames a College of Veterinary Medicine with stiffer entrance requirements and a longer and fuller course of instruction than any college of human medicine in this country."[52] Smith was only in the Iowa Agricultural College veterinary school for two years. A reticent and inward man, he was, as L. H. Pammel remembers, resented by some, "perhaps because he was the brother-in-law of Dean Stalker."[53] Developing tuberculosis, he moved to California, where he died in the next decade.

At the university-affiliated veterinary schools, student enrollment was low. Iowa State College had only fifty students studying veterinary medicine. For the 1894–1895 academic year the veterinary school budget was lean: Dean Stalker, $1,600; Dr. W. E. Harriman, professor of pathology, $1,500; Dr. Niles, assistant professor of surgery and obstetrics, $1,700; and A. R. Wake, house surgeon, $0. In 1894, Iowa State College graduated 8 men with the DVM degree; Penn had 22 graduates receiving the VMD. The numbers were dwarfed by those of the Ontario Veterinary College, where 139 graduated with a VS degree (6 from Iowa) and the Chicago Veterinary College, granting the MDC to 65 graduates (4 from Iowa).[54]

The veterinary hospital at Iowa State College, 1905. The hospital opened June 1, 1885, and closed in 1912 when the Veterinary Quadrangle opened. Senior veterinary students (Class of 1905) stand in front. R. R. Dykstra, the dean at Kansas State College for three decades, is the tall man, fourth from right.

Physician Wilbert E. Harriman replaced Smith to teach basic sciences.[55] After completing his junior year at Iowa State College in November 1892, Harriman had enrolled in the medical school at the State University of Iowa and at the close of his year's work won the prize offered for the best examination in histology. Returning to Ames in the spring, he completed his science course, graduating in November 1893. In May 1894 he had passed the examination of the State Board of Medical Examiners and, without a medical degree, began the practice of medicine at Gilbert, Iowa. In October 1894, Harriman, like Smith before him, went east to enroll in Jefferson Medical College in Philadelphia. Awarded the MD degree in May 1895, Harriman returned to practice medicine in Ames and was hired by Iowa State as college physician and surgeon and professor of pathology for the School of Veterinary Medicine.

Harriman taught histology to the first-year veterinary students, pathology in junior and senior years, and general surgical therapeutics in the senior year. He also taught a physiology class that included freshman veterinary students and juniors and seniors in the general science course. A popular professor on campus, Harriman also taught seniors in the ladies' domestic science course.

The veterinary hospital on the hill rapidly became inadequate. The daily care of inpatients and surgical procedures where an operating table was not advised had to be done outside. In cold months all this created a spectacle on the hill, where passersby were aghast at veterinary students standing in snow and mud with gooseflesh on their bare arms. The veterinary hospital also contained the anatomy dissecting rooms. Dissections were not begun in the fall semester until cold weather set in because fresh animal carcasses were used and would not "keep fresh" in warm weather.

On the Iowa State campus in those days there was "a feeling that the veterinary students were a 'different kind of animal' from the rest of the student body, that they did not care for the same things, that their ideals were at variance, and that for these reasons they did not need the same accommodations and comforts as other students."[56] Why veterinary students were not so refined was raised in a faculty meeting, and Stalker replied that it must be the influence of the head of the department.

L. H. Pammel was an internationally renowned botanist and a major influence on the development of veterinary medicine in the 1890s. Born in LaCrosse, Wisconsin, of German immigrant farmers, he had graduated from the University of Wisconsin and Washington University and came to Iowa Agricultural College in 1889 as head of the Department of Botany. His interests and research papers were on poisonous plants and he edited that section in the *American Journal of Veterinary Medicine*. His large textbook on poisonous plants was used by every veterinary college in North America.[57]

Plant toxins were a serious threat to midwestern livestock in the nineteenth century. By 1899 Pammel taught botany courses each year in the three-year veterinary program: general botany, first year; pharmaceutical botany, second year; and in the third year, bacteriology—it was the first course in bacteriology for veterinary students in this country. Two decades later, Pammel produced a comparative study on the curricula of veterinary schools that stressed the importance of rigorous science in the curriculum.

In the early 1890s, Pammel was making a unique social contribution to science at Iowa State College by mentoring and promoting two extraordinarily gifted graduate students: George Washington Carver, the first black graduate student, and Ada Hayden, the first woman (and only the fourth person) to be granted the PhD degree. Carver finished his BS degree with a thesis titled *Plants as Modified by Man*. Under Pammel's direction he completed the master's, and in 1896 was hired by Booker T. Washington, the first president of Tuskegee Institute, to head the agriculture department there. Searching for a black American with a graduate degree, Washington had found only one; George Washington Carver would be the first in an impressive line of black American Iowa State graduate students who would help create modern science at Tuskegee.

FUNDS FOR IOWA STATE EXPERIMENT STATION work were directed to rabies of cattle, finding the toxic agent of cornstalk disease in cattle, contagious abortion in mares and cows, and tuberculosis in cattle. At the time, tuberculosis was a major problem in dairy cattle and bovine tuberculosis, transmitted to humans through milk, was a widespread cause of disease and death. Reporting on the veterinary section of the Iowa Agricultural Experiment Station in 1895, Dean Stalker and Professor Niles found tuberculosis to be more prevalent in cattle than was supposed and stated: "During the past two years the work has consisted principally of investigations concerning bovine tuberculosis. Tuberculin as an aid in diagnosis has proven of great value."[58] The first report published by Stalker was *An Investigation of Bovine Tuberculosis in Which Special Reference Is Made to Its Existence in Iowa*.

Nationwide, departments of veterinary science were testing cattle with tuberculin. Nelson S. Mayo, heading the Department of Physiology and Veterinary Science, used the new tuberculin test at Kansas Agricultural College; his disclosure of tuberculosis in the college dairy herd caused an intense, partisan discussion. The Board of Regents terminated Mayo in 1897 and ordered a retest by the college veterinarian, Paul Fischer, who called in Bureau of Animal Industry veterinarian T. A. Geddes and James Law from Cornell to assist in testing. Vindicating Mayo, the animals he had declared reactors were positive on retest and were slaughtered and the carcasses burned.

Bacteriology laboratories were being added in most agricultural colleges. In November of 1895, an additional $100 was added to the Iowa State College budget when a request was made for laboratory facilities to teach bacteriology. Struggling for another three years and frustrated with his low salary and the little money budgeted for research, William Niles resigned to accept an offer to work for the BAI. A consistent supporter and contributor to the Iowa Veterinary Medical Association, Niles had been particularly popular among veterinarians in the state.

James Wilson, professor of agriculture and director of the Experiment Station at Iowa State College, was a friend of Niles. He had become secretary of agriculture in President McKinley's cabinet in 1897 and was instrumental in getting Niles into the BAI. Born in Scotland, Wilson was secretary of agriculture longer than any cabinet officer in history. The BAI moved Niles to a new position in western Iowa, where he was assigned to investigate the effectiveness of an antiserum against the hog cholera bacillus in a seriously spreading outbreak of hog cholera in southwest Iowa.

Dean Stalker asked the Board of Trustees for $75,000 for new facilities for the veterinary school. An editorial by the new associate editor of the *American Veterinary Review* in 1899 noted that Iowa State College "under the wise guidance of Professor Stalker, has made a national reputation . . ."

15. THE 1890s: HORSE MARKETS AND ENROLLMENTS DROP

James Paget, a first-year medical student at St. Bartholomew's Hospital in London, discovered larvae of the roundworm *Trichinella spiralis*. Dissecting a human cadaver, he noted small white specks in muscle that when examined microscopically proved to be cysts with tiny worms inside. The worm larvae were connected to disease when a German girl, preparing meat for Christmas, developed fever and myalgia. Brought to a Dresden hospital, she died after fifteen days of excruciating muscle pain. When pathologist Friedrich Zenker removed a sliver of muscle from her arm, crushed it, and examined it microscopically, he saw dozens of the same tiny worms wriggling about. Zenker reported trichinosis as a new disease.

Germany solved the trichinosis problem when pathologist Rudolf Virchow, working with rural veterinarians, revealed that pigs suffered the same disease and that it moved into humans through infested pork. He noted the insidious nature of trichinosis: the encysted worms could survive for decades and be activated years later by stress, even by severe sunburns. Virchow's progress in promoting licensure and pathology training for veterinarians in Germany paid off when trichinosis disappeared as a problem in German pork. In 1866, pathologists in a hospital in a suburb of Hamburg, examining tissue from a woman undergoing breast cancer surgery, found masses of trichina cysts in her muscle tissue; ten years previously she had lived with her brother in Davenport, Iowa, where both had suffered a severe muscle disease. As meat imports increased, Europeans began to worry about the safety of American pork.[59]

Beginning with Austria-Hungary and Italy, one by one, European countries banned importation of American pork. Under pressure from the livestock industry, the Bureau of Animal Industry received a new mandate on August 30, 1890, when a meat inspection act was approved providing for inspection of bacon and salt pork; it was amended the next year to include veterinary inspection of live cattle, hogs, and sheep whose meat was destined for export. In Chicago, an exacting microscopic study of trichinae in pork done for the BAI by H. J. Detmers showed that about 2 percent of hogs from certain sections were infested but that hogs in some states were free of these parasites—safe enough for Americans but not for Europeans. To overcome the trade barriers, microscopic inspection of meat samples to detect trichinosis was begun by the BAI in 1892; it was to protect the market, not the public. Pork to be exported to countries that required such inspection were examined, but not pork destined for public consumption in the U.S.

VETERINARY EDUCATION WAS CHANGING rapidly to meet the new challenges. Curricular standards were becoming more rigorous, surgical anesthesia had arrived, and the new discipline of bacteriology had led to astonishing discoveries in infectious diseases. Successful vaccines and antitoxins became

USDA Bureau of Animal Industry laboratory for microscopic examination of pork for the parasite causing trichinosis. The program stemmed from European bans on American pork. (U.S. DEPARTMENT OF AGRICULTURE PHOTOGRAPH.)

available for the veterinarian. University-affiliated schools were being innovative and moving to a three-year curriculum.

Conflict was growing with the large private schools over increased standards. The private American Veterinary College's Professor J. S. Robertson boasted at the annual banquet of the national organization that "a Yankee does not have to attend college half as long as a German or a Frenchman, to learn how to pick up a horse's foot."[60]

To deal with the conflict over standards for veterinary education, the American Veterinary Medical Association resolved that no student enrolled after January 1, 1893, could become a member of the association after graduation except that he graduated from a college having a course of three years. Academic faculties resisted any intrusion by the association. Iowa State's Dean Stalker wrote: "I am pleased to see that there is a conservative spirit manifesting itself, and little of the disposition to dictate to colleges what they must or shall do."[61]

In 1894 the BAI's curricular standards became a requirement that had to be met before a new school would be certified to grant a veterinary degree.[62] Because the BAI employed so many veterinarians and because the Army had already set down rules for employment, aspiring veterinary schools complied with BAI standards. Schools that did not meet the standards would not be approved to grant the DVM, VS, or VMD degrees.

Tiny private, for-profit veterinary schools that had developed in the closing decade of the nineteenth century were having problems big time. Most lacked students, faculty, funds, and facilities and disappeared. The Iowa Veterinary College founded in Des Moines was short-lived (1890–1894); it conferred the DVS—Doctor of Veterinary Science degree—on only thirteen students. The Northwestern Veterinary College in Minneapolis (1881–1890) suffered the same fate. The Queens University veterinary department closed after only four years and nine graduates. Many private schools that had started—Southwest Veterinary College in Dallas, Southern Veterinary College in Atlanta, and Wichita Veterinary College—failed to meet BAI standards, were never accredited, and went out of business. Some state schools that were offering courses in veterinary science could not meet the standards and were not approved to open as a school of veterinary medicine.

By 1895 most veterinary schools had moved to a three-year course of study; the large private veterinary schools in Chicago and Kansas City seemed to be thriving. Schools in the U.S. persisting with only two years of study were the Chicago Veterinary School, the Ohio Veterinary College in Cincinnati, and the two schools in Washington, D.C.: the United States College of Veterinary Surgeons at 222 C Street NW and the National Veterinary College at New Jersey Avenue and O Street. Blind to the advancing standards and demands of science, all four would close in the next decade.

To provide scientifically competent veterinarians for the BAI, Director Salmon had established the National Veterinary College in Washington, D.C., in 1892.[63] Unable to hire well-trained graduate veterinarians, Salmon and the staff were behind the creation of the new college. It was designed as a private school staffed largely by BAI scientists, and the faculty included Salmon as dean with faculty members F. L. Kilbourne, Veranus Moore, and the parasitologist Charles Stiles. Unfortunately, Salmon had modeled the National Veterinary College on a minimalist curriculum with few entrance requirements and short terms, espousing a trade school concept with a term of two years. Salmon was widely condemned for his approach. The president of the McKillip Veterinary College in Chicago, highly critical of the project, joined with other midwestern schools and worked to force its closure. The National Veterinary College suspended operations in 1898 due to lack of students, and

Salmon's subsequent attempts to transform the college into an exclusive postgraduate school failed.[64]

In the 1890s, veterinary schools associated with universities were in hard times. The school at Iowa State College, after twenty years of operation, was in a grim state; it had few students and lacked proper facilities, and the faculty was aging and seemed out of date. Facilities at the other state-supported schools—Penn, Cornell, and Ohio State—were not much better. In the Midwest, the new large private veterinary schools seemed more popular. Most farm boys from Nebraska and the Dakotas decided on the big city and left for the Kansas City Veterinary College; those from Iowa and Wisconsin enrolled in the Chicago Veterinary College. Perhaps they avoided Iowa State College since the veterinary course had increased from three to four years.

As the new century approached, teaching of veterinarians at Iowa State College had been in the two buildings erected in 1885 on Memorial Union Hill. Space was woefully inadequate. But now, there were few students in veterinary medicine and the faculty was too small and had been there too long. William Niles had retired on June 30, 1898, and the names of Professor Harriman and house surgeon Harry Titus disappear from the faculty listing for the next academic year, 1899–1900. The remnants of the faculty seemed less than distinguished.

William Niles had been a tireless participant in the state's veterinary meetings and was highly popular among practicing veterinarians. The Iowa Veterinary Medical Association passed a lengthy resolution stating that faculty of the veterinary school are overworked and that they resolved that they "deplore the actions taken by the trustees of the State Agricultural College in disposing of the services of one of the ablest men in the West in experimental and scientific veterinary medicine."[65]

At the Nebraska Veterinary Medical Association meeting in Lincoln, officer George P. Tucker instructed secretary A. T. Peters to inquire into the matter of the "Trustees of the Ames Veterinary College, of Iowa, relative to the removal of a competent veterinarian from its faculty . . ."[66] Peters, the University of Nebraska's veterinarian, routinely attended meetings of the Iowa Veterinary Medical Association and was on the IVMA committee for army legislation. In light of recent outbreaks of rabies, he was pushing Nebraska to create a position of state veterinarian.

Controversy over the resignation of Professor Niles from the college faculty caused turmoil that brought change to the "Veterinary Department." In July, the Board of Trustees received proposals for reorganization from Dean Stalker and from representatives of the Iowa Veterinary Medical Association, as well as a petition for change from the veterinary students. The board appointed a committee headed by Iowa State president William Beardshear to study how the veterinary school could be reorganized.

In the end, Stalker was out as dean of the school and President Beardshear, unable to find a man with sufficient scientific background, assumed the position of interim dean of the Division of Veterinary Medicine. It seems that Stalker had been eased out of the deanship as the century turned, but there is no record of how it happened.[67] It may have been that he had become outdated—he was unfamiliar with the new science of infectious diseases, and his expertise in poisonous plants was no longer at the forefront of animal health concerns. Maybe his storytelling abilities had become less captivating and supporting. Quaker Millikan Stalker, like his mentor Andrew Smith, eschewed personal vanity and feelings of entitlement from his position; his inability to promote his own professional work (and to praise the work of others) was perhaps a failure of leadership. Stalker had been extraordinarily proud of his veterinary clinic building on the hill and had wanted to extend the building south to what would become the main thoroughfare of the college. Perhaps his departure was tied to a younger, different vision for a new veterinary complex north of the campus, closer to the countryside and away from the hubbub of a developing campus Dog Town.[68]

THROUGHOUT THE NORTH AMERICA of the 1890s, new scientific discoveries appeared each week and were spurring medical and veterinary research. For scientists there was a new tool. Charles Chamberlain, a young assistant working in Louis Pasteur's laboratory, was seeking a way to produce clean water for his experiments. To filter contaminated water, he used an unglazed porcelain tube with pores too small for tiny debris and visible particles to pass. When it was discovered that Chamberlain's filters also excluded bacteria from water, the porcelain filters found worldwide use in laboratory research and industrial processes.

In the next decade, biological researchers used Chamberlain filters in a unique way—to separate toxins from bacteria-contaminated solutions. Passing crushed leaf extracts of diseased tobacco plants through the Chamberlain filter, Russian scientist Dmitri Ivanovsky found that the filtration fluid was free of bacteria but still caused tobacco mosaic disease; the disease was not caused by bacteria. Dutch microbiologist Martinus Beijerinck, repeating the same experiments, reused the word *virus*—Latin for poison—to name what was passing his filters. Both Ivanovsky and Beijerinck suspected that the agent causing disease in tobacco plants was a soluble toxin.

The medical world was changed with the report in 1898 by Friedrich Loeffler, a physician and bacteriologist who had reported that foot-and-mouth disease of cattle was caused by a filterable virus; solutions containing the disease-causing agent passed through Chamberlain filters and were free of bacteria but would cause foot-and-mouth disease when given to cattle. At the time, no virus had been discovered as a cause of human or animal disease. Other animal plagues were soon found to be filterable viruses—fowl plague, a respiratory disease decimating poultry in Italy in an explosive outbreak in 1878 was shown to be caused by a filterable virus.

Loeffler had the MD degree from Berlin and spent five years with Robert Koch before becoming professor at the university in the Hanseatic town of Greifswald. In the rural area he had developed a serious interest in animal diseases and on an island within the city provenance, the Isle of Riems, Loeffler built a small laboratory for his studies in cattle. In 1910 it became Germany's Federal Institute for Animal Health for investigations on dangerous animal diseases. Today, it is Europe's finest veterinary biosafety laboratory for dangerous animal pathogens and bears the name Friedrich Loeffler Institute.

AT THE DEMOCRATIC NATIONAL CONVENTION in Chicago on July 9, 1896, populist politician William Jennings Bryan from Nebraska delivered his Cross of Gold speech. Nominated for president, he was decrying the gold standard as a tool of rich financiers over the toiling farmers of the Midwest and South. It was leading to an ownership society, with massive income disparities arising through inherited wealth as opposed to earnings. Bryan ended with: "You shall not crucify mankind upon a cross of gold." But his real message was the populist creed that rural America was being victimized by dynastic patrimonial capitalism: "Burn down your cities and they will arise again by magic; but destroy our farms and grass will grow in the streets of every city of the nation." Perhaps the greatest orator in American politics, Bryan lost to McKinley in the election.

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Advertisement in the *American Veterinary Review*, 1912.

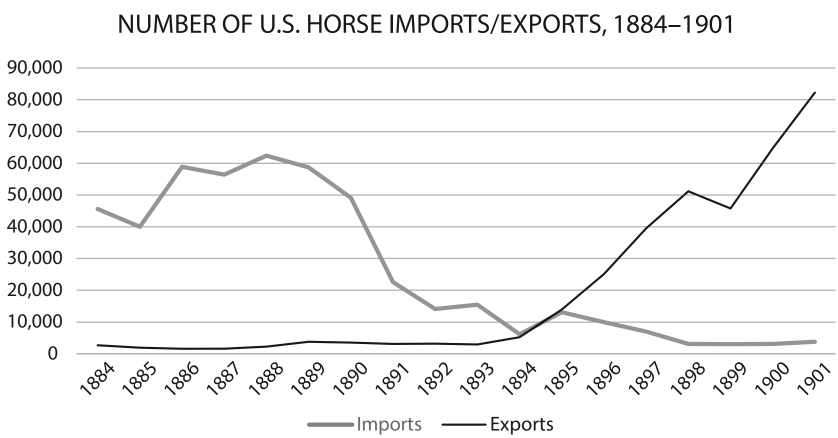
AT THE CLOSE OF THE nineteenth century, there had been no famous small animal clinics and clienteles. Colleges that had professors of small animal medicine and that listed canine medicine as a special area of study included the University of Pennsylvania and McKillip in Chicago. The School of Veterinary Medicine at Penn was the first to construct modern accommodations for the hospitalization of small animals. In the Midwest, Chicago was the exception: McKillip Veterinary College had a small animal clinic, and a pioneer small animal hospital was built by Leon Young, who, after graduating in 1896, established an exclusive practice in Chicago. But elsewhere in the Midwest, facilities for small animals were rudimentary.

AT THE ANNUAL MEETING OF THE U.S. Veterinary Medical Association in Omaha in 1898—the name was changed to the American Veterinary Medical Association during the meeting—the keynote address by President Salmon deplored the current state of military veterinarians.[69] Amidst adulterated and dangerous meat supplies and catastrophic disease of military horses there were only thirteen positions for veterinarians as noncommissioned officers—there were two vacancies because of two deaths from glanders acquired from infected Army horses. At the meeting, John Treacy from the 8th Cavalry gave a paper pleading for Congress to address the serious defects in the Army veterinary services. In the Spanish-American War the next year, Treacy died from yellow fever in Cuba and veterinarian Sam Gelston vanished during service in the Philippines.[70]

Salmon, assisted by Secretary of Agriculture James Wilson and Rush Shippen Huidekoper, had worked throughout the year on legislation to improve the standing of Army veterinarians. Huidekoper had moved to Washington, D.C., to lobby full time for the bill—he wanted an independent veterinary corps with a colonel at the head. The bill provided that veterinarians (two for each regiment of cavalry) would have the rank, pay allowances, and retirement benefits of a second lieutenant. The bill passed the House, had the endorsement of the secretary of war, was agreeable to the president, and its sailing seemed clear in the Senate. At the last minute, the bill was sabotaged and failed to pass in the short second session of the 55th U.S. Congress in December 1898. Huidekoper, who had done the lion's share of work on the bill, was not discouraged.[71] His continued efforts were largely responsible for improving the status of veterinarians in the Army.

At the same meeting in Omaha, a fledgling group of educators, the Association of Veterinary Faculties and Examining Boards, met to elect officers and plan for future meetings; Stalker was appointed president and Merillat, secretary-treasurer. They were to organize the literary program for the next year's meeting; Law from Cornell, Pearson from Penn, and others agreed to present papers the next year. But there was no follow-through. With no public explanation, neither Merillat nor Stalker went to the meeting. It was held in New York City with Marylander A. W. Clement as president—there may have been a longstanding chip-on-the-shoulder resentment from what they perceived as elitist put-downs from the East. Perhaps it was simply due to the economy and an increasing fear for the profession in the western states.

NEAR THE END OF THE NINETEENTH CENTURY there was a collapse in the horse industry. Imports of horses into the U.S. for the decade beginning in the mid-1880s had been rising but then began a rapid decline. Not only was the nation not importing horses, the low prices in the economic panic of 1893 were immediately reflected in exports of horses. The low price of horses attracted foreign buyers. In 1894, the outbreak of war in South Africa gave impetus to the export trade as the need for military horses grew rapidly there and in Britain. But that was an artificial stimulus. By 1900 it was clear that the horse industry was in decline.



Number of horse imports to and exports from the United States, 1884–1901. (DATA FROM *ANNUAL REPORT OF THE BUREAU OF ANIMAL INDUSTRY*, 1901.)

The decline of the horse market had a direct impact on veterinary school enrollments. An editorial under the headline "Veterinarians Becoming MDs" in the *American Veterinary Review* for April of 1896 noted veterinarians leaving the profession: "On account of the great depression in the equine industry, especially in the Western States, many veterinarians have become discouraged and not a few are seeking to perfect themselves for human physicians. At the Keokuk Medical College, in Iowa, alone there are three former practitioners who expect to graduate in the class of '98. They are Dr. D. C. Thomas, late of Iowa Falls, Iowa; Dr. R. C. Blackburn, late of Hinckeley, Ill.; and Dr. Robert Robb, late of Terre Haute, Ind."

There was some brave resistance. The November 1899 issue of the *American Veterinary Review* contained an editorial titled "Passing of the Automobile," which extolled the merits of the horse and predicted that even though the excessively rich in Newport flaunted theirs, "the automobile has seen all the popularity it will ever enjoy . . ." It damned the *New York Herald* for promoting the automobile—the *Herald*'s editors had predicted that the City would "in a very short time have three hundred in active operation in the streets of New York."

A more realistic view appeared in the 1901 *Annual Report of the Bureau of Animal Industry*; it dealt with "motive forces supplanting animal power." The writer noted that traction power formerly supplied only by horses was giving way, first, to the cable car and, later, to the electric street railway. Afterward, it predicted, the bicycle and then the automobile would do the same: ". . . the impression was quite prevalent throughout the civilized world that an era was approaching when the usefulness of the horse would be greatly curtailed. Extremists went so far even as to forecast a horseless age."

PART IV

LIVESTOCK AND VETERINARIANS GO WEST

1900–1920

The 1900 census revealed the U.S. population to be 76,212,168, a 21 percent increase in ten years. The geographic population center had moved west—six miles southeast of Columbus, Indiana. It was the Gilded Age, a time of turmoil and changing social patterns. While handshaking at the Pan American Exposition in Buffalo, President McKinley was shot by an assassin and died one week later on September 14, 1901. New president Teddy Roosevelt took office. It was a time of astonishing discoveries of infectious diseases. There were new microbes, bacterial vaccines, and sanitation methods. A concept of public health was emerging, but Americans were playing catch-up to Rudolf Virchow's use of veterinarians to control zoonotic diseases on German farms in order to protect human health.

Farmers ignoring veterinary advice produced grim events. In Tennessee, farmer E. T. Richards vaccinated 105 mules with anthrax vaccine produced by the H. K. Mulford Company in Memphis. Three days later the mules began to sicken and die. By the end of the week, 41 were dead. Alleging that it had sold vaccine contaminated with live anthrax bacilli, Richards brought suit against the company. He lost. Farmer Richards had used non-sterile bottles and syringes and had left fluid vaccine open to dust. His mules had died of tetanus.[1]

Some vaccines sold for human use *were* contaminated and caused serious problems that could have been prevented by veterinarians. In St. Louis in 1901, ten of eleven children inoculated with contaminated diphtheria antitoxin died of tetanus; the company producing the vaccine had no veterinarian, and the horse whose blood provided the antitoxin had died of tetanus. There were similar reports of contaminated smallpox vaccines in New Jersey. Anti-science scalawags had a heyday. An ad in the *Commoner*, a weekly newspaper owned and edited by William Jennings Bryan in Lincoln, Nebraska, was headlined "Vaccinopathy: Is It a Medical Delusion?" and "What Profiteth Your Babies if Their God-Made Blood Is Periodically Tainted With Pus Vaccines."[2] All of this led to federal regulatory control of vaccine production—regulations welcomed by the manufacturer to restore public trust in its products. The 1902 Biologics Control Act was followed in 1906 by the Pure Food and Drug Act, which established the U.S. Food and Drug Administration.[3]

To spread information about the benefits and safety of new science, sectional veterinary organizations were organized. The most powerful was the Missouri Valley Veterinary Association. It had a membership of seven hundred, greater than the American Veterinary Medical Association, and its organizers often took the lead in state associations in Iowa, Nebraska, Kansas, Missouri, and Oklahoma to improve practice laws and influence Congress.[4]

District veterinary organizations comprising adjacent counties and even adjacent states appeared—the Keystone, New York County, Illinois-Indiana, and Eastern Iowa Veterinary Associations. The Eastern Iowa group originated two unique practices: publication of vital animal statistics in the Midwest and annual clinics not associated with its meetings. In October 1905 the Iowa-Nebraska Veterinary Medical Association began publishing a periodical bulletin with A. T. Peters, head of Animal Pathology at the University of Nebraska as editor. Cities also developed local veterinary associations but tended to deal with business matters—city ordinances, ethics, advertising, fees, and meat and milk inspection rules. The record for uninterrupted activity for city associations is held by the Chicago Veterinary Society.[5]

Scientific advances were giving rural veterinarians real tools to deal with disease in horses. Cocaine and chloral hydrate for anesthesia came into general veterinary use in the 1890s. The new hypodermic syringe was available—especially the reusable syringe patented by H. J. Detmers—and caused morphine to replace laudanum for pain relief in animals. Tetanus antitoxin, produced by Roux and Nocard in France in 1893, was rushed into immediate use. Within a year, the Pasteur Institute laboratory was using 136 horses for antitoxin production. Louis Pasteur claimed to have discovered a bacterium that caused hog cholera, and vaccines were marketed for sale. But like many claims of the day, he was wrong. The best that veterinarians could do about rampant hog cholera or any other infectious disease of pigs was to quarantine and segregate animals from farms and pastures affected by whatever was causing this lethal contagious disease.

THE NEWSPAPER IN RUTLAND COUNTY, Vermont, reported in 1894 a new neurologic plague of children; it had killed eighteen and left twelve paralyzed. Physician Charles Caverly, noting single cases in large families, pronounced that polio "could not possibly be contagious."

16. PRIVATE VETERINARY SCHOOLS: CHICAGO, KANSAS CITY, AND INDIANAPOLIS

By 1900, the livestock industry had moved west into the Corn Belt. At railheads in the Midwest, massive stockyards concentrated food animals and the industries they spawned. The Union Stock Yard and Transit Company in Chicago was employing twenty-three thousand people and producing over 80 percent of the nation's meat.[6] New by-product industries created leather, soap, glue, gelatin, fertilizer, buttons, perfume, and violin strings. Meatpackers named Armour and Swift moved in and by 1900 had developed refrigerated railway cars to ship beef carcasses. Veterinarians were in demand—the concentration of animals had created "shipping fever" and "stockyards pneumonia."

Private veterinary schools in large cities of the Midwest were flourishing. The Chicago Veterinary College established in 1883, Kansas City Veterinary College in 1891, Indiana Veterinary College in 1891, and Chicago's McKillip Veterinary College had dominated veterinary education for nearly a decade (see appendix II). The Chicago Veterinary College had a three-year curriculum in 1905 and billed itself as the largest veterinary school on the continent. It had access to the legions of horses required for urban transport in Chicago and to the meatpacking houses and massive stockyards along Halsted Avenue filled with cattle, sheep, and pigs. Many of them carried disease.[7]

Chicago Veterinary College was at its prime, with large classes and a new building using the entire block at 2537 South State Street. Enrollment was at record levels, close to 500 students. It even had a football team that played suited up in red and gold. A second school in Chicago, McKillip Veterinary College, enrolled over 340 students. McKillip had an enormous veterinary practice: the school report for 1899 listed 37,562 cases treated with 3,800 surgical

Chicago Veterinary College, 2537 South State Street, Chicago, Illinois. (REPRINTED FROM PROSPECTUS 1906, P. 50, CHICAGO VETERINARY COLLEGE. COURTESY OF THE HATHITRUST DIGITAL LIBRARY.)

and 1,320 dental operations.[8] In 1903, Mignon Nicholson graduated from McKillip Veterinary College, the first women to receive a veterinary degree in the U.S.

The Chicago Veterinary College seniors received the DCM degree (for Doctor of Comparative Medicine). In 1907 there were 115 graduates, 20 from Iowa—one was Charlie Titus from Edenville, the brother of Harry, who had been the house surgeon at Iowa State College. That same year other private colleges had similar numbers: the Kansas City Veterinary College graduated 77 (2 from Iowa) and the Indiana Veterinary College in Indianapolis had 28 graduates.[9] In stark contrast, the state-supported, university-associated veterinary schools were struggling. At Iowa State College only 8 seniors graduated from the veterinary school; the new veterinary schools at Washington State and Kansas State Colleges had only 4 and 7 graduates in 1907.

The Indiana Veterinary College at 459 East Washington Street in Indianapolis was also prospering. It had been chartered by the state in 1892 and had a large student body. Its advertisement in the *American Veterinary Review* in 1905 offered tuition at $75 per semester; $200 got you tuition for all three years.

Kansas City Veterinary College, led by Iowa Agricultural College graduate Sesco Stewart, graduated its first class of three in 1892 with the Doctor of Veterinary Science degree after six months of study. The college grew rapidly; the school magazine for 1912, the *Kansas City Veterinary Quarterly*, shows a student body of 380 taught by a faculty of 23. The school advertised an extraordinary academic program directed to fieldwork: 40 percent of the Bureau of Animal Industry veterinarians were graduates of the school. It had a band and glee club, installed the veterinary fraternity Alpha Psi, and fielded teams for football and basketball as well as gymnastics and wrestling. Teams wore uniforms with the school colors of blue and old gold that displayed an Atlas supported by crossed femurs.

The Kansas City Veterinary College and the Western Veterinary College, a second school in Kansas City, were the backbone of the fledgling Kansas City Animal Health Corridor. The Corridor began in 1867 with the first cattle drive up the Chisholm Trail from Texas. Like Chicago, the Kansas City Stockyards were built in 1871 to provide better prices for the cattle and meatpacking industry. Today, the Corridor includes many corporations serving animal health and nutrition.

Kansas City Veterinary College's dean, Sesco Stewart, as president of the American Veterinary Medical Association in 1903, criticized the new private veterinary schools popping up all over the country. He cited his competitor in Kansas City, the Western Veterinary College, that had only five students attending in fall term of the 1902–1903 session yet had graduated seventeen in the spring. Stewart recommended that the AVMA send representatives to inspect academic institutions. There was no action.

WHEN THE PRIVATE VETERINARY COLLEGES in Chicago, Kansas City, and Indianapolis were at peak enrollment, the federal government was facing a serious problem in Chicago, Kansas City, and New York. Stockyards, slaughterhouses, and dairies of the big cities were being accused of producing contaminated meat and milk. The force behind the revelation was an Indiana native and former Purdue University chemist, Harvey Washington Wiley, who had been hired as chief of the chemistry division of the U.S. Department of Agriculture in 1883.[10]

Wiley's first target was the dairy industry. Several crooked dairies in large cities were diluting milk with water and adulterating it with plaster of Paris (to make spoiled milk look white) and pureed animal brains (to give the appearance of a heavy cream layer). Wiley spent over twenty years concentrating on safe milk, butter, and canned meats, promoting accurate labeling and removal of dangerous preservatives—formaldehyde, borax, and copper sulfate were common additives to prevent putrefaction. His political acumen and flair for publicity helped him survive blistering attacks by trade groups, but his campaign was often blocked by powerful industry titans.

New U.S. president Teddy Roosevelt was a major proponent of legislation for food safety. His distrust of the meatpacking industry came from the putrid meat sold to the Army that he was forced to serve his troops during the Spanish-American War. Fortified with formaldehyde to prevent decay, canned meat earned the name "embalmed beef" from the press. Roosevelt also knew that the U.S. was the only industrialized nation without strict laws forbidding the sale of contaminated and adulterated food. Then came unexpected support from an extraordinary book.

The Jungle, published serially by Upton Sinclair in 1905, was an exposé of unsanitary conditions and deception in the meatpacking industry. The book contributed to the passage of the Pure Food and Drug Act of 1906. Exaggerated in many areas, the crude prose established Sinclair as a muckraker. In *The Jungle*, Sinclair wrote of ethnic groups showing how unrestrained capitalism had created destructive forces that suppressed culture and family morals. The publicity led to systematized meat inspection by veterinarians within the USDA Bureau of Animal Industry.[11]

17. PUBLIC VETERINARY SCHOOLS: THE SECOND-GENERATION PIONEERS

At Iowa State College, Dean Stalker was asked to step down and President Beardshear took the reins, acting as dean of the Division of Veterinary Medicine. His first goal was to build a faculty. From the University of Pennsylvania, Beardshear hired J. H. McNeil (for anatomy and surgery) and L. A. Klein (for medicine and sanitary science) to begin in September 1900. With them came the latest German-based methods of teaching, the science of

Robert Koch and Julius Cohnheim, and the influence of Leonard Pearson's new Germanic curriculum at Penn.

L. A. Klein taught medicine and sanitary science, published *Principles and Practice of Milk Science*, and translated Fröhner's *Allgemeine Therapie für Tierärzte* into the English *General Therapy for Veterinarians*. Klein had spent one year with the Bureau of Animal Industry before coming to Ames and left in 1902 for Clemson Agricultural College. Seven years later he was appointed dean of the veterinary school at the University of Pennsylvania.

Plans for the Veterinary Division, like all else at Iowa State College, were put on hold by two disasters in 1902: President Beardshear died on August 5 in his campus home, the Knoll, and Old Main burned to the ground on August 14. For eight months the Division of Veterinary Medicine was without a dean.

On April 7, 1903, McNeil was appointed dean. McNeil had graduated from the University of Pennsylvania in 1899 and had remained one year there as house surgeon. Arriving at Iowa State, he proved to be an inspirational teacher and an outstanding academic veterinarian. A close friend of President Beardshear, his extraordinary intelligence and capacity for work put "new life and energy into the Division after its reorganization." According to Charles Stange, he had "never known a truer friend."[12]

J. H. McNeil would be an extraordinary dean, attuned to student needs and an "enemy of misrepresentation."[13] McNeil put in place the first four-year course in veterinary medicine in any college in the U.S. Interested in the breeding of livestock, he was active in attempts to help the livestock breeder and was one of the first to urge systematic control of tuberculosis in cattle. McNeil made heroic but unsuccessful pleas to the Board of Trustees for badly needed new buildings for the Veterinary Division; money was tight and budgets grim.

There was an economic panic in 1907. A run on Knickerbocker Trust Company deposits on October 22 set in motion events that led to severe monetary contraction, and the fallout led Congress to create the Federal Reserve System. Astonishingly, student enrollments were slowly rising in both rural Iowa State and urban Pennsylvania, and both needed new buildings. But at Iowa State there was no relief from the cramped quarters and overworked faculty.

At the end of the 1907 term at Iowa State College, two young faculty members resigned. The faculty now was McNeil and three recent graduates: R. R. Dykstra, Stange, and W. E. Madson. Unable to convince the state legislature of the pressing need for new facilities, Dean McNeil resigned in protest on September 30, 1908, and moved to Ohio State as professor of surgery. Later he would spend five years with the Brazil Land and Cattle Company and, after returning, serve as chief of the BAI of New Jersey.

After Beardshear's death, President Storms had acted as dean of the veterinary college, and he was again acting dean after McNeil resigned. Storms fully supported the construction of new veterinary buildings and made the case in strong terms to the Board of Trustees. Finally, the board members concurred. Their report of 1908 stated that "more adequate provision must speedily be made for this division of our college. We should either frankly abandon the veterinary department or provide for creditable work." The report gave great credit to McNeil, stating: "Such men can not be secured for the salaries we are paying."[14]

In March the Iowa State Board of Trustees reported that Charles H. Stange had been selected as dean of the Veterinary Division effective February 4, 1909. In July the state legislature abolished the old system of government by boards of trustees and a new State Board of Education was appointed. The next year building plans were perfected and funding was secured for the new Veterinary Quadrangle.

An impressive editorial in the *American Veterinary Review* of 1907 by botanist L. H. Pammel pushed for science in the veterinary curriculum and compared course requirements of the University of Pennsylvania, Cornell University, and Iowa State College. All three schools had demanding science curricula at the time but differed in their emphasis on the horse: Iowa required twenty-one units of animal husbandry, whereas Cornell required three and Penn none. Iowa and Penn had an additional two units on horseshoeing, but Cornell had none. Pammel's plea for scientific rigor was timed well. Dean McNeil had resigned at Iowa State over lack of facilities, Law was one year away from retiring at Cornell, and Pearson had two years remaining at Penn. Those were big shoes to step into.

AT THE UNIVERSITY OF PENNSYLVANIA in Philadelphia, the veterinary department was struggling. It was in temporary quarters from 1901 to 1907 in a remodeled car barn. The original building had been needed as a site for the expanding medical school. In August 1905 a fire broke out on the second floor that killed nineteen dogs and destroyed valuable school records and exhibits, including a collection of horseshoes belonging to the Master Horseshoers' National Protective Association of America that had won medals at the Paris Exhibition in 1900.[15]

Ambulance entering the arch of the quadrangle of the veterinary school and hospital in Philadelphia. The modern elegant building at Penn opened in 1913. (COURTESY OF THE UNIVERSITY ARCHIVES AND RECORDS CENTER, UNIVERSITY OF PENNSYLVANIA.)

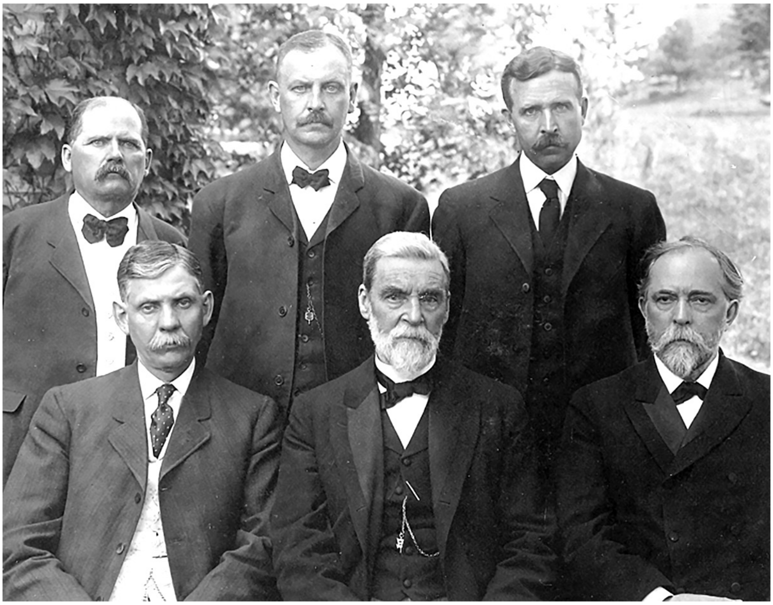
Veterinary science at Penn had improved, not declined, during its time in the temporary car barn, largely due to the quality of its faculty. Dean Marshall retired and was replaced in 1897 with an Indiana native, Leonard Pearson. A Penn veterinary school graduate, Pearson had a pre-veterinary BS degree in agriculture from Cornell and had done postgraduate study in Berlin and Dresden.[16] In his teaching, Pearson emphasized diseases of cattle, sheep, swine, and chickens over horses and changed Huidekoper's French-based teaching program to one of German methods using the English translations of *Physical Diagnosis* by Malkmus in Hannover and *Special Pathology and Therapeutics of the Domestic Animals* by Friedberger and Fröhner in Berlin. Pearson's changes predicated the future in veterinary education. The appointment of Pearson as state veterinarian and secretary of the State Livestock Sanitary Board made the school the center of veterinary field investigations in Pennsylvania. The period gave Penn a worldwide reputation in science, and when the school moved into its marvelous new building in the fall of 1913, enrollment spiked immediately.

AT THE OHIO STATE UNIVERSITY, enrollment spiked in 1904. In the first two decades since the founding of the school in Columbus, the School of Veterinary Medicine had struggled; the number of graduates in each class had varied from none to five (in two years there were none and in three years only one). David S. White, who took the reins from H. J. Detmers, began as dean in 1896 with the comment that the "struggle for existence of (the veterinary department) is too pathetic to relate."[17] Detmers's four-year curriculum plan had been reduced to three but still was too demanding to compete with the two years offered by most.

White had graduated from the school in 1890 and spent three years of study in European veterinary schools. For thirty-three years (until he retired in 1929), White was successful in popularizing the school in Ohio. He secured funds for a veterinary laboratory building in 1903 and a veterinary clinic in 1909—billed as the "finest and largest veterinary building west of the Alleghenies." Six years later, a small animal hospital and a cattle clinic were added.[18] White hired the finest faculty, including anatomist Septimus Sisson from Kansas State College, whose textbook *The Anatomy of Domestic Animals* was the standard for fifty years.

ENROLLMENT HAD ALSO SPIKED at Cornell University: the freshman class in 1907 was thirty-five in the "entire attendance" of seventy-seven students. Among them was Florence Kimball, the first woman in the nation to graduate with the DVM degree. When Dean James Law retired in 1908, there were other signs of progress. In the next five years under the new dean, Veranus Moore, BS, MD—physician turned veterinarian—the veterinary college at Cornell opened an ambulatory clinic, established an outstanding quarterly, the *Cornell Veterinarian*, and initiated plans for new clinics that were completed in 1913 and included a four-story building for large animals and two three-story buildings for small animals and farrier duties.

Walter L. Williams, professor of surgery, had gained fame in obstetrics. Educated at Illinois Technical University—now the University of Illinois—he had been a student at the Montreal Veterinary College from 1878 to 1879, where he was taught pathology and physiology by William Osler (he did not have an academic degree). Licensed to practice in Illinois, he later joined the faculty at Purdue University and then at Montana State College. Williams was a careful scientist and prolific writer who published on a range of diseases, from the pathology of glanders to colic in horses arising from arterial blockage caused by invasion of the mesenteric arteries by nematodes. At Cornell he was renowned for his expertise in breeding diseases and ethics; his textbooks on these subjects remained the standard for fifty years.[19] His most celebrated student was William Hagan, legendary next generation dean at Cornell.



Cornell University faculty, 1904. Seated (*left to right*): Veranus Moore (Pathology; second dean, 1908–1929), James Law (dean, 1896–1908), Simon Gage (Histology and Embryology). Standing (*left to right*): Walter Williams (Surgery), Pierre Fish (Physiology; third dean, 1929–1931), Grant Hopkins (Anatomy). Law, Moore, and Williams were presidents of the American Veterinary Medical Association; Fish, editor of the AVMA's journal. (COURTESY OF RARE AND MANUSCRIPT COLLECTIONS, CORNELL UNIVERSITY LIBRARY.)

In New York City, a circular letter dated December 16, 1907, was received by veterinarians from the Cornell University Medical College announcing the establishment of an animal hospital and dispensary at 408 East 26th Street. It was an appeal to veterinarians in the City to send them animals—"horses and cattle excepted"—for purposes of teaching surgery to medical students. All branches of surgery would be available: ophthalmology, otology, laryngology, gynecology, genitourinary, and general. A disclaimer was included in the letter: there would be no experimental work on the animals.[20]

THE ADAMS ACT PASSED BY CONGRESS the previous year became operational in 1907; it provided an increase of $3,000 each year to state experiment stations for research on diseases of livestock. The money was a capstone for a highly successful year for many fledgling veterinary colleges. It was the year Colorado and Alabama established veterinary schools, Michigan authorized one, and Kansas, established two years previously, received a state appropriation of $70,000 for a veterinary school building. Pennsylvania approved $100,000 for the school in Philadelphia, which acquired another $150,000 from private sources to construct the most complete veterinary school building in the country.

Funds from the Adams Act were not available to private veterinary colleges, and they missed the stimulus for research. In the coming decade, deprived of science, they would be at a serious disadvantage in the dilemma that awaited them. In 1900, statistician Karl Pearson published his chi-square test of goodness of fit, a formula for measuring how well a scientific hypothesis fits observation. In theory, a die will fall equally often on each of its six faces. But when rolled a hundred times, one number often comes up more frequently, for in practice there is chance and the ratios are almost always different. How well does the hypothesis that the die is fair fit the data? The chi-square test was important to pioneer scientists; it provided a measure of how well their hypothesis and data corresponded. Statistics and chi-square began to change how scientists worked and how national leaders accepted new scientific information.

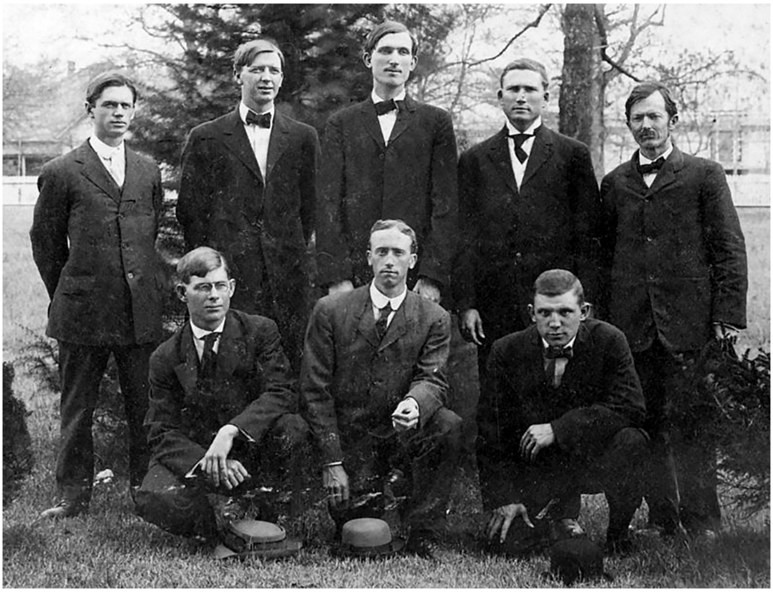
In 1908 few politicians knew or cared about chi-square. The country was still seriously vulnerable to livestock plagues and to human disease from unsafe food. State laws were lax and sanitary commissions were in the hands of the agricultural producers. Few had veterinarians as members on the sanitary commission, and West Virginia and Tennessee, as well as Utah, Idaho, and New Mexico in the West, were particularly backward. Of the six New England states, only Massachusetts had a state veterinarian, Austin Peters, as head of the state sanitary commission—Peters had helped save the livestock industry during the recent foot-and-mouth disease outbreak. Agricultural states in the Midwest and South had good scientists and effective programs.

Many states without veterinary schools had outstanding professors in departments of veterinary science in schools of agriculture: veterinarians Cary and Giltner in Alabama, Craig in Indiana, Connaway in Missouri, Van Es in North Dakota, and Lewis in Oklahoma made great progress in promoting sanitation and control of zoonotic diseases. Institutional reports to the USDA on research done with experiment state funds revealed that most schools had none or listed simply "work in progress." Exceptions were Alabama, which reported investigations of contagious epithelioma of chickens, cottonseed meal poisoning, bovine mastitis, and milk bacteriology. Minnesota reported studies on hemorrhagic septicemia and swamp fever, and Michigan on hog cholera.

IN THE FIRST TWO DECADES of the twentieth century, six new state land grant schools of veterinary medicine were established in agricultural regions: four to serve farming and ranching areas of the Midwest/Great Plains, one in the South, and one to cover the wheat farms of the Palouse prairies. The founding deans of four schools were graduates of Iowa State College. The College of Veterinary Medicine at the State College of Washington graduated its first class in 1902; enrollments were few—the number of graduates from 1902 to 1908 were two, zero, two, four, two, three, and five.

At Alabama Agricultural and Mechanical College in Auburn, the Department of Physiology and Veterinary Science became the School of Veterinary Medicine, with professor Charles Allen Cary as dean; its first class graduated two years later. Cary, often listed as the father of veterinary medicine in the South, was Alabama's first state veterinarian; he was, like his mentor Stalker, an expert in poisonous plants and the force for elimination of the ticks of Texas cattle fever, the use of antiserum for hog cholera, and tuberculosis testing in cattle for safe milk. A socially conscious Presbyterian (and superintendent of their Sunday school in Auburn), Carey was supportive of efforts in Tuskegee to teach veterinary science. Realizing its social risk, Cary invited George Washington Carver to speak at the 1903 Alabama Live Stock Association state meeting in Birmingham—both Cary and Carver were alumni of Iowa Agricultural College.[21]

Kansas State College had developed a solid academic program in veterinary science and graduated its first veterinarian in the winter term of 1907. The next year it completed an impressive building for the new Division of Veterinary Medicine, led by Professor Schoenleber. In August 1911, R. R. Dykstra resigned as professor of anatomy at Iowa State College to become professor of veterinary science at Kansas State College. Born in Groningen, Holland, he had graduated from high school in Orange City, Iowa. At Iowa State he had advanced to the rank of full professor in six years. Dykstra Hall at Kansas State College was named for his extraordinary leadership as dean from 1919 to 1948, nearly three decades in the formative years of growth in the Kansas State Division of Veterinary Medicine. Stange too would be dean at Iowa State for three decades. The two were colleagues and friends, and their two veterinary schools were rural-based, struggling to build modern facilities in an agricultural economy, and heavily influenced by farm and ranch practices.



The first graduating class in veterinary medicine at Alabama Polytechnic Institute. Standing (*left to right*): Ward Giltner, William Rufus King Beck (Camden, Ala.), Isham Smith Ingram (Auburn, Ala.), William Monroe Howell (Baker Hill, Ala.), Charles Cary. Seated (*left to right*): George Bascom Sparkman (Tampa, Fla.), Percy Wilbur Hudson (Auburn, Ala.), Armstrong Hill (Sylacauga, Ala.). Giltner moved to Michigan State College as bacteriologist and dean. (COURTESY OF AUBURN UNIVERSITY SPECIAL COLLECTIONS AND ARCHIVES.)

EMERGING COMPLEXITIES OF SCIENCE and access to it for the university-affiliated veterinary schools provided a big advantage. As the private veterinary schools closed one by one, the ten state-supported schools survived. Despite World War I and the agricultural depressions that followed, all would prosper and provide the faculties, curriculum, and inspiration for today's thirty-five modern colleges of veterinary medicine in North America.

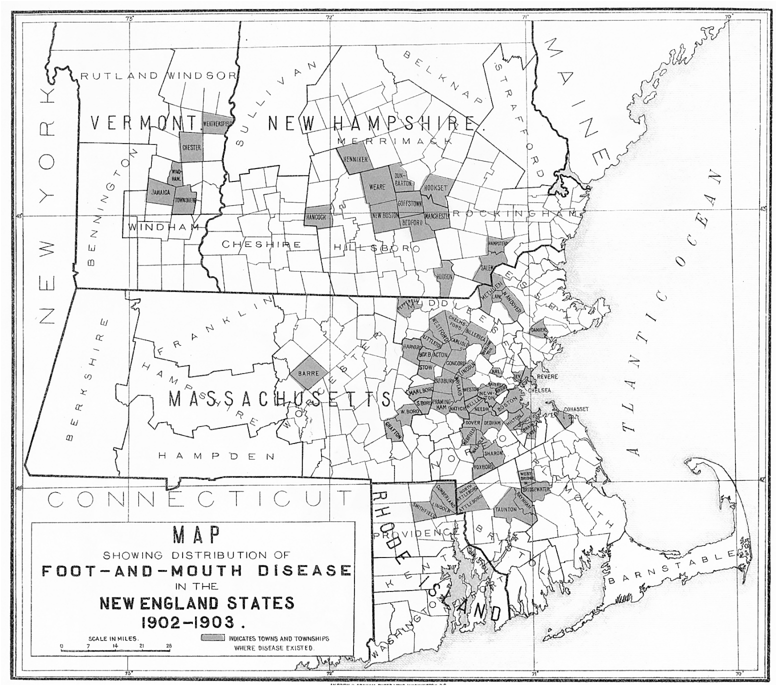
Some progressive state-supported veterinary schools folded during the agricultural depressions (see appendix III). The University of Georgia had a fine program but lost state support during the Depression. Others were destined never to succeed. Advertisements for the College of Veterinary Science at the University of West Virginia described a suspicious out-of-state arrangement: the first year was at Morgantown, the second and third years at 132 Washington Street in Pittsburgh—but there was no information on facilities or faculty. Equally dubious was the California Veterinary College in downtown San Francisco; it had affiliated with the University of California San Francisco but was unable to attract students, dedicated academic faculty, or funds to continue operating.

18. THE BUREAU OF ANIMAL INDUSTRY AND HOG CHOLERA

As the new century began, the Bureau of Animal Industry under director Daniel Salmon was proving its worth many times over in protecting the livestock industry. An unexpected calamity had begun in November 1902 when the local chief of the Massachusetts BAI telegraphed headquarters that a disease he had examined in Rhode Island dairy cows appeared to be foot-and-mouth disease.[22] Cows were standing in their stanchions without eating, drooling saliva into the feed bunk. They had painful ulcers of the mouth and feet and swollen udders with ulcers and abscesses. The weight loss of affected cows was striking. Calves failed to nurse, and the loss of milk production was catastrophic. The diagnosis of foot-and-mouth disease was confirmed and the work of eradiating the disease began, including the hurried summons of BAI veterinarians from throughout the country to New England. The disease had existed since August and had spread rapidly into neighboring states. The massive effort to find, test, and slaughter infected animals was effective, and the disease was eliminated from New England by the end of 1903.

Foot-and-mouth disease continued to require constant vigilance; it again appeared on a hog farm outside of Niles, Michigan, in August of 1914, and by the next February, twenty states were affected. The BAI went into action, imposing quarantines throughout the Midwest. This time, the national publicity began to have an impact and there was renewed interest in the veterinary profession, with effects as diverse as education and sanitary laws. One of the benefits that resulted from this plague was the introduction of short courses to educate veterinary practitioners by veterinary colleges.

BAI DIRECTOR SALMON ASSIGNED HOG cholera work to his best scientist, the chemist Emil A. De Schweinitz. In the 1890s, De Schweinitz did a variety of animal injection studies using Salmon's hog cholera bacillus and produced an



Foot-and-mouth disease in New England counties. Mapping outbreaks of the disease by the Bureau of Animal Industry was critical in its control. Disease first appeared in 1902 and rapidly spread to adjacent states. (REPRINTED FROM THE *BUREAU OF ANIMAL INDUSTRY REPORT* FOR 1903.)

antiserum that would protect guinea pigs infected with the bacillus. The antiserum needed to be tested under field conditions. In Iowa, the field studies of the BAI's William Niles were underway. Then in 1897, when hog cholera outbreaks were massive, the secretary of the USDA organized field tests to be done in Iowa and the governor of Iowa selected Page County for the BAI's experimental work on Salmon's hog cholera bacillus.

Injecting several Page County swine herds with the "immune serum" developed by De Schweinitz, Niles found little reduction in mortality from hog cholera at the end of the season. What was worse, Niles wrote De Schweinitz that the hog cholera specimens he was receiving from outbreaks in the field did not contain any agent that would sicken guinea pigs or any other laboratory animal as did Salmon's hog cholera bacillus.

Salmon dispatched the young biochemist Marion Dorset[23] to Iowa to coordinate the Page County work and to repeat the tests with the antiserum of De Schweinitz that had been prepared by immunizing pigs with his *Bacterium cholera-suis*. On arriving by train in Sydney, Iowa, at night, Dorset inquired about the fires glowing in the hills around town and was told by the hotel clerk: "Them's the fires of dead hogs that farmers can't do nothin but burn."[24] Dorset, short and slight with a limp and no experience with hogs, only observed as Niles injected antiserum into pigs in several test herds. Several days later, Niles and Dorset returned to observe the pigs. They had all died on every farm that was treated. It was clear: the De Schweinitz antiserum against Salmon's hog cholera bacillus had nothing to do with hog cholera.

Emil De Schweinitz and Marion Dorset began to wonder about one of these new "filterable viruses" being the cause of hog cholera. What had caught their attention was the report from Friedrich Loeffler that foot-and-mouth disease of cattle was caused by a filterable virus. Perhaps some unidentified tiny agent like the one causing foot-and-mouth disease might be causing hog cholera in Fremont County. They placed an order for a Chamberlain filter with Pasteur Laboratories.

In 1905, to deal with the growing disasters of hog cholera, the BAI moved its fieldwork from Sidney, Iowa, near the Nebraska border where Niles was working, to a new hog cholera field station near Ames. A small building was constructed on a hill east of town across the Skunk River. Niles was placed in charge, with the specific assignment to produce an antiserum and a protocol for its use to prevent hog cholera.

Dorset was again assigned to Iowa, this time at the Ames station with Niles to investigate the cause of hog cholera in view of producing a vaccine. Using the Chamberlain filters, he established that the hog cholera agent was much smaller than bacteria. It was not retained by the filter as bacteria should have been but passed into the filtered fluid. The results made it clear—the cause of hog cholera was not the hog cholera bacillus as proposed by Salmon, Smith, Pasteur, Billings, and a host of others but one of these new filterable viruses. Dorset and the team published their results in the *Twenty-First Annual Report of the Bureau of Animal Industry* in 1904.

The discovery of hog cholera virus focused Niles's research on producing antiserum and developing a protocol for use that would provide immunity in the pig against hog cholera. In 1905, using a plan devised by Dorset, Niles began antiserum production at the Ames laboratory and in the next season used it in a limited number of pigs. The results were "most favorable."

Niles enticed his friend, South Carolina physician Charles McBryde, to join him in the BAI work in Ames to expand the investigations. In the spring of 1907, over two thousand pigs in forty-seven herds in Story and Boone Counties in Iowa were vaccinated by Niles and McBryde under normal farm conditions; pigs were injected with a small amount of infectious blood from an animal with active hog cholera simultaneously with varying amounts antiserum—blood serum from recovered pigs that were immune to hog cholera. When a hog cholera epidemic came in the fall, all of the vaccinated pigs remained healthy while 89 percent of the unvaccinated pigs died.

By the next year, Niles, McBryde, and Dorset had perfected hog cholera antiserum production and the dosages that would protect pigs. Their process was patented by the USDA to ensure the right to its free use. Using the antiserum simultaneously with a small amount of dangerous virulent virus, immunity resulted without any signs of disease; the process soon became known among veterinarians and farmers as the serum and virus method of vaccination.

To prove that his vaccine protocol was effective, Niles took the Great Western overnight passenger train from Des Moines to Kansas City and arranged to test the serum and virus technique in the Kansas City Stockyards. Spending a month selecting appropriate shoats (young pigs after weaning) from the surrounding countryside, he arranged pens and designed a large-scale experiment that had groups of pigs receiving virus only (no serum), serum only (no virus), and both virus and serum in 15, 20, and 25 cc amounts. The pigs receiving virus alone should die and all others should be protected.

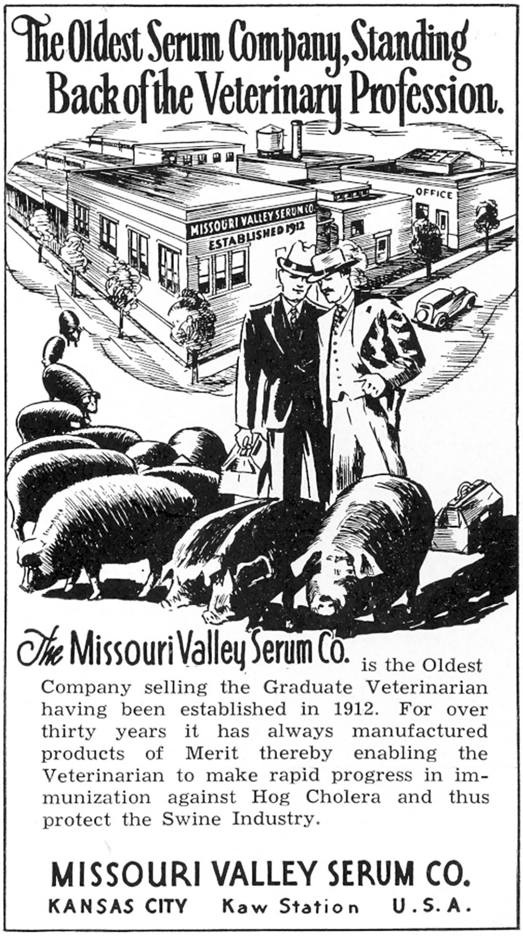
News of the experiment got around, and every morning there would be groups of salesmen, shippers, farmers, and journalists visiting the Stockyards to check on the outcome. The results were spectacular. By the fifteenth day, all of the virus-only pigs had died; none of those receiving serum sickened. Publication by the journalists in the group made the spectacle widely known and established public acceptance of the new technique.

Within a month, a dozen new companies started up around the Kansas City Stockyards to harvest and process hog cholera antiserum.[25] Failures of supply to the Army veterinary hospitals in World War I had shown the lack of any

Hog cholera station, Ames, Iowa, 1910. Scientists William Niles, Marion Dorset, and Charles Neil McBryde (*left to right*) devised the vaccination protocol that saved the pig industry.

capacity for American production of veterinary drugs. Before the war, veterinarians had procured crude drugs or were their own pharmacists. Mortar and pestle, scales, and ointment slabs were standard equipment of the practitioner. The enormous demand for hog cholera antiserum and the high prices of pork inspired new industries in the Corn Belt. In the next half-century new companies in Kansas City would grow, from the commercial hog cholera antiserum production center to the premier site of the veterinary pharmaceutical industry.[26]

Despite the rapid commercial buildup to develop and market hog cholera antiserum and virus, the products produced covered only a fraction of the needs in the pig-producing states of the Midwest and South. Rushing to save their swine industry, veterinary colleges and state experiment stations moved to make up the deficit. Kansas State College built a small antiserum plant on the old college farm in 1908 and began sales to the public in early 1910. Unable to meet



Advertisement for hog cholera antiserum. (REPRINTED FROM *THE VETERINARY STUDENT*, 1938. COURTESY OF THE *IOWA STATE UNIVERSITY VETERINARIAN*.)

demands, in 1913 the Kansas Board of Regents ordered a new two-story brick building be constructed. Completed in 1914 on a hill north of campus, Research Hall and its swine pens produced and sold hog cholera antiserum until 1920.

In 1913, a year when Iowa was producing over one-sixth of the hogs in the nation, a wave of hog cholera again swept across the Midwest; the number of deaths in Iowa was just under three million. Although hog cholera vaccination was underway, there was not enough antiserum. Because commercial companies were not able to meet the increasing demand for antiserum, the Iowa legislature solved the problem by establishing the Iowa State Biological Laboratory at the college. A law that provided for a laboratory for the manufacture and distribution of hog cholera antiserum, toxins, virus, and biological products was approved on April 23, 1913, and became effective when published in the newspapers the *Register*, the *Leader*, and the *Des Moines Capital*. No one was distrusting the government.

Southern states too were making progress. The state legislature in Alabama appropriated $25,000 for its hog cholera antiserum plant, which opened in 1915 in Auburn. A report from Georgia was that "within the past two years, a State Veterinary has been appointed; a Department of Animal Pathology has been installed at the Georgia Experiment Station, and a Department of Veterinary Science has been installed at the State College of Agriculture and Mechanic Arts of the University of Georgia. The State has a good Veterinary Practice Law, a State Board of Veterinary Examiners, and a lively State Veterinary Association. The hog industry is growing by leaps and bounds and it is expected that the State Legislature at the next session will make appropriation on the manufacture and distribution of hog cholera serum."[27]

The Iowa State Biological Laboratory report for 1915 describes a conference held in Agricultural Hall on the campus of the Iowa State College for the purpose of implementing the new serum and virus method. It was attended by concerned veterinarians throughout the country.[28] The previous year a foot-and-mouth disease outbreak in Illinois had been spread by contaminated hog cholera antiserum produced by a serum company at Chicago's Union Stockyards.

By 1918, approximately 96 percent of the hogs in Iowa had been vaccinated and there had been constant decline in hog cholera in the state. The original cost of purchasing antiserum from Iowa State was two cents per cc, and this had been reduced to one-and-a-half cents. With increasing use, commercial companies began production so that the college received permission to close the State Biological Laboratory and convert the buildings to laboratories for veterinary research.

In 1915 Marion Dorset was the first person to be granted an honorary degree by Iowa State College—a doctor of veterinary medicine degree presented on recommendation of the veterinary school faculty. By then both Niles and Dorset had become legendary scientists in the swine industry. Hog cholera would persist for another fifty years because of the nature of the disease to remain hidden in between waves of disease. Its reappearance was often tied to foibles of those involved: failures to vaccinate, fly-by-night serum producers selling unstable or diluted antiserum, and delays in the laboratory diagnosis to confirm the disease—an event that made it too late to prevent spread of hog cholera.

19. VETERINARY EDUCATION, CHARLES STANGE, AND THE FLEXNER REPORT

The Committee on Intelligence and Education of the American Veterinary Medical Association issued its annual report in 1904. Ignoring Kansas City Veterinary College dean Sesco Stewart's critique of the previous year, it included a list of colleges to be accredited by the AVMA but had used only information supplied by the school. The report was favorable to a number of "colleges" of dubious credentials. A favorable report was made for the Collins Veterinary College in Nashville, Tennessee, but an investigation the next year revealed that the college had been "chartered by the State of Tennessee but owned and run by a non-graduate. There was not a qualified veterinarian connected with the faculty. Diplomas were issued at random—no faculty, no course, no college."[29]

After three years of ignoring the problem, a committee was appointed by the U.S. secretary of agriculture to investigate veterinary schools. The committee's report released in 1908 was a "bombshell."[30] It placed the veterinary colleges into three classes: A (those colleges whose graduates would qualify to sit for the U.S. Department of Agriculture civil service examination for employment in the USDA); B and C (those whose graduates who would not).[31] The report was not accepted by the Education Committee of the AVMA.

IN 1908 THE AMERICAN MEDICAL ASSOCIATION directed its new Council on Medical Education to investigate medical schools in North America. The intent was simple. Medical school curricula should be standardized, with a minimum of two years of basic sciences and two years of clinical training in a teaching hospital. To provide data on the state of medical education, the AMA's new Council asked the Carnegie Foundation for the Advancement of Teaching to survey medical education in the U.S. and Canada and propose changes. The Carnegie Foundation appointed Abraham Flexner, neither scientist nor physician, to direct the survey, and for two years Flexner's committee toured medical schools in North America.

The Flexner Report was released in 1910. It recommended that physicians be trained in a scientific manner, state licensure procedures be strengthened, and medical schools be given control of their teaching hospital. The Report gave high marks to only a few medical schools: the Universities of Michigan, Western Reserve, and Wake Forest in the U.S. and McGill and Toronto in Canada. Highest praise was given to the new medical school at Johns Hopkins University, which was recommended as a model in North America.

The Flexner Report damned the status of most medical education in the U.S. In the end, it would cause the number of MD-granting institutions in the U.S. to go from 160 in 1904 to only 66 in 1935. It called Chicago's 14 medical schools a "disgrace to the state" and declared that Chicago was "the plague spot of the nation." In Canada, only the school at Western University was deemed inadequate by the Report, and none closed.

The hospital of the University of Iowa Medical School was called a "well-intentioned but feeble institution" and it was recommended that the school either reform substantially or close. It had opened in 1898, the first university teaching hospital west of the Mississippi River, but its meager funding by the state legislature was reflected in patient care. In the end Iowa responded, creating a functional and beautiful hospital that opened in 1928 and progressed to the great institution it is today.

The Flexner Report also forced nationwide closure of schools of osteopathy, chiropractic medicine, electrotherapy, homeopathy, naturopathy, and eclectic medicine (which based therapy on botanical remedies). Only the American Osteopathic Association was able to bring some osteopathic medical schools into compliance with the Report. Early lack of leadership and vision for medicine in Iowa led to quasi-medical businesses: the Palmer Chiropractic operation in Davenport, the Still Osteopathic School in Des Moines, and the Iowa Homeopathic College of Medicine in Iowa City. For a period, the University of Iowa had two medical schools operating simultaneously: the allopathic medical school (the college that survived) and the Iowa Homeopathic College of Medicine, started in 1876 as the Homeopathic Medical Department. The Board of Regents allocated funds for a homeopathic school building and hospital, which opened at the corner of Jefferson and Dubuque Streets in Iowa City in 1895. Homeopathy had been contradicted by a wide range of scientific studies across chemistry, biology, medicine, and psychology, and the positive results shown by a few studies were found to be due to chance, flawed research, or reporting bias. The lack of science caught up to homeopathy and the school and homeopathic hospital closed in 1919.

FOR THE SUSCEPTIBLE BOYS WHO hadn't finished high school, scalawags were still offering veterinary diplomas by mail order for a reasonable fee. In August 1910, young farm boys in Eden Township read a two-line advertisement for college by mail order in the local newspaper, the *State Centre Enterprise*. It offered a great deal: "AMERICAN INSTITUTE OF VETERINARY SCIENCE, Chicago, IL. Complete Course in Veterinary Medicine with examination and diploma in 3 months." No one applied and the scam vanished.

WHEN THE FLEXNER REPORT WAS RELEASED, several veterinary schools had better facilities and more rigorous curricula than many of the poorer medical schools. Yet the Report also swept through veterinary education. At Iowa State College, a young and receptive Dean Charles H. Stange was attentive to demands for medical reform and reorganized the Division of Veterinary Medicine to meet the new standards. Stange, the third veterinarian to be dean, was fluent in German and attentive to German science, often translating articles and books for U.S. consumption. Pursuing graduate studies at the University of Chicago, he returned in 1908 to accept a position with Iowa State.[32]

During his tenure from 1909 to 1937, Stange's extraordinary contribution was to insert rigorous science into veterinary education. His predecessor, Dean McNeil, had made Iowa State the first to require a four-year curriculum for the DVM degree (in 1906). Stange would add to that by leading Iowa State to be the first to require high school graduation for matriculation (1911) and one year of pre-veterinary college work (1931). J. F. Smithcors, in his book *The American Veterinary Profession*, stated that Dean Stange "had a greater influence on veterinary education in this country during the past two decades than did any other member of the veterinary profession."[33]

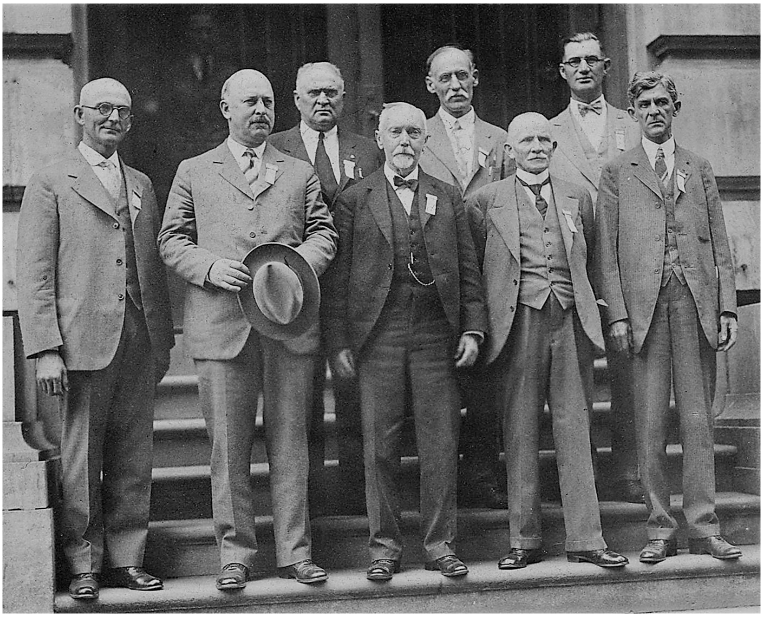
In his first speech at the AVMA annual meeting of 1911 in Toronto, Stange promoted higher standards with more science in the curriculum and cautioned that "live stock interests are demanding not more, but better men—men capable of solving the many and complex problems incident to modern veterinary science." Attendees from state schools applauded him for having "the nerve" to speak out; those from private schools called it "lack of judgement."[34]

In North America at the time there was great controversy and debate among veterinarians over raising entrance requirements and increasing the time of study for educating veterinarians. In Canada, the Ontario Veterinary College had no educational requirement for matriculation, shifting attendance records, and short terms yet attracted many students; in contrast, Montreal, with stiff matriculation exams, strict requirements for attendance, and long courses, attracted few students and folded. In the U.S., Harvard, with high entrance requirements and long courses, failed to attract enough students to perpetuate itself; an editorial in the *American Veterinary Review* exhorted its members to advise potential veterinary students to avoid Harvard due to its "meagre clinical facilities, attitude of its faculty, and high cost of tuition." Salmon's National Veterinary College, with minimum standards, also disappeared in a few years. There seemed to be other factors at work.

In the Midwest, veterinary schools were increasing standards and having increasing enrollments. Perhaps it was a midwestern phenomenon. In discussing the history of the debate, the historian Louis Merillat wrote that "no one seems to have been influenced by the fact that each time Iowa raised its entrance requirement and lengthened its course, its enrollment increased."[35] The Kansas City Veterinary College, after increasing its requirement and putting up new buildings, soon forced two other veterinary schools in the city to close. Then again, the success in Kansas City may have been based on music—the Kansas City Veterinary College had an outstanding school band and a glee club that performed regularly in the city.

Stange would lead the Iowa State College veterinary school through its most striking period of growth—beginning with the construction of the new complex of buildings, the Veterinary Quadrangle, the State Biological Laboratory north of the Quadrangle, and a new veterinary teaching hospital. To design the new Veterinary Quadrangle, Stange had visited the new buildings at Penn and had traveled to Europe, returning home with the concept of multiple departmental units connected by elegant covered walkways. The result was practical and architecturally pleasing. When it opened in 1912 after being decorated with gargoyles and landscaped with ivy and evergreen, the new building had a beauty unmatched by any veterinary school in the country.[36]

Iowa State College had the leading veterinary faculty and physical plant in the country. A letter to Stange from Walter Crocker at the University of Pennsylvania, at the time America's best-known veterinary pathologist and most



Reunion of Iowa State College Veterinary Medicine faculty, AVMA annual meeting, ca 1924. Front row (*left to right*): Charles Murray, John Mohler (chief, Bureau of Animal Industry), L. H. Pammel (Botany), George Judisch (Pharmacology), unconfirmed, L. A. Klein (dean at Penn). Back row (*left to right*): McNeil (New Jersey, former dean), F. R. Ahlers (Anatomy), Charles Stange (dean, Veterinary Medicine).

outspoken critic, stated: “Penn is the only school in this country at this time that gives a thoro course in pathology and it does not have the facilities that Ames has. . . . To my mind you are in the lead in every subject but pathology and with Dr. Benbrook at the head of that department veterinary supremacy is absolutely yours.”[37] In the dean’s report to the president, Stange writes that “in order to facilitate the work of this division and increase its proficiency, it has been divided into departments.”[38]

The Association of State and Provincial Veterinary Colleges met for its annual meeting at Hotel Astor in New York City on September 2, 1913. F. S. Schoenleber of Kansas State College was president and L. A. Klein of Penn, vice president. Reports were that there were twenty-four hundred students enrolled in all veterinary schools in the U.S. and three hundred in Canada. The list of veterinary colleges accredited by the USDA Bureau of Animal Industry included eight state-supported and eight private schools.

THE DIVISION OF VETERINARY MEDICINE at Iowa State College needed a pathologist to replace Professor Dimock, who had moved to chair the Department of Veterinary Science at the University of Kentucky in 1918. William W. Dimock was known internationally; he had been chief veterinarian of the National Board of Health in Cuba, and his move was a serious loss to the faculty.[39] The new faculty person would have to be a competent pathologist and have the capacity to deal with diagnostic pathology at a national level. Iowa State had started a diagnostic laboratory in 1912 that had been opened to help veterinarians and farmers with difficult problems in animal disease. The operation, working in the basement of the Veterinary Pathology Building, had expanded considerably and more help was needed. Swine influenza was a new viral disease appearing throughout the Midwest, and there was no virologist and no technology to identify or grow a virus.

Stange's letters of inquiry in March about outstanding candidates revealed a paucity of experienced pathologists. Dean Oscar Brumley at Ohio State had no one. Professors from departments of veterinary science—Roderick from North Dakota and Robert Graham at Illinois—were contacted but proved to be blind leads. V. A. Moore, the dean at Cornell, "regrets that we do not have anyone available" and recommends that Stange contact A. R. Ward at the BAI and Walter Crocker, the feisty veterinary pathologist at the School of Veterinary Medicine at the University of Pennsylvania.[40] Crocker was the author of the only book on veterinary pathology and autopsy techniques in English.

Stange receives a response from Walter Crocker, who lays out his salary and technical requirements for the position. But Penn quickly responds with a 25 percent increase in salary and an appointment at the Wistar Institute, and Crocker will stay at Philadelphia. He sends an extraordinary letter to Stange recommending his former assistant, Benbrook. Writing that there was no one else, he tells Stange of the incompetence in veterinary pathology in eastern institutions: "Fitch could not do an autopsy or discuss lesions to save his life. He came down from Cornell and spent three days with me to pick up enough postmortem pathology to write a book on. His trouble is he can't tell postmortem decomposition from antemortem change. Look at the new chief of the pathological division at Washington. He was out to see me last August with Fitch and he wouldn't risk looking into a microscope at a tumor Fitch could not diagnose. He would not take a chance." Crocker ends his letter: "If you will have Dr. Benbrook do one complete autopsy on a horse or cow as a demonstration . . . you will admit it to be the first time you ever saw an autopsy."[41]

Edward A. Benbrook accepted Stange's offer to join the research department at Iowa State College and to be responsible for the Veterinary Diagnostic Laboratory, and moved to Ames in 1918. Appointed head of the Department of Veterinary Pathology a year later, he held that position until 1955 and was a leader of the College of Veterinary Medicine longer than any other faculty member. Exploiting the technology he had learned at Penn, he applied microscopy and photography to work.[42]

20. WORLD WAR I: BIOWARFARE, PREJUDICE, AND THE U.S. ARMY VETERINARY CORPS

On a cold November night in 1915, a stevedore walked silently through the darkened dockside corrals at the Breeze Point wharf off the shipyards in Newport News, Virginia. Awaiting the trip to European remount depots, mules and horses purchased by British and French agents crowded the corrals. Dockworker John Grant carried a brown paper package containing rubber gloves and two needled syringes filled with brownish fluid. Jabbing the syringes into the rumps of as many animals as he could, Grant dumped the remaining fluid into the watering troughs. The brown fluids were cultures of the glanders bacillus and the horses would sicken and die within the next four weeks—the carcasses thrown overboard at sea—or, better from Grant's view, arrive alive to spread glanders to European remount depots.[43]

The possibility that Germany might resort to biological warfare against the neutral America's livestock industry was a persistent worry since the European War started.[44] The U.S. was shipping horses and mules to the Allies—animals that were being used to expand their transport and cavalry. In 1915 Germany began a clandestine program of sabotage along the eastern U.S. coast.[45] Attempts to bomb or derail trains headed for British remount depots in Canada and Newport News, Virginia, did not succeed, and biological attacks failed because an uneducated saboteur named Erik von Steinmetz allowed bacteria in the cultures to die. German agents in Baltimore, surreptitiously employed by the North German Lloyd Steamship Company, needed a microbiologist. They found one in Anton Casimir Dilger, a physician in the Imperial German Army working in Serbia. He was a microbiologist and U.S. citizen, spoke perfect English, and held an American passport. He had been born on a horse farm named Greenfield near Front Royal, Virginia. His father, an artilleryman, held the Medal of Honor earned at the Battle of Chancellorsville. In Germany, his grandfather had been a biologist and his maternal great-grandfather a respected physiologist. His three American sisters had married Germans and lived there; Anton Dilger followed to be educated and earned his medical diploma from Heidelberg University.

With orders to build a laboratory that could produce glanders and anthrax germs, Dilger returned to the U.S. and rented a fashionable two-story brick house in the 5500 block of Thirty-Third Street NW near Connecticut Avenue, close to Chevy Chase Circle in Washington, D.C. Working with his brewmaster brother Carl and housekeeper sister, he converted the basement into a bacterial laboratory and began to produce virulent liquid cultures of bacteria. German agents from Baltimore stopped by each week to pick up bacterial cultures for dockworkers willing to infect horses in shipping depots in New York, Baltimore, Norfolk, and Newport News. For one year—until 1916—recruited longshoremen moved among stockades where animals were being shipped, sticking them with lethal germs. Dilger was interviewed by the Bureau of Investigation but cleared of suspicion. Although the Dilger operation killed thousands of horses, it did not influence the war. One estimate was that two and a half million horses and mules were exported to Europe during World War I.

A New York City police detective and head of the bomb squad, having information on Steinmetz's failed attempt at biowarfare, ordered doubling of the guard at the city's dockside horse corrals. He began asking around about saboteurs. In late January, Dilger—cautioned by one of the German agents that "they're on to us"—returned to Germany. He was awarded the Iron Cross. Brother Carl switched to producing incendiary bombs, one of which was connected to the Black Tom explosion in New Jersey. As police were closing in, Carl too returned to Germany. Another employ moved to Missouri.

The diseases that had developed in farm livestock were never officially reported. An outbreak of anthrax in cattle in Harford County, Maryland, close to the

Pennsylvania line, was reported in 1915 and noted to be rare for the territory.[46] On October 17, 1917, a suspicious fire destroyed much of the Kansas City Stockyards, burning to death twelve thousand cattle and six thousand hogs; they were doused with oil and incinerated where they lay the next day.

The National Defense Act of 1916 raised the national Army by nearly 50 percent. The next year, war came for the U.S. when the British passed on to the Americans a telegram they had intercepted in which the German foreign minister, Arthur Zimmerman, invited Mexico to join the war against the U.S. with a promise to help Mexico regain Texas, New Mexico, and Arizona. The impact of America's entry into the war on veterinary students was made clear when the Selective Service Act was enacted on May 18, 1917. It required all males aged twenty-one to thirty to register for the draft. In the next two years, two and a half million men were drafted and two million more men volunteered for military duty.

IN 1918, GERMANS WERE THE DOMINANT immigrant group in America. Taking over entire small communities in the Midwest, they spoke German at home as well as in their churches and German schools. In New York City the German Veterinary Association met monthly for presentations in German. The Nebraska City German language newspaper, the *Nebraska Deutsche Zeitung*, had been serving immigrants since 1861 and had nationwide circulation.

As World War I raged on and doughboys of the American Expeditionary Forces were being gassed and killed in France, the public turned against German immigrants. In Davenport, Iowa, twenty-seven teachers were fired for the crime of teaching German. The prosperous German Savings Bank in Carroll was vandalized three times, covered in yellow paint (the color of traitors) until it changed its name. A German immigrant farmer was dragged around the town square in Audubon by a noose until he agreed to buy war bonds. Sauerkraut became liberty kraut. Iowa towns changed their Germanic names. In Tama County the town of Berlin became Lincoln. Guttenberg reverted to Prairie La Porte, the name given it by French explorers. In Indiana, East Germantown was renamed Pershing—with some irony: the German Pershing family name had been changed from Pfoerschin.

President Wilson fanned the flames of misplaced prejudice in a 1917 Flag Day speech, saying that Germany had "filled our unsuspecting communities with vicious spies and conspirators." In Collinsville, Illinois, a mob of citizens lynched Paul Prager, who had made pro-German comments. It was the same year so many sons of German immigrants died for America; one was Otto Radke of nearby Barrington, Illinois.

On May 23, 1918, Iowa governor William Harding issued the Babel Proclamation, an executive order that declared English to be the official language of the state. The proclamation forbade Iowans from using foreign languages in schools, for public speeches, and for "conversation in public places, on trains, and over the telephone." At Iowa State, the major textbook on clinical veterinary medicine was German—Dean Stange spoke fluent German and had translated sections of the book into English for its American publisher, the Chicago Book Company. He was uncertain if its use would be prohibited. Governor Harding had also prohibited the use of foreign languages for religious ceremonies. He received a letter of protest from a Norwegian Lutheran pastor in Decorah, writing that if he gave his sermons in English, 95 percent of his congregation would not understand him. The German branch of the Methodist Church, at its general meeting in St. Louis, encouraged its churches to discontinue German services.

The governor, not about to leave any foreigners untouched, tells the crowd at a Fourth of July celebration in Sac County that it is not only Germans that must assimilate but also those from "the filth of Denmark." As the war ended in November, the hysteria abated. Guttenberg returned to its original name. The matter ended officially in 1920 when the U.S. Supreme Court struck down Nebraska's English-in-Schools law—and by extension all other Babel laws.[47]

The Babel episode had one impact on veterinary science. At the end of the war, interned Iowa State College veterinary professor Schern could leave Germany. His home in Bromberg had been assigned by the 1919 Treaty of Versailles to the re-created nation of Poland. Having gotten word of anti-German sentiments in Iowa, Schern did not return to America but took a position in Uruguay.

IN THE SUMMER OF 1913, Kurt Schern had been brought to Iowa from the Kaiser Wilhelm Federal Research Institute for Agriculture in Bromberg, Germany, to be the first director of the new Department of Veterinary Investigation at Iowa State College. College president Pearson had met Berlin veterinary professor Ostertag on a trip to Germany and suggested that Stange write to him for candidates. Schern, Ostertag's first choice, was hired and came to Ames, bringing his assistant, Paul Purwin. Schern had been educated at the University of Leipzig in natural science, and the Berlin Veterinary College, where he graduated in 1904 (his professors had been mentored by Robert Koch and Rudolf Virchow). At Bromberg, Schern had started as an assistant in the veterinary section to work on diseases of cattle and had just been promoted to a post in Berlin.[48]

Schern spent the first year in Ames supervising the installation of laboratory equipment. Most had been ordered from Germany and was failing to arrive because of the unstable political conditions in Europe. The European War struggled on for three years with the increasing likelihood that America would be sucked into the battle. During mid-summer 1914, despite the risk, Schern left to attend the World Veterinary Congress in London. For three summer months tensions had increased, and on August 4 Britain declared war against Germany. The World Veterinary Congress was canceled after the first lecture. Schern fled to Germany via Holland and was interned, unable to leave the country.

Veterinary colleges lost both students and faculty to the war. All had enlisted and were gone with the U.S. Army's American Expeditionary Forces, shipping off to France. Gone from Iowa State College were the veterinary surgery staff of Bemis and Guard, the head of the ambulatory clinic, N. L. Nelson, and a research scientist, L. E. Willey. In January 1918, Majors George McKillip, Bemis, and Blair were ordered to Camp Lee to form three veterinary units for overseas duty. Each division sent overseas had a full veterinary unit: twelve officers and fifty-one enlisted men—veterinary students, agriculture students, stablemen, and farmers, as well as horseshoers, saddlers, and pharmacists. Four schools—for blacksmiths, farriers, teamsters, and packers—were established at Camp Grant on ninety-six acres near Rockford, Illinois. Major McKillip's Veterinary Hospital No. 6 was the first unit sent to France, arriving in April. In February 1918, D. S. White from The Ohio State University, D. H. Udall from New York, and C. J. Marshall from Pennsylvania were commissioned as majors and rapidly promoted to lieutenant colonel in the Veterinary Corps.

Dean Stange remembers 1917 and the onset of war as a "nightmare." President Pearson moved to Washington to be assistant secretary of agriculture, and Dean Stanton was once again asked to step in as acting college president. The campus was "turned into a training camp," with the Student Army Training Corps dominating the college for the year. Stange writes: "We did not know always to whom we were responsible, the acting president or the chief military officer. Both claimed jurisdiction." Fraternity and club houses were transformed to barracks and the gym was used for a mess hall "to and from which the students marched in military formation."[49] Defined study hours were set aside and students were required to congregate in assigned rooms, where an officer was designated to supervise the study.

Veterinarians west of the Mississippi River who enlisted in the Veterinary Corps were sent to the veterinary section of the Medical Officers' Training School at Fort Riley, Kansas, the home of the Army's Cavalry School. In the East, there were veterinary officer training schools at Camp Lee, Virginia, and Camp Greenleaf (Fort Oglethorpe), Georgia.

After finishing basic training, veterinary officers were sent to the new School for Meat and Dairy Inspectors in Chicago. Established in June 1917 to train both officers and enlisted men, it adapted the methods used by the Bureau of Animal Industry. When the course was completed, officers were assigned to the Quartermaster Corps to inspect procurement of meat destined for shipment to France for the American Expeditionary Forces. The first class of thirty received the assignment to inspect beef and bacon racks in commercial freezers, railroad cars, and loading storage sites in a commercial chain that stretched from Utah to New York.[50]

Finding so many defects in the food chain, the Veterinary Corps was soon inspecting every link. With bacon, inspectors examined selection, trimming, piling, curing, overhauling, brushing, smoking, wrapping, boxing, and shipping. They were so successful in removing dirty procedures that their work spread to all meat products as well as cheese, butter, lard, and oleomargarine. Soon, a reinspection of all meat products was added at the Port Supply Office in New York. Suspect specimens from military food inspections were sent to be examined at the newly established Army Veterinary Laboratory Service. The laboratory was critical for detecting bacterial contamination of the military food supply. Arrangements had been made with the School of Veterinary Medicine at the University of Pennsylvania for quarters to set up the laboratory.[51]

Veterinarians with orders to join the U.S. Army European force, the American Expeditionary Forces, arrived in France to encounter horses that had been cared for poorly and treated badly. The cavalry had forgotten lessons of horse care learned in the Spanish-American and Civil Wars. In the Army, even good cavalry riders were often inattentive to the health of their steeds.

French military officers were appalled by the health and living conditions of horses in the U.S. Army. Worried that their diseases would spread to French farms, the premier of France organized the Franco-American veterinary liaison mission that allowed French veterinarians to inspect U.S. Army horses and recommend treatments. They found strangles, glanders, pneumonia, mange, and pink eye. To encourage American veterinary care, the French refused to supply Americans with fresh horses. This drove the U.S. Army to place an Army veterinarian in Paris and the surgeon general to begin organizing a veterinary reserve corps. By October 1918, five thousand veterinary officers were in service.

The liaison mission improved conditions throughout the war zones of France as U.S. Army veterinary hospitals were created to deal with equine diseases as well as injuries from mustard gas, wounds, and the debility of improper care. One of the best was the Third Army Veterinary Hospital, commanded by its chief veterinarian, Major H. E. Bemis, enlisted from the surgery staff at Iowa State College. Improving diagnoses by coordinating case materials with the Army's central veterinary diagnostic laboratory, Bemis proved to be an exemplary officer for the Veterinary Corps.

WHEN THE ARMISTICE WAS DECLARED on November 11, 1918, there was a logistics problem of transporting soldiers of the American Expeditionary Forces back to the U.S. The Army commanding general decided that the way to expend the surplus energy of two million American young men was to start an education program and he founded the American Expeditionary Forces University at Beaume (Côte-d'Or). Science courses were offered and undergraduates were to receive academic credit on their return home. Included was a veterinary college, the School of Veterinary Medicine of the American Expeditionary Forces University. Major George McKillip of Chicago was appointed dean and Major D. H. Udall of Cornell was the principal teacher. In the end, it was not possible to transfer credits to American universities and, as the soldiers were transported home much faster than expected, the AEF veterinary school lasted only from February to June.

As soldiers returned home from Europe in 1918, the influenza epidemic came with them. The Spanish flu had come in three successive pandemics

State Gym at Iowa State College converted into a hospital during the influenza outbreak in 1918. The locker rooms were used as a morgue. (COURTESY OF THE IOWA STATE UNIVERSITY LIBRARY SPECIAL COLLECTIONS AND UNIVERSITY ARCHIVES.)

in 1918—first in spring, then in fall, and again in winter. It would kill nearly fifty million people worldwide. Influenza had a devastating impact on college campuses. At Iowa State College, the gymnasium was changed from wartime mess hall to college hospital and morgue. The college was quarantined by the military officer in charge, and all persons going to and from the campus were required to have passes. Guards were stationed at all college entrances. Parents coming as a result of a telegram to see a son or daughter sick with influenza (who were often dead when the parents arrived) were transported in specially designated cars.

PART V

ASCENDANCE

The Agricultural Depressions of 1920–1940

Fourteen months after World War I ended there was a sharp deflationary national recession. It didn't last long—from January 1920 to July 1921. But on September 16, 1920, at 12:01 p.m., a bomb containing one hundred pounds of dynamite and fifty-five hundred pounds of cast iron weights exploded in front of the J. P. Morgan Bank at 23 Wall Street, killing two horses and thirty-eight people and causing $2 million in damage. Carried in a horse-drawn wagon, it killed mostly secretaries, clerks, and messengers. The Wall Street bombing was never solved but was thought to be the work of Italian anarchists. Its impact was a transformation of the Justice Department's Bureau of Investigation into the relatively autonomous Federal Bureau of Investigation—the FBI.

The short deflationary recession in 1920 was quickly followed in mid-1921 by the beginning of an astounding period of economic prosperity. The Lost Generation was attuned to the new technological advances spurred on by the war that were being developed and marketed on a large scale: automobiles, telephones, and radios. The St. Louis Cardinal games could now be heard in real time. And silent movies were coming to town. It was the Roaring Twenties, with shortened hemlines, flappers, and art deco styles. Modernity was replacing tradition.

But in the rural Midwest and South, the agricultural depression of the 1920s was prolonged and would meld without economic recovery into the Great Depression of the 1930s, and then into World War II. World War I had brought good times to agriculture economies. Good markets and governmental price supports during the war had increased income for farmers, and this in turn had led naturally to increased production as well as increased borrowing for land acquisition. When the war was over, wartime markets collapsed and overproduction of food and fiber led to price deflation. Unlike the rest of the country, farmers never emerged from the transient 1920 depression. Too many were still owing money to the bank, and their women were not enjoying the glitz of the new Jazz Age.

By the mid-1920s, America's farmers in the Midwest and South had their backs to the wall; the veterinarians went with them. The agricultural economy had tanked, consumer goods were costly or out of reach, and prices for corn and hogs were below what it took to produce them. But high freight rates and local taxes continued. Farm income dropped precipitously, from $15.5 billion in 1919 to $8.1 billion in 1921. More than two-thirds of bank failures took place in ten states of the South and Midwest. Veterinarians were not being called, and livestock diseases were compounding hard times on the farm.

A farmer in Eden Township got his leg caught and mangled in a corn picker. A salesman who had dropped by rushed him to St. Thomas Hospital in the county seat. There was limited money for vaccines and no doctor had insisted he be immunized for tetanus. Ten days later farmer Ladwig died the painful death of unremitting muscle spasms from tetanus. It was the midst of the agricultural depression and there was little income to deal with the many outstanding bills. Farmer Ladwig did leave one legacy for veterinary medicine—his young son Vaylord, who would enter veterinary school in 1939 and achieve fame for his work in diseases of swine.

The rural veterinarian, no longer a "horse man," was now the man who determined profit or loss should bovine tuberculosis, hog cholera, swine brucellosis, or any other serious disease break out among farm animals. Hog cholera vaccination had saved pig farmers, but now many could not afford the vaccine. The same was true for other vaccines, such as the new bacterins to protect against hemorrhagic septicemia and tetanus. The mosquito-borne disease western equine encephalitis was sweeping the Midwest and there was a vaccine for that too—if you still had horses.

21. AGRICULTURAL DEPRESSION AMIDST A NATIONAL BOOM: THE 1920s

Veterinary college enrollments dropped precipitously during World War I. When the war ended, students returned to veterinary school but not at prewar levels. In 1920 there was a marked decline; reductions in 1921 were still more precipitous and in 1922 there were no appreciable gains. Student numbers in private schools were serious: that year, enrollment in the private Indiana Veterinary College dropped from 137 in 1921 to 69 the next year; in Missouri, matriculation in the St. Joseph College of Veterinary Medicine went from 102 to 74. In the *American Veterinary Review*—renamed the *Journal of the American Veterinary Medical Association*—there were advertisements for free tuition for veterinary students from the Agricultural and Mechanical College of Texas and from Michigan Agricultural College. At Iowa State College, by 1924 the graduating class of the Division of Veterinary Medicine was half the number finishing in 1918. In the Veterinary Clinic, too, patient admissions were down. Several days might pass without any animal being admitted, and at one point there was only one large animal in the hospital pens. Academic veterinary medicine was again at a crossroads (see appendix IV).

In rural veterinary practices there were still many apprentice-trained veterinarians. John R. Mohler, chief of the Bureau of Animal Industry—the BAI—explained at the 1922 annual meeting of the American Veterinary Medical Association that fully one-third of all veterinarians licensed to practice by individual states had not graduated from an approved veterinary college and did not have adequate training to administer and interpret the results of the tuberculin test. In the Midwest, there were scalawags with offers for veterinary education focused on specific problems: Farmer Miles's school at Charleston, Illinois, Graham's Breeding School at Kansas City, and Salsbury's Poultry Disease School at Charles City, Iowa. These tiny proprietary "schools" were owned by one person or a small group, operated for profit, and under the total control of the owner. They were offering limited veterinary science with the intent to qualify for veterinary practice of limited scope.

Private veterinary schools were responding by reducing entry requirements. At the May 1919 meeting of the Federation of Veterinary Colleges of North America held in Chicago, the private veterinary schools had decided not to maintain the entrance requirements prescribed by the surgeon general for the Army—and adopted as their own by the AVMA—but instead to meet only the lower requirements of the BAI for examination for a position as BAI veterinary inspector. But the nation needed veterinarians with more science, not less. Their actions sealed the fate of the private veterinary schools, and within five years they were no more.

The George Washington School of Veterinary Medicine closed in 1918.[1] The Chicago Veterinary College, like the state veterinary schools, had increased its curriculum to four years, but it was too late; the school rapidly declined after

World War I ended and closed its doors at the end of term in 1920. It had operated for thirty-seven years with 2,610 graduates, one of whom, Alonzo Melvin, was the second chief of the BAI. But veterinary education and the demands for science had changed. The Kansas City Veterinary College closed, sending students and their records to Kansas State College; some students went to Colorado Agricultural College and others to the private St. Joseph Veterinary College in Missouri.[2] The Indiana Veterinary College took in students from the closed Chicago schools and held on until 1924, and three years later the last private school, the U.S. College of Veterinary Surgeons in Washington, D.C., closed its doors.

Practicing veterinarians wanted to know what the outcome would be. Veranus Moore, the new dean at Cornell University, addressed the issue, noting that in 1910 there had been nearly 12,000 licensed veterinarians in the U.S. but in 1922 there were only 8,692 graduate veterinarians. He gave three reasons for the decline: the motor car, the bad agricultural economy, and extension of a federal mandate to test dairy cattle for tuberculosis.[3] Correct on all points, Moore glossed over the impact of the last point.

Dairy farmers were objecting to tuberculin testing, but tuberculosis in cattle was emerging as a lethal zoonotic disease, and the enormity of the problem in human health was only now being recognized. One public health challenge—bovine tuberculosis—was shifting the focus of veterinary medicine.[4] Emphasis was now on science and the demand was for college-trained *graduate* veterinarians. Apprentice-trained veterinarians were disappearing: in Edenville, Iowa, H. S. Titus placed an advertisement for the sale of his practice in the *Journal of the American Veterinary Medical Association*.

In 1922, the *Journal* published an agonizing letter about W. D. Odom, an employee of a Georgia dairy farm; it was his personal testimony on the danger of tuberculosis in milk. Ten years previously, in the fall of 1912, veterinarian W. M. Howell, the meat and milk inspector in Valdosta, Georgia, had TB-tested the progressive dairy herd with which Odom worked. Using the new intravenous tuberculin test, Howell found one "reactor"; the cow was killed and shown by postmortem examination to have tuberculosis. The second cow, judged "suspicious," was removed from the dairy but moved by Odom to his residence in Columbus, Georgia, to be milked for his family—and to prove his belief that tuberculosis could not be "contracted from cows." Odom "felt that the office of Milk Inspector was graft, to give some man an easy job." He was wrong. In the next ten years bovine tuberculosis caused the death of his wife, the permanent disability of his son, and the hospitalization of his two daughters for years in a tuberculosis sanitarium. The *Journal* included a heartbreaking photograph of Odom and his dwarflike seventeen-year-old son, Jesse, whose tuberculosis had settled in his bones. Jesse weighed fifty-one pounds; he had weighed fifty-four pounds in 1912.[5]

Tuberculin, the product used by veterinarian Howell in Georgia, was a crude suspension of tuberculosis bacillus proteins that had been developed by Robert Koch to treat tuberculosis. It didn't work in human patients with active tuberculosis: when injected intravenously, it caused fever but had no effect on the disease. Taking note of its capacity to incite fever, physicians began to use tuberculin as a diagnostic agent; it gave confusing results. In London, nine out of ten individuals given the test reacted positively, yet only one in ten had active tuberculosis.[6]

In the U.S., veterinarians began to use tuberculin as a diagnostic test for cattle. Known in the trade as Koch's Old Tuberculin, it could be ordered from Pasteur Laboratories in Chicago, New York, and San Francisco. Given *intravenously* to a cow, tuberculin produced a measurable increase in body temperature to indicate the cow had active tuberculosis. The first published article on the tuberculin test in cattle had been from a lecture given by Leonard Pearson at the Pennsylvania Veterinary Medical Association meeting in Allentown on September 5, 1892. It was a time-consuming method. Pearson recommended a temperature reading at the time of intravenous tuberculin injection at 6 p.m. and for fifteen hours thereafter at three-hour intervals. Veterinarian John Faust of Poughkeepsie, New York, was the first to use tuberculin to diagnose tuberculosis in cattle on the farm. On May 19 and 20, 1893, he tested a herd of thirty-four cows in poor health; thirty-two were condemned and slaughtered. The New York State Board of Health did postmortem examinations and found advanced tuberculosis in all. The report, printed in tabular form, was sensational.[7]

Tuberculin testing of cattle in Iowa was begun about the same time.[8] The federal government's demands that cattle be tested for tuberculosis was not sitting well with some farmers despite the scary evidence of danger. Veterinarians were caught in the middle. Bovine tuberculosis had emerged as a hidden public health dilemma and a serious killer of humans, particularly children. The BAI produced a "moving picture" on stories of milk-transmitted tuberculosis called *Out of the Shadows*, sending it free to theaters throughout rural areas.

PRESIDENT OF THE AMERICAN VETERINARY Medical Association in 1924, Iowa State College's Dean Stange addressed the AVMA with the comment that research and education must be depended upon to keep the veterinary profession from lagging behind its sister professions. Others were saying that no more schools were needed at the time, but the ones that were still open would have to be improved in order to meet the demands of the future. Even in the state institutions, enrollment in veterinary schools was low. In his 1924 presidential address, Dean Stange also pressed for adoption of the statement of policy: "There is a lack of recognition in the profession as well as outside as to the real purpose. . . . No country on earth is so safe for animal industry as is this continent, due very largely to the organization and efficiency of the veterinary profession. . . . These facts, however, have an economic and sociologic significance not generally understood."

By the late 1920s, colleges of veterinary medicine in the land grant state universities were again prospering, with larger classes and increased funding. Faculties had stabilized, perhaps too much so, but the professors would be the men who guided the schools for the next ten years. Most were in mid-career, were well-trained, and would be leaders in the science and education of the profession for two decades. The more progressive agriculture and veterinary schools had found a new way to reach farmers. Radio station KSAC at Kansas State had been the first to have a regular program on veterinary medicine in 1924; it was instrumental in changing the minds of the public on tuberculosis testing. Stange soon followed in Iowa, using WOI, the new radio station on campus, to promote animal health issues in Iowa. He also organized the first student chapter of the AVMA to promote professional development. Some weren't getting the message.

Although most didn't see it, times were changing. Dogs and cats were requiring more sophisticated treatments, public health institutions needed veterinary expertise, and infectious diseases in large medical centers began to seek help for their laboratory animals. The Mayo Clinic had first hired a veterinarian to care for its experimental animals in 1915. In 1922 it added John G. Hardenbergh, and then Carl F. Schlotthauer[9] in 1924—both would be leaders in the veterinary profession.

THE ECONOMIC DISASTER OF THE 1920S agricultural depression had driven rural parts of the nation to a moral crossroads. Concerned about slang, couples in parked automobiles, Spanish fly, and "illicit dancing," citizen groups were adopting control regulations. In rural Iowa, a notice was posted in the Ringsted

Opera House banning "wiggly dances." At the University of Iowa, Professor Frank J. Miller argued that "in the age of jazz, our speech is clipped and clawed, mangled and misused, bespattered with obscure and obscene frothings from the melting pot."[10] Most complaints were trivial; some were transformed into regulations that were not.

In Tennessee, farmer and state representative John Butler successfully lobbied for an anti-evolution law. The Butler Act, passed by the Tennessee legislature in March 1925, made it unlawful to teach human evolution in any state-funded school. Because similar laws had been addressed in South Carolina and Kentucky, the American Civil Liberties Union announced that it would finance a test case should anyone be accused, and when substitute teacher John Scopes agreed to be tried for violating the Butler Act, the contrived event was underway. Held in the small town of Dayton, Tennessee, in July 1925, it was the first trial to be broadcast on national radio.

As expected, the Scopes Monkey Trial—*State of Tennessee v. John Thomas Scopes*—drew intense national publicity. William Jennings Bryan argued for the prosecution and Clarence Darrow spoke for the defense. But it had been rigged. The town of Dayton promoted the trial for publicity, the fundamentalist atmosphere favored the prosecution, and the pro-biblical judge threw out some of the defense's countering use of the Bible. Scopes was convicted and fined $100, but the trial was thrown out on a technicality.

Although a political hoax, the trial did energize fundamentalists, and by 1927 there were thirteen states that had considered some form of an anti-evolution law. Creationism arrived as a concept, not from Tennessee or any other place in the South but from places like California and Michigan. It would continue in various forms well into the next century.

The reigning moral crusade in the 1920s boom had not been creationism but Prohibition, and it packed so much political muscle that at the time most politicians didn't oppose it. The Anti-Saloon League was the Moral Majority of its day, the vanguard of a powerful fundamentalist movement that pushed anti-evolution legislation as vehemently as it did its war on booze. The Scopes Monkey Trial in Tennessee seemed to have sparked and promoted the anti-intellectualism that carried the day.

WHEN THE INFLUENZA PANDEMIC OF 1918–1919 had dissipated, there was no agreement on what microorganism had caused the disease in either pigs or humans. Streptococci and other bacteria had been isolated from human influenza patients who were reported to have caused the disease, but no scientist could fulfill Koch's postulates for proof—that the responsible organism could be cultured in the laboratory and the cultures, when injected into animals, faithfully reproduced the disease. Chamberlain filters were being used to establish that viruses caused influenza, but there was no animal model for influenza, and the 1918 influenza viruses were too dangerous to try human inoculation to prove that filtered nasal washings would cause influenza.

In Britain, the government's Medical Research Council had dedicated its funds to investigations of filterable viruses as causes in human disease, and in 1922 it hired microbiologist Patrick Playfair Laidlaw to develop a research program devoted to filter-passing agents that caused human disease. Research was to be done in Laidlaw's laboratory at the National Institute for Medical Research, a forty-acre agricultural site at Mill Hill in north London. Funds from private sources were obtained for the Medical Research Council to construct a small laboratory at the site with space to house animals.

Laidlaw enlisted the research farm veterinarian G. W. Dunkin to help develop an experimental animal model of human influenza. They selected canine distemper, an ancient plague in Britain, as the best model. Frenchman Henri Carré had reported a virus as causing canine distemper and the Italian Pontoni had produced a vaccine for the disease, but the English-speaking world was skeptical. As with human influenza, the cause of canine distemper was proposed to be a bacterium.

Canine distemper had been a worldwide plague of dogs and foxes for over a century—Edward Jenner of smallpox vaccine fame had published an accurate clinical description of it in 1809.[11] Early clinical signs suggested kennel cough, but distemper rapidly progressed to pneumonia, with discharges of mucus and pus that produced scabby rings around the eyelids and nose; it was particularly dangerous in puppies. The clinical signs and pathologic lesions of acute canine distemper resembled those of the severe human influenza that had occurred in 1918–1919; and just as in the medical dogma of human influenza, the cause of canine distemper was being debated: was it caused by a virus, as reported by Carŕe, or was it due to the bacterium *Bordetella bronchiseptica* that was being isolated from the lungs of dogs with distemper? An editorial in the *Journal of the American Veterinary Medical Association* declared: "*Bacillus bronchisepticus* has been accepted as the causative agent of canine distemper in this country."[12]

Turned out, dogs were not an ideal model for human influenza. The experimental disease was variable and, although pneumonia was complicated by secondary bacterial infection just as in human influenza, canine distemper was capriciously lethal: it destroyed the lymphoid system of the dog and consequently the dog's capacity to produce immunity. Dogs that survived acute disease progressed to a variety of lethal, tissue-damaging processes, including destruction of intestinal linings, bloody diarrhea, and encephalitis. And using dogs seemed to be inhumane (and also would attract noisy antivivisection protests).

In 1924, Laidlaw and Dunkin began to use ferrets, highly susceptible to canine distemper, as an experimental animal. Nasal fluids from a dog sick with canine distemper, which they filtered to remove bacteria, when dropped into the nose of ferrets regularly produced disease. Within forty-eight hours, ferrets were dying of respiratory infection and pneumonia.[13] This discovery of canine distemper virus by Laidlaw and Dunkin was the beginning of a long and distinguished decade that included a distemper vaccine that saved the lives of millions of puppies. Their research also gave rise to the discovery of human influenza virus at Mill Hill in the 1930s[14] and, in the 1950s, to the discovery of interferons, a family of signaling proteins produced by virus-infected cells that induce nearby cells to activate their antiviral defenses and speed to recovery.[15]

22. 1929: PRELUDE TO BAD TIMES

The stock market crash and bank failures of November 1929 put the entire country in a downward spiral and into the Great Depression. Urban folks were in the tank and seemed worse off since rural areas had adapted to hard times. But now there was widespread unemployment and financial collapse—not only in America but globally. For farmers there were bank failures, farm foreclosures, and loss of income. In Edenville, Iowa, both the Farmers Savings Bank and the Rhodes Savings Bank went under. For veterinary students, studies seemed to be more serious and frivolity less appropriate.

As the Christmas season of 1929 began, prospects for a merry holiday seemed grim. For those receiving the gift of a pet bird, there was an added unwelcome gift. In Baltimore, the pet shop on North Eutaw Street had parrots for sale. On

Veterinary Pathology class, Iowa State College, 1929 (Class of 1932). Formal dress was required for class. Professor Benbrook, against the windows; Assistant Professor Merchant in back corner at right; Roy Conaway, future practitioner in Edenville, fourth person from bottom in the middle (third) row.

December 15, Simon Martin, a chamber of commerce worker in Annapolis, Maryland, bought a parrot for his wife, Lillian. He asked his daughter and her husband to keep the bird for ten days so that Lillian might be surprised on Christmas Eve. By then the parrot was not eating, had lost weight, and seemed to be breathing with difficulty; it had puffy inflamed eyes and droppings that were watery and greenish. The next day the parrot was dead. By the new year, the Martin families were severely ill with similar signs—cough, headache, and fever that rapidly progressed to pneumonia. On January 6, 1930, they were examined by a physician, who sent a report to the Baltimore City Health Department. Knowing of an outbreak in California of a disease among bird fanciers called parrot fever, the Health Department sent a telegram to the U.S. Public Health Service in Washington, D.C., which forwarded the message to George McCoy, director of the U.S. Hygienic Laboratory, the nation's first medical microbiological facility.[16]

New cases of parrot fever soon appeared. Four employees of a Baltimore pet shop fell sick. Then, Daniel Hatfield, chief of communicable diseases in the Baltimore City Health Department, sickened and died on January 23; his assistant, "Shorty" Anderson, died on February 8. Those deaths got political attention. In Baltimore the mayor alerted the governor. New cases popped up in Providence and Chicago. In Toledo, Ohio, a woman whose husband had returned from Cuba with two parrots died. The *Washington Post* reported that "parrot disease baffled the experts." It had killed influential citizens and press coverage was immediate and intense.

About the same time, veterinarian Karl Friedrich Meyer,[17] the director of the George Williams Hooper Foundation for Medical Research in California, reported in December 1929 that shell parakeets (lovebirds) from a San Francisco pet shop had caused pneumonia in humans. Meyer's investigations on what he called psittacosis were instrumental in discovering the nature of the microorganism and how it spread in birds and other animals. *Chlamydia psittaci* became the prototype of a new class of animal and human pathogenic bacteria.[18]

At the U.S. Hygienic Laboratory in Washington, D.C., medical pathologist Charles Armstrong had been placed in charge of the parrot fever investigation. Armstrong tracked down thirty-six parrots sold by the Baltimore pet store before Christmas and traced the disease to humans in several states. The causal bacterium was detected by injecting mice with samples of blood and nasal discharges from patients and examining their tissues for proof of disease. Armstrong sought the full host range of the organism by exposing parrots as well as guinea pigs, monkeys, and pigeons to infectious material.

George McCoy, the U.S. Hygienic Laboratory director, seeing the highly infectious nature of the disease and the hazards involved in laboratory work, tells Armstrong to be more careful in handling diseased animals. Armstrong's response was that disinfecting premises, cages, and equipment would take time away from their studies. It was a mistake. Armstrong developed parrot fever, and in March, when the prognosis seemed lethal, McCoy took over the parrot fever work—successfully treating Armstrong with convalescent antiserum from a recovered human patient. Nine more Hygienic Laboratory employees sickened the next week and McCoy ordered the building evacuated, the test animals killed and incinerated, and the building fumigated. On May 26, 1930, the U.S. Congress passed the Ransdell Act, which provided $750,000 for destruction of the abandoned U.S. Hygienic Laboratory building and for construction of two new replacement buildings; Congress also approved a change in the laboratory's name to the National Institute of Health.[19]

Veterinary faculty, Iowa State College, 1929.[20] Front row (*left to right*): Anderson, Foust, Benbrook, Dukes, Merchant, Walsh, Purwin, McNutt, Lee. Back row (*left to right*): Emmerson, Covault, Aitken, Biester, Rice, Chivers, Stange, Murray, Bergman, Patterson, Guard. F. D. Patterson, a Black American, became president of Tuskegee Institute and founded its College of Veterinary Medicine. Dukes achieved international acclaim as a physiologist at Cornell and Guard the same as a surgeon at Ohio State. Rice, suffering from laboratory-acquired brucellosis, died a few weeks after the photo was taken. Stange, Murray, Bergman, and Merchant[21] were successive deans at Iowa State College from 1909 to 1963.

IN 1929, VETERINARY DIAGNOSTIC LABORATORIES were dangerous places. Ill-equipped to handle dangerous pathogens, their staff was at risk from rabies, tetanus, and other plagues. The laboratory at Iowa State College was still operating in the cramped quarters of a basement in the Veterinary Quadrangle. C. D. Rice, the veterinarian in charge, developed a small linear skin wound on the back of his neck. Rice had worn a rubber apron with a contaminated cloth band around his neck that passed over the area. The wound slowly progressed with nasty inflammation and redeveloping scabs. The site had been infected with *Brucella abortus*, the cause of brucellosis. There was no treatment and no cure. The disease rapidly progressed as bacteria spread into the bloodstream and throughout his body. Rice died after suffering for six weeks. His obituary in the campus magazine *The Alumnus* noted that after hovering between life and death for three weeks he died in the college hospital on November 18, 1929: His "infection went through its cycles, his temperature rising from normal to above 107 and falling at regular intervals. Each recurrent onset of the disease left him so much weaker." Dean Stange gave the laudation at his funeral.

THE ENROLLMENT CRISES OF THE 1920s had subsided. They had been severe at The Ohio State University, where the faculty committed to a promotional program to attract students. Tuition and fees were reduced, county agents were encouraged to promote veterinary school, and radio station WEAO (now WOSU) was used to promote college programs. It worked. In 1929, David S. White retired as dean after thirty-four years and was replaced by Oscar V. Brumley, veterinary pathologist, secretary of the college, and coach of the veterinary student soccer team that won the intercollegiate tournament. Brumley departmentalized and led the college to astonishing success for sixteen years.

As the fall term ended in 1929, academic deans were concerned about the declining morals of students and what seemed to be a declining interest of young people in veterinary medicine. After U.S. president Warren Harding died, the scandals of his presidency came into the light, including the oil rights Teapot Dome scandal, corruption in the Justice Department, a Veterans Bureau scandal, and Harding's affairs with his mistresses. It seemed a losing task to promote virtue among the students.

The nationwide social ambience of the 1920s provided fodder for backsliding. To faculties, it seemed to be an "anything goes" environment, and the scandals of the Harding presidency did little in the way of providing examples. Old social rules were out. Iowa State College students were now allowed to play cards and dance. Alcohol was still excluded from campus and Dog Town, and Professor Covault still periodically made the rounds of the downtown bars to send any veterinary students home with a reprimand and threat of expulsion.

In 1929, near the campus of The Ohio State University, a twenty-four-year-old medical student named Theora Hix was found brutally murdered, her body dropped in a rifle range. An autopsy determined that she had been struck twenty-nine times in the head with an instrument like a ball-peen hammer; curiously, there was a discrete cut in the neck that with some precision had severed the carotid artery. Information from neighbors was that a short, stocky, well-dressed professional-looking man wearing glasses had been frequently seen with Hix. First settling on a young horticulture faculty member who had left residua of his fixation and attempts to date Hix, the police received information that veterinary school professor Snook was the authentic boyfriend.

James Howard Snook was a successful and high-profile professor and head of the Department of Medicine in the veterinary school. He had invented the Snook hook, a surgical instrument used worldwide to retrieve the uterus from the abdominal cavity in spaying dogs and cats. He was a founding member of the Alpha Psi veterinary fraternity and a member of the U.S. Olympic Pistol Team, which won the gold medal in the men's thirty-meter team military pistol event at the Olympics in Antwerp, Belgium.

Snook had a three-year sexual affair and wanted to end it and eliminate the traces to spare his wife and family from scandal. He was arrested and tried for the murder. The jury was shocked by the activities and the language used to describe their sexual encounters. Words unknown to the jurors were devastating to the case. Hix had been a femme fatale of sorts who used cocaine and barbital as well as cannabis and cantharis (aka Spanish fly), and Snook had helped her to procure drugs from an Ohio State University pharmacy. Worse from Snook's view was that when petulant she taunted him that his penis was smaller than that of her other lover.

The trial lasted thirty days, but the jury took only twenty-eight minutes to convict Snook. He was sentenced to death and executed in the electric chair at the Ohio Penitentiary on February 28, 1930. Snook was buried in Columbus. His tombstone omitted his last name; it read simply James Howard.

23. PUBLIC HEALTH AND DISTRUST OF GOVERNMENT: THE TUBERCULIN WAR

For rural veterinarians, the 1930s were sobering times. Clients were paying the bills with meat and produce, and often with sewing machines, typewriters, and other accoutrements purchased in better times. Income in rural practices declined with livestock prices, and mass production of the Model T Ford accelerated its takeover of the horse. More veterinarians were leaving practice to work in public health; college courses in meat and dairy products inspection had become an integral part of veterinary education. But still, less than half of the animals produced for meat in the U.S. were subjected to government inspection—most were being killed by the butcher in small towns and villages.

During the Depression, veterinarians flocked to professional meetings to learn new science—always in formal dress despite the searing heat of the Midwest and Great Plains. In states without veterinary colleges, departments of veterinary science in colleges of agriculture kept rural veterinarians abreast of new techniques, changes in regulatory law, and political winds. Veterinary practitioners meeting, Oklahoma A&M College, Stillwater, Oklahoma, 1930. Keynote speaker Benbrook in fourth row, fourth from left.

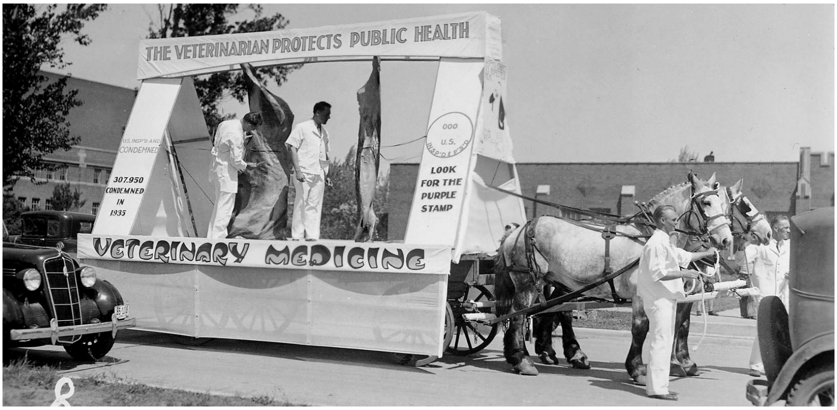
By 1930, it was obvious that bovine tuberculosis was spread through milk to humans and was responsible for a disturbing share of the fatal disease nationwide, yet some farmers still refused to remove tuberculous cattle from their herds. In the United States, fifty thousand people were dying annually of tuberculosis. In humans, tuberculosis was called consumption because it consumed the patients in a protracted agonizing death. Most cases were caused by the human pathogen *Mycobacterium tuberculosis*. But cattle carried their own strain, *Mycobacterium bovis*, which caused the same progressively fatal disease in owners of tuberculous cattle and in people who drank raw milk. Contaminated milk was particularly dangerous for young children. The New York Board of Health stated in a report that "a large percentage of infant tuberculosis . . . is of bovine origin." Ten percent of tuberculosis-causing chronic bone disease and arthritis in humans was due to *M. bovis*.

Cities and towns were establishing public health officers they called sanitarians. Almost all sanitarians were veterinarians, and for them, tuberculosis was a growing concern—not only because it had such impact on animal and human health in rural areas but because using tuberculin injections to test for TB in cattle had become controversial and sometimes dangerous.

Where bovine tuberculosis was rampant, farmers were still resisting attempts to cull their herd of infected cows—and they were organizing. Called on to prevent the spread of this terrible disease, some veterinarians were caught in the middle of their oath to care for animals and public health and the resistance of angry and hostile farmers to test for the tuberculosis in their herd.

The cooperative federal-state-industry effort to eradicate tuberculosis from cattle had been initiated in 1917, and the Iowa Legislature passed the Iowa Tuberculin Law a few years later. Federal veterinarians were employed to test all cattle herds with tuberculin—injecting tuberculin subcutaneously and measuring body temperature twenty-four hours later: a rise in temperature suggesting tuberculosis. The test's specificity and sensitivity were problems but it was the only test available, and even though imprecise, tuberculin did detect tuberculosis in seriously infected dairy herds.

In 1930, the inaccurate temperature test was replaced by a new reliable and proven-effective skin test using an improved tuberculin. The test was done by the veterinarian, who lifted the tail and, using a tiny needle, injected a very small



Food safety and public health became a province of veterinary medicine in the 1930s. Veterinary student parade entry, Iowa State College annual student celebration VEISHEA in 1937. VEISHEA was coined from the five divisions at Iowa State College: Veterinary Medicine, Engineering, Industrial Science, Home Economics, and Agriculture. The importance of veterinarians in public health expanded in the 1930s.

amount of tuberculin into the hairless fold of skin under the tail head. The veterinarian returned the next day to "read" the test. If the cow was normal, so was the skin at the injection site; if the cow had tuberculosis, the injection site would be inflamed—red, warm, and swollen. The federal program was carried out by the Bureau of Animal Industry, who produced and used a new purified and standardized tuberculin for all tests, labeled PPD, for purified protein derivative.

The federal tuberculin testing law over which controversy arose provided that Iowa was defined as an accredited area for the eradication of bovine tuberculosis. Cattle were required to be tested and to be condemned if the tuberculin test was positive. Under the provision of the law, indemnities were paid to farmers whose cattle reacted to tuberculin. But some farm groups were resisting. In 1931, the fight against tuberculin testing flared intermittently until March, when objectors refused to permit testing of cattle on several occasions, gathering in force to prevent tests from being done.

On March 9, 1931, when veterinarians attempted to complete the tuberculin test on cattle at the William Butterbrodt farm near Tipton, Iowa, a force of twenty state agents and deputies was called in for protection. They were defied by several hundred farmers. The deputies were armed but had instructions not to fire. Nonetheless, several vigilantes were hit in the back of the head and the sheriff, receiving a blow in return, called the state's Department of Criminal Investigation, saying the situation was beyond his control. Peter Malcom, chief of the Iowa Division of Animal Industry, was attacked, the radiator of his car filled with mud, gas line broken, tires slashed, and windows smashed. Newsmen and photographers were called unkind names; some were beaten.

A judge issued an injunction restraining the farmers from interfering with the tests, but on August 21, veterinarians were repulsed in attempts to test cattle at three other farms. The farmers were cited for contempt, and farmer Fogg pleaded guilty and was fined $50. The others pleaded not guilty and were released on $100 bonds. Their fight was carried on in the courts and in the state legislature, but an attempt to obtain repeal of the compulsory test law failed in the general assembly. Several times, test suits instituted in various counties were carried to the Iowa Supreme Court but were dismissed when that body held that it did not constitute a federal question.

Mr. Lenker, the state president of the Farmers Protective Association, and Curtis McKinnon of New London, vice president, broadcast objections to the test over an Iowa radio station at noon. "We are opposed to the bovine tuberculin test as it is administered because we consider it unreliable, inaccurate, because it doesn't detect the worst reactors, because it ruins our cattle, because many of the tested cattle die while others abort and give milk that is unfit for human consumption," said Mr. McKinnon, adding that "the present program was put over by fraud and misrepresentation." C. F. Curtiss, the dean of Agriculture at Iowa State College, was attacked for being a director of Armour & Co. "God gave us the cow, and what God gave us, no veterinarian can do better," concluded McKinnon.

Deputies met at the courthouse at Tipton shortly after noon Monday and then went to the J. W. Lenker farm southeast of Tipton, near Wilton Junction. They were followed by a crowd of about four hundred objecting farmers who had defied a posse of sixty-five deputies and had driven them from the farmstead. Clubs and showers of mud were used by the crowd of defiant objectors to drive the deputies from the farm. After several automobile windows were smashed and several deputies injured, the deputies abandoned their attempt to enforce the test and left the farm. Tear gas bombs had proved ineffective and it was decided that a stronger force was needed to carry out the objective.

Iowa governor Dan Turner, on a mission to Washington, D.C., issued a proclamation with a message for the press: "If we don't have law and order, we haven't got anything," Governor Turner said. "The tuberculin test law is the plain law of the state and will be carried through. We are not going to let up a bit." National Guard adjutant general W. H. Bailey was instructed to order out soldiers to enforce the bovine tuberculin test law. By Monday night, a force of 1,880 troops had been mobilized. Mobilization orders were underway for thirty-one units, one-third of the National Guard strength of the state. Troops convened in Des Moines, then left on the Rock Island train at 7 a.m. the next morning. National Guard units that mobilized came from twenty counties. Service units also mobilized included medical units but not the band. Although the cavalry troops were used, their horses were not taken to Tipton.

Field headquarters of the 113th Cavalry was located three miles north of Durant at an appropriately named site, the Bunker Hill School. Its duties were to block the roads leading to farms where veterinarians were testing cattle. Cattle testing was to begin as soon as all were in camp. Military units encamped at the county fairgrounds. Army life in Camp Bovine wasn't all that great for the troops. Arriving after dark Tuesday night, soldiers had to pitch their tents by artificial light. A drenching rain fell at 6 a.m. Wednesday as reveille sounded, but skies cleared before noon. Four members of the Centerville football team that had gone through the 1930 season 10–0 were scheduled to play Moulton on Friday. A Centerville player said there was one consolation: "We understand two members of the Moulton team also are in camp."

All passes to the camp were revoked after 6 p.m. But further relief had come when some of the objectors drove up to the camp during the afternoon with a wagonload of watermelons and distributed them among the troopers. The astonishing civility between troopers and farmers was seen again the next day when farm wives served coffee and cake to the soldiers and veterinarians—a quirkiness of Iowa civility no longer seen.

The *Des Moines Register* headlines on Thursday morning, September 24, were "STATE TO TEST CEDAR COWS TODAY" with subheadings of "Troops Ready to Use Force if Necessary" and "Lenker Farm Believed First on List: Says He Sold Herd." The 168th Infantry was moved to the Lenker farm north of Wilton early in the morning of September 24 to protect the state's cattle testers.

Cattle testing began the next day. Veterinarians worked in four groups, each group accompanied by a troop of 113th Cavalry and a machine gunner from the 113rd Infantry. On Friday morning, September 25, the *Des Moines Register* headlines were "STATE TESTS LENKER CATTLE HERD." The subheadings of "Believe Cedar Resistance Is Near An End" and "Soldiers Locate Stock After Chief Objector Is Arrested" told the story. Reporting from Tipton, the *Des Moines Register* stated that "the backbone of resistance to enforcement of the bovine tuberculin test in Cedar County seemed to have been broken Thursday night when veterinarians and guardsmen climaxed the arrest early in the day of J. W. Lenker, principal objector, with the discovery and injection of his herd during the afternoon." Lenker was sent to prison in Anamosa.

A petition was circulated at a mass meeting of Henry County residents that threatened nonpayment of the remainder of the year's and 1932 taxes if Governor Dan Turner did not accede to their request that Lenker be released from the Anamosa Reformatory and that soldiers be removed from Cedar County. Further resistance to state veterinarians attempting to test cattle for tuberculosis under the state law occurred on Sunday, when one thousand men and women gathered in a protest meeting under leadership from the Des Moines County Farmers Protective Association.

On October 23, the foes of the test dispersed as the crisis neared and as all of the fourteen hundred members of the National Guard encamped at the fairgrounds in Burlington were activated. The last of the guardsmen arrived by train from northwest Iowa on Thursday evening. There was no active resistance as the cattle were tested by twelve veterinarians.[22]

Most farmers understood the long-term benefits of having tuberculosis-free herds. But with the overzealous push by the organizers, it was understandable that farmers with productive purebred herds were those most angry about the test program. Loss of high-producing cows would take their profit, and in some cases their business, as the indemnity paid would not cover the price of an expensive purebred animal.[23]

At the other extreme there were poor-quality herds where a scammer welcomed the test. During the waiting period, after tuberculin had been injected under the skinfold, these scalawags would severely pinch the test site with pliers, causing acute inflammation that would be read the next day as positive. They would be paid indemnity for the worthless cow that greatly exceeded its price on the market. So it goes with any federal program ever devised.

24. A DEPRESSION PARADOX: CULTURE AND SCIENCE

Contradicting most predictions in the 1930s, veterinary colleges were having steadily increasing enrollments—up at both rural Iowa State College and urban Penn. The economic downturn had restricted incomes of rural veterinarians, but it had also reduced the "opportunity cost" of college. During good times, the cost of lost earnings by going to college is high; in the 1930s it was low—high school graduates, facing scarce jobs and poor wages, were increasingly leaning toward college. Veterinary medicine was changing focus, and that, too, was a pull into the profession.

At the 1933 annual meeting of the American Veterinary Medical Association in Chicago, Iowa State College dean C. H. Stange, with no small prescience, argued that educational change was required to meet "difficulties in getting some members of our profession, who were educated primarily in diseases of the horse, to interest themselves in diseases of cattle and swine. . . . The lack of interest in food hygiene in many sections is undoubtedly due very largely to the fact that the veterinarians as students received little or no instruction in this subject . . ." From Kansas State College, Dean Dykstra writes to Stange, congratulating him on Iowa State's progress and reminding him that of the eleven veterinary colleges in the U.S., five had deans that were Iowa State graduates.

Many editorialists, previously adamant that service to agriculture was the only legitimate objective of veterinary medicine, began to restate their opinions. The scientific education that veterinary students received in anatomy, physiology, pathology, and microbiology, as well as in public health and food safety, was increasing their value to the Army and to several governmental agencies, both state and federal. Employment opportunities for veterinary graduates were growing in meat inspection, disease control, and public health.

The great working strength of American society had prevailed in the 1930s. In tough economic times, Americans have less patience for the false and intrusive religious scolds that thrived in the bubbles of the Harding and Coolidge presidencies. Culture wars were a luxury the country could not afford. Once in office, Franklin Delano Roosevelt jump-started the repeal of Prohibition by asking Congress to legalize beer and wine just days after his March 1933 inauguration and declaration of a bank holiday. The precedent for science, education, and global responsibility was back, and there would be a forty-year exodus for the creationist ayatollahs to again begin their comeback in the 1970s.

Programs of the Roosevelt New Deal got people employed. The new Works Progress Administration, funded for nearly $5 billion (at 6.7 percent of the GDP), authorized building bridges, roads, dams, and school buildings. On the Iowa State campus there were new dormitories and laboratories, and Grant Wood began painting his murals on the walls of the library. The Civilian Conservation Corps was especially important in rural America. Because Iowa had already responded to the depression, a long-range, shovel-ready plan was in place when the CCC program was announced. So impressed was President Roosevelt that he told CCC director Fechner to "give Iowa all it wants."

The massive nationwide closure of poorly run medical schools driven by the Flexner Report had fostered programs that were equally poor in their faculty and training. In Iowa, because of concern that the osteopathic and chiropractic schools lacked science in their programs, the 46th General Assembly passed the Iowa Basic Science Law in 1935. Signed by Governor Herring, the law created a unique medical board, the Iowa Board of Examiners in the Basic Sciences, which was to provide an "examination in the basic sciences" and "issue a certificate of proficiency in the basic sciences, which certificate shall be a pre-requisite to eligibility for examination for license to practice medicine and surgery, osteopathy, osteopathic medicine and surgery and chiropractic or any other system or methods of healing."[24]

The board was to be composed of six members from universities with colleges of medicine, dentistry, and veterinary medicine and was authorized to conduct a written examination on the subjects of anatomy, physiology, chemistry, pathology, bacteriology, and hygiene. The examination was to be given in Des Moines four times each year with a fee of $10. Iowa State professor E. A. Benbrook was a charter member and, when the board was ordered to keep a correct record of the proceedings and the questions submitted in the examination of the applicant, the task was assigned to Benbrook, who had been elected the board secretary. About the same time, an addition to the Code of Iowa made operations of the University of Iowa Hospitals and Clinics and the Iowa State College veterinary hospital exempt from the law that prevented regents institutions from operating competitive businesses.

Dean Charles Stange died on Sunday morning, April 26, 1936, keeling over from a coronary thrombosis while digging dandelions in his front yard. His funeral in the Iowa State College Memorial Union was attended by eleven hundred people; his eight pallbearers were the college professors Covault, Bergman, Foust, Fowler, Walsh, Murray, Benbrook, and Merchant. Stange had been dean since 1909, president of the AMVA, the man behind moving science into the curriculum, and a major force for advancement in veterinary education in North America.

Veterinary students petitioned to have the new veterinary clinic, then under construction, named the Charles Henry Stange Memorial Clinic. Stange's last legacy came from campus sculptor Christian Petersen, who, at Stange's request, designed a large bas-relief for the college with the theme "the protection of human health by guarding animal health through the development of vaccines." The dean at the Art Institute of Chicago, when asked to review the design, noted that "there was too much pain represented" in the "stress and struggles of the animals"; Petersen humanized the profession by adding the *Gentle Doctor* statue to stand in front of the bas-relief.[25]

Iowa State's Edward Benbrook had become one of the premier veterinary pathologists in the nation. Internationally renowned for expertise, he would become a charter member and president of the American College of Veterinary Pathologists and receive the highest distinction for faculty at Iowa State, Covault Distinguished Professor, in 1966. His students Hilton Smith, Russell

Runnells, and Leon (Zlotnick) Saunders achieved international fame in Texas, Michigan, and Pennsylvania. Perhaps his greatest legacies were two graduate students who became pioneers in veterinary medicine: Margaret Sloss, a woman, and Frederick Douglass Patterson, an African American.

25. NEW DEAL: DISCOVERIES IN INFECTIOUS DISEASE

Comparative medicine appeared as an academic department in the largest and more progressive medical institutions in the 1930s. Their mission was to exploit animal models of human genetic diseases, cancer, and nutritional deficiencies. It was a golden opportunity to systematically investigate how those diseases developed, using experiments in animals that could not be done in humans. Departments dedicated to comparative pathology appeared at research institutions as diverse as the University of Michigan, the Armed Forces Institute of Pathology, and the Mayo Clinic.

As microbiology had become an integral part of medicine, zoonotic diseases—tuberculosis, tetanus, and other diseases transmitted from animals to humans—moved to a dominant position in scientific research. Brucellosis was a centuries-old killer that caused abortion in cattle, contaminated milk, and involved a spectrum of disease in humans that included acute "undulant fever," neurobrucellosis, and chronic infections of the spine. It was taking a heavy toll on farmers and consumers alike. In 1936, the Bureau of Animal Industry did field trials in Illinois, Ohio, Maryland, and Wisconsin on a new vaccine for brucellosis that would prevent abortion in cattle. The results were so good that strain 19 vaccination of calves was officially adopted to control brucellosis in cattle.

The brucellosis success story had started with a sick cow in the BAI dairy herd in Maryland. Victor's Lady Matilda, born in Pennsylvania, joined the BAI's herd, where she established two records for milk production before becoming sterile. Serologic tests indicated she had brucellosis, and John Buck, a BAI bacteriologist, isolated the causal *Brucella abortus* from Lady Matilda in June of 1923. Having determined the bacterium to be virulent, he moved on, mislaying a single slant culture under some papers, where it stayed for two years.[26]

Later, when Buck's research had not been going well (killed bacteria were not working as vaccines), he remembered Louis Pasteur's vaccine for fowl cholera, which had come from a dried bacterial culture that had been mislaid. He wondered if his cultures stored at room temperature for two years might also have become weakened—that they might not cause disease yet persist as an infection long enough to make a cow immune. The resurrected bacteria were passed through 19 cultures in the lab (the final culture was called *Brucella* strain 19) and injected into calves. The results astonished Buck: calves given strain 19 developed antibodies and were protected as pregnant adults from abortion; and, just as important, the mutant strain 19 did not spread within the herd. By 1936, the new strain 19 brucellosis vaccine was being used by veterinarians throughout North America.

PROGRESS IN TECHNIQUES FOR CULTURE of bacteria and for understanding how bacteria caused disease in animals and humans had been astonishing. Viral diseases were another matter. Some viruses would infect mice in the laboratory, but most had been impossible to culture in the lab and were difficult to propagate in any meaningful way. A major breakthrough in virus research appeared in 1931. Ernest Goodpasture, a medical pathologist at Vanderbilt University, discovered that many viruses would grow in membranes of the developing chicken embryo. Within a year, influenza virus was being grown in chick embryos. Viruses that caused smallpox, chickenpox, mumps, and yellow fever also grew in chick embryos and were funneled successfully into vaccine production. Research laboratories studying viruses began to order embryonating chicken eggs by the thousands. A chick embryo rabies vaccine was developed to replace the dangerous Pasteur vaccine made of animal brain emulsion. The newly emerging encephalitis-causing mosquito-borne viruses—named arboviruses—grew well in chick embryos; the system was used to produce vaccines for horses against a newly emerging disease, western equine encephalitis. In 1938 a brain-tissue, formalin-killed vaccine had been available, but it was replaced the next year by a more effective vaccine grown in the new chick embryo technology.

AT IOWA STATE COLLEGE, funds accrued from the disenfranchised and demolished State Biological Laboratory for hog cholera antiserum production were used to purchase land south of the campus and to build the Veterinary Research Institute. One of the first mandates was to investigate the confusing syndromes of encephalitis in cattle and horses. One of the institute's contributions was to differentiate the emerging mosquito-borne viral disease western equine encephalitis from "moldy corn encephalitis," which was shown to be due to a toxin from the *Fusarium* fungus that grew on corn.[27]

The Veterinary Research Institute at Iowa State had dropped some projects to concentrate on this new emerging disease. Western equine encephalitis virus in horses was most serious west of the Mississippi River. In the U.S. there were 3,929 cases reported in 1936, 173,889 in 1937, and 184,862 in 1938. The virus had been first isolated from a horse brain in the San Joaquin Valley in California by veterinarian Karl Friedrich Meyer, an American Swiss-born veterinarian. WEE had slowly moved through the West, spreading in a bird-mosquito life cycle. Horses and humans were dead-end hosts; they did not circulate virus in the bloodstream to perpetuate the infection back into the mosquito vector.

The institute had just solved a similar problem in cattle. For four decades a lethal brain disease of cattle called sporadic bovine encephalomyelitis had been killing young cows throughout the Midwest. Calves would become stiff, knuckle

Veterinary students were taught the practical aspects of veterinary pathology in the postmortem room, where they collected specimens of diseased tissue for microscopic examination. Here: autopsy tables in the new Stange Memorial Clinic in 1939. Professors Runnells (*left*) and Benbrook (*right*) are in white coats. Runnells finished his career at Michigan State University, where he wrote the first complete textbook on veterinary pathology.

at the fetlocks, stagger, circle, and fall over. Most would have peritonitis and inflammation in membranes lining the other body cavities. Some veterinarians suspected the disease was caused by a virus; others, a plant poison or toxin. The villain turned out to be a tiny bacterium (now named *Chlamydia percorum*). It was discovered in Iowa at the Veterinary Research Institute in the late 1930s by veterinarian Sam McNutt, who grew the bacterium in the yolk sac epithelium of a developing chicken embryo. According to historian Leon Saunders, "the delineation as a clinical, pathologic, and etiologic entity was due to the efforts of one man—S. H. McNutt."

DRIVING OUT TO THE WEST EDGE of Eden Township in August 1939, Iowa veterinarian Roy Conaway was to attend to a three-year-old quarter horse stallion owned by Hugh Alexander. The acreage lay on the timbered and grassy valley of Clear Creek. Hugh was a good horseman and had two days previously noticed that his stud had been off feed and unable to drink, the water running out of his nose as he tried. By the end of the day he was grinding his teeth and the muscles of his lips and jaw as well, as his tongue and tail seemed to be paralyzed. The next morning, he was lethargic and "stupid," his head hanging low, his demeanor depressed, and unresponsive to stimuli; by nightfall he was walking in circles in one direction, swaying and stumbling. This morning he had been unable to rise after falling.

For Conaway, the diagnosis was easy: high fever, time of year, grassy lowland, progressive neurologic signs—all of which had appeared in three other horses in the area the previous weeks. The brain of one had been sent to the diagnostic laboratory at "the college" and the report had come back as western equine encephalitis—scary because human patients had developed encephalitis caused by the same virus. It was very closely related to the more ferocious eastern equine encephalitis virus isolated in 1931 from horses in Massachusetts (and from thirty children who died in 1938 in the Northeast).

Roy Conaway had been an outstanding athlete who had played football and run track in college. A good student, he was strong and sleek—and highly intelligent. He taught surgery for one year at the new veterinary school at Oklahoma A&M College and had been assistant state veterinarian in Missouri. At the top of his game, he had a beautiful wife and two handsome children. But in the physically demanding rural practice, he would tragically succumb to common risks for veterinarians in rural practice of the time—speed and alcohol. The

Allied Laboratories advertisement for western equine encephalitis vaccine for horses, 1939. (REPRINTED FROM *THE VETERINARY STUDENT* 4 (1942): III. COURTESY OF THE *IOWA STATE UNIVERSITY VETERINARIAN*.)

faster you drove through the countryside the more calls you could make, and more calls meant more money. But speed and alcohol proved fatal. Driving late and alone on a bitter cold January night, Doc Conaway was killed instantly in a one-car crash.

LATE SUMMER OF 1939 WAS AN UNEASY TIME. Hitler's troops had massed along the German-Polish border, Franco ruthlessly consolidated power in Spain, and a Soviet-Japanese confrontation in Mongolia exposed Japan's plans for Asia. Life was unsettling at home as well. Residue of the long Depression and the 1925 Scopes Monkey Trial had fostered conservatism and even creationism that was persisting in rural areas of the country. Steinbeck published his earthy novel *The Grapes of Wrath* in 1939 as a literary response to the Dust Bowl and Great Depression. An immediate best seller, it was burned in bonfires of protest to its language in several places and was banned in Kern County, California, one of the locations in the story. The book was banned in Illinois, St. Louis, and Kansas City, as well as in Ireland and Turkey (where publishers were arrested). Defenders took to the press, suggesting that those banning the book were "afraid of change and new ideas."

PART VI

DUTY REQUIRED

World War II and the Science Boom

The world's most famous veterinarian in 1939 was South African scientist Sir Arnold Theiler. Director of the Onderstepoort Veterinary Research Institute and then founder and dean of the veterinary school at the University of Pretoria, he had discovered, documented, and solved more new animal diseases than any scientist who ever lived. Cattle production could survive in the parasite-ridden terrain of South Africa because of his vaccine against rinderpest. He had been knighted by the British and awarded medals in Germany and France.

Theiler came to the U.S. in 1934 to the International Veterinary Congress in New York and made one side trip to visit Charles Stange and the veterinary facilities at Iowa State College. Theiler's oldest son, Hans, was a veterinarian in Pretoria; his daughter Gertrud, a renowned veterinary parasitologist at Onderstepoort; and his youngest son, Max, an MD, had left for America to work on the fearsome mosquito-borne tropical disease yellow fever. Gone from the U.S. by the 1930s, yellow fever virus persisted in monkeys living in the tropical rain forest canopy in South America. Its reputation as a ferocious killer persisted as well.

The Rockefeller Institute in New York City was America's foremost medical research laboratory and the nation's repository of yellow fever viruses. South African immigrant physician Max Theiler, one of Rockefeller's most eminent scientists, was in charge of the repository. He had, in 1937, developed the extraordinary strain 17D as a potent vaccine. It was close to 100 percent effective in preventing yellow fever and rarely caused side effects—and would win the Nobel Prize in Medicine for Max Theiler in 1951.

Professor Ryōichi Naitō, a distinguished Japanese microbiologist, en route from a meeting in Germany to return to his home laboratory at the Tokyo Imperial University's Institute for Infectious Disease, stopped to visit Max Theiler at the Rockefeller Institute. Naitō was on his way to a new field assignment in Manchuria, which had just been overrun by the Japanese—they had given the three northeast Chinese provinces the new name Manchukuo. By the way, he tells Theiler while at Rockefeller, he wishes to acquire a vial of the highly virulent *Asibi* strain of yellow fever virus. That was very strange. Yellow fever did not exist in Asia, and a League of Nations resolution had prohibited the introduction of yellow fever virus into any Asiatic country. The director of Rockefeller refused Naitō's request.

About the same time, a laboratory technician at the Rockefeller Institute named Glasounoff, who was working on a yellow fever project in monkeys, was contacted clandestinely on the streets of New York by a stranger who would pay him $3,000 if he would get the *Asibi* strain for him on the sly. No deal. Sometime later, Naitō made yet another request by mail for the yellow fever *Asibi* strain from the Rockefeller Institute and, when refused, attempted to obtain *Asibi* surreptitiously from a Rockefeller laboratory in Brazil. As reports about Japanese microbiological laboratories in Manchukuo and their interest in hot yellow fever viruses accumulated in government intelligence offices, the news had a remarkable impact on their preparations for national defense.

26. WAR: THE HOME FRONT

The profound influence of German science and textbooks on American veterinary medicine that had lasted for seventy-five years—from 1860 to 1935—ended when the European War began in 1939. Nazi Germany's multifront exploding war in Europe was making it increasingly difficult to communicate. It was clear to most reasonable citizens that the nation would have to deal with Germany or with Japanese expansion, or both. A national survey in summer 1940 reported that 67 percent of Americans believed that a German victory would endanger the U.S., and if that happened, 88 percent supported the nation being "armed to the teeth." The Lend-Lease bill was passed in early 1941, allowing President Roosevelt "to lend, lease, sell, or barter arms, ammunition, food or any defense article to the government of any country whose defense the president deems vital to the defense of the United States." Congress and citizens began to think about military preparedness.

As folks were settling in for a rest after Sunday dinner on December 7—many had been tuned to NBC Radio, where the program *Sammy Kaye's Sunday Serenade* was just finishing up—regular programming was broken by a tense one-liner: "FLASH: Washington. President Roosevelt has just announced that the Japanese have attacked Pearl Harbor, Hawaii, from the air." Some had the habit of listening to the CBS Sunday afternoon concert by the New York Philharmonic—they were playing Shostakovich's Symphony No. 1, which had been interrupted by the same message.

The Associated Press had put out the first bulletin on President Roosevelt's message at 2:22 p.m. EST, and it had gone into every network, breaking into all regular programming. In New York City, station WOR interrupted the broadcast of the Giants and Dodgers football game. Soon, another bulletin broke in, in the midst of an advertisement for Jell-O Pudding, that Army and Navy bases around Manila in the Philippines had been bombed. NBC Radio put on the familiar H. V. Kaltenborn, summing up with his rapid-fire delivery what was known about the bombing. Kaltenborn, the best-known newscaster of the day, was a Milwaukee native with a crisp Wisconsin-Germanic dialect tempered by days at Harvard. He made it clear that the nation was at war. His program concluded with the messages that "Sheriff and Police personnel stand-by for notice" and that "citizen volunteers go quietly to their assigned area." The next day, President Roosevelt gave his inspiring "Day of Infamy" speech to the combined joint session of the U.S. Congress, which thirty-three minutes later formally declared war on Japan.

There had been thousands of deaths in Pearl Harbor, but none more tragic than that of William Ball, a sailor from Fredericksburg, Iowa. The sorrowful chain of events that followed his death was set in motion when Ball's boyhood buddies, five brothers from nearby Waterloo, Iowa, heard of his death and walked out together to avenge their friend's death by enlisting in the Navy. They requested that they remain together, and the Navy granted their wish. On November 14, 1942, the cruiser the brothers were serving on, the USS *Juneau*, was sunk by the Japanese in a battle off the coast of Guadalcanal in the Solomon Islands. Two months later, Mrs. Tom Sullivan received the news, not by the usual telegram but by a special courier, telling her that all five of her boys had been lost at sea. The tragedy of the Sullivan brothers became a national symbol of heroic sacrifice, and their parents toured the country to promote patriotism and bond sales.

Six months later, another grievous loss: 1939 Heisman Trophy winner Nile Clarke Kinnick Jr. was killed in a Navy training flight. Downed in the Gulf of Paria between Trinidad and the east coast of Venezuela, he had flown off the carrier USS *Lexington* and crashed-landed into the water when his engine developed a massive oil leak. Kinnick was a 5′8″ 167-pound dynamo halfback on the State University of Iowa football team—All-American, Male Athlete of the Year, he played it by the flight book to the end. His body was never recovered.

In the weeks after Pearl Harbor there were more scares. The most serious threats in the early days of the war had been the German submarines sinking Allied freighters within sight of the Atlantic beaches. In June of 1942, there was the bombardment of Fort Stevens in Oregon by a Japanese submarine that had moved up the Columbia River. The fort commander ordered lights out, and there was no damage to the fort and there were no injuries. Nonetheless, it caused defensive moves up and down the northwest coastline and a general uneasiness among us all.

Oregon had another distinction. During the war, the Japanese sent thousands of balloon-borne bombs to the west coasts of the U.S. and Canada, and a few drifted as far as Iowa and Kansas. Large paper balloons, each carrying several thirty-pound bombs timed to explode from three to five days after launching, were released in Japan to ride the high-velocity stratospheric air currents across the Pacific. Most failed to go off, and only one caused casualties. The fatal bomb landed on Oregon's Mount Gearhart, where the Reverend Archie Mitchell drove with his wife and five parish kids for a vacation. Searching for a campsite while Mitchell parked the car, the wife and youngsters discovered the bomb on the ground. It exploded, killing all six.

AS THE WAR GOT UNDERWAY, food rationing for civilians was begun. Meat and butter restrictions were severe. To overcome rationing on meat, some funky industries developed. Horsemeat consumption increased during the war, especially in the eastern U.S. It did not require meat ration points, and most people could not distinguish between beef and horsemeat. The muscle fibers are finer than beef, and the glycogen deposited in muscle makes it sweeter. The Davis Packing Company in Estherville, Iowa, began operating in January 1940 under the USDA Meat Inspection Service and slaughtered up to seventy-five horses per day.[1] The veterinary inspector, O. W. Anderson, was responsible to ensure that all horsemeat was conspicuously labeled using a six-sided stamp with light green ink, in contrast to the round stamp and purple ink used on cattle, swine, and sheep carcasses.

Rationing of butter caused people on the home front to seek alternatives. In 1943, Wisconsin was first and Iowa second in the nation in dairy production. Despite increased production, veterinary food inspectors in the Army Quartermaster Corps were having difficulty getting enough butter. At Iowa State College, food experts were working overtime to support the war effort. Economics professor Theodore Schultz organized a series of pamphlets on emergency food strategies, the first appearing in January of 1943. Shultz's research focused on ways that powerful interest groups distort economic inefficiency in tariff policy, tax systems, and agricultural production. At Iowa State for only five years, he was head of the Department of Economics and Sociology, and support from President Friley had allowed the department to flourish.

Pamphlet #5, *Putting Dairying on a War Footing*, appeared in April 1943. Produced by a doctoral student in economics, O. H. Brownlee, it analyzed conditions that had resulted in a shortage of dairy products for soldiers and recommended rationing and shifting milk to the most productive uses. Among other solutions, it recommended that American households substitute margarine for butter. Dairy industry leaders went ballistic. Their goal was clearly to achieve "complete extermination of oleo," and they ferociously descended on Iowa State president Friley with pressure to retract the pamphlet. Finding Friley consistently unavailable for meetings, they took their complaints to the press. The adverse reaction in Iowa to Brownlee's pamphlet #5 was prompt, vociferous, and vehement for Iowa State to retract it.[2]

But Schultz was supported nationally. *Time* published an article of support, "The Butter Atheist," and *Newsweek* facetiously reported that Iowa's dairy leaders had "found a traitor in their ranks," a reference to Iowa State College. An economist from Harvard praised the pamphlet, and an assistant to the U.S. secretary of agriculture, Iowa State alumnus Carl Hamilton, reported to Friley that the pamphlet had been well received in Washington.[3]

Rural legislators and financial donors were insisting that science be devoid of policy arguments. President Friley began a series of deflecting actions—committees formed to study the matter. Agriculture Experiment Station director and Graduate College dean Robert Buchanan announced that Iowa State needed to “tighten its definition of allowed social science reports.” When things were not resolved, Friley moved to replace Collegiate Press editors whose reviews had supported the pamphlet and appointed a committee to reorganize the Department of Economics and Sociology.

That was the last straw, and Schultz unexpectedly resigned from Iowa State College. He accepted a position at the University of Chicago as chair of the Department of Economics, where he would lay the groundwork for what would become known internationally as the Chicago school of economics. Schultz would win the Nobel Prize in Economics in 1979 for his work in agricultural policy. The moves of President Friley and Dean Buchanan presaged a post-war pattern of administration that succumbed to political pressure, easing the discomfort of the day instead of laying groundwork for long-term policy for independence and truth in science.

Unlike today there was no faculty tenure, and many land grant universities were not viewed as sources of innovative machines or as business incubators; several lost prestige and dollars for not pursuing patents on products they produced. At Iowa State College, the first computer was built during 1939–1942 in the basement of the Physics Building. Mathematician and physicist John Vincent Atanasoff, with his graduate student Clifford Berry, built a successful automatic electronic digital computer. The first of its kind, it used binary digits to represent numbers and data, did calculations electronically (not by wheels or mechanical switches), and had a system that kept computation and memory separate. No one applied for a patent; Atanasoff moved, and the work was discontinued. When the war ended, the ENIAC computer, which had a changeable stored program, was patented and millions of dollars went to corporations. But in 1973, in the case of *Honeywell v. Sperry Rand* in a suit on patent rights for the ENIAC computer, the U.S. District Court for Minnesota ruled—based largely on the inventors of ENIAC having visited Atanasoff—that the ENIAC patent was invalid and the computer had been a derivative of the Atanasoff invention.

MIDWEST FARMS IN THE WET SUMMERS of the war years were plagued by an increased loss of livestock to anthrax. Rotating through the Iowa State Veterinary Diagnostic Laboratory, senior student Vaylord Ladwig studied tissue specimens from an anthrax outbreak in cattle. The disease had occurred on four farms in central Iowa, three of which were in the same drainage area. On the original farm in the outbreak, the first death occurred without the farmer noticing signs of disease; the deaths were thought to have been due to a lightning strike. During the next week six more steers died, and when autopsies were done there were the unmistakable signs of anthrax: swollen hemorrhagic tissues, massive bloody engorgement of the spleen, and blood in the intestine. The report on specimens that had been sent to the diagnostic laboratory in Ames stated that the blood smears, bacterial cultures, and animal inoculations all revealed *Bacillus anthracis*. Microscopically, billions of bacteria in the bloodstream had obliterated the liver and spleen.

On the anthrax farms contaminated areas were cleansed, with attention to preventing the spread of bacteria. Iowa Code regulation 22 required that "all carcasses of anthrax-infected animals must be burned within 24 hours intact without removal of the hide" and that contaminated flooring, mangers, feed racks, watering troughs, buckets, litter, soil, and miscellaneous utensils must be burned, and if made of metal must be disinfected with "Cresolis Compound, U.S.P. or any reliable disinfectant recommended by the Bureau of Animal Industry, or a regularly qualified veterinarian." The first case had been sent to the rendering plant, the operator of which developed cutaneous anthrax around a trivial wound he had received the previous day. The remaining herd was given anthrax antiserum and anthrax bacterin, both available commercially.

Vaylord Ladwig published the results of his clinical case in the student journal *The Veterinary Student* in the fall of 1943.[4] He graduated that year in the new fall class and was immediately commissioned as an officer in the U.S. Army Veterinary Corps. The Army had fulfilled its quota for veterinarians by 1943, and Ladwig took the offer of an immediate discharge to serve the farm economy, desperately in need of large animal veterinarians. He returned to Iowa and a veterinary practice. Upon graduation, these students, when approved by their local draft board, were given a certificate of graduation stating that they had served in the Army of the United States and had been discharged to return to rural practice, an essential occupation. And as requested by the War Department, Professor Packer sent tubes of his cultures of *Bacillus anthracis* to the new biowarfare laboratory at Camp Detrick.

IN 1944, THE DOORS OPENED for a new veterinary school at Tuskegee Institute in Alabama. The pioneering force behind the plan was an extraordinary African American. Frederick D. Patterson, born in Washington D.C., attended Prairie

View Normal School in Texas, where he was mentored by an Iowa State College veterinary school graduate—Class of 1918—Edward B. Evans. On Evans's advice, Patterson enrolled at Iowa State College and graduated with the DVM degree in 1923; it was the same year that African American football player Jack Trice—for whom the Iowa State University stadium is named—died after injuries he received in a football game with Minnesota. Offered a position as meat inspector, Patterson was influenced by Dean Stange, who cautioned that it should be only a temporary one—that as a graduate of Iowa State College more was expected of him. Patterson took a teaching position at Virginia State College in Petersburg, Virginia. He returned to Iowa State College for the MS degree in pathology in 1927. He was supported by the General Education Board of the Rockefeller Foundation, whose goal was to improve the quality of teaching in the South's black colleges. He worked under E. A. Benbrook's tutelage in the Veterinary Research Institute.[5] Offered a position to teach veterinary science and bacteriology at Tuskegee Institute, Patterson left for Alabama in 1928. A second GEB grant got him to Cornell University for a PhD in bacteriology.

Patterson would become the pioneering and most prominent African American veterinarian in the nation. In his career, he was president of Tuskegee Institute for twenty years, a driving force behind the formation of the Tuskegee Airmen during World War II, and a recipient of the Presidential Medal of Freedom. Patterson wrote in his autobiography, *Chronicles of Faith*: "The absence of animosity encouraged me to see veterinary medicine as a field in which I could practice without being hampered by the racial stereotypes and obstacles that would confront me as a medical doctor, for example. I found the teachers of Iowa State helpful whenever I approached them. Educationally, it was a fine experience."

But there was subtle racism during his veterinary school years. Listed simply as Fred Patterson in the 1923 *Bomb* yearbook, he had been a member of the YMCA and the Veterinary Society—but not of the Dixie Club, an official college club composed of "students and faculty from southern states." Perhaps Patterson's greatest legacy was his ability to use his intelligence and logic to rise above any insult from local popinjays, all the while maintaining his demands for perfection and equality. Of all the pioneering struggles for science in veterinary medicine, those of Frederick Patterson required the most devotion. Not all obstacles came from white Americans; one black critic allowed as how the

Tuskegee statue of Booker T. Washington, *Lifting the Veil of Ignorance*, really was education covering the eyes of blacks to the real problems of racism.

Frederick Patterson left Iowa to earn the PhD degree at Cornell University, joined the faculty of Virginia State College as head of their School of Agriculture, and was appointed the third president of Tuskegee Institute at age thirty-four

First faculty at Tuskegee School of Veterinary Medicine, 1945. Front row (*left to right*): William H. Waddell (Ambulatory Clinic), Edward B. Evans (dean), Frederick D. Patterson (president, Tuskegee Institute), Edward G. Tripp (Bacteriology and Public Health). Back row (*left to right*): George W. Coopers (Large Animal Medicine), Lloyd B. Mobiley (Anatomy), Thomas G. Perry (Small Animal Medicine). Background: *Lifting the Veil of Ignorance* statue of Booker T. Washington; artist: Charles Keck; dedicated 1922.

in 1935. During the war years of the early 1940s he worked tirelessly to create educational opportunities for black youth. In 1942, the Tuskegee Institute Board of Trustees approved a program of cooperation with the State of Alabama to create a school of veterinary medicine at Tuskegee. Patterson opened the School of Veterinary Medicine in 1944, the same year he established the United Negro College Fund that today awards scholarship for students in thirty-seven private black colleges and universities. The first dean, Edward B. Evans, had been Patterson's mentor at Prairie View Normal School. Three department heads at Tuskegee were Kansas State College graduates: Lloyd B. Mobiley (Anatomy), Thomas G. Perry (Small Animal Medicine), and Theodore S. Williams (Pathology).[6] When Evans resigned in 1946, Williams transformed Tuskegee into a competitive veterinary college with demanding courses and graduate programs. Williams earned his MS degree in veterinary pathology under E. A. Benbrook in Iowa.

27. VETERINARY CORPS AND BIOTERROR

After Pearl Harbor had been bombed and the United States entered World War II, Secretary of War Henry Stimson wrote to Frank Jewett, president of the National Academy of Sciences, requesting a study on biological warfare. The academy chose Dr. Edwin Fred of the University of Wisconsin to organize the group under the clandestine name War Bureau of Consultants. It included twelve scientists, with members from the Army Chemical Corps, Surgeon General's Office, Department of Agriculture, Public Health Service, and the Army's Ordnance unit.[7]

The report of the War Bureau of Consultants' study on biological warfare that was submitted to Secretary Stimson recommended that a biowarfare research program be started. Stimson obtained President Roosevelt's approval, telling him in a memorandum of April 1942 that "the matter must be handled with great secrecy as well as great vigor." Proceeding from Roosevelt's approval, the U.S. Army quickly established a research facility for biowarfare, using as its base the tiny Chemical Warfare Service at Camp Detrick, a small outpost on the edges of Frederick, Maryland. It would become a posting with a big impact on veterinarians in the U.S. Army.

To advise the commanding officer at the newly expanded and renamed Fort Detrick, a germ warfare advisory group of eight civilians headed by George W. Merck, president of the pharmaceutical giant Merck and Co., was established in mid-1942. It operated during the war as a faux New Deal welfare agency called the War Research Service. It was felt that a civilian advisory group would prevent the public from concluding that offensive bioweapons were under consideration. The tasks were complex; they included staffing with research scientists with expertise in human, animal, and plant diseases, as well as specialists in ordnance for delivery of microbes and entomologists to breed mosquitos and ticks that could spread disease.

Physicians specialized in infectious diseases, already in demand by the Medical Corps, were scarce and badly needed at Camp Detrick. Also in demand were Veterinary Corps officers, highly trained in microbiology, chemistry, and food safety. Nearly all biological agents considered to be potential warfare agents caused zoonoses—diseases transmissible from animals to humans. Among the most dangerous microbes with high bioweapon potential that were selected for study at Camp Detrick were those that caused brucellosis, anthrax, glanders, plague, and tularemia, and several viruses that caused encephalitis. They were all killers of both livestock and humans. The first disease to be studied was brucellosis, but so many workers became infected that the disease was abandoned in favor of anthrax.

Once the scientists were assembled, the task of selecting and acquiring the most dangerous disease agents was begun. By January 1943, the War Research Service had contracted William A. Hagan of the Cornell School of Veterinary Medicine to explore offensive uses of botulism and J. Howard Mueller of the Harvard Medical School to study anthrax—both agents that remained the focus of biowarfare research during the war. Strains and isolates of anthrax and other bacteria were requested from veterinary schools. Samples of *Bacillus anthracis* were sent to Camp Detrick by Professor Allen Packer from Iowa State College.

The Camp Detrick director initiated secret work in about twenty-eight U.S. universities, including Harvard, Columbia, Cornell, Northwestern, Ohio State, Notre Dame, Wisconsin, Stanford, and California. Some urgency had been given to the project by the powerful new German V-1 buzz bombs, which could be loaded with biowarfare agents and directed against soldiers.[8] Other small military research and development laboratories dedicated to biological and chemical warfare were tucked away in rural communities. As the Roosevelt administration pushed warfare readiness in 1941, the Army established facilities for research and testing of chemical and biological weapons: Pine Bluff Arsenal in Arkansas, Rocky Mountain Arsenal in Colorado, the Dugway Proving Ground in Utah, and laboratories at Plum Island, New York, Camp Sibert, Alabama, and Camp Beale, California. Stocks of anthrax were sent from Camp Detrick to the United Kingdom prior to D-Day as a retaliatory possibility. The War Disease Control Station in Grosse Île, Canada, was a cooperative venture of the Canadian Ministry of National Defense and the U.S. Secretary of State that involved the U.S. Public Health Service, the U.S. Army (Raymond A. Kelser), and the U.S. Department of Agriculture (Harry W. Schoening). Their contribution was the development and production of a vaccine against rinderpest. At the end of the war, the excess stock of remaining rinderpest vaccine was sent to be used in China.

The Commission of Epidemiologic Survey was established by the secretary of the Army, with oversight responsibility for the Walter Reed biowarfare defense program at Fort Detrick. It was to collect data important for the medical program. Richard Shope, the first director, from 1941 to 1945, was succeeded by Theodore E. Woodward and William Tigertt.[9]

The mission of Fort Detrick was separated into two programs: the defensive biowarfare protection program to develop vaccines was be a subsidiary of Walter Reed Army Medical Center in Washington, D.C., so that physicians and veterinarians assigned to this program were delegated to the Medical Corps, and the offensive biowarfare attack program run by the Chemical Corps, to which veterinarians were assigned for duty. It seems that a large number of Veterinary Corps officers were assigned to Chemical Corps duty because it might appear inappropriate to the public that the Army Medical Corps would work in offensive bioweapons.

New veterinary officers assigned to Fort Detrick were not allowed to enter the hot zones where research was done until they had been immunized. There was a three-month waiting period, during which they were vaccinated for all diseases being investigated in their assigned area and to undergo testing to see that immunity had developed. An assignment to the virology-rickettsiology unit required vaccines for smallpox, yellow fever, Rift Valley fever, Rocky Mountain spotted fever, and measles, as well as three kinds of hemorrhagic fever and three kinds of equine encephalitis—eastern, western, and Venezuelan. Everyone received new experimental vaccines against anthrax, brucellosis, and plague. They were to work in a dangerous environment, one in which several laboratory workers had died of viruses and bacteria.

Much of the research on animals involved aerosols of microbes. The aerobiology unit had become internationally recognized for its expertise on particle size, airflow rates, and lung penetration. In all labs, animals on study with infectious agents were held in special cage banks with air that was filtered during entry and exit. The filters, known as HEPA filters, were the current state of ventilation technology. When a young employee at Fort Detrick died of anthrax, the gossip around the post was that he was a safety engineer who had entered the bacteriology building codes indicating that he had been immunized for anthrax but had not been, and while he was changing fluorescent light bulbs, dust trickled down on him that contained anthrax spores. But no veterinary officers actually knew what the details were. In 1960, a report to the Armed Forces Epidemiological Board recorded a young military volunteer who had died of inhalation anthrax in 1958 after receiving a series of inoculations of killed and live vaccines, including one against anthrax. It was all very mysterious, and still is (see appendix V).

All biowarfare labs had large insectariums and test sites to support studies on vectors to carry dangerous microorganisms. The Pine Bluff Arsenal in Arkansas developed the first weaponized agent, a cluster bomblet, based on the British M114, to deliver *Brucella suis*, a cause of brucellosis in humans and pigs. In Utah, the Dugway Proving Ground was the field test site for the Chemical Corps.

The U.S. anticrop research was directed to wheat and rice. This program stockpiled more than thirty thousand kilograms of spores of the fungus that causes stem rust of wheat, *Puccinia graminis tritici*. Weapons systems to deliver anticrop agents were modified from military bomblets developed to drop propaganda leaflets. The bombs were loaded with spore-bearing turkey feathers, an effective means to deliver these agents over a wide area.

Field studies with biowarfare agents had notorious unintended consequences (and sometimes for screwups). Operation Big Itch was an entomological field test to determine coverage and survivability of uninfected fleas as vectors for biological agents. Guinea pigs, placed on the ground as monitors, were to be bombarded with fleas from the air. During one test, one of the bomblets malfunctioned, releasing fleas into the aircraft that then bit the pilot, navigator, and one observer.

One of the Veterinary Corps's major responsibilities was the care of military dogs. As World War II had gotten underway, the secretary of war authorized the quartermaster general to establish war dog training centers; the Veterinary Corps was to care medically for the dogs and would have to become expert in tropical diseases. The first training center start-up was in August 1942 at the Front Royal Virginia Quartermaster Remount Depot, a permanent cavalry horse remount facility. Three others were opened later in 1942: Camp Rimini, Montana, San Carlos, California, and Fort Robinson, Nebraska, which had been the largest remount station in the U.S. Intended to supply the Army, trained dogs were quickly taken up by the Marines and then by the Navy and Coast Guard.

Basic training for dogs lasted twelve weeks. Dogs were taught to obey verbal commands and gestures, to work under gunfire, and to adapt to wearing gas masks. The dogs were trained for specialized duty; sentry duty and sled dogs were the big fields, but then there were dogs specialized for courier duty, for mine detection, and as scouts. Selection of dogs was important. Most uses demanded dogs that were big, strong, and agile, but the scouting dogs, which had to operate silently and with stealth, had to be of medium size. There were seven preferred breeds: German shepherd, Belgian sheepdog, Doberman pinscher, Siberian husky, malamute, Eskimo dog, and farm collie. Some dogs were unsatisfactory even for sentry duty—the Great Danes were too big and the hunting breeds were too distracted by scents. In battle zones, dogs were used to detect mines and other explosive devices, especially in the South Pacific. In the jungles, they were also used in exploring cave systems, detection of land mines, and guarding sleeping marines.[10] For the Medical Corps, dogs carried first aid to wounded soldiers on the battlefield. For the Signal Corps, dogs were trained to carry reels of telephone wire on their back that played out the wire as the dog moved forward. Crossing a battle zone with speed spared the lives of signal wire operators.

Military dogs were especially effective on Guam, an island territory of the United States since 1898. Guam had been captured by the Japanese three days after Pearl Harbor. The Marines landed to retake the island in July of 1944, accompanied by the 2nd and 3rd Dog Platoons. Mostly Doberman pinschers, the dogs were used as sentries and scouts on nearly five hundred patrols. The National War Dog Cemetery, a memorial to war dogs at Naval Base Guam, honors dogs that were killed in service with the U.S. Marine Corps during the Second Battle of Guam.

American troops treat a wounded Doberman pinscher on Orote Island, Guam, a military staging area during World War II for the battle of Guam. Both ferocious and intense, Dobermans were the preferred breed for sentry duty. (W. EUGENE SMITH/THE LIFE PICTURE COLLECTION VIA GETTY IMAGES.)

In World War II, military war dogs were returned home after the war and given to their former owner or the new adopted owner. Sadly, dogs used in Vietnam were euthanized prior to the U.S.'s departure from the country. In 2000, President Bill Clinton signed a law that allowed dogs to be adopted by their handler, and that has been the case since then.

28. POSTWAR INVESTIGATIONS OF ENEMY BIOLOGICAL WARFARE

In August 1942, a Japanese plane had flown out of the western sky and circled low over the rice paddies that surrounded the village of Congshan in the eastern Zhejiang Province of China. Villagers noticed a trail of smoky dust coming from its tail. Two weeks later, village rats started dying en masse—the first signs of the coming deadly human plague. For two months the fevers raged, eventually killing 404 villagers, one-third of the population, before Japanese troops moved in on November 18 and started burning down plague-ridden houses and cruelly taking tissue samples from the sick, often without anesthesia.[11] No outsider would hear of this tragedy, and no Japanese officer would ever admit to any connection with their war effort.

The Kwantung Army, the largest and most prestigious unit of the Imperial Japanese Army, had been formed after the Japanese had defeated Russia in 1905. Stationed in the weak nation of Manchuria, the Kwantung was to "assert influence in the area." Its commanders, Hideki Tōjō and Otozō Yamada, operated semi-independently from Tokyo, and in the 1930s Japan annexed Manchuria. During the war, U.S. intelligence reports suggested that the 731st Division of the Kwantung Army had built a biowarfare unit in Manchuria. It was true.

As the advancing Soviet Army crossed the Siberian-Manchurian border at midnight on August 8, 1945, the Japanese destroyed their biowarfare plant at Camp 731. The remaining prisoners were killed and records removed to Korea, and then to Japan. The Unit 731 commander, a Japanese army surgeon named General Shirō Ishii, fled for Korea and on to Japan. There he disappeared, falsifying a death certificate showing that he had been killed in the war.[12]

The advancing Soviet Army captured several Unit 731 soldiers who failed to escape. Quickly placed on trial for war crimes were Yamada, the commander of the Kwantung Army and direct supervisor of work at Camp 731, and eleven other Japanese officers, including Lieutenant General Takaatsu Takahashi, head of the Veterinary Division of the Kwantung Army. They received sentences of two to twenty-five years in prison.[13] Evidence at the trial revealed that the Japanese had infected cattle and contaminated pastures and waterways with "epidemic germs."

As the war was winding down, there were growing concerns in the U.S. Army about the frightening possibilities of the Japanese using of bioweapons in an all-out last-ditch stand in the homeland. The two highest-ranking officers at Camp Detrick, Colonel Murray Sanders, the director, and his assistant, Lieutenant Colonel Arvo Thompson of the Veterinary Corps, had been assigned to work at the nation's new germ warfare base, Camp Detrick. They wondered: What if bubonic plague bacteria had been inserted in the balloon bombs that were floated over the Pacific Ocean?

Intelligence reports were vague, with only hearsay evidence of what was going on in Manchuria. And, of course, there was nothing in the press about these fears and what should be done about them. But the truth was, during the final months of the war, Japan planned to use bubonic plague as a biological weapon against San Diego in an attack code-named Cherry Blossoms at Night. The plan was set for September 1945 but was never launched.

When the war ended, the U.S. Military Intelligence wanted to know the details about the Japanese biological war effort. Arvo Thompson and Murray Sanders received orders for a top-secret mission to Japan, with orders to investigate unconfirmed reports about horrendous Japanese biological warfare research and to locate Japanese military officers who had been involved. When the Japanese surrendered in August 1945, they left for Japan immediately, landing in Yokohama, to get to the bottom of the "grapevine of intelligence" about the Japanese germ warfare program.

Thompson and Sanders arrived in Tokyo on Christmas Day, 1945, two of the first Americans to enter Japan. U.S. Intelligence uncovered evidence that the director of the Japanese biological warfare laboratory in Manchuria, General Shirō Ishii, was still alive. Tracking him down, they found Ishii in one week. His interrogation began immediately. Ishii's testimony was one of denial and confusion.

When interviews began, Sanders and Thompson had sifted through prisoners for a translator, unwittingly selecting Lieutenant General Ryōichi Naitō—the microbiologist who had tried and failed to get yellow fever virus from Rockefeller Institute in New York. Once his role as third in command of Unit 731 was discovered, Naitō became a primary interviewee. Over a ten-day period Sanders and Thompson questioned Naitō, who finally gave them a twelve-page document that acknowledged the existence of Unit 731 but denied that humans were used in experiments.[14]

The interviews with Ishii had gone on for ten weeks when Sanders was detailed back to the States, and the investigation was taken over by Thompson. In interviews, Ishii misled Thompson at their first meeting by stating, "Our work was to protect our soldiers," and "We did not do any experiment on large animals." He also denied any knowledge of any airborne biowarfare assaults. Reports from China had indicated that the Japanese Army had bombed several sites with ceramic bombs filled with fleas carrying bacteria to cause bubonic plague—Naitō gave no information about that, either.

Arvo Thompson concluded his interview with Ishii on February 25 and submitted his report on May 31, 1946.[15] In the intervening time, Sanders had recommended to General MacArthur that the United States promise Ishii that no one involved in biowarfare will be prosecuted as a war criminal. A top-secret cable from MacArthur had gone from Tokyo to Washington, reporting that Ishii stated that if guaranteed immunity from war crimes in documental form for himself, superiors, and subordinates, he would describe the program in detail. A report in December 1947 by Edwin Hill, chief of basic sciences at Camp Detrick, described some of the technical data secured from the Japanese during an official visit to Tokyo by Hill and Joseph Victor, who had interviewed those in charge of Unit 731. Later, Ishii reportedly came to Camp Detrick to reveal his methods for the use of anthrax. Ishii mysteriously disappeared from public records, but papers that appeared years later placed him at Fort Detrick. Naitō returned to civilian life in Japan and founded the Japan Blood Bank, which became the Green Cross Corporation, a leading pharmaceutical company that employed several officers in Unit 731.[16]

Arvo Thompson returned to the U.S. and in 1948 took his own life for reasons never explained publicly. It would take years for Thompson's report to be declassified and made available to the public. When released, the report revealed that in 1931, shortly after the Japanese had occupied China's northeast provinces and Manchuria, General Ishii had developed a biological warfare experimental station, including a prison for human subjects. Using the name Togo Unit (after the admiral who had defeated the Russians in 1905 at Tsushima), Ishii had built the first biological lab in Manchuria in a reconditioned soy sauce distillery outside Harbin. In 1938, the Japanese Army moved to a new location called Pingfan, fifteen miles south of Harbin, that operated simply as Unit 731.

Deep in the remote plains of Manchuria a large proving ground called Anta was built. Ceramic and metal bombs and weaponized contents for delivery of anthrax and other bacteria had been tested at Anta. Delivery vehicles bearing anthrax included fruit, vegetables, meat, water supplies, feathers, and chocolates. A third biowarfare camp, Unit 100, had been created in 1936 for agroterrorism. Called by the Japanese the Hippo-Epizootic Unit or the Kwantung Army Stables, it was commanded by veterinarian Lieutenant General Yumiro Wakamasu and based ten kilometers south of Hsinking at the village of Men-chiangtung (Mogatong). Staffed by Japanese veterinarians and a seven-hundred-man force, the unit did research on animal diseases, including vaccines and serum production for horses and studies on diseases in sheep and cattle. In 1941 it began mass production of anthrax and glanders and studies on their effectiveness in spreading animal disease in the climate and geography of Russian Manchuria.

In August 1946 the U.S. team received a report that implicated Japanese veterinarians in human experimentation, especially Motoji Yamaguchi, head of Unit 100's human experiment section: "The above veterinary surgeons dissected many war prisoners of the Allied Forces at the outdoor dissecting ground of No. 100 Army Corps at Hsinking (Changchun), Manchuria."[17] Human experimentation had been part of the operation of Unit 731 from the start. The first studies were done on prisoners who were sentenced to death at the Harbin Prison; they were expanded to include spies, dissidents, and local worker agitators, many from the white Russian population in Harbin. Russian and American prisoners were reported to have died there from bubonic plague, typhus, and hemorrhagic fever. Experiments involved the sequential killing of prisoners to study how disease developed. Research recorded by General Kitano Masaji was that "mouse brain suspension . . . was injected . . . and produced symptoms after an incubation period of seven days. The subject was sacrificed when fever was subsiding, about the twelfth day." Survivors revealed horrific episodes of vivisection—the Japanese had proceeded with the autopsies by vivisection—collecting tissue while the patient was alive and screaming in pain. It was estimated that three thousand people died in experiments at Unit 731.[18]

In an interview as an old man, Sanders told reporters that MacArthur and other top U.S. military officers decided that they had their hands full in the seething cauldron of postwar Japan and that immunity should be granted to the Japanese scientists involved. He believed that the main reason for keeping silent was that they did not want to involve the emperor. The real reason seems more practical: more information could be gleaned from Ishii by granting immunity.

THERE WERE POSTWAR SEQUELS to the methods developed in Japanese chemical and biological warfare. On the rainy afternoon of January 26, 1948, a man entered a Tokyo suburb branch of the Teikoku Ginko Bank ("Teigin") at closing time and poisoned sixteen people, including the entire staff and the children of the caretaker. The assassin pretended to be a Dr. Yamaguchi, come to immunize the victims against dysentery, which he claimed had been found in the area. Wearing an official Health Ministry armband, he presented a card proclaiming himself "Technical Officer, Ministry of Health and Welfare" and added that he was working under the guidance of the Americans and that a Lieutenant Parker would soon be along to check that the work had been carried out thoroughly.[19]

All victims were simultaneously induced to take a deadly poison in teacups, a move that Yamaguchi first demonstrated calmly, stressing how important it was to take the liquid, thought to be cyanide, on the tongue. Only four survived. The motive of the killer remained hazy; he had taken only money laying on desks. A connection with Unit 731 had been implied but never authenticated. An innocent painter and sometime pornographer, Sadamichi Hirasawa, was falsely arrested for the crime. After a coerced confession, he was sentenced to death but died in prison of natural causes in 1985 at the age of ninety-five. Japanese officials had refused to sign the death warrant for his execution.

Writing about the Teigin event in his novel *Occupied City*, David Peace produced a fictional character, Murray Thompson—derived from a conflation of Murray Sanders and Arvo Thompson. The fictional Thompson dies in the hospital, perhaps to keep him quiet. The real Thompson's suicide was laid to mental illness as a consequence of his failure to bring Ishii to justice, allowing him freedom and transport to the U.S. *Occupied City* contains quotes from despairing letters supposedly written by Veterinary Corps lieutenant colonel Arvo Thompson to his superiors and to his wife, Peggy. In one of his last letters he says, "I swear to you, Peggy, that I *did not know* that human guinea pigs had been used when I suggested the arrangement [to grant immunity to Ishii]."

RETURNING HOME WHEN THE WAR ENDED, veterans had carried burdens of tragedies. Veterinary Corps officers from the heartland had especially bitter memories of early war in the Pacific. Shortly after the bombing of Pearl Harbor, the Japanese had completed their takeover of the Philippines. The U.S. Army, trapped on the Bataan peninsula, had moved to the island of Corregidor and finally surrendered. On April 9, 1942, the Japanese began moving 80,000 surviving Americans and Filipinos seventy miles inland, with horrifying physical abuse, torture, and wanton killing along the route; 650 Americans and 18,000 Filipinos died in the Bataan Death March.[20] Several veterinary officers died on the march or in Japanese prisons. Captain Clayton H. Mickelsen, DVM (Washington State College, 1939), had been in charge of the health care of horses and mules in the Philippines. He survived transport to Japan but died in a prisoner of war camp in Kyushu on February 10, 1945, a few months before the Japanese surrendered. One veterinary officer survived the Death March, William S. Gochenour Jr., who spent the rest of his military career in scientific research at Fort Detrick and supervising the laboratories for the Commission on Epidemiologic Survey.

Survivors of the Bataan Death March, who had also lived through brutal transport and atrocity-laden prisoner of war camps in Japan, brought back a strange story. Captain Burton Thomson of the Veterinary Corps had been shot in Corregidor by an American traitor named Provoo, who was cooperating with the Japanese. John David Provoo, a U.S. Army staff sergeant assigned at Corregidor in 1942, spoke fluent Japanese, had converted to Buddhism, and had aided the Japanese in controlling surrendering Americans.

Captain Thomson had grown up in Swea City, Iowa, and graduated from the Iowa State College veterinary school in the Class of 1938. At 6′5″ and weighing 250 pounds, he had played basketball for the Cyclones. A Delta Upsilon fraternity man, he had married the Tri-Delta queen of the veterinary ball and had left an infant son behind when he departed for the Philippines. In Manilla, Thomson had been assigned to head food inspections of the Quartermaster Corps. In the first days after capture at Corregidor, Thomson had developed a combative relationship with Provoo, refusing to give the victors the remaining food supplies hidden in the tunnels and meant for American soldiers. With Provoo's complicity, Thomson was driven into the jungle and shot by the Japanese.[21]

After the war, Provoo was court-martialed, tried, and convicted of treason in New York. On appeal, his release was granted on the basis that prosecutors had introduced his homosexuality, which had improperly influenced the court. Avoiding prison, Provoo returned to postwar Japan.

29. PRELUDE TO THE SCIENCE REVOLUTION

When World War II ended, the business of the country rapidly moved back into the civilian economy. Returning military veterinarians provided a young vital workforce eager for new technical innovations, spreading American products into the global void caused by the destruction of European and Japanese industries. To keep abreast of new techniques and drugs developed during the war, practicing veterinarians flocked to state and national professional organizations and to meetings offered by state extension programs.

Returning soldiers took advantage of the new GI Bill, the provisions of which paid for tuition, books, and much of the costs of college. One of the greatest

Veterinary practitioners' meeting at the California Polytechnic Institute, 1949. Veterinary pathologist E. A. Benbrook demonstrates an autopsy on a horse. In the postwar boom, veterinarians flocked to state and local meetings for the latest technology. Note the formal dress.

economic recovery programs ever created, the Servicemen's Adjustment Act of 1944, required that veterans must have served in the active Army or Navy on or after September 16, 1940, must have been discharged from the active service under conditions that were other than dishonorable, and were not over twenty-five years old at the time of entry into active service.[22]

By 1947, most land grant colleges had student bodies double the prewar enrollment. To ease the crisis, prefab wooden barracks and round-roofed metal barracks obtained as Army surplus units were built on campuses for classrooms and housing. To accommodate the massive student loads, existing veterinary schools doubled their faculties. Most pioneer veterinary schools began planning and built new facilities. One of the most expansive was the veterinary school at Ohio State. Because it was hemmed in by two campus powers on the east side of the Olentangy River, the medical school and the football stadium, Dean Krill negotiated a tract of land on the west bank of the Olentangy for a new

College of Veterinary Medicine campus adjacent the Agriculture campus. The building committee composed of department chairs began with a $2 million structure for the basic sciences—dedicated in 1958 and named Sisson Hall, after the famed professor of anatomy.

Eight new veterinary schools were established in land grant institutions—double the number there had been before the war. In the Midwest there were five new schools—at the university in Illinois, Minnesota, Purdue in Indiana, Oklahoma, and Missouri. Elsewhere, new schools appeared at the University of Georgia and the University of California at Davis. The new schools were sucking up new young faculty from the established schools more quickly than they could be replaced. Both new and old schools were scrambling to build competitive research programs.

The 1950s brought a striking change of mission and refocus of the veterinary profession. There was an increase in demand for health care of dogs and cats. The economy was booming and people were spending money on their pets. Easterners had a long history of health care for companion animals, and after the war small animal hospitals were being added to even small towns. In New York City, the Westminster Dog Show had gotten its name from a long-defunct hotel in Manhattan. Sporting gentlemen meeting there to drink and fib about their shooting trophies formed a club that in 1877 put on a dog show at Gilmore's Garden, the forerunner of Madison Square Garden. To everyone's surprise the show attracted over twelve hundred entries. Westminster's coveted Best in Show award was first given in 1907. It was won by a smooth fox terrier bitch, Ch. Warren Remedy. She would win the next two years as well and still holds the record for winning Best in Show three times.

New multiauthored textbooks on small animals appeared—*Canine Surgery*, *Canine Medicine*, and then *Feline Medicine*—all authored by new experts in the field. McGrath at Penn published *Canine Neurology* and Miller at Cornell, *Anatomy of the Dog*. Advancements in sciences for surgery, neurology, and renal disease in dogs and cats were astonishing. Clinical pathology laboratories for testing blood and urine were becoming more sophisticated, and the data produced led to big-time experts and to advances in teaching clinical medicine.

The major progressive academic centers for companion animal health were at Penn and Cornell, as well as in the new schools in California, Colorado, Minnesota, and several others. Prewar, only a few of the midwestern veterinary students had been interested in specializing in small animal practice, but new small animal clinics had appeared in Des Moines, Omaha, Kansas City, and Minneapolis and were more profitable, had better hours, and took less toll on the physical body than large animal practice. For students, there were increased admissions of dogs and cats into Stange Memorial Clinic at Iowa State College.

The surge in small animal veterinary medicine was centered in New York City's Animal Medical Center and in Boston's Angell Memorial Hospital. The Animal Medical Center had begun in the Lower East Side in the heart of New York's largest poor and immigrant section, and by 1920 the hospital had been treating nine thousand patients annually. Difficulties began in 1921 with the death of Ellen Prince Speyer, the sponsor and supporter, and worsened during the Depression. In the postwar boom the hospital prospered, and in January 1960 construction began on a new $4 million facility on 62nd Street just west of the East River near Franklin Delano Roosevelt Drive and the Queensborough Bridge. The new facility opened in 1962 with new initiatives that included intern and residency programs, 24-7 emergency veterinary service, and staff increases that went from twenty in 1960 to seventy in 1980—and included three board certified veterinary pathologists. Postgraduate courses in clinical veterinary medicine were added, and Animal Medical Center was billing itself as the largest hospital for small animals in the world.

Surgical instruments for small animals had improved strikingly. Many new instruments, like the Mayo forceps and the Kelly hemostat, had been developed for human surgery and bore the names of famous institutions and surgeons. Those for special veterinary surgery were developed by veterinary surgeons, including stainless steel templates for artistic ear trims and the Snook hook used to snare the uterus from the abdominal cavity during spay operations using a tiny incision.

Public interest about nutrition for small animals was increasing, and so were markets for dog and cat foods. Mark L. Morris, who graduated DVM from Cornell University in 1929, built his new small animal hospital in Edison, New Jersey. He had started veterinary school at Colorado State College but was asked to leave in the clinical years because he was devoted to small animals, not to livestock. In his small animal practice, Morris had a common but frustrating problem: chronic kidney disease in old dogs. Despite treatment, kidneys failed progressively and dogs died. Morris was convinced that a low-protein diet would protect the delicate membranes in the kidney that filtered blood to make urine; he reasoned that these membranes were being overwhelmed by too much protein.

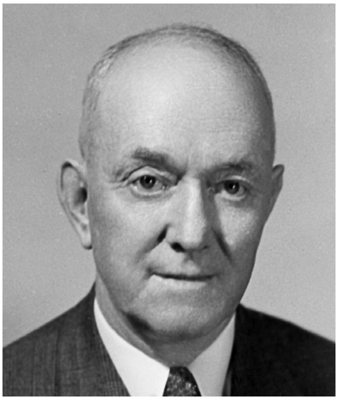
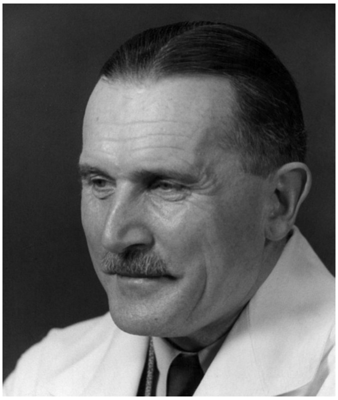
Devising a soft wet diet that was palatable but low in protein, he began making it in his home, canning it in a pressure cooker for his patients. The special diet was so popular that demands from clients overwhelmed his tiny home operation. Morris contracted with the Hill Packing Company in Topeka, Kansas, to manufacture the diet, which they marketed as Prescription Diet k/d (for kidney diet) and sold only through veterinarians. It was astonishingly successful. Sales of k/d led to p/d (for puppy diet), and then to other specialized diets. The expanding market led to a personal fortune, much of which was diverted to a foundation, established in 1948, dedicated to research on the health care of companion and wild animal species. The foundation project got its stimulus when the Morris diets led to the recovery of Buddy, the guide dog of Morris Frank, who just happened to be an ambassador of The Seeing Eye, one of the first organizations for the blind. This was the spark for starting the Buddy Foundation, which changed its name to the Morris Animal Foundation in 1948. In the late 1950s, the foundation was headed by Mark L. Morris Jr., who led support into wildlife disease studies. Today the foundation supports such diverse diseases as contagious cancer in Tasmanian devils, lead poisoning in bald eagles, and the gut microbiome in obese dogs.

THE PHARMACOLOGIC ARMAMENTARIUM in veterinary practices changed after World War II with the appearance of antibiotics, sulfonamides, and parasiticides. There were barbiturate anesthetics, diethylstilbestrol for reproductive efficiency, and a new rabies vaccine for dogs grown in chick embryos. Veterinarians in private practice were increasingly innovative and developed new technology. The first antibiotics to be marketed for animal health—tyrothricin for skin infections and penicillin for mastitis—were for streptococci, staphylococci, and other gram-positive bacteria. Perhaps more important for treating bacterial disease in animals was the appearance on the market of streptomycin for gram-negative bacteria.

Streptomycin was discovered in 1943 by Albert Schatz, a twenty-three-year-old Chilean graduate student working in the laboratory of Selman Waksman, a Ukrainian-born soil microbiologist at Rutgers University. Schatz found two strains of the fungus *Streptomyces griseus*—one from a heavily manured field, the other from the pharynx of a chicken—that produced a toxin that killed gram-negative bacteria.[23] From June to October, working night and day in the wartime atmosphere, Schatz developed a fermentation system that would produce useful amounts of this new mycotoxin, which they called streptomycin. Shown to be effective against *E. coli*, *Salmonella* species, and other gram-negative bacteria, it appeared that streptomycin could fill the gap in the spectrum of antibiotic therapies.

Waksman was department chairman and took over as the front man for streptomycin. At a national microbiology meeting, he met veterinary pathologist William Feldman from the Department of Experimental Medicine at Mayo Clinic, who was working with a model of human tuberculosis in guinea pigs. He advised Waksman to undertake the search for an antibiotic against human tuberculosis.[24] According to Schatz, Waksman was "afraid to move Mycobacterium tuberculosis into his laboratory" but agreed to undertake a project to test streptomycin with Feldman and H. Corwin Hinshaw, a renowned tuberculosis expert and physician at the Mayo Clinic.[25] It was agreed that experimental work would be done at Mayo Clinic using Feldman's guinea pig model to prove that streptomycin was effective against tuberculosis bacilli. Feldman designed the tuberculosis therapy experiments in animals; they were highly successful and established streptomycin as the first antituberculosis drug. Feldman developed tuberculosis during his investigations with tuberculous guinea pigs and was cured with streptomycin.

Selman Waksman never acknowledged Schatz's discovery and contributions. Rutgers University patented streptomycin and the drug was produced commercially by Merck and Co., with whom Waksman had a financial arrangement. Streptomycin made millions for the university. Waksman finagled a contract whereby he and Schatz would only receive $1 for their work. Clandestinely, another part of the Rutgers deal gave Waksman 20 percent of the royalties—$350,000 in the first few years. Waksman, falsifying stories about the scientific work, took the entire credit for the discovery of the mycotoxin, the method for fermentation, and its killing capacity for bacteria. He was awarded the Nobel Prize in 1952 for the discovery of streptomycin. Years later, Feldman visited Schatz in Santiago, Chile, on a trip to South America and was surprised to learn that the streptomycin he had used in guinea pigs had been produced by Schatz, not Waksman.

Two veterinary scientists of the mid-twentieth century who solved problems of great zoonotic plagues. William Feldman (*left*), veterinary pathologist in the Department of Experimental Medicine at the Mayo Clinic, developed the first experimental analytical system for chemotherapy of a bacterial disease, developing doses and proving that streptomycin was curative in tuberculosis. He later established treatments for human leprosy. Karl F. Meyer (*right*), veterinary epidemiologist and immunologist at the Hooper Medical Foundation Institute of the University of California San Francisco, was called by colleagues the American Pasteur for his discoveries of the pathogenesis of psittacosis, western equine encephalitis, brucellosis, plague in wildlife, and several other zoonotic diseases. (FELDMAN PHOTOGRAPH REPRINTED BY PERMISSION OF THE MAYO FOUNDATION FOR MEDICAL EDUCATION AND RESEARCH; COURTESY OF THE W. BRUCE FYE CENTER FOR THE HISTORY OF MEDICINE, MAYO CLINIC, ROCHESTER, MINNESOTA. KARL F. MEYER SIGNED PORTRAIT, 1935, MEYERPORTRAIT1, UCSF HISTORY COLLECTION, COURTESY OF UCSF ARCHIVES AND SPECIAL COLLECTIONS.)

FOOT-AND-MOUTH DISEASE was a perpetual danger. Shipments of zebu cattle to North America began in 1945; their entry was only approved after strong pressures from American and Mexican cattlemen. Newly arrived cattle were to be detained on an isolated quarantine station off the coast of Mexico. When the second shipment was released from quarantine into the mainland of Mexico, foot-and-mouth disease was identified on December 26, 1946. As allowed by the Tariff Act of 1930, the U.S. border with Mexico was closed. The Mexico-United States commission to eradicate the disease was one of the best examples of American international cooperation against an economic threat. Through a program of testing, slaughter, burial of dead animals, vaccination, and disinfection of premises, foot-and-mouth disease was eliminated from Mexico in May 1953.

Diagnosed in central Canada in February 1952, foot-and-mouth disease had been introduced by a German immigrant farmworker carrying meat in his luggage; he had worked on the farm for only three days, but ten days after he left, the farmer noticed his pigs were off feed and salivating excessively. The outbreak occurred in midwinter on only forty-two premises involving seventeen hundred cattle. Extremely cold temperatures restricted human movement, and the highly efficient response by Agriculture Canada rapidly eliminated the disease. Nonetheless, it cost the Canadian government $800 million in dead livestock, compensation to farmers, and a drop in the cash value of Canadian livestock by $540 million.

Fears that the proposed Pan-American Highway linking Pacific coastal areas of the American continents would spread foot-and-mouth disease led the National Security Council, under pressure from American livestock interests, to persuade Congress that no more U.S. funds should be allocated for construction.

IN THE LATE 1940S A Yugoslavian refugee physician named Stevan Durovic claimed that he could successfully treated cancer in dogs and cats with a substance he had isolated from serum obtained from horses given the fungus *Actinomyces bovis*, which caused lumpy jaw in cattle. Durovic's claim was backed by Illinois senator Paul Douglas and a prominent medical physiologist in Chicago named Andrew Conway Ivy, who was vice president of the University of Illinois with responsibility for the disciplines of medicine, dentistry, and pharmacy. Ivy had graduated with degrees from the University of Chicago and carried great weight in the scientific world. He had taught at Northwestern and been president of the American Physiological Society, and he was the most prominent physician to testify at the Nuremberg trials for Nazis being tried for medical experimentation.

Ivy tested krebiozen in human patients and claimed success in many of them. In his falsified report to the medical community the drug sounded promising, and, despite the warnings of medical oncologists, the government was pressured to test it. Ten hospitals and cancer research centers tested krebiozen on human cancer patients; none of the independent researchers observed any effect of the drug. Tested in laboratories of the National Cancer Institute and the Food and Drug Administration, krebiozen was found to be nothing more than creatine in mineral oil. It took fifteen years, but in 1964 Ivy and the Durovics, as well as their Krebiozen Research Foundation, were indicted for releasing mislabeled drugs into interstate commerce. The trial ended in a hung jury, but Ivy's reputation as a scientist was destroyed.

There were other postwar scalawags. "Chiropractic for Animals Has Grown Into Research Projects for Students" was printed in the *Coffeyville* (Kan.) *Journal* in 1953. An illustrated article, it related how a local man, a former pre-veterinary student who was then attending the Palmer School of Chiropractic in Davenport, Iowa, was spearheading a movement for veterinary chiropractic. He proposed the wobbly idea that his training would lead to expertise in diseases where "adjustments" would be helpful, including "such obviously responsive diseases as blackleg, hog cholera, tuberculosis and anthrax."

Before and during the war, racial discrimination was operated without restraint in the United States, with serious consequence in academia. Tuskegee Veterinary School was founded in 1944 to address the issue of discrimination in admittance of black Americans for professional study. The Middlesex Veterinary School in Boston had started in 1935 for similar reasons. It had been a component of the Middlesex College of Medicine and Surgery, established to avoid the Jewish quotas of Ivy League schools. Both veterinary and medical schools closed in 1947 when the Waltham campus was transformed into Brandeis University.[26]

Early medical and veterinary professions looked askance at ethics of chemists, pharmacologists, and other medical men selling commercial preparations. Before World War I, selling a proprietary remedy by veterinarians or physicians was considered a debasing enterprise. The commercially connected veterinarian was embarrassing or dubious and was not wanted in the membership of associations. The Conference of Research Workers in Animal Diseases did not allow veterinarians representing commercial companies to attend its sessions—they could talk in the hotel lobby but could not participate as scientists.

W. J. Martin, a pioneer Illinois practitioner, resigned from the American Veterinary Medical Association for fear of being expelled because he wanted to manufacture a cresylic acid emulsion and advertise it for sale in veterinary journals. After World War II, views began to change when it dawned on everyone that being a research scientist and a commercial veterinarian were not mutually exclusive. Veterinarians began not only to insert science into business but to make a profit in the change.

30. THE ATOMIC AGE

Nuclear energy research increased when World War II was over. Atomic bombs were built and tested at sites in the western U.S., sometimes with unwanted results. It was soon a serious issue and radiation disease was much on the public mind. Newsreels about survivors in Hiroshima and Nagasaki provided far greater shock and awe than did the still photos of the horrendous fire-bombing of Dresden, Hamburg, and Tokyo. Patients damaged from exposure to high doses of radiation were labeled survivors of "atomic bomb disease." The world was learning of birth defects and leukemia suffered by children of Japanese atomic bomb survivors. The film *Them!*, about giant atomically mutated man-eating ants that developed near Alamogordo, New Mexico, from radiation after tests in White Sands, was a sellout; not to fear—the case was solved by two entomologists from the U.S. Department of Agriculture, an eccentric old scientist and his beautiful daughter, using knowledge and skill to tie formic acid and other clues to the ants.

All of this led to fear that cancer might arise from radioactive fallout released in the U.S. during nuclear testing. Talk of an atomic apocalypse moved from the religious fringes to household conversations in American homes.[27]

Citizens shifted in their views and began to worry that our former allies, now turned enemies, would employ some of the horrific weapons that had been considered for use—atomic bombs, gas warfare, and biological warfare. The Cold War began to scar the mindset of Americans at home; in the midst of recovery, genuine worries led to serious problems. The Red Scare of McCarthyism began in 1949 when the Soviets tested their first atomic bomb. The arms race had begun, and along with it a bomb shelter craze. In its overzealous investigations to seek out communists, the House Committee on Un-American Activities and its Senate counterpart did 109 investigations. The malignant behavior of Senator McCarthy and his demagogy, lies, baseless accusations, and hunt for imaginary "communists" in every facet of life was debilitating to the American dream and the Constitution. "McCarthyism" became a term for making accusations without regard to evidence and truth, and on December 2, 1954, the U.S. Senate voted sixty-five to twenty-two to condemn McCarthy. It would be over fifty years before McCarthy's record of political falsification would be broken.

CODE-NAMED OPERATION CROSSROADS, testing of nuclear bombs on the Bikini Atoll in the Pacific Ocean began in spring 1946. Over twenty nuclear devices were detonated between 1946 and 1958 at different sites—on the reef, on the sea, under the water, and in the air. Abel, the first bomb of Operation Crossroads, was detonated in the air to prevent surface materials from being drawn into the fireball.

Later, hydrogen bomb tests would be far more explosive than anticipated and would lead to acute radiation sickness in inhabitants of neighboring islands and in the crew of a Japanese fishing fleet. Testing of Mike, the first hydrogen bomb with fifty times the power of the Hiroshima bomb, was detonated in the South Pacific in November 1952. An atmospheric hydrogen bomb test named Castle Bravo led to fallout that fell far beyond the predicted exclusion zone, contaminating the crew of a Japanese fishing boat, the *Daigo Fukuryū Mara*—the Lucky Dragon. The crew sickened and one died of acute radiation sickness.

Animals were tethered at various locations in ships around the perimeter of the bomb test to determine the doses of radiation received from the bomb. Goats, pigs, guinea pigs, and white rats were placed on twenty-two target ships. Sheep received neutron and gamma radiation that would have been lethal to anyone on the ship. Mice were placed outside the lethal zone in order to study possible mutations in future generations. The air blast that followed detonation killed many of the animals, but most would suffer acute radiation sickness. It was estimated that every unprotected location on the ship received 10,000 rem of initial nuclear radiation from the fireball. People deep in the ship would be protected from 90 percent of the radiation but still would have received a lethal dose of 1,000 rem and died of acute radiation sickness.

Radiation contamination of the environment from atomic testing was not on the public conscience in the 1950s, but there were predictions it could have a serious impact on grazing livestock. Then, during May of 1953, two atomic bomb blasts at a test site in Nevada rained fallout on herds of sheep grazing nearby. The U.S. Atomic Energy Commission had tested Nancy and Harry, two high-yield bombs. As clouds of dust and radiation rolled down Utah valleys, ranchers reported radiation burns on sheep grazing downwind of detonation sites. Wool sloughed off in clumps. Within a short period, two thousand ewes and twenty-two hundred lambs died, roughly one-eighth of the ewes and one-fourth of the lambs.

Complaints were made, and a team of veterinarians was dispatched to collect tissues and bone samples from surviving sheep for radiologic analysis at the radiation lab in Oak Ridge. Later, sheep were experimentally exposed to intense radiation at Los Alamos in an attempt to duplicate the disease. It was astonishing, even at the time, that scientists at a Hanford, Washington, lab who studied effects of radioiodine on ewes suggested that the "sheep did not die from irradiation because doses were too low and they did not die from doses to thyroid because that is a slower cause of death." However, two veterinarians who had examined the sheep concluded that the lesions on surviving sheep were similar or identical to those produced at Los Alamos and that "radiation was at least a contributing factor to the loss of these animals." [28]

The sheep had died from additive and prolonged effects of radioactive, contaminated grass in their stomachs. Thirty years after this incident, documents that had been previously classified were released, stimulating lawsuits against the government in relation to human leukemia. Utah ranchers initiated a lawsuit alleging suppression of information after atomic testing. It was reported in the journal *Science* that sheep exposed to only 4 rads of external gamma radiation might have gotten a dose of 1,500–1,600 rads in the gastrointestinal tracts, and fetal lambs may have received a thyroid dose of 20,000–40,000 rads.

The story was not corrected until the 1990s, when the courts found that the U.S. Atomic Energy Commission had suppressed scientific data and pressured veterinarians to revise their conclusion. Motivated by a desire to prevent general alarm, they had extensively investigated these events but had not revealed potentially compromising field observations and critical data from laboratory experiments.[29]

IN THE SUMMER OF 1950, North Korea, with Soviet backing, started the Korean War. Outraged by the invasion, President Harry S. Truman approved the use of U.S. military action on the ground. There was an embarrassing start that cost the lives of thousands of GIs. The draft had been active, and it looked as though most young men finishing high school and enrolled as pre-veterinary students would be facing military duty. Should military duty be deferred until after graduation from veterinary school, or be done after finishing high school, which would take advantage of the GI Bill for college expenses?

Then the problem disappeared. The American war machine, built to an unstoppable force, by 1952 had taken the capital Pyongyang and, with contributions from United Nations troops, had pushed the North Korean Army back to the boundary with China. A stalemate was reached when China entered the war to protect its border with Korea. China had pushed the U.S. back to the 38th parallel, where it stalled. A truce was declared but there was no peace treaty. The stalemate left things in limbo. The conflict had cost thirty-three thousand American lives, yet there was no victory to celebrate, no memorable movies,

Sergeant Reckless was a Mongolian breed mare purchased in Seoul for $250 to transport ammunition for a recoilless rifle platoon in the Korean War. Trained by her handler on only three trips, she set a record for solo trips under fire, avoiding tripwires and explosives. Making fifty-one round trips in one day in 1953, she was awarded Purple Hearts for two injuries. Returned to the U.S., Reckless died at Camp Pendleton, California, while being treated by veterinarians for injuries received from a fall.

and no Greatest Generation myths. Except for those returning as veterans, most veterinary students soon forgot about the war.

FOR VETERINARY STUDENTS WHO had taken a deferment during the Korean War, the county draft board called a few months before graduation. Most would apply for and receive a commission as a first lieutenant in the Veterinary Corps and head to San Antonio, Texas, to begin military life. By the late 1950s, each U.S. Army Medical Basic Training class at Fort Sam Houston had about forty veterinarians, four hundred dentists, and four thousand physicians.

For those in the Army Medical Basic Training class, there was an introduction to the work of the Veterinary Corps coupled with military responsibilities—how to march, salute, fire the M1 rifle, crawl under machine gun fire, and find the way back to base when deposited ten miles out in Camp Bullis—the only risk was a tick-borne rickettsial infection called Bullis fever that infested the woods. Basic training also included a Mass Casualties course in which veterinarians, dentists, and nurses were educated in the flow of patients in the case of an atomic bomb attack. They would be assigned triage duties that shunted human casualties into various treatment strategies—immediate, delayed, and for the lethally injured, none.

After basic training, veterinarians had six weeks in Chicago at the Veterinary Corps's Meat and Dairy Hygiene School, followed by reassignment to the Quartermaster Corps to work in food and meat inspection. In each class, some veterinary officers were assigned to scientific research positions in the Veterinary Section of the Armed Forces Institute of Pathology, to a military medical laboratory, or to the Army Biological Laboratory at Fort Detrick in Frederick, Maryland. The germ warfare lab at Fort Detrick grew as a major posting for veterinarians. By the end of the 1950s, 35 percent of the Veterinary Corps was stationed there. New veterinary officers were reassigned to either the Chemical Corps for the offensive program or the Medical Corps for the defensive program.

Among young officers of the Veterinary Corps, word got around of a plan to train veterinarians as paratroopers. The idea was to provide a cadre of junior military veterinary officers to be paradropped into inaccessible agricultural areas in which a dangerous disease outbreak in animals was occurring that would affect the U.S. military. The gossip was roundly ridiculed by junior officers as

Steve Canyon cartoon, 1960. (© KING SYNDICATE.)

an off-the-wall, zany idea. Less than a month later the comic strip *Steve Canyon* carried a multi-episode story of Canadian Veterinary Corps officers being parachuted into an anthrax outbreak in Scotland. There was a sudden conversion to seriousness since in the 1950s the cartoonist had an inside connection to military planning and *Steve Canyon* had an uncanny ability to predict military events.[30]

In the end, the paravet idea had a ring of truth. Early in the war, Britain had established its biological warfare laboratory at Porton Down in Sussex. In 1942, they tested the effects of anthrax in sheep on Gruinard Island, an uninhabited island off the Scottish coast. Bombs filled with anthrax spores were placed atop a pole supported by guy ropes and exploded over eighty sheep tethered in the area. Exposed sheep developed anthrax and several died. Monitoring after the tests revealed that the soil of Gruinard Island, highly contaminated with anthrax spores, would be too dangerous to be inhabited by sheep and humans and was quarantined. In the 1960s, the local population, concerned about anthrax spores, had caused grief among the government. In 1986, decontamination efforts used tons of formaldehyde sprayed over the test site. By 1990, the island was considered safe and returned to the owners. Documents on anthrax contamination of Gruinard Island were declassified years later and were documented in at least ten books and one episode of *Foyles War*, the television series on wartime Britain.

In 1954, the Soviets had constructed a biowarfare test site called Aralsk-7, where they weaponized anthrax spores, bubonic plague bacilli, smallpox, brucellosis, and tularemia. In 1971, the accidental release of weaponized smallpox infected ten people, killing three. Aralsk-7 was on Voz (for Vozrozhdeniya) Island in Uzbekistan, located in the Aral Sea near the Uzbekistan-Kazakhstan border. The nearby town of Kantubek, where workers and scientists lived, once had a population of 1,550. Today it is uninhabited, lying in ruins.[31] The facility was closed in November 1991. In 2002, through a project organized and funded by the U.S. Department of Defense Threat Reduction Agency and assisted by the Uzbekistan government, ten anthrax burial sites were decontaminated.

RETURNING MILITARY VETERANS of the Korean War who suffered chronic injuries filled the Walter Reed Army Medical Center in Washington, D.C. On its campus, the Walter Reed Army Institute of Research—WRAIR for short—had become the largest biomedical research facility in the Department of Defense. Dedicated to investigating infectious diseases, neuropsychiatry, and other military medical problems, WRAIR included several veterinarians in scientific research. In later years, veterinarian Paul Hildebrandt (who had discovered canine ehrlichiosis in military dogs during the Vietnam War), was placed in charge of the WRAIR Pathology Division, which included both medical and veterinary scientists.

During the Korean War, the Army had built a bomb-proof concrete bunker of a building on the Walter Reed campus to house what was then the internationally renowned Armed Forces Institute of Pathology—AFIP, in military jargon. Founded in 1862 as the Army Medical Museum, AFIP provided second opinion diagnostic consultations on medical, dental, and veterinary specimens from both military and civilian sources.[32] AFIP served as an international consulting center as well as a source of pathology reference materials for education and expertise; it included a large Veterinary Section that for four decades trained young veterinarians as pathologists and played a major role in the specialty of veterinary pathology. Board certification by the American College of Veterinary Pathologists, founded in 1948 as the first specialty group for veterinarians, was much in demand by pharmaceutical companies for evaluation of their emerging drugs in animals.

The global reach of the U.S. diplomatic and military services following World War II included the construction of medical laboratories throughout all global military zones. The Veterinary Corps tracked and investigated emerging diseases of military importance, facilitated local public health programs, and kept its ear to the ground about biological warfare implications. Research laboratories had been established worldwide during World War II by the WRAIR and the sister agency, the Naval Medical Research Unit (NAMRU), which focused on infectious diseases that needed veterinary expertise. The Navy unit in Cairo, Egypt—NAMRU-3—was faced with a problem of encephalitis in donkeys and mules. The brain disease developed in the autumnal wet season when mosquito populations were high. In 1965, the Veterinary Corps's Captain Paul Hildebrandt was detailed to Egypt; his previous investigations of Venezuelan equine encephalitis got him to NAMRU-3 to investigate the problem. Once he was in Cairo, the animal tests done to establish a viral cause for the dying animals were negative—an unexpected surprise. Hildebrandt's microscopic analysis of brain tissue from mules that died revealed tissue changes not of encephalitis but lesions typical of toxicity—leukoencephalomalacia—which suggested moldy corn poisoning, not viral encephalitis. Turns out, corn being harvested from fields along the Nile River had been shucked and sorted by women and children who put good ears in one pile for human consumption and moldy ears in another for livestock feed. The donkeys and mules had been poisoned by a mold toxin.

The post–World War II ascendance of the United States as the world power—economic, military, medical, and political—translated into relative global political stability. The Marshall Plan and icons of American democracy—the Declaration of Independence, Constitution, and writings of Jefferson, Madison, and Lincoln—lent a background of stability in which American science was spread to prosper throughout the free world.

PART VII

TRANSFORMATION

Veterinary Science Beyond 1960

For a decade after World War II there had been concerns nationwide that the population was dumbing down. Then, in fall 1957, the Soviet Union launched its satellite Sputnik. Ban the Bomb movements appeared by banner-carrying activists. There was discontent about the "damaging effects" of modern science. The reality was that the nation was failing in science education. The National Defense Education Act of 1958 was passed by legislators and signed by President Eisenhower, who believed the U.S. was falling behind the Soviet Union in education. The Act led directly to biology textbooks that stressed the cell's organelles and genes in life processes and evolution as a unifying principle of biologic change.

Evolution, clearly established in science for several generations, was no longer controversial among responsible citizens. The new discipline of evolutionary biology had been solidly built on the convergence of such diverse technologies as biology, anthropology, and physical chemistry. Darwin's evolution through continual genetic change in species was being revolutionized by Stephen Gould's stasis theory of punctuated equilibrium, preaching that there is a uniform, steady, gradual transformation of entire animal lineages—once a new species appears on the fossil record it becomes stable, with individuals showing all evolutionary change for most of its geologic history.

By the 1960s, the biological sciences were being transformed. Electron microscopy, protein chemistry, and DNA technology were being refined and used to explain how life processes work and how they are controlled by genes. The Romanian American George Palade combined biochemistry with electron microscopy of cellular structure to lay the groundwork for another new discipline, cell biology. Together with Belgians Albert Claude and Christian de Duve, for discovering the protective cellular organelles they named peroxisomes and lysosomes, Palade won the Nobel Prize in 1974. There were leapfrog advances in technology and theory that began to link biochemistry, genetics, and virology into yet another new discipline, molecular biology.

In infectious disease research, scientists for the first time could see viruses inside the cell. Electron micrographs showed how viruses replicate within cellular organelles, solving problems in a few days that had been hanging around for decades. Scientists were publishing pictures of the ultrastructure of viruses and of how they attacked and killed cells.[1] Influenza viruses could be seen attaching to cilia in the respiratory tract. Herpesviruses were photographed killing epithelial cells and in their sneaky move up the nerves to hide out in the brain. New adenoviruses were discovered that caused cold-like respiratory infections that could move into serious systemic disease in many species. To detect specific virus-infected cells under the light microscope, sophisticated labeling techniques were developed using antibodies complexed with fluorescent dyes.[2]

In the next decades, Nobel Prizes in Physiology and Medicine were awarded for work done in the 1950s. Veterinarian Harry Rubin[3] won the Lasker Award in 1964 for his discovery of the first cancer gene—*src*, short for sarcoma—showing that every cancer cell carried the virus and suggesting that it was a viral gene that drove the cell to malignancy. His work was done before cloning and genetic sequencing appeared, and it paved the way for the new field of viral oncogenesis. Rubin and his graduate student Howard Temin devised techniques to measure the virus in chick embryo cells in culture. The 1975 Nobel Prize went to Renato Dulbecco for his discovery of other new cancer-causing viruses and to Temin and David Baltimore, who had discovered reverse transcriptase, an enzyme that cancer viruses use to take over and control DNA metabolism. In 1976 the Prize went to Barry Blumberg for research on hepatitis B virus and Daniel Gajdusek for kuru.

Veterinary students bearing superb science credentials were highly qualified for biological research and began a transformation of veterinary science that not only attacked critical problems in animal health but burnished the reputation of the profession. Science and society were making a big transition. In a national poll taken four decades later, veterinarians were rated high as the "most trusted profession," second only to nurses.

31. NEW PROGRAMS, NEW LABORATORIES: MALARIA, POLIO, AND NEW VIRUSES

After the war, the government's World War II Malaria Control in War Areas program, located in Atlanta, Georgia, became a new agency under the U.S. Public Health Service dedicated to research and development for the control of malaria. Because malaria was still common in the South, the new agency remained in Atlanta. Named the Communicable Disease Center, its specialties were malaria, engineering, and entomology—nearly 60 percent of its staff and budget were dedicated to mosquito control.

From its beginning, the malaria control program at the Communicable Disease Center had a problem. DDT, short for dichlorodiphenyltrichloroethane and used in World War II to control mosquitos and body lice, was being used throughout the world. In 1945, dangers were recorded by U.S. Fish and Wildlife Service biologists, who warned that the use of DDT in marshes might be killing wild birds.[4] By the 1960s, clues began to appear around the world that DDT was killing avian species and was also accumulating in soils and the tissues of wild animals. The food chain effect seemed ominous: plants accumulate toxins, herbivores get them from plants, carnivores from their food, and, finally, humans—if the rate of absorption is higher than the rate of loss.

The long struggle to legislate against the use of DDT began later when its effects were conspicuous: peregrine falcons and osprey began to disappear from their North American ranges along the Atlantic Seaboard. DDT was causing soft-shelled eggs, which were easily broken in the nest. Reproduction failed and bird populations declined. It took ten years, but DDT was finally banned for use. Alternative mosquito control chemicals appeared.

The Communicable Disease Center (now known as the Centers for Disease Control and Prevention—the CDC) quickly grew into related areas, and within a decade it was assigned new programs: venereal disease in 1957, tuberculosis in 1960, and immunization programs in 1963. To work at the center, veterinarians were commissioned officers in the U.S. Public Health Service, and the expertise gained in the science milieu of the laboratories provided leaders for the coming decades. Many of these veterinary scientists matured into international scientific experts.

MEDICAL RESEARCH WAS FOCUSED ON POLIO when World War II ended. For two decades, infantile paralysis had crippled and killed children in the developed countries of the world. Poliomyelitis virus attacked the brain and spinal cord, killing neurons that controlled muscles of the legs and diaphragm. Survivors were left crippled and, in severe cases, unable to breathe. Gruesome iron lungs, which compensated for paralyzed diaphragms, appeared in children's hospitals. In the dog days of late summer, children were to avoid swimming pools, summer camps, and county fairs. Yet infantile paralysis seemed to be capricious, afflicting some children but not their siblings. Curiously, it seemed to occur more commonly in the cleanest households. Disturbing for scientists studying epidemiology, paralytic polio was practically unknown in Egypt and other countries with poor sanitation but widespread in developed nations—one of the worst outbreaks was during 1952 in Sweden.

Massive funding was available for research, but vaccine development was seriously hampered by one block: the difficulty in growing polio virus. The virus did not replicate in chick embryos, and assays in mice were not accurate. A polio-like virus from mice—discovered in 1937 by Max Theiler at the Rockefeller Institute—was a model for studying pathogenesis, but it was not all that helpful for the human infection. Human poliovirus would infect monkeys, which were a much better model, but they were costly to maintain. Polio research was laborious, time-consuming, and expensive, and for most scientists, unproductive. It required hundreds of rhesus monkeys imported from India on a massive scale. Veterinarians specializing in laboratory animals were required to care for all these experimental animals and a new field was born: laboratory animal medicine.

Rhesus monkeys were a serious danger to laboratory workers. Imported monkeys commonly had tuberculosis and measles acquired from their captors in India. They also carried a killer virus: their own version of human cold sores, a local infection of the lips and mouth that healed without treatment. Monkey B virus behaved like its close relative, human herpes simplex virus. The problem was that if transmitted to humans, monkey B virus caused an inescapable and uniformly fatal encephalitis for which there was no vaccine or treatment, and no survival. By 1960, monkey B had killed thirteen scientists and technicians working with monkeys, including three physicians and two veterinarians.[5]

The inability to sustain isolated cells in the laboratory—in vitro in scientific lingo—was the limiting factor in polio research. The breakthrough came in 1952 when John Enders at Harvard Children's Hospital published his report on the growth of poliovirus in the laboratory. He successfully perpetuated cells from monkey kidneys by placing them in glass tubes containing a growth fluid that allowed the cells not only to survive but to support the replication of poliovirus. With Enders's discovery, the race to produce a new polio vaccine was on. In 1955 the first polio vaccine was licensed. John Enders's cell culture system had been the major medical discovery in polio research that led to the vaccine, and it won him the Nobel Prize.

The new technology to grow viruses in vitro—outside the living animal—had direct impacts on medical and veterinary science: cell cultures from pigs, calves, dogs, and cats were developed to isolate viruses from diseases in animals. New polio-like viruses were found that caused encephalitis in pigs, mice, and chickens. Vaccines based on cell culture technology quickly appeared against feline distemper, canine distemper, infectious hepatitis, and rabies in dogs.

In the next decade, the growth of high-population livestock operations would be possible because of vaccines produced against viruses of cattle and pigs. Cornell University established the Veterinary Virus Research Institute in 1950, renamed two years later as the James A. Baker Institute. Using the new cell culture technology, Cornell scientists discovered the causal viruses of several great plagues of cattle: virologist John H. Gillespie, James A. Baker, and Peter C. Kennedy reported the viral cause of infectious bovine rhinotracheitis—IBR for short—and pathologist Peter Olafson explained the pathogenesis of BVD—bovine viral diarrhea.

The close similarity of monkeys and other nonhuman primates to humans and the striking success in polio research was soon extended into other investigations. In 1962, several National Primate Research Centers were established by Congress, designed to be a national network of laboratories and scientists that specialize in studies of high-profile human diseases, ranging from autism to multiple sclerosis and other nasty neurologic disorders. The primate centers worked cooperatively with the National Institutes of Health as well as private foundations, industry, and other governmental agencies. For veterinarians whose science overlapped with medicine, the primate centers were a big stimulus.[6] The New England Regional Primate Center associated with Harvard University had an outstanding Department of Comparative Pathology. Veterinary pathologists Ronald Hunt and Norval King discovered how cancer is caused by several primate viruses. *Herpesvirus saimiri*, an indigenous and noncytopathic virus of squirrel monkeys (*Saimiri sciureus*), when infecting other new-world monkey species (such as owl monkeys, spider monkeys, or marmosets), produced a rapidly progressive cancer—a malignant T cell lymphoma that killed in thirteen to twenty-six days with massive invasion of body organs by malignant lymphocytes. The malignant cells did not contain the virus, only the viral genes.

Veterinarian Ralph Brinster at the University of Pennsylvania was developing new techniques for growing mouse embryos in cell culture and to manipulate embryos to study embryonic cell differentiation. One of the most celebrated veterinary scientists, Brinster founded a new discipline that dealt with transfer of foreign genes into mammals, transgenic stem cell implants, in vitro fertilization, and deletion of genes—knockout mice. He was elected to the National Academy of Sciences in 1987 and received the Presidential Medal of Honor from President Obama in 2010.[7]

32. COMPARATIVE MEDICINE: MODELS FOR LEUKEMIA

In 1908 two veterinarians, Vilhelm Ellermann and Olaf Bang, working at the Royal Veterinary School in Copenhagen, published a report that proved what field veterinarians had been telling them for some time, that avian leucosis—a form of leukemia in chickens—was a transmissible disease. Their disciplined experiments proved that to be true, and that whatever was causing the disease was much too small to be a bacterium. At the time, the status of human leukemia was vague; some physicians even suggested that human leukemia was not a "true tumor." No one in medical science took leukemia in chickens seriously.

Close on the heels of the Danes was a report in 1911 from the Rockefeller Institute in New York City. Peyton Rous, also working with chickens, discovered that a tumor composed of fibrous connective tissue—the Rous sarcoma—was transmissible by a virus. No one in medicine thought much of that either. The response of the scientific community to these seminal discoveries on virus-induced cancers ranged from disinterest to disbelief.

To deal with continuing losses to the poultry industry from leukemia and lymphoma, the Bureau of Animal Industry established a poultry research laboratory in the 1930s in East Lansing—close to Michigan State University. The big poultry problem was the avian leukosis complex, a group of lymphomas and soft tissue tumors called big liver disease, range paralysis, and gray eye according to the organ in which the lymphoma tumors grew in the sick birds. At one end of the spectrum was avian leukemia, its viral nature established by the Danes in 1906; at the other end was Marek's disease, a lymphoma first described by a Hungarian veterinarian in 1907. Marek's disease became a serious problem in the 1950s when the industry moved to large crowded flocks grown in confinement. In 1967 the herpesvirus that caused Marek's disease was discovered independently by Richard Witter at the Regional Poultry Laboratory and by English veterinarians. The virus was the only animal model for human lymphomas caused by the newly discovered Epstein-Barr herpesvirus. Witter followed the course of viral infection and showed that the Marek's disease herpesvirus replicated to complete virus only in epithelium of the feather follicles of the skin and that as feathers grow, they shed infectious dander—the key to virus persistence and its elimination from chicken flocks. For his research, Witter was elected to the National Academy of Sciences.

NATURALLY OCCURRING LEUKEMIA IN MICE was reported to be caused by a murine leukemia virus in 1951; in baby mice the virus first multiplied in the bone marrow and spread to the thymus to initiate the cancer in white blood cells. Soon there were large families of murine leukemia viruses, each named after their discoverer: Gross, Moloney, Rauscher, Friend, and others. The payoff day from the astonishing research in the 1930s on viruses that caused cancer arrived in the 1960s.

Leukemia was the hot topic for cancer research and spurred federal money to investigate animal models. Feline leukemia virus, the Rous sarcoma virus in chickens, the papilloma viruses in several animals, and the cancer-causing viruses of mice soon became universal models for cancer caused by viruses in the new field of viral oncogenesis. There were detractors. So many hypotheses were being tested in mice that one congressman referred to the National Cancer Institute as the "National Mouse Cancer Institute." But by 1960, the older models of cancer in chickens to study human disease were resurrected. The importance of discoveries in the past was obvious when Peyton Rous of the Rockefeller Institute was awarded the Nobel Prize in 1966 for his discovery fifty-five years earlier of the Rous sarcoma virus in chickens (see appendix VI).

IN 1964 A BRITISH VETERINARY PATHOLOGIST reported in the journal *Nature* that a virus caused leukemia in cats. William Jarrett, working in the veterinary school in Glasgow, had been called by a practicing veterinarian, Henry

Pfaff, who had noticed a cluster of cats with lymphocytic leukemia. Suspecting a viral cause—it was a common disease in domestic cats—Jarrett successfully transmitted the cancer from one cat to several kittens. The cancer was contagious and could be passed horizontally—from cat to cat. Jarrett showed unequivocally that it was caused by a virus, feline leukemia virus. Astonishing electron microscopic photographs of feline leukemia virus by Jarrett's colleague H. M. Laird published in the *Journal of the National Cancer Institute* four years later left no doubt that the virus was infecting cells of the cat. Their discovery was the coup de grâce for those who did not believe in viruses causing cancer.

The importance to human health was obvious, and federal funds from the National Institutes of Health for cancer research in animals were soon available to explore how viruses cause cancer. Financial support for comparative medicine was becoming available, and for the strongest programs easy to come by, especially if you had expertise in some field related to cancer.

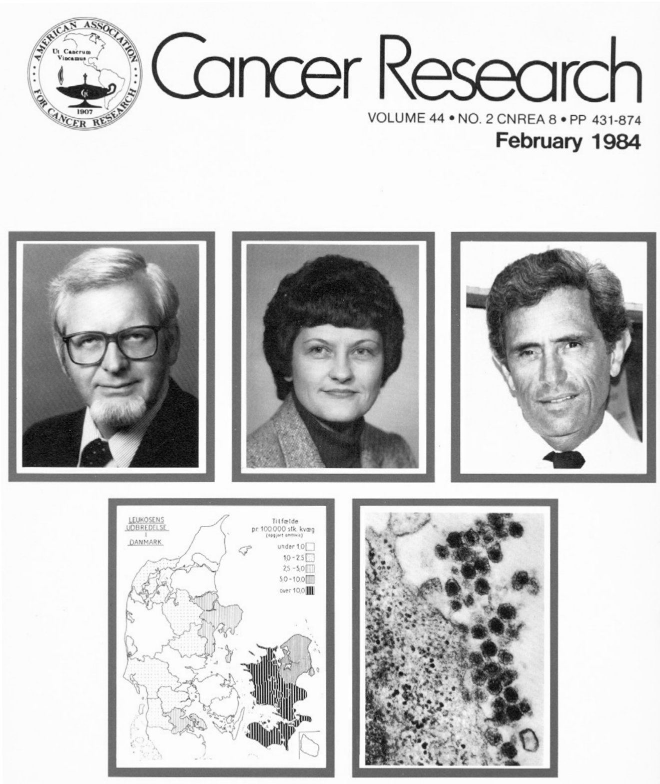
BOVINE LEUKEMIA HAD SIMMERED in the early 1960s as a public relations problem for the dairy industry; there was concern that milk-drinking children might be at risk. Leukemia was most prevalent in dairy cattle, whose individual health was more closely monitored than in beef cattle or other bovid species. The disease could be diagnosed early from blood samples by a massive increase in numbers of abnormal malignant lymphocytes, the white blood cells that in normal animals circulate in the bloodstream and are the source of immune reactions that protect against infectious agents.

In Europe, the Danes had led the way by their discovery of a clinically silent preleukemia phase of the disease—a slow but progressive elevation in the number of lymphocytes in circulating blood. On that basis, Denmark had started a program of screening dairy cattle for bovine leukosis and culling the cows that had this persistent elevation in lymphocytes. Hans Jørgen Bendixen, a veterinary officer of the Danish Veterinary Services, mapped the occurrence and incidence of bovine leukosis in Denmark—data that revealed the enzootic nature of the disease and led to his plan to remove affected cattle from the herds to eliminate it.

The crap hit the fan in 1967 when a medical virologist at the University of Pennsylvania, R. M. Dutcher, published what he believed to be leukemia virus particles in the milk of dairy cattle. He had examined milk from cows with leukemia, but the particles he saw in the electron microscope could not be distinguished from amorphous particles of protein; they appeared to be residual milk proteins, not viruses. But that didn't matter since the damage had been done—the press had played this out over all channels, dairy farmers were angry, politicians got involved, and funding was approved for bovine leukemia research. The U.S. Department of Agriculture's Agricultural Research Service responded with major projects in four states.

At the University of Wisconsin, Carl Olson was an early recipient of some of those funds and showed that leukemia could be transmitted from sheep to cattle. A graduate student of Olson, Janice Miller, was the first to find the bovine leukemia virus. Artificially stimulating cell cultures of lymphocytes from the blood of cattle with persistent lymphocytosis, a preleukemia stage, she detected the virus using electron microscopy. Her results were quickly confirmed by scientists in California, Minnesota, and Nebraska, all of whom had received USDA grants to study bovine leukemia. Miller was elected to the National Academy of Sciences and spent the remainder of her productive career at the National Animal Disease Center (NADC) achieving credits for developing diagnostic tests for the identification of proteins of the agent of mad cow disease, bovine spongiform encephalopathy, and improvements in other diagnostic tests needed in animal diseases.

It was soon clear to science that BLV did not pass into commercial cow's milk and presented no public health risk. However, American dairy associations saw it as a public relations problem that might affect the market and pressured the USDA to study how the virus behaved in cows. At the new NADC, a young veterinary virologist was hired to investigate how BLV infected milk cows and caused leukemia.[8] Martin Van Der Maaten began growing cells in culture, inoculating them with white blood cells from a Holstein cow with preleukemic, persistent lymphocytosis; the cow was weak and emaciated and had generalized enlargement of lymph nodes. No BLV grew in the cultures. But the cultures *were* growing a new virus, one never before seen. Electron microscopy of the new virus revealed it to resemble visna virus, which had recently been reported from Iceland to cause a chronic, paralysis-inducing demyelination of the brain in sheep. Van Der Maaten called his new virus a "visna-like syncytia-producing virus." When cattle were given the new virus, it caused persistent viral infection and generalized lymphadenopathy; no overt clinical disease resulted, and



Discovery of the virus that caused leukemia in cattle by Janice Miller at the University of Wisconsin was a major scientific event. The cover of the journal *Cancer Research* from February 1984 was dedicated to scientists who established the cause and behavior of the virus in cattle. Top (*left to right*): Hans Jørgen Bendixen, DVM, Denmark; Janice Miller, DVM, University of Wisconsin; Jorge F. Ferrer, MD, University of Pennsylvania. Bottom: Bendixen's map of leukemia incidence in Denmark (*left*) and Miller's electron micrograph of BLV (*right*). (COURTESY OF *CANCER RESEARCH*.)

studies of the new virus were abandoned. A decade later, the virus was named bovine immunodeficiency virus—BIV for short—the first retrovirus of its kind to be isolated, predating by a decade the identification of its close relative, the human immunodeficiency virus. When HIV was identified as the cause of AIDS, scientists at the National Institutes of Health remembered the Van Der Maaten paper and called for isolates of his original BIV.

In the larger progressive veterinary schools, scientific challenges of the new age were met head-on. Veterinary scientists at Ohio State, Cornell, and elsewhere soon clarified how the feline leukemia virus hides out in the cat and masquerades to cause not just cancer of lymphocytes but many different life-threatening changes.

At the Department of Veterinary Pathology at The Ohio State University, Professors Clarence Cole, Richard Griesemer, and Adalbert Koestner had set a high bar, creating the best in veterinary science. The productive research environment led directly to discoveries in the pathogenesis of leukemia viruses, but also in neurologic diseases of animals and in the complex relationships in calcium metabolism. The Ohio State veterinary school gave rise to Charles Capen, John Shadduck, and Thomas J. Rosol—all major leaders in pathobiological research and the advancement of veterinary science on the national level.[9]

At Ohio State, veterinary pathologist Griesemer, in cooperation with virologists from the medical school, secured funding for the Special Virus Cancer Program to investigate the safety of newly emerging leukemia viruses in animals. Using their new facilities for germ-free technology—germ-free because the viruses were grown in tight isolation in bubble chambers and would not be exposed to external microorganisms—they discovered how feline leukemia virus developed in kittens. Veterinary pathologist Edward Hoover and colleagues showed that the FeLV affected the bone marrow, causing destruction of blood cell–forming stem cells. That led to studies on immunodeficiency and progressive white blood cell dysfunction, as well as an effective inactivated FeLV vaccine for cats. Hoover made career-long contributions to FeLV research, discovering viral proteins in circulating white blood cells. Throughout his career, he expanded on this discovery and made major contributions to how viruses cause cancer.[10]

Turns out, FeLV was first multiplying in the bone marrow and then spreading to lymphoid tissues to cause leukemia, but its damage in bone marrow led to the suppression of many other stem cells—red cells that transport hemoglobin, neutrophilic white blood cells that are the first line of defense in bacterial infections, and monocyte, the white blood cells that mature into scavengers bearing "eat me" signals that gobble up bacteria and remnants of tissue damage. The clinical manifestations of the destruction of these different blood cells resulted in cats with life-threating anemia, immunosuppression, and an inability to fight infectious disease. The similarity of the disease to that of humans made it a superior model for research.

Veterinary scientists hired by leading cancer centers made major contributions to feline leukemia. William David Hardy Jr., working in the Laboratory of Veterinary Oncology at Memorial Sloan Kettering Cancer Center in New York City, developed diagnostic tests for FeLV as well as other small animal diseases. Hardy's work began with investigations on the transmission of FeLV in randomly selected outbred populations of cats.[11]

Veterinarian Myron Elmer "Max" Essex in the School of Public Health at Harvard University was beginning his research that linked immunosuppression to retroviral infections in animals and humans.[12] Essex received the Lasker Award jointly with the discoverers of human immunosuppressive virus (HIV). AIDS, short for acquired immunodeficiency disease syndrome, had been first reported clinically in June 1981 in five drug-using male homosexuals with rare pneumocystis pneumonia; two years later, the American Robert Gallo and French Luc Montagnier had independently reported in the same issue of *Science* the discovery of a retrovirus they believed to cause AIDS. For the next decade, veterinarian Essex, working at Harvard and in Africa, made an astounding spectrum of discoveries that included simian T cell leukemia virus (STLV) and simian immunosuppressive virus (SIV), as well as the human immunosuppressive virus-2 (HIV-2) and the surface protein gp120 that is used in blood screening for HIV infection. Human HIV appears to have evolved in humans infected with the simian viruses in West Africa. Appointed chair of the Botswana-Harvard AIDS Institute Partnership, Max Essex is perhaps the most awarded veterinarian for scientific research for discoveries that linked leukemia and immunosuppression.

33. GRASSROOTS MANDATES: THE NATIONAL RESEARCH CENTERS FOR LIVESTOCK DISEASES

Fort Terry, an abandoned military base on a tiny island off the eastern tip of Long Island, eighty miles east of New York City, was deeded to the U.S. Department of Agriculture in the early 1950s. The USDA's Agricultural Research Service built the new Plum Island Animal Disease Center, dedicated to protecting the livestock industry through research on foreign animal diseases—pestilences that would be disastrous if moved into North America. The major project was foot-and-mouth disease—dangerous because of its catastrophic impact, extreme infectiousness, and highly variable genetic makeup—making vaccine production difficult and often ineffective. The unit would also investigate African swine fever and other dangerous foreign animal diseases and maintained a scientific staff at the ready for any global emergency. The new Plum Island facility had some drawbacks: the site required the USDA to operate a navy to move employees and animals into the site, and its limited mandate did not alleviate the overcrowded research buildings at the Beltsville labs outside an increasingly congested Washington, D.C.

To place research closer to the problems in the field, Congress provided funds in the 1960s for the Agricultural Research Service to establish laboratories in the Great Plains, Palouse, and Intermountain regions: the Veterinary Toxicology and Entomology Research Laboratory near Texas A&M University, the Animal Disease Research Unit at Washington State University in Pullman with John Gorham in charge, and the Poisonous Plant Research Laboratory near Utah State University in Logan. Some of these laboratories made striking discoveries. In Utah, pregnant sheep grazing *Veratrum californium* gave birth to lambs with cyclopia (a single median eye) when ingesting the plant only on a very precise date: the fourteenth day of gestation. To study respiratory disease in chickens, Funds for the South established the Southeast Poultry Research Laboratory in Athens, Georgia, in 1962; with the continuing importance of avian influenza, the lab developed diagnostic tests that became a critical link in protection of the poultry industry under the direction of veterinary virologist Charles Beard.

In 1956, a report titled *Veterinary Medical Science and Human Health* released by the subcommittee of the House Appropriations Committee chaired by Hubert Humphrey determined that approximately $65 million a year was being spent by the federal government on veterinary services and that new research facilities were needed. Veterinary facilities at the Beltsville Agricultural Research Center were badly out of date (and developers and other government agencies coveted the prime urban agricultural land at the site). The subcommittee approved a new animal disease laboratory at a cost of $20 million to be located near a school of veterinary medicine and authorized a ten-person committee to select a site.[13]

The final decision had been between Iowa State and Colorado State. The report of the Investigative Site Committee stated that its choice of the Iowa location was based on Iowa State—that it was "an outstanding scientific center and would provide opportunities for cooperation between the laboratory and college." The quality of the graduate college, its outstanding library, and Iowa State College laboratories in basic sciences of biology, chemistry, physics, nuclear research, mathematics, and statistics were all reasons for the selection of Iowa. Furthermore, the facts that Ames was "far removed from any critical industrial areas" and was a good community with "excellent public schools" were convincing to the committee. "One of the strongest things favoring Iowa State," Wilbur Plager of the National Swine Growers told the *Ames Tribune*, "is that Iowa State unquestionably is closer to all types of livestock and poultry production than any other institution."

Funds for construction of the laboratory were included in an appropriation bill signed by President Eisenhower on July 27, 1956, and four days later the USDA and Iowa State announced that the new "Federal Animal and Poultry Disease Laboratory" would be located on the 318-acre site two miles east of Ames. For the director of the new laboratory, William A. Hagan, an internationally recognized scientist and dean emeritus of Cornell University, was selected.[14] Hagan had published widely in both medical and veterinary journals on infectious diseases of livestock, including tuberculosis. Even so, the new position would be a difficult one.

Named at the dedication ceremony in 1961 the National Animal Disease Laboratory (and renamed the National Animal Disease Center [NADC] in 1973), it was to house cooperating units of the USDA. It would be the major laboratory of the Agricultural Research Service but would also house the regulatory Animal and Plant Health Inspection Service's Veterinary Services Laboratory, which would appoint an assistant director. Turns out that despite good intentions, there was as much competition as cooperation. Director Hagan did not last long in the position; he died on February 1, 1963, at thirty-thousand feet while en route to London from Chicago for a meeting in Geneva. The Agricultural Research Service appointed the assistant director, Chester Manthei, as the new director.[15] To attract new graduates into science, young veterinarians were given time off to work toward their PhD degree in microbiology, pathology, or physiology at a university of their choice—it was a science-driven mini–GI Bill of enormous long-term impact, one that was killed as a measure of cost cutting in the 1980s.

The National Animal Disease Laboratory, like all units of the Agricultural Research Service, planned its research program through consensus of three forces: the scientists doing the work, the administrative National Program Staff housed in Washington, and national organizations of livestock producers, which influenced congressional budget allocations. Once each year these three groups got together to strategize at the American Animal Health Association annual meeting. There, scientists presented their research data, producer groups prioritized their needs, and the regulatory agency responsible for field programs, the Animal and Plant Health Inspection Service (APHIS), adjusted their programs. When decisions were reached, administrators of the National Program Staff approved budgets for the research program for the coming year. It was a remarkable interaction that worked well, an unacclaimed jewel of the U.S. government. It was often confrontational but always effective. Each producer group held its own session, listened to research reports from scientists, and decided where its push for congressional money would be directed. In the 1960s, their needs were clear.

National Pork Producers: Eradicate hog cholera. The serum and virus vaccine of William Niles and Marion Dorset had eliminated hog cholera as a major threat, but vaccination was expensive. The threat of a disease breakout remained. After World War II, large swine confinement operations began to appear that were causing producers to promote an eradication program. In the 1950s, the USDA's APHIS proposed that hog cholera be eradicated—Canada had eradicated hog cholera. Good idea, but there was a roadblock. The laboratory identification of hog cholera was expensive and time consuming—too slow and costly for a large-scale eradication program. Susceptible test pigs were given a suspect tissue suspension and observed for thirty days for signs of disease to confirm the diagnosis. The American Association of Veterinary Laboratory Diagnosticians had developed an elaborate systematic procedure as a guide to diagnosis—factors weighted according to their importance: herd history, clinical signs, lesions, and white blood counts; it was subjective and imprecise. After considerable lobbying by the producers, legislation was passed by Congress for a national hog cholera eradication program in September 1961.

At the National Animal Disease Laboratory, the problem was assigned to William Mengeling, who applied the new immunofluorescent antibody, or FA, test to detect hog cholera virus. In the microscopic FA test, specific hog cholera antibodies are tagged to fluorescein (which emits fluorescence when activated by ultraviolet light) and the labeled antibodies applied to a glass slide containing infected cell cultures or animal tissue. Attaching to the virus, the dye emits fluorescence that can be seen by the scientist. Fluids from blood or tissue specimens obtained from suspected hog cholera cases in the field were added and allowed to grow to cell cultures; the positive FA procedure proved the presence of hog cholera virus. The test was adopted in state and federal laboratories and was the major factor in U.S. hog cholera eradication.[16]

American Beef Association: Prevent Escherichia coli *diarrhea.* Diarrheal disease was a major factor limiting red meat production in the 1970s; the bacterium *E. coli* was a major disease problem for calves and pigs throughout the world. It killed animals and was also a problem in food contamination, where it could kill humans. The NADC devoted one of its major units to *E. coli* research and hired veterinary pathologist Harley Moon to sort out this complex disease.[17] Moon's work defined how *E. coli* attached to intestinal epithelial cells in pigs, calves, and sheep and how it triggered cuplike indentations to facilitate bacterial attachment. His "attaching and effacing" entry mechanism was a new concept in enteric disease. Moon's research would also lead to the use of vaccines based on fimbriae, the tiny surface hairs on bacterial surfaces. Fimbria-based vaccines proved highly successful in the protection of farm animals from *E. coli* disease.

Moon's investigations found new strains of *E. coli* that produced an enterotoxin—a toxin that acted on the cells lining the intestine to block absorption and make them secrete excessive water into the gut to cause diarrhea. Loss of water and dehydration could kill the piglets. The relevance of enterotoxins came in 1993, when an outbreak of *E. coli* in humans arose from contaminated beef patties in seventy-three Jack in the Box fast-food restaurants in Washington, California, Nevada, and Idaho. Most victims were under ten years of age; four died of a new toxic hemolytic uremia syndrome, and many more were left with permanent kidney and brain damage. Health inspectors traced the contamination to the Monster Burger—billed as "so good it's scary"—which had been cooked at a temperature too low for a time too short. The father of seventeen-month-old Riley Detweiler took up the cause, with constant press coverage, congressional hearings, and immediate action by the USDA, the National Cattlemen's Beef Association, and the American Meat Institute, which transformed the national approach to meat safety.

American Dairy Association: Control mastitis and milk fever. Cows with milk fever go off feed, rapidly progress to tetany and collapse, and quickly develop changes in respiration that signal impending death. Drain of the mother's calcium into her milk makes her own blood calcium drop to lethal levels. Milk fever appears at the onset of calving, when the cow is unable to mobilize enough calcium to compensate for its loss at the beginning of lactation. It afflicted nearly 6 percent of dairy cattle in 1980 and cost the dairy industry a quarter of a billion dollars. The dairy industry made certain that the NADC was conducting prominent research in this area. Ron Horst and his colleagues discovered that milk fever was caused by an interplay of dietary calcium with potassium, sodium, and magnesium that disturbed the acid-base balance in blood, which in turn prevented the action of parathyroid hormone and its control of calcium in the birthing cow. The simple addition of chloride to feed would prevent the metabolic alkalosis and parathyroid blockade. Horst's team would go on to make contributions to vitamin D metabolism and develop techniques for the assay of vitamin D and its metabolites.

In 1989, veterinary microbiologist Marcus Kehrli reported his discoveries of how white blood cells of the cow behave in mastitis. He found that hormones increasing during birthing suppressed bacteria-killing white blood cells and that this effect could be overcome by treatment with colony-stimulating factor, a cell-to-cell communication cytokine. As an offshoot of the study, Kehrli discovered a genetic defect, bovine leukocyte adhesion deficiency, coining the acronym BLAD. Holstein dairy cattle that were overly susceptible to bacterial diseases had a mutation in the gene that formed a critical protein that controlled the activity of these important circulating white blood cells. The gene defect made the cow unable to add surface receptors (called the β2 integrin adhesion molecules) to its white blood cell surfaces; the absence of these receptors on neutrophilic leukocytes made them unable to function as microbial-killing cells in the blood that are the first line of defense against bacterial disease. The BLAD gene was carried by many of the most-used sires and cows of the breed. Kehrli's development of a diagnostic polymerase chain assay for detection of the BLAD gene solved a big problem for the Holstein cow.

American Sheep Industry Association: Eradicate viral pneumonia in sheep. Joining the National Animal Disease Laboratory after his graduation from veterinary school at The Ohio State University, Randall Curry Cutlip was inclined to sheep. He had been a sheep shearing champion—he had won shearing contests at the State Fair of West Virginia and the International Stock Show in Chicago—and was assigned to deal with respiratory diseases. For the next three decades he unraveled the mystery of how adenoviruses, parainfluenza viruses, and mycoplasmas cause acute pneumonia and the role that superinfecting *Pasteurella* bacteria play in the sheep respiratory disease complex. It was a difficult task; sheep are notorious for masking signs of disease, often being "asymptomatic" when first ill.

Later in his career, Cutlip attacked ovine progressive pneumonia, a chronic and insidious respiratory disease caused by a new emerging group of retroviruses—called slow viruses or maedi/visna viruses—that infected 25 percent of North American sheep. Cutlip developed a definitive immunodiffusion diagnostic test for the disease. For his pioneering work, he was given an award from his alma mater and was named the Agricultural Research Service Scientist of the Year.

National Cattlemen's Beef Association: Develop a killed brucellosis vaccine. The brucellosis eradication program for cattle was begun in 1934 by the USDA. The attenuated live vaccine, strain 19, was available and was responsible for the elimination of brucellosis in most of the states in the country. By the 1980s, the only remaining states that had bovine brucellosis were Oklahoma and Texas, and the only remaining focus of endemic bovine brucellosis caused by the bacterium *Brucella abortus* was the bison herds grazing in Yellowstone National Park. In the final mop-up of the disease there was a big problem with the strain 19 vaccine. Live bacteria in the vaccine caused vaccinated cattle to develop antibodies, making it impossible to determine whether a positive blood test had resulted from natural infection or from the vaccine. What was needed was a new vaccine, one that did not incite antibodies in the cow that would produce a misleading positive test that would be mistaken as a natural infection.

In 1986, under pressure from the National Cattlemen's Association (NCA), Congress budgeted more than $60 million per year for five years directed to the eradication of brucellosis in cattle. Most of this would go to the field operations of the USDA's APHIS; $10 million was designated for research at the Agricultural Research Service's National Animal Disease Center, with two sub-grants of $1 million each mandated for universities in the two states that still had brucellosis in cattle: Texas A&M and Oklahoma State University. Annual meetings were to be held to present progress to APHIS and NCA that would justify funding.

In the annual meetings held in 1987 and 1988, all fund recipients failed to report significant progress. This caused progressively increasing criticism and condemnation of the NADC. The report of essentially no progress again in September of 1989 led to mandates for change. The NADC director was fired and replaced by Dr. Harley Moon, who removed the head of the NADC Brucellosis Research Group and replaced him with me. The mandate was to achieve the leadership, management, and research plans required for development of a killed Brucella vaccine against brucellosis in cattle. The first meeting with the NCA was brutal. A member from Texas publicly noted the research failures and demanded progress, saying, "You guys in Iowa are sitting on your ass doing nothing." The cattlemen were insisting that a killed vaccine be produced. To be fair, there had been no progress.

Testifying at a U.S. House Agricultural Committee special meeting, an agricultural research scientist explained that a killed vaccine would not work; the congressmen were promised that a new live vaccine could be produced in five years using a mutant strain that lacked the lipopolysaccharide component that reacted in the field test.[18] Bacterial candidates for use as a vaccine were screened: Were they safe? Did they persist for long enough to produce immunity? Did they cause human infection? Experimental designs for a progressive system of testing of candidate strains revealed a superior candidate: RB51, a natural mutant discovered by Gerhard Schurig, a scientist at Virginia Tech University. In tests to determine immunogenicity and protection, RB51 was clearly effective. The contract for production was written for the Colorado Serum Company in 1995, meeting the goal of five years as promised to the NCA.

34. OLD PLAGUES IN THE WILD: THE NATIONAL WILDLIFE CENTERS

Brucellosis in bison in Yellowstone National Park had smoldered for years—it was first reported by the Bureau of Animal Industry's John Mohler in 1917. In the 1920s, forest ranger veterinarians began to vaccinate bison with live brucellosis strain 19 vaccine. Persistent objections from Indian tribes and recreational groups led to the abandonment of bison vaccination. Then the National Park Service's postwar operational change to a natural environment policy—without human interference of any kind—increased brucellosis in Yellowstone bison. National Park Service officials never observed abortion in bison; despite a high number of bison with positive blood tests for brucellosis, they insisted that infected animals in the park did not abort. But they did. Brucellosis can only be maintained in wild elk and bison by abortion—the billions of bacteria on

Rangers sampling bison for brucellosis in Yellowstone National Park, 1927. Vaccination for brucellosis in bison was begun in the 1920s but stopped when the park shifted to natural management without human intervention. (FROM THE YELLOWSTONE NATIONAL PARK ARCHIVES, U.S. NATIONAL PARK SERVICE.)

infected placentas are licked by new hosts. Bison give birth unobserved at night and aborted fetuses are eaten by scavenging carnivores before morning.

The problem was that infected bison migrating outside the park to the north could infect cattle in the Paradise Valley of the Yellowstone River—keeping Montana ranchers in an expensive perpetual state of quarantine and mandatory vaccination, and the U.S. Department of Agriculture from declaring the nation's cattle free of brucellosis. In the winter of 1996–1997, Yellowstone herds had more than thirty-four hundred bison; 30 to 40 percent of them reacted positively in laboratory tests for brucellosis. Only 1 to 2 percent of the large elk population in the park had positive tests. Harsh weather that winter forced record numbers to starve and others to leave the park in search of forage. National attention focused on management strategies—including shooting bison—used to prevent spread of the disease from bison to cattle that grazed on lands adjacent to the park.

In 1997, Secretary of the Interior Bruce Babbitt asked the National Academy of Sciences to undertake a six-month study of brucellosis in the Greater Yellowstone Area—the GYA—to look at the issues, including the extent of bison infection and potential for a vaccine program and the transmission of *Brucella abortus* among cattle, bison, elk, and other wildlife. The official position of the National Park Service was that brucellosis did not cause infected bison to abort their fetus—a troubling stance. The study began as "Brucellosis in the Greater Yellowstone Area." To expedite matters, the National Academy of Sciences used a new paradigm. Instead of a committee of experts, it used a new approach: there would be only two experts who would interview all parties involved. The coauthors were to be a veterinary scientist (me) and mammalian ecologist, Dale McCullough, a professor of wildlife biology in the Department of Environmental Science at the University of California, Berkeley.[19]

The plan was to have informational meetings for input of concerned citizens in each of the states in the GYA—Wyoming, Montana, and Idaho. Controversial from the start, there were several major power bases attempting to influence the direction of the study. The two major players were the National Park Service and the U.S. Department of Agriculture, but there were powerful groups on the periphery: state Departments of Agriculture and Departments of Wildlife Conservation from states surrounding the park. There was strong support from ranchers, state livestock organizations, and the State Veterinarian's Offices from Wyoming, Montana, and Idaho. There were equally strong rejections by Indian tribes, recreationalists, and elk hunters.

The study held informational meetings in Bozeman, Montana, Jackson, Wyoming, and Idaho Falls, Idaho. The first of these was on the campus of Montana State University. Security was tight, and the campus police had a presence in the auditorium. One in the audience had thrown bison feces on the Montana governor the previous week, but nothing was tossed and the meetings went well. What we found was that brucellosis was infecting GYA bison and that the possibility of transmission to cattle was high. Elk were another matter. Although brucellosis is not readily transmitted in nature because pregnant elk sequester during birthing, Wyoming has state-sponsored feed grounds where elk congregate in winter and give birth in high population densities, making them a serious threat for promoting infection. The study received good reviews. Over the next two decades elk became the major source of brucellosis in the GYA, requiring yet a third study by the National Academy of Sciences.

RABIES PERSISTS IN NATURE with a unique strategy. How rabies virus survives and propagates in wild animals was reported in 1969 by scientists Frederick Murphy and Richard Diercks at the Communicable Disease Center in Atlanta.[20] They discovered that in foxes, bats, and other biting animals, rabies virus replicates to large amounts in two sites: the salivary glands and the brain. Brain infection induces a change in the normal fearful or avoidance attitude of the host to one of aggressive behavior in which, in carnivores at least, the host will attack and bite potential hosts. In the salivary glands, large amounts of rabies virus are produced—new viruses budding from the glandular cells into the lumen of salivary ductules are released into the saliva, which during an attack by a rabid animal maintains rabies virus in nature.

Rabies vaccination programs in dogs were begun during the 1940s and 1950s and effectively controlled, and even eliminated, the circulation of canine rabies in North America. But that did not solve the problem. Rabies was being maintained in nature by wildlife. As the incidence in humans and domestic animals declined, the danger of wildlife remained. Since 1990, 24 of 26 human cases of rabies have been associated with rabies virus variants maintained by bats; only 2 of these cases involved a report of a definite history of an animal bite; for the rest, the likely route of infection was transmission by bite during contact with a bat that was ignored, unnoticed, or forgotten. The incidence of rabies in wild mammals in 1996, as determined by cross-sectional analysis of passive surveillance taken from data of state and territorial public health departments, showed that of 4,454 cases of animal rabies, 91 percent involved wildlife species. During 2017, 24,458 bats were tested; 5.9 percent were confirmed as positive for rabies. Those numbers, although fluctuating according to rabies virus variants, are close to the same data from today.[21]

Mixing rabies vaccine in small packets of food disguised as bait and delivered in the wilderness by airplane has proven effective. In Switzerland, use of baited oral vaccine for two decades resulted in a rabies-free status in 1998; the same procedure was successfully used in France into 2000. In Canada, a program started in 1985 led to substantial decreases of reported cases of rabies in fox populations. In the U.S., sixteen states, most along the Appalachian Mountain chain from Alabama and Georgia to Maine, have used oral rabies vaccines for raccoons.

Reemergence of a canine rabies variant virus in South Texas during the later 1970s led to the use of oral vaccines along the Rio Grande River, a program that reduced the spread of rabies in coyotes and gray foxes, and from them into dogs. Use of a recombinant vaccine, vaccinia virus bearing a rabies glycoprotein—targeting raccoons and gray foxes as well as coyotes in Texas—has shown promise. In Texas, state regulations that prohibited translocation of wild species for hunting helped to reduce accidental spread to unaffected areas.

FOWL PLAGUE, A EUROPEAN DISEASE of poultry that was new to the U.S., broke out at a live poultry market in New York City in 1924. Rapidly developing signs of respiratory difficulty and pneumonia were brief and lethal; a massive number of birds died within hours after being infected. The source of the virus was traced to vials of fowl plague virus that had been imported in 1923 by a laboratory scientist working on unidentified filterable viruses. The disease was eliminated by the removal of sick birds and quarantine but had rapidly spread—in most cases by contaminated railcars—to New Jersey, Connecticut, and Pennsylvania. By April 1925, fowl plague had spread to the Midwest—to Indiana, Michigan, West Virginia, Missouri, and the Chicago suburbs.[22] The fowl plague virus had come from Europe, and there were outbreaks there again in the 1950s. The mystery of fowl plague virus was solved when in 1955 virologist Werner Shäfer in Germany reported it to be a type A influenza virus.

In the twentieth century there were four pandemics of human influenza, each identified by the letters H and N, used by scientists to identify the variance of two proteins; the symbols are for viral surface proteins that are important for the virus to infect respiratory tract cells—H for hemagglutinin, used for attachment to host cells, and N for neuraminidase, to support release of progeny virus. The influenza virus causing the pandemic of 1918 was H1N1; in the pandemic of 1957 it was H2N2, and in 1968, H3N2—both less dangerous than the 1918 virus. Then, in 1977, a reappearance of the H1N1 flu virus brought near panic to public health officials—unjustified, as it turned out—who feared the return of the massive human deaths of 1918.

The real significance of all this came in the 1970s when Robert Gordon Webster, New Zealander farm boy turned virologist at St. Jude's Children's Hospital in Tennessee, proposed that influenza virus genes were being recombined—a process called genetic recombination—to increase virulence, and in the process, endowing the new virus strain to move into new animal species. Input into the story had come from Hélio Pereira, Webster's mentor at the National Institute for Medical Research in London, and from veterinarian Bernard Easterday at the University of Wisconsin—who demonstrated the natural transmission of swine influenza from pigs to humans. In the end, migratory aquatic wildfowl were discovered to have globally spread the fowl plague virus—renamed avian influenza—to mammals and humans.[23] The ability of influenza viruses to rapidly mutate according to the needs of their avian or mammalian hosts was an astonishing revelation.

The impact of wildlife on human influenza started with the Asian flu outbreak in humans during 1957–1958. It had been caused by a new strain H2N2 that contained genes from avian influenza. A decade later, the flu pandemic of 1968–1969 in which one million people died was caused by an influenza virus with yet another mutation in its neuraminidase, H3N2, and appeared to have arisen from an antigenic shift from the avian genes of the 1957 virus. The outbreak was first reported in Hong Kong on July 13, 1968, and by September had spread into Vietnam, Singapore, India, and the Philippines. Soldiers returning from Vietnam brought the virus to California, and by December of 1968 it had become widespread throughout the U.S. In the next year, thirty-eight thousand Americans died of influenza.[24] It was clear that the story of influenza in humans began in the Orient and involved intercontinental migratory pathways of birds. Wild aquatic birds infected with viruses that carried the full variety of influenza A virus genes were the natural reservoir—new influenza strains were arising from the genetic recombination of viral genes in a partially immune host with a mixed infection of two different influenza viruses.[25]

PLAGUE IS THE RAT FLEA–TRANSMITTED bacterial disease that caused the massive death loss in Europe in the 1300s; bubonic plague, aka black death, appeared as skin blotches from internal bleeding and lymph node swellings the size of eggs in the groin and armpits that oozed pus and ulcerated to produce boils. Plague persists in wildlife in North America in reservoirs of rodents. Existing largely in prairie dogs, chipmunks, and ground squirrels, sylvatic plague can spread to less susceptible species such as dogs, coyotes, and other Canidae that, although relatively resistant, have a close relationship to wild rodents. In contrast, cats, bobcats, mountain lions, and other Felidae are especially susceptible and will develop pneumonic plague, the pattern of disease in black death. The bacterium that causes plague, *Yersinia pestis*, is scary in the U.S., partly because of its designation as a Class A bioterror agent by the Department of Homeland Security.

Plague has been monitored by a unique laboratory for the study of wildlife health, the Smithsonian Conservation Biology Institute (SCBI), which was established in 1974 as a unit of the National Zoo to be used for zoological research and studies on captive reproductive physiology. One component, the Global Health Program, is run by veterinary scientists who monitor and investigate infectious diseases in wildlife. Their interest is anthrax, a serious problem in Kenya, and their research is centered on Gray's zebras and how vultures, with their astonishing tolerance of animal pathogens, might spread the disease. SCBI's location, the site of the Front Royal Remount Station constructed when Congress purchased forty-two farms in the area for a Quartermaster Corps Remount Station in 1909, is a unique heritage for its veterinarians.[26]

Endangered species and problems with their reintroduction into the wild is a major issue with the SCBI, particularly in the return of the black-footed ferret, which faced extinction from a combination of canine distemper and loss of food and habitat. Canine distemper has been associated with mass mortalities in red pandas, palm civets, raccoons, African wild dogs, Island foxes (in California), Amur tigers, and African lions in the Serengeti. A big problem is that the protection of one species often leads to the destruction of another.

Black-footed ferrets depend on prairie dogs for their diet and disappear when their food source is destroyed. The black-tailed prairie dogs—herbivorous rodents in western grasslands—experience short epizootics of plague that result in widespread die-offs interspersed with periods of plague inactivity. Plague is carried by fleas and their astonishingly rapid multiplication cycles. To save the ferrets, fleas were killed by spraying potent insecticides into prairie dog burrows; fleas were killed but so were all other insects. Prairie dog burrows are a food source for a suite of bird species; when their insect food supply was destroyed, the mountain plover disappeared.[27]

DUCK PLAGUE, A HERPESVIRUS DISEASE new to the U.S., killed forty thousand waterfowl in the fall and winter of 1972–1973; by January, 40 percent of the one hundred thousand mallards had died while overwintering at the Lake Andes National Wildlife Refuge in South Dakota. Adding to the problem was that survivors became carriers of the disease, spreading duck plague along the flight paths. Throughout the region, state fish and game facilities could not deal with a problem of this magnitude, and the National Wildlife Health Center was opened in 1975 in Madison, Wisconsin—a state with a strong history of wildlife disease research—with the mandate to prevent, control, and investigate wildlife diseases. Today, the NWHC is involved in many serious environmental problems, including lead shot poisoning, plague, botulism, chronic wasting disease in deer, and oil spill toxicity in eagles, seabirds, and harbor seals.[28] Inexplicably, the new NWHC was placed within the U.S. Geological Survey in the Department of Interior—a political move that separated it from the scientific veterinary expertise in the Agricultural Research Service.

Few academic institutions investigated wildlife disease in the 1960s. Colorado State University maintained an active wildlife group that led research on chronic wasting disease. At the Ontario Veterinary College, an impressive wildlife disease unit was active with Lars Karstad,[29] who reported a new disease of deer, epizootic hemorrhagic disease; Karstad's career included African wildlife as well as diseases of marine animals. The Department of Veterinary Science at the University of Wisconsin, as in several other states with ample wildlife habitats or inland waterways, began to be active in infectious diseases of mammals and fish.[30] Washington State University developed an active program on the diseases of fur-bearing animals in cooperation with the federal government. Two of their scientists—John Gorham and Donald Cordy—discovered the rickettsial cause of salmon poisoning in dogs and foxes.

Chronic wasting disease remains a serious threat to both wild and domestic elk and deer in North America.[31] Insidious, with very long incubation periods, the uniformly fatal neurologic disease has overtones of paralytic disease for other species. The National Wildlife Research Center, a component of the USDA's Animal and Plant Health Inspection Service, is a modern research laboratory in the foothills campus of Colorado State University that can track chronic wasting disease. Its program surveys and undertakes field investigations on rabies, influenza, tuberculosis, plague, and tularemia in wild birds and mammals.

MANY INFECTIOUS DISEASES ARE MAINTAINED in nature by arthropod vectors—mosquitos, flies, and ticks—which are monitored by federal and state laboratories, including the Centers for Disease Control and Prevention, the Center for Vector-Borne Disease at the University of Rhode Island, and the National Center for Veterinary Parasitology at Oklahoma State University. In North America, the blacklegged or deer tick, *Ixodes scalpularis*, is a vector for many of the most serious tick-borne diseases, including anaplasmosis, ehrlichiosis, and Powassan virus disease. It is the primary carrier of the bacterium *Borrelia burgdorferi*—the cause of Lyme disease in dogs, horses, and humans—and is one of the fastest growing infectious diseases diagnosed in the U.S.

The number of canine Lyme disease cases recorded increased from 250,000 in 1915 to nearly 350,000 in 2019—paralleling similar increases in canine anaplasmosis and ehrlichiosis. Lyme disease is notoriously difficult to diagnosis in dogs, and the actual infections may be ten times that number. Most dogs exposed to *B. burgdorferi* develop only subclinical infection, and those that become sick show vague clinical signs of anorexia, lethargy, and depression. Appearing in the veterinary clinic with fever, swollen joints, and enlarged lymph nodes, Lyme disease in dogs is difficult to assess.

Prior to 1970, the blacklegged tick was not viewed as an important vector of disease. Agricultural deforestation, as well as hunting and habitat loss of white-tailed deer, the primary host, restricted the tick to the Northeast and Upper Midwest. After World War II, the increasing creep of suburbia into the forested Northeast with the reforestation of farmland led to recovered deer populations; this, in concert with climate change—milder winters, earlier springs, and warmer summers—promoted the blacklegged tick.[32]

BATS ARE BIOLOGICAL SUPERVILLAINS. A diverse group—over twelve hundred species, second only to rodents among mammals—they harbor more dangerous viruses for animals and humans than any other. Bats are natural reservoirs for rabies, Ebola and Marburg viruses, the paramyxoviruses Hendra and Nipah, and the coronaviruses SARS, MERS and, in 2019, the SARS-2 (that causes the disease COVID-19 that occurs in humans and mink).[33] Evidence is emerging that the destructive nature of SARS-2 is tied to its sneaky use of the body's normal receptor molecules for angiotensin-converting enzyme—a messenger molecule present on blood vessel surfaces in lungs, kidneys, and heart used to control blood pressure.

Most coronaviruses are passed through an intermediate host to infect humans: severe acute respiratory syndrome (SARS) appeared in 2003 when horseshoe bats infected Himalayan civets and raccoon dogs sold for meat in Wuhan, China; Middle East respiratory syndrome (MERS) arose in Saudi Arabia in 2012 when the host was the dromedary camel. Just as the bird-pig-human progression leads to human influenza, the bat-camel-human progression (with its 35 percent fatality rate) led to MERS.

Animal coronaviruses rarely need an intermediate host: infectious bronchitis in chickens, porcine epidemic diarrhea virus (PEDV), and swine acute diarrhea syndrome (SADS) coronaviruses do not require other species for transmission.

In cats, the coronavirus that caused mild feline infectious enteritis changed through genetic recombination to the lethal coronavirus of feline infectious peritonitis. They are scary viruses; the genetic codes of coronaviruses have high rates of mutation and genetic recombination.

Ecological surveillance reveals that intraspecies coronavirus transmission occurs when pulses of high levels of virus occur in bat populations and a "spill-over phenomenon" occurs that infects other species.[34] Seasonal epidemic cycles can be brought on by stress from nutritional deficits, reproductive adversity, and intercurrent disease. The omnipresence of bats—they are 20 percent of all mammals—coupled with our ignorance of how their immune systems work, makes them a high risk for pandemic emergence of host-adapting coronaviruses.[35]

35. NEW PLAGUES: SCRAPIE, MAD COW DISEASE, AND THE PRION

For two centuries, farmers in Scotland had lost sheep with a progressive brain disease they called scrapie—so named because in the first stages of disease affected sheep would scrape their skin raw against trees and fences. Soon the scraping sheep would walk with a bunny-hop gait, their hind limbs uncoordinated with the front—a high-stepping gait like a donkey trot, unable to extend the hind fetlocks. Then there were tremors of the head, grinding of teeth, and finally an inability to stand, paralysis, and a prolonged death.

Scrapie was endemic in black-faced British breeds of sheep and was being diagnosed in Iceland, France, and Germany in sheep imported from Britain. After World War II, scrapie appeared throughout the world's sheep-raising areas: Canada in 1946, then Australia and New Zealand and the U.S. in 1947—by October, scrapie was diagnosed in seventy flocks in nineteen states. The disease occurred only in sheep over eighteen months old. Although at first glance it seemed to be inherited, it did not follow a pattern of Mendelian inheritance. Despite multiple attempts, no virus, bacterium, or any other infectious agent could be identified as causal, yet scrapie appeared to be passed to flock mates and newborn lambs. Proving what field veterinarians already suspected, Scot scientists at the Moredun Institute near Edinburgh transmitted scrapie from sick to normal sheep.[36]

Scottish and Icelandic veterinary pathologists, examining brains from affected sheep, documented what was going on.[37] Neurons, the body-controlling cells in the brain, were dead. Dying neurons formed large vacuoles, making the brain tissue look like a sponge. The scientific term they applied to this spongy brain affliction was transmissible spongiform encephalopathy—TSE for short. Still disconcerting was that no evidence of a virus was found. But then, scrapie was not associated with human disease. Scots had been eating mutton, cooked and rare, muscle and brain, for over a hundred years and there had been no evidence for a scrapie disease in humans. Scrapie was an outlier. There was nothing else quite like it.

In the 1950s, veterinarian Dieter Burger, working toward his PhD at the University of Wisconsin, drove north to visit a mink farmer in Barron, Wisconsin, whose mink were dying from a progressive neurologic disease. The mink had developed abnormal behavior that began with disorientation and stumbling and ended in paralysis and death. Examining the brains of dead mink, Burger found spongy, vacuolated changes, noting that they were similar to scrapie in sheep; he called the disease mink encephalopathy. It was the second description of what was soon to become a really scary group of diseases.

Then came news of a degenerative neurologic disease of the cannibalistic Fore people in New Guinea that began with trembling, slurred speech, and unsteady gait. Victims wasted away, finally dying after paralysis and coma. Uniformly progressive and fatal, it was thought by the tribe to be due to sorcery from ancestral ghosts. By the 1950s it was killing about two hundred members each year, mostly women and children. Tribesmen called the affliction cassowary disease, confusing the wasting aspects of the disease with tuberculosis. Cassowaries are large ratites, flightless birds that lack a keel bone. They are aggressive and dangerous because of their razor-sharp claws and have been known to kill humans; and cassowaries have a high incidence of tuberculosis.

Australian patrol officers in the area reported the disease to Canberra, calling it *kuru*, the Fore word for shivering, and noted that it might be a hereditary mental condition. Kuru was found only in the Fore tribe, whose ritualistic funerary cannibalism involved relatives preparing and eating tissues of deceased family members. Men ate the muscles and liver while consumption of the brain was relegated to women and children.

In the 1950s the American medical scientist Daniel Carleton Gajdusek, in Papua New Guinea to observe kuru, began looking for plant toxins as plausible causes. The significant lead in Gajdusek's study of kuru was pointed out by the veterinary pathologist William Hadlow: "On the similarities of two progressive degenerative disorders of the central nervous system—namely scrapie affecting sheep, and Kuru affecting the Fore natives in the Eastern Highlands of New Guinea . . . their overall resemblance is too impressive to be ignored."[38]

Following Hadlow's clue, investigators began to use sheep scrapie as a model for kuru, and both would become models for the rapidly expanding species range of the TSEs. Soon added to the TSE list were Creutzfeldt-Jakob disease in humans, chronic wasting disease in deer and elk, and a new and terrible disease in Britain, mad cow disease.

CJD, shorthand for Creutzfeldt-Jakob disease, was a very rare, spontaneously occurring human fatal neurodegenerative disease which, like scrapie, had no causal agent and fit no pattern of genetic inheritance. But by the mid-1950s, it was clear that CJD, although arising spontaneously, could be passed from patient to patient when inadvertently introduced into the brain or eye by contaminated medical instruments. It was resistant to disinfectants. Clusters of human CJD appeared years after patients had corneal transplants, implantation of brain electrodes, or other probes that had been used on a previous patient with CJD. Whatever was causing CJD was not destroyed by common hospital sterilization procedures and was being transmitted from one patient to another.

In the mid-1960s, Colorado research scientists began seeing a strange neurologic disease—they were calling it chronic wasting disease. Affected deer appeared to be starving and stumbling with an abnormal gait. Unable to swallow, they inhaled their feed, and many were dying of aspiration pneumonia. The disease had appeared in a closed herd of captive mule deer in the Denver Zoo and in deer penned in research facilities in Fort Collins—deer that had been captured on the western mountain slopes.

The Denver Zoo had sold deer to the Toronto Zoo, where in 1978 veterinary wildlife pathologist Ian Barker at Ontario Veterinary College saw microscopic lesions in the brain of dying deer that he noted were similar to those of scrapie in sheep. Beth Williams—who had graduated DVM from Colorado State and had taken a residence in zoo medicine in Toronto—examined Barker's histologic slides. Returning to Colorado State to begin a graduate program in veterinary pathology,[39] she began her studies in chronic wasting disease. It was the beginning of a distinguished career; in 1980 Williams reported chronic wasting disease as one of the TSEs. The next year, Terry Spraker at the Colorado State Veterinary Diagnostic Laboratory found elk with chronic wasting disease in Rocky Mountain National Park. No one was paying much attention—not even deer hunters.

Then, the real horror stories began. With some press drama, mad cow disease was reported in England. Veterinarians were calling it bovine spongiform encephalopathy. First appearing in British cattle in the 1980s, it was believed to have started when cattle were fed meat and bonemeal containing abattoir brain tissue from sheep with scrapie. Affected cows were first noticed to have an abnormal gait, tremors, hyper-responses to stimuli, and other behavioral changes. Progressing to paralysis and death, thousands of cattle were afflicted and died in Britain and then in France. The official eradication that ensued, which required the killing of thousands of cattle and the burning of carcasses, led to public fear, export bans, and worldwide adverse publicity.

The scariest disease of all—for people at any rate—was the discovery that an unusually large increase of neurologic deaths in Britain of rapidly progressive CJD was related to eating brain tissue from cows with mad cow disease. The new human disease, called variant Creutzfeldt-Jakob disease, had been first noted in Britain in 1987 and shown to be acquired from eating sausages that had been processed to include the brains and spinal cords of cattle that had bovine spongiform encephalopathy. The troublesome thing was that the numbers of patients were rising rapidly; more than 175 people would be dead by the end of the decade before the disease had been stopped. There was some controversy about how the disease had begun—in 2005 Alan Colchester, a neurologist at the University of Kent, suggested that the source of bovine spongiform encephalopathy in cattle was not scrapie from sheep but the CJD prion that had been imported in bonemeal from India that contained human tissues of Indian patients with CJD.

The breakthrough to understanding the TSEs came in 1982, when Stanley Prusiner at the University of California San Francisco presented evidence that the infectious agent of scrapie was not a virus that contained instructional genes—the agent had no genetic templates of DNA or RNA. Turns out, it was a misfolded protein Prusiner called a prion (he designated the prion protein in scrapie PrP^{Sc}). PrP^{Sc} had originated from a corresponding normal body protein, PrP^{c} ("c" for cell), that had become improperly folded. Prusiner did not know the normal function of PrP^{c}, and although scientists discovered it to be a protein that is inserted in the brain's neuron surface membrane, its activity still remains mysterious.

The prion was an astonishing concept. Prions lacked genes, components assumed necessary for an infectious agent to replicate—there was no DNA or RNA, the nuclei acids required for transmission of genetic information.[40] Prions "infect" a new host and cause disease by blocking a normal protein; inserting themselves, they act as surreptitious templates to cause a normal protein to be folded improperly into a misfolded version that does not function, cannot be degraded for removal, and accumulates inside the brain cells to cause mischief.

The normal PrP^{c} molecule was found to be relatively unstable—an alpha helix—and the greater stability of the misfolded version, PrP^{Sc}, allows it to become the dominant template and take over the protein synthesis pathway for PrP^{c}. Progressive accumulation of the PrP^{Sc} causes it to aggregate inside the cell and to polymerize outside the cell into PrP^{Sc} amyloid, tightly packed beta sheets that assemble into amyloid fibrils that can be seen with the electron microscope. Damage results when the abnormal protein accumulates and kills neurons and polymerizes outside the cell as amyloid fibrils around tiny blood vessels.

It was clear that scrapie prions were dangerous misfolded proteins that could arise by spontaneous mutations, and once formed could be passed to other animals in contaminated needles and instruments. It was also discovered that when first transmitted, the prion protein replicated in the lymphoid tissues of the intestine and then spread to the brain—a discovery that made possible a diagnosis of TSE by biopsy of the rectal lining cells to detect PrP^{Sc}. At Iowa State University, Heather West Greenlee, doing research on the eye, discovered that these misfolded proteins affected retinal cells and that ophthalmic examination could be used as a diagnostic tool before the nervous signs of disease appeared. How prions kill neurons is a hot topic in neuroscience research—much of it applicable to human diseases like Parkinson's and Alzheimer's.

PART VIII

EPILOGUE

New Age — Same Risks, New Game

The social upheavals and anti-Vietnam riots of the 1960s led to activist movements opposing industrial toxins, vaccines, and genetically modified foods. Any change could be fair game, even if science-based. People began to lose trust in science. The number of Americans who felt "a great deal" of confidence in science and technology declined from more than half in 1966 to about a third in 1973.

In the late 1970s and early 1980s there was a global economic recession. The U.S. was suffering serious *stagflation*, an inflationary period accompanied by rising unemployment with lack of growth in business that was related to diminished consumer demand. Inflation soared to double digits. Worse, in the face of rising interest rates—the prime rate reached 21 percent—banks and savings and loan institutions, the S&Ls, were constrained by regulations from allowing market rates on their savings accounts. S&Ls rapidly lost reserves as people pulled their money from low interest accounts, opting for money market accounts. In the end, $1 trillion worth of assets would be lost by the S&Ls and were seized by the government. The savings and loan crisis of the 1980s was the greatest collapse of the U.S. financial institution since the Great Depression.[1]

Public distrust crept into education. In 1980, the five-member school board in the small town of Kanawha in North Central Iowa banned the use of John Steinbeck's novel *The Grapes of Wrath* in high school English classes. Despite its historic relevance and enduring legacy for farmers, parents had complained about the harsh language in the book and pieces involving prostitutes. Worse, there was mention of the elephant's trunk as an analogy to a penis. Few of the good people of Amsterdam Township had read the book, despite that it had put into print the economic struggles of their day-to-day lives. As the battle for the ban gained momentum, there was even some tsk-tsking that there were communist overtones in the book. The citizens of Kanawha had done nothing new; they were responding to leadership scalawags who resurrected a ban-the-book movement from the 1930s. They were not alone. A thousand miles to the north, in a school in Morris, Manitoba, creationists banished *The Grapes of Wrath* in 1982.

The economic viability of rural North America—and with it, the political culture—had shifted. A new twist, creation science, had emerged in the 1960s in an attempt to explain the fossil evidence of evolution as a record of the Genesis flood narrative and that modern life-form diversity was a result of predesigned genetic variability due to the degradation of the perfect genomes that God had created. Always just over the horizon, in the 1980s it had turned into a pesky and destructive force that attacked science education in high schools and universities alike. Eugenie Scott, who headed the National Center for Science Education, in her book *Evolution vs. Creationism*, explained the biological, geological, and molecular background for the science of evolution. She noted that the disbelief in the complexity of biology suggested not a deficit in evolution but the inability (or perhaps unwillingness) of some minds to grasp the unknown.

In an Iowa statewide poll taken in early 2000, when asked if cuts in state government had any impact on their lives, 70 percent of respondents had answered no. Editorialists in the *Des Moines Register* used this as evidence that Iowa taxpayers weren't really being seriously affected by four years of budget reductions. That cutting the budget of the highway patrol doesn't affect highway safety or that loss of support for education doesn't influence the skills and abilities of the workforce is bonkers—someone out there was living in la-la land. But that was the wrong question. When stated that way, one is surprised that the response wasn't that 90 percent felt unaffected. The right questions are Do cuts in education have long-term effects on economic development? and Does cutting agriculture and animal health programs have serious impacts on food production? Then let us see what the answer is from a reasoned and clear-thinking group of taxpayers.

Foot-and-mouth disease in Britain provided a stark lesson in 2001—a specter of mass burning of carcasses, loss of farms, and reduced meat production. The disease developed after government policies in the 1980s reduced diagnostic centers and veterinary inspection services, leaving the country with a highly vulnerable food industry. There was no immediate damage, and surely 70 percent of British citizens polled would have said they were "unaffected" by budget cuts. Yet, disaster arrived when three sequential breaks in the food safety chain occurred together: illegal import of meat from Asia, the failure of restaurant garbage to be cooked before being fed to swine (as required by law), and a failure of a depleted veterinary diagnostic program to quickly recognize the disease when it first appeared. Coming together, these breaks in the food safety chain allowed foot-and-mouth disease virus to spread widely before it could be easily confined. In the end, six million cattle and sheep were killed, costing the British government $16 million—all of this from the nation that gave origin to "penny-wise and pound-foolish."

An outbreak of a foreign disease in livestock could be economically devastating. Competing forces are at work in the budget processes so that political plans to economize veterinary and agricultural budgets are always linked to reasons deftly rigged to appeal to those uninformed in the complexities of food supply, a mindless philosophy that asks, Why do we need farmers when we have grocery stores?

36. THE FARM CRISES OF 1980–1995: DISTRUST OF SCIENCE

Global recession and the fight against rampant inflation slashed demand for agricultural products and led directly to the farmland crisis of the 1980s. The epicenter of the farm crisis was Iowa. For farmers, the boom of the '70s became the bust of the '80s. Surplus production continued, land prices had risen, too many farmers were carrying too much debt, interest rates rose to historic highs, and the new Reagan administration tried to cut back on government support. The Federal Reserve Board tried to slow inflation by raising interest rates, but that increased the cost of doing business, especially on the farm. A survey done by the Federal Reserve of Chicago revealed that the farm mortgage interest rate peaked at 17.5 percent, and when farm income bottomed out in 1983, farm sales started and farm protest movements heated up. Many farmers took Secretary of Agriculture Earl Butz seriously when he told them to "get big or get out."

To promote economic development in selected areas of the country, the U.S. Congress, persuaded by the lack of veterinarians and the importance of livestock in the Great Plains states, had authorized and funded the Old West

Regional Commission. Chartered in 1972, the OWRC was composed of the governors of Montana, Nebraska, North and South Dakota, and Wyoming, with a federal cochairman appointed by the U.S. president; it identified livestock as a major part of the region's economy. The University of Nebraska proposed a Regional College of Veterinary Medicine, and in 1974 the OWRC approved a plan for the project. In 1978 a nonprofit corporation, the Veterinary Education and Service Program, was formed with state representatives; it hired Burnell Kingery—retired as dean at the University of Missouri—as project director, with a mandate to seek accreditation from the Council on Education of the American Veterinary Medical Association.[2]

Then in the mid-1980s, following the agricultural economy, numbers of applicants to veterinary schools nosedived. At Iowa State University, in concert with the recession, applications for veterinary school declined rapidly. By 1985 there were barely enough applicants to fill the spaces allotted—down from the 1950s when there were nearly ten applicants for each slot, a time when it had been more difficult to get into veterinary school than into medical school. Nebraska governor Bob Kerrey signed a bill markedly reducing Nebraska's contribution to the OWRC plan, and support from other cooperating states declined as existing colleges increased proposals for contracts to educate OWRC-area veterinary students.

A Nebraska Livestock Industry Task Force explored the possibility of forming a program with an existing college of veterinary medicine and visited four veterinary schools: two were interested. At Iowa State University, President Parks, for reasons neither stated nor understood, put the kibosh on any contract proposal. With Kansas State University, an agreement was approved where Kansas would take thirty students each year in its four-year program from Nebraska. In 2005 the University of Nebraska terminated the contract in favor of a contract program at Iowa State University whereby students spent the basic science years at Nebraska and the clinical years at Iowa State University.

By the mid-1980s it was clear that most veterinary schools and research institutes were facing problems of both money and facilities: they lacked modern laboratories, animal rooms, and postmortem facilities required to compete for national programs based on isolation of dangerous disease agents. Few had spaces to work with the most dangerous bacteria and viruses that required biosafety level 3 containment—rooms with controlled access, filtered air systems, and heating plants to sterilize water and sewage leaving the unit. There were none of those at any veterinary school in the Midwest or Great Plains. At the sprawling National Animal Disease Center, the situation was similar: an aging physical plant with no capacity for animal work with deadly pathogens that required biosafety level 3 containment. In contrast, Canada had replaced its out-of-date national laboratory near Ottawa two times with modern facilities since the original National Animal Disease Laboratory had opened in 1961. The nation was being tardy in dealing with advances in modern veterinary science.

For the pig industry, new high-density "confinement" operations increased the risk of respiratory disease and other lethal swine plagues. Despite the bad times, veterinary research facilities began to see increased funding throughout the Midwest. Faced with new emerging diseases in pigs brought on by changes in husbandry, research funding had also improved. At Iowa State University's Veterinary Medical Research Institute, William P. Switzer developed a team to investigate a serious emerging disease of pigs, atrophic rhinitis. By the mid-1980s his work had developed a successful vaccine used for the control of *Bordetella* infection in pigs. In the succeeding decade, Switzer and his graduate students made major contributions to respiratory diseases of swine. The vaccines that were developed from Switzer's lab would be judged one of the 150 most valuable contributions in all of Iowa State history, and Switzer would accumulate awards, including Distinguished Professor in 1990, Iowa Inventor Hall of Fame, and the doctor honoris causa honorary doctorate degree from the University of Vienna in 1979.[3]

As dean and distinguished professor, Richard Francis Ross, one of Switzer's graduate students, would make significant changes in academic veterinary medicine and agriculture. In the 1990s he recruited faculty with outstanding scholarly records for positions of critical leadership. Raising the bar, Ross demanded high quality in teaching, research, and service.[4] At other research universities, investigations on diseases of food-producing animals were making major discoveries, spurred on by administrators who were leaders, not managers—managers lead people to do things right; leaders *do the right things*.[5]

Contributions of veterinary scientists began to be recognized throughout the world. Four veterinarians were elected to the prestigious National Academy of Sciences: Janice Miller and Harley Moon from the National Animal Disease Center in Iowa, Richard Witter from the Regional Poultry Laboratory in Michigan, and Edward Hoover—trained at The Ohio State University—from Colorado State University. Over twenty veterinarians who contributed to medical progress, some as scientists and some as leaders in comparative medicine, were elected to the Institute of Medicine, part of the National Academy of Sciences.[6] Veterinarians Myron "Max" Essex from Harvard and John B. Glen of Scotland received the Lasker Award—Glen in 2018 for his discoveries of the antiparasitic drug propofol and for short-acting anesthetics. The ultimate award came in 1996, when Peter Doherty, an Australian veterinarian, won the Nobel Prize for Medicine for discoveries on how white blood cells attack and kill virus-infected cells.[7] William C. Campbell, trained in the Veterinary Science Department at the University of Wisconsin, won the Nobel Prize for the discovery of the drug avermectin and its derivative, ivermectin—both alleviating parasitic infection in livestock and people.

Despite the emerging duties of veterinarians in public health and zoonotic diseases, and their role in food safety, economic downturns occasionally lead to zany changes in the food industry that can lead to disaster. In 1988, an unusual case cluster of human thyrotoxicosis—an increase of thyroid hormone—appeared. It was traced to a slaughterhouse that had put thyroid glands of cattle carcasses in its ground beef; people had been poisoned by eating thyroid tissue in their burgers.[8]

37. THE GENDER SHIFT

The April 1897 issue of the *American Veterinary Review* carried news from England that Principal Williams of the New Veterinary College in Edinburgh, Scotland, had brought suit against the Royal College of Veterinary Surgeons in London to compel the RCVS to admit for its licensing examination a "lady" who had qualified academically but was refused by the examiners on account of her sex.[9] An accompanying editorial in the journal by an American veterinarian noted that of all learned societies, that of veterinary surgeon was least appropriate for women, and concluded there would be no need for lawsuits "if women, instead of seeking notoriety by any means in their power, would be content to fulfil those duties for which they are fitted by nature . . ."

A half-century later, the view in much of rural America had not changed in a way that mattered.[10] To midwestern farm boys of the 1940s, it had seemed as if most rural veterinarians were honest, capable, and tough *men*—their work required both strength and physical stamina, and caution was required to deal with danger of large animals. News was not uncommon of veterinarians killed on the farm—gored by a dairy bull, kicked in the head by a horse, or fatally infected with glanders. The occupational hazards of the job were real and, like service in the infantry, viewed as man's work.

Rural practice was often dirty and smelly. Evaluations for pregnancy and reproductive disease required that veterinarians spend a good bit of time with their arm up to the shoulder in a cow's rectum and colon. There were almost no female veterinarians practicing in small towns of the Midwest in the prewar 1930s. At least I never heard of one. The six veterinary colleges in the Midwest/Great Plains—Iowa State College, The Ohio State University, Kansas State College, Colorado State College, Michigan State College, and Texas A&M College—did not or only rarely did admit women for study.

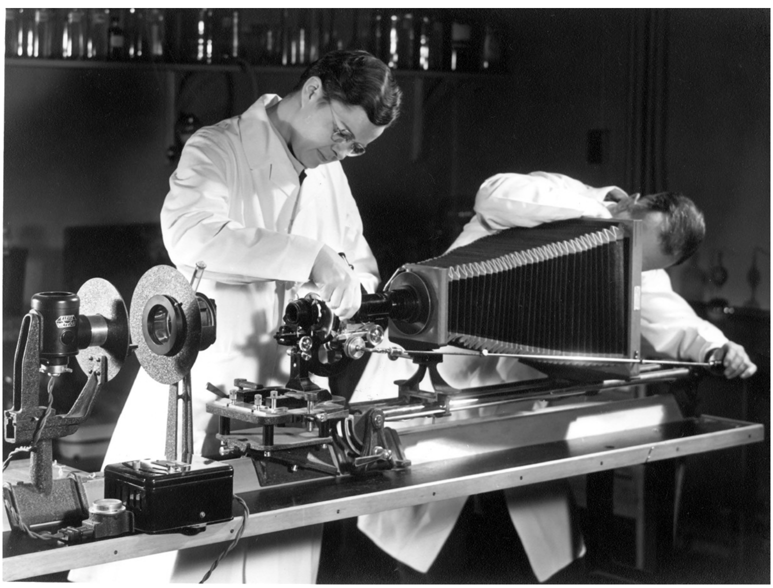
It was not only the physical demands that excluded women in the mind of the farmer, but that a great deal of the work of the veterinarian dealt with items farmers typically deemed not appropriate for the company of women. Veterinarians had to deal with abnormalities of the penis, infections of the genital organs, injuries arising from mating, and, most of all, castration of young male animals. The view was that these tasks were to be done where women of the farm were not present. This exclusion fit with the male camaraderie and earthy ambience of the veterinarian's visits to the farm and an accompanying tendency to sustain primal humor that even churchgoing Methodists could adopt. One of the stories passed around was about an elderly farmer who had a stud horse that would not perform. To get him more interested, the veterinarian prescribed a syrupy green tonic. After one dose, the horse improved greatly, mounting several mares. When his inquisitive neighbor asked what was in this tonic the farmer replied, "I don't know but it tastes like mint."

ADMISSION OF WOMEN TO U.S. veterinary schools began in the 1930s in the midst of progressive movements during the Great Depression. Progress was slow and singular.[11] By 1838 there were twenty-one female veterinary graduates in the U.S., and ten more were added the next year. None had gone into scientific research—perhaps because none were asked or even encouraged.

Two women got into veterinary science through the back door of science. In 1938, Margaret Sloss had been the first female to graduate with a veterinary degree from Iowa State College. Not approved through the standard admission process, she had chipped away at veterinary courses as a graduate student in veterinary pathology until the faculty agreed that she could be a special case and finish the clinical courses for graduation. Her friend and colleague Lois Calhoun followed the next year; she began as an anatomy technician and spent her career as professor and head of the Department of Anatomy at Michigan State College. Both Sloss and Calhoun had been "special cases" and were not included in the official class picture. But decades later, both were celebrated for their lifelong roles in the advancement of women in science, surviving professionally in a difficult and repressive time for women.

In 1944, Margaret Sloss was invited by Eleanor Roosevelt to a luncheon for women's activists at the White House in Washington, D.C. A college leader told her that if she accepted the invitation, he would see to it that she would not be employed at Iowa State; Sloss did not go to Washington. She would never reveal who had put the kibosh on her trip to the White House, but fingers pointed to veterinary medicine dean Henry Bergman.

World War II stopped women's entry into veterinary schools in the U.S. At Iowa State College, Dean Bergman's daughter, determined to be a veterinarian, was blocked in admission by her father. The medieval mix of tradition,



Margaret Sloss (*left*) and Edward Benbrook preparing to take a photomicrograph from a histologic slide of animal tissue, ca 1938.

patriotism, and duty that ruled over prospective students was not limited to women. The son of Professor Edward Benbrook, taking his father's course in veterinary pathology, received a failing grade. Forced to wait a year to repeat the course, he was drafted into the Army. At the end of the war, Stanley Benbrook returned to complete his veterinary degree and to specialize in veterinary pathology, his father's discipline.

When women replaced men in many home front jobs during World War II, there had been a liberating phenomenon that didn't go away. Young girls having an interest in science in the 1950s were no longer persuaded to bypass veterinary medicine as a career. Graduating from high school with more science and superior in pre-veterinary science courses, they were being selected by veterinary colleges for their entering classes. Foremost in the gender shift in veterinary medicine was the increasing interest of women in science and animal health. The rise involved a spectrum of societal change that included greater participation of females in biological sciences in K–12 education to motivational factors that drive women into veterinary medicine.

It was a long overdue sign of success. The trend had begun in the 1950s and was a welcome and encouraging sign of the progress of women in science. By the 1980s, women outnumbered men in the veterinary school at Cornell; that change was slower in rural areas of the Midwest.[12] Iowa State College, dominated by rural agriculture, was a latecomer and had not admitted women to veterinary school until the 1960s. A decade later, surprising everyone—academicians and demographers alike—was the rapid and dominating increase of women in veterinary medicine.

EQUALLY SURPRISING IN THIS GENDER SHIFT was a downside, the declining interest of men in veterinary medicine as a career. In the fall of 2002, Iowa State University admitted 105 students to the freshman veterinary class, 23 of them men—22 percent males, the lowest in the history of the college. The numbers reflected a continuing trend in colleges of veterinary medicine in North America; one midwestern college that year reported only 4 men in a class of 104. Beginning in the 1990s, the gender of entering students became even more skewed—sufficiently so to suggest that something was wrong—just as it was when males dominated the profession (see appendix VII).

In rural America, the gender shift was due in part to changes in agricultural production. Moves to mechanized agriculture from horsepower in the 1930s, and then to large commercial enterprises that used fewer veterinarians, led to a decline of farm families that traditionally supplied male students to agriculture and veterinary medicine in land grant universities. There was a decline in the number of students interested in production animal medicine.

Were economic issues driving the gender shift? Salaries offered in the private sector had not increased appropriately to the costs of education and student debt load. No longer competitive with medicine, dentistry, or other health professions, salaries were perhaps a major reason that men were bypassing application to veterinary school. In the *New York Times* for Sunday, June 9, 2002, an article by Yilu Zhao headlined "Women Soon to Be Majority of Veterinarians" quotes Debra Nord, director of Princeton's program in the Study of Women and Sexual Difference: "The expectation today is that if the men do not provide the full household income, they should at least provide the major part of it. A lot of men also do not expect their wives to earn full salaries in the child-bearing years."

MANY FEMALE VETERINARIANS WHO MATURED in the 1960s achieved fame for their work in an astonishing array of scientific problems: veterinary pathologist Janice Miller discovered the bovine leukemia virus at the University of Wisconsin; Lisa Nolan pursued the molecular biology of *E. coli* infections in animals; Joan Hendricks studied circadian rhythms and the molecular biology of sleep disorders using a fruit fly model at the University of Pennsylvania. Patricia Conrad of the Coastal and Marine Sciences Institute at the University of California, Davis, worked with pathogenic protozoa; veterinary microbiologist Margie Lee developed expertise in epidemiology of meat- and poultry-borne food pathogens; clinical pathologist Claire Andreasen promoted the science of education and joined Joan Hendricks as a pioneer in the One Health program; veterinary pathologist Linda Cork investigated the retroviral-caused caprine arthritis and encephalitis; and Corrie Brown at the University of Georgia contributed to the international monitoring and control of global infectious diseases of animals.

There are other women who did their graduate work in veterinary science and, although not veterinarians, made major contributions to animal health. Linda Saif at the Ohio Agricultural Research and Development Center was elected to the National Academy of Sciences and the National Academy of Inventors for her research in viral enteric diseases of animals, especially those transmissible to humans. An expert in coronaviruses, she served on the World Health Organization study of the SARS coronavirus.

What we know about livestock behavior and its use in preventing cruelty and promoting humane treatment, especially during slaughter, has been created by animal scientist Temple Grandin. Born of a wealthy Boston family, she used her autism to understand the animal's response to pain. Named one of 2010's one hundred most influential people in the world by *Time* magazine, and elected to the American Academy of Arts and Sciences and National Women's Hall of Fame, Grandin has changed the way commercial livestock are handled and processed.

Hannah Carey, professor in the School of Veterinary Medicine at the University of Wisconsin and an expert on the gut microbiome during mammalian hibernation, was elected to the presidencies of the American Physiological Society and FASEB—the Federation of American Societies for Experimental Biology—a conglomerate of twenty-nine scientific groups with 130,000 members worldwide.

Nutritionist Catherine Woteki had worked at the Universities of Maryland and Nebraska and was dean of Agriculture and Life Sciences at Iowa State from 2002 to 2005, when she left to be the chief scientist for the U.S. Department of Agriculture from 2010 to 2015, with responsibilities for the Research, Education and Economics unit, which administered the Agricultural Research Service, National Institute of Food and Agriculture, the Economic Research Service, and the National Agricultural Statistics Service, as well as the National Agricultural Library and the National Arboretum. She was elected to the Institute of Medicine and was a major force in nutrition, food safety, and agricultural risk policy for two decades. Woteki was fired by President Trump, who nominated a radio talk show host as her replacement as chief scientist.

38. BIOPOLITICS

The Biological Weapons Convention of 1972—its official title was The Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction—was designed as a supplement to the 1925 Geneva Convention, which prohibited the use but not possession or development of the weapons of biowarfare. Submitted by the British, the Biological Weapons Convention treaty was eventually ratified in 1975 by 22 governments and later signed by 103 nations, including the U.S. and the Soviet Union. The Nixon government ratified the Biological Weapons Convention and was an honorable force behind the disassembly of the offensive wing for germ warfare at Fort Detrick.

The U.S. biological warfare lab at Fort Detrick had already been disenfranchised in 1969 by President Nixon's resolution that "the U.S. shall renounce the use of lethal biological agents and weapons, and all other methods of biological warfare." Pathogens causing anthrax, botulism, and plague, as well as those of wheat stem rust, rye stem rust, and rice blast, were destroyed. Nations that signed the treaty were to do likewise, including the Soviet Union. Many of the buildings at Fort Detrick that were vacated after the Biological Weapons Convention was ratified were transformed into the new Frederick Cancer Center. The defensive Walter Reed biowarfare unit that remained was reconstituted as the U.S. Army Medical Research Institute of Infectious Diseases—USAMRIID—and it assumed control of some of the empty buildings.

In the mid-1980s, articles had begun appearing in the Soviet veterinary journals reporting an anthrax outbreak among livestock. In the spring of 1979 there had been a deadly anthrax outbreak during which large numbers of sheep and cattle had died in clusters around Sverdlovsk, a city of 1.2 million people east of Moscow. Information gleaned by Western scientists from the medical reports and from seminars given by Soviet physicians indicated that humans had also died of anthrax: 79 people had developed gastrointestinal anthrax, with 64 deaths; 17 had developed cutaneous anthrax with no deaths.

The Soviet government-controlled press reports included information that patients had developed intestinal anthrax after eating contaminated meat and cutaneous anthrax after contact with diseased farm animals. The reports did not tell the reader that the geographic areas affected were close to a Soviet military base in Sverdlovsk. Experts in North America and Europe suspected that a major cover-up of the anthrax outbreak might have been orchestrated through destruction of reports by veterinarians and physicians, and that the public explanation from the Soviet government that meat from anthrax-infected animals had been sold privately and was the source of anthrax was a hoax. Debates appeared in the Western press about whether these cases were natural or accidental and, if the latter, they had resulted from activities prohibited by the Biological Weapons Convention of 1972.

To the scientific community on the outside, the real cause was both clear and ominous: *Bacillus anthracis* had been released accidentally by Military Compound 19, the soviet germ warfare lab in Sverdlovsk, which was suspected to be secretly and illicitly involved in research on agents of biological warfare. The covert research exposed by this event placed in jeopardy any agreement to destroy weapons for biological warfare.

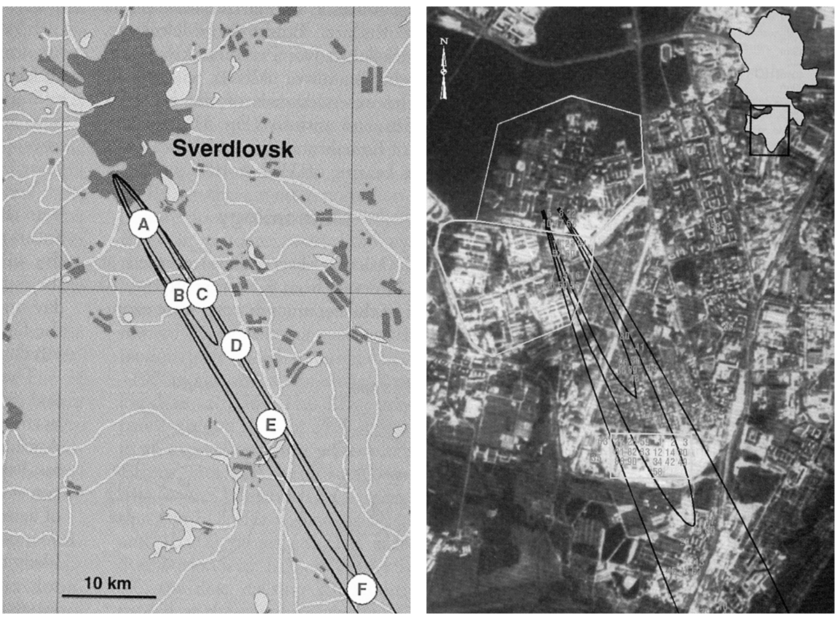
One group of American scientists, headed by Harvard professor Matthew Meselson, approached the problem indirectly by collecting information on disease incidence, geographic topography, temperature, wind patterns, particle size, and military bases. Epidemiologists noted that during the first week of April 1979, livestock, mostly sheep and swine, had died of anthrax in villages located along a narrow zone that extended from the military microbiology compound in the northern end to the end of the city limits two and a half miles to the south. The wind patterns and ambient temperatures told the story.[13] The scientists concluded that the outbreak in sheep was an aerosol of anthrax bacilli that began in Compound 19, that prevailing wind patterns had blown it in a narrow zone, and that the outbreak had occurred on April 2. Similarly, of the seventy-seven tabulated human patients, most had lived and worked in the southern area of the city and some at Compound 32, an army base in the affected area.[14]

In a 1989 scientific meeting in France, Russian microbiologist Vladimir Pasechik defected to the British embassy in Paris. Angered that he had been forced to work at Biopreparat on weaponization and missile aerosols of plague bacteria, Pasechik spilled the beans to British intelligence officials on the Soviet biowarfare program.

Mikhail Gorbachev, as head of state of the Soviet Union from 1988 to 1991, added two new words to workaday English*: perestroika* (restructuring) and *glasnost* (openness). The changes he made led both to freedom and the end of the Cold War and to dissolution of the Soviet Union. They also led to food shortages, rationing, and the awakening of long-suppressed nationalism. Glasnost also confirmed an astounding story of biological weapons research that had been revealed to U.S. Intelligence by Russian veterinarians and medical pathologists.

In May 1992 after the Soviet collapse, Gorbachev's successor, Boris Yeltsin, when asked about the anthrax event was quoted as saying, "The KGB admitted that our military developments were the cause." Sverdlovsk is now known by its prerevolutionary name of Ekaterinburg, the area where, years before, Czar Nicholas and his family were brutally murdered by the Soviets. Compound 19 was a military microbiology facility on the outskirts of the city. The Soviet government announcement in 1979 that it had been developing an improved vaccine against anthrax but knew of no escape of *Bacillus anthracis* was a lie. Local public health records of the epidemic had been confiscated by the KGB.

Colonel Kanatzhan Alibekov, the former physician and first director of Biopreparat who had overseen the Soviets' biowarfare program, emigrated to the United States in 1992. Becoming a U.S. citizen and taking the new name Ken Alibek, he confirmed all suspicions about the Sverdlovsk incident. Alibek worked as a biodefense contractor, testifying later that the Iraqi weapons of mass destruction had probably not been completely destroyed, testimony that would play a key role in President Bush's decision to invade Iraq.[15]



Pathway of airborne particulates from a military base in southern Sverdlovsk. *Left:* Villages with anthrax in sheep and other farm animals (A to F). Populated areas in dark gray, roads light gray, and wind directions, black lines. *Right:* Satellite photograph, locations of human patients when exposed. Rectangle encloses part of the city in the photo. Compounds 19 and 32 and a factory are outlined. (REPRODUCED BY PERMISSION FROM M. MESELSON ET AL., "THE SVERDLOVSK ANTHRAX OUTBREAK OF 1979," *SCIENCE* 266 [1994]: 1202–8.)

The 1990s also opened communication with two Russian pathologists, Faina Abramova and Lev Grinberg, who had carried the heavy workload of autopsies during the Sverdlovsk anthrax epidemic and who had first concluded that all their cases had died of inhalational anthrax. Before they could be published, the autopsy reports had been confiscated by Soviet government officials and further efforts on reporting had been suppressed. But Drs. Abramova and Grinberg hid their personal notes, photographs, and microscopic slides among ancient papers and debris. After the collapse of the Soviet Union, when a team of American scientists came to their city, their materials were retrieved, reviewed by the Americans, and reported in the Russian medical literature.[16]

THE USAMRIID AT FORT DETRICK was one of the few places in the world that could handle BL4 agents—the lethally dangerous human pathogens that are highly infectious with a high fatality rate and for which there is no vaccine, therapy, or cure. USAMRIID's contributions to national and global protection have been enormous. Its vaccine to protect against Venezuelan equine encephalitis quelled an outbreak in Texas in 1971 that affected animals and humans. When Rift Valley fever broke out in Egypt in 1977, the USAMRIID vaccine was used to protect people at high risk, including soldiers of the United Nations Peacekeeping Force, laboratory workers, and research workers at risk of the disease they work with such as vaccines for Ebola hemorrhagic fever.

USAMRIID became the reference laboratory for the World Health Organization and a collaborator with the Communicable Disease Center in Atlanta to deal with global diseases; the complex in Frederick, Maryland, houses a sixteen-bed research ward and isolation facilities to deal with extremely dangerous human pathogens. A veterinarian, Colonel David L. Huxsoll, was commander of the institute from 1983 to 1986. Huxsoll had graduated from veterinary school at the University of Illinois and had a PhD in microbiology from Notre Dame. A career military officer, he commanded a staff of six hundred, including twenty-six veterinarians, twenty physicians, and nearly one hundred research scientists. A national asset, USAMRIID acts as an authority in the panic that develops in any incident of biowarfare. A major goal of any biowarfare attack is the public panic that follows. Wild statements by those involved, multiple hypotheses by the press, and quotes from incompetent "experts" all required that the authoritative source of USAMRIID be available.[17]

Nancy Jaax, a veterinary pathologist, was the chief of the Pathology Division at USAMRIID from 1989 to 2000, where she began investigating Ebola virus.[18] Ebola virus and its cousin, Marburg virus, are classed as lethal BL4 agents. In October of 1989, when monkeys began dying at a primate quarantine facility in Reston, Virginia, it was Nancy Jaax who identified the causal agent as a unique relative of the highly dangerous Ebola virus. Turns out that this new "Reston virus" was nonlethal to humans, but the furor it created was memorialized by Richard Preston, author of the 1992 *New Yorker* article "Crisis in the Hot Zones" and the 1994 best seller *The Hot Zone*. The book was the basis for a movie, *The Hot Zone: A Terrifying True Story*, and a National Geographic series by the same name.

In 1991, expert inspection teams were sent to investigate Iraq's capacity to produce weapons of mass destruction. The choice to lead the biological warfare inspection team of thirteen members going to Iraq was the Army's expert on biological warfare defense in the Veterinary Corps, Colonel Huxsoll. The Iraqis readily admitted to the inspection team that they had operated a biological weapons research center at Salman Pak, twenty-two miles southeast of Baghdad, with units working on anthrax, botulism, and *Clostridium* bacteria but had shut it down. They had been afraid that it would be bombed. During its two-week stay, the team inspected ten sites, including vaccine production facilities, pharmaceutical plants, R&D labs with fermentation capabilities, and units designed to allow work with agents hazardous for animals and humans. No evidence of biological weapons production was uncovered.

IN EARLY AUGUST 1999, Tracey McNamara, veterinary pathologist at the Bronx Zoo, began noticing dead crows on the zoo's grounds—unusual because crows are roadkill consumers and resistant to many avian diseases. Sending samples to the New York State Department of Environmental Conservation, she waits several weeks before being told there was only evidence of "metabolic bone disease." Turns out, NYSDEC had been receiving an unusually high number of dead crows since early June. Its "wildlife pathologist," concerned about pesticides, was able to determine that the birds were not dying from any of several common problems but could not identify a clear cause—political speak for unable to make a diagnosis. Perhaps this was because NYSDEC lacked expertise: its "pathologist" was not adequately trained in either veterinary medicine or pathology.[19]

On Monday, August 23, the chief of infectious diseases at Flushing Hospital in Queens called the New York City Department of Health to report an unusual number of patients dying of encephalitis, most with an unusual complaint of muscle weakness. A week later, samples of brain tissue and blood are sent to the CDC's Division of Vector-Borne Infectious Diseases in Fort Collins, Colorado; on September 8, the CDC announced the cause of deaths in New York City as St. Louis encephalitis virus, the most common mosquito-borne disease in the nation. The CDC had been unable to isolate a virus from the tissue samples, but there were anti-flavivirus antibodies in the blood serum, and slides of brain tissue had reacted positively in immunolabeling tests. The diagnosis, although incorrect, led officials at the New York City Department of Health to begin mosquito control efforts.

In the Bronx Zoo, flamingos, cormorants, and other species were being found dead in their cages. Doing autopsies, McNamara found hemorrhages in the brain and dead Purkinje cells—neurons in the cerebellum that control movement and balance—and there were areas of damage in the heart, kidney, liver, and intestine. The dead necrotic areas in the organs were typical of viral-induced damage, and no bacteria were found in histologic sections of the damaged areas. She ran through the viral diseases that killed birds quickly. Newcastle disease and influenza were at the top of the list, but those were respiratory diseases, and there were no signs of damage to the lungs; the Bronx Zoo had flocks of chickens and turkeys in its petting zoo and they were not dying. The virus was killing only new-world birds—from North and South America. Eastern equine encephalitis was also at the top of McNamara's list, but the zoo's old-world emus, exquisitely sensitive to EEE, were healthy. So, what was it?

Thinking her dead birds might be dying of a zoonotic disease, McNamara sends samples to the U.S. Geological Survey's National Wildlife Health Center in Madison, Wisconsin, and telephones the wildlife pathologist at the New York State Department of Environmental Health. She also contacts the CDC's Division of Vector-Borne Infectious Diseases in Colorado, telling them of her concerns that the virus killing her birds is related to the same agents causing encephalitis in humans; she was told that they had identified the New York City human outbreak as St. Louis encephalitis virus and did not have time to work on a "veterinary disease."

McNamara sent tissue samples of the dying birds to the USDA's National Veterinary Services Laboratory in Ames, Iowa. She requested that any suspect virus be examined by electron microscopy—finding viral particles of 40 nm diameter would strengthen the link between the bird and human outbreaks (since eastern equine encephalitis is 60 nm). Within a few days, a poultry virologist had isolated a virus from the suspect tissues. On September 15 he calls McNamara, telling her that the virus was a 40 nm flavivirus that did not cross-react in tests for any of the viruses in the group that caused disease in animals in the U.S. He recommended that since they did not have test antigens for viruses that affected only humans, she should pursue efforts to find precisely what flavivirus this might be.

It was a serious matter: the dangerous members of the flavivirus group included the viruses that caused yellow fever, dengue fever, Japanese encephalitis, West Nile fever, and several other rare flaviviruses of African origins—many of them capable of causing catastrophic illness in humans. McNamara was frightened, reasoning that one could not be sure that this rapidly spreading virus might infect humans (including technicians in her laboratory), or worse, that it had been weaponized as part of some scary bioterror program.

With the National Veterinary Services Laboratory information at hand, McNamara called Colorado and was again rebuffed; a technician tells her in a condescending tone that they had no interest in her birds or her samples and that they had "little faith" in the quality of work done in a veterinary laboratory, and suggested that the NVSL had isolated a contaminant virus. McNamara begged him to reconsider, with explanations that birds in her zoo, known to be susceptible to St. Louis encephalitis virus, were not dying, that serum from flavivirus patients are notoriously cross-reactive with related viruses in the flavivirus group, and that this disease had the potential for incredible human death loss. A second rebuff.

Frustrated with disinterest from the CDC and the incompetence of the state's "wildlife pathologist" laboratories, McNamara called the USAMRIID at Fort Detrick in Maryland. There, virologists ruled out both St. Louis encephalitis and eastern equine encephalitis and called the results in to CDC in Colorado. Retesting their samples, they found only West Nile virus, one they had never encountered in North America.[20] West Nile virus had been first isolated from humans it had killed in Uganda in 1937 and had periodically spread to West Asia and the Middle East. Could West Nile virus be killing birds and humans in New York—an idea the CDC had rejected? But their diagnosis didn't fit: St. Louis encephalitis virus did not kill birds. Perhaps West Nile was the culprit in both humans and birds. The virus isolated in Iowa was sent to the CDC in Colorado, where it was confirmed to be West Nile virus.

The discovery that the outbreak was West Nile fever had immediate responses from public health units. This was a disease that had never been reported in North America, and its spread would kill not only humans but horses. It also would infect dogs and cats, adding a new dimension of danger. The CDC requested new tissues from McNamara and from the NVSL in Iowa. They isolated West Nile virus.

Finally, the third week of September the puzzle pieces *officially* came together. On September 27, the CDC confirmed in a news release that a "West Nile-like" virus was responsible for the encephalitis outbreaks in New York City. In the end, thousands of birds had died and, in the sixty-two human cases of West Nile fever, there had been seven deaths. The CDC press release made no mention of the USDA's National Veterinary Services Laboratory or the Army's USAMRIID. An official government report compiled in Washington concluded that "better communication is needed" and that "links between public and animal health agencies are becoming more important."[21] Again, more political speak: animal health and public health had been *one health* for a century.

The problem had been that too many governmental agencies did not understand the critical role of surveillance and the art of listening and communication it requires. The West Nile virus episode had been a master class in arrogance, ignorance, and scientific dysfunction of disease surveillance. But it was a minor event compared to what was coming. The same governmental failure to communicate and to meld all parties into a force for surveillance and rapid response was soon surpassed by a far greater debacle: the failure of federal agencies to communicate was greasing the skids for bioterror.

39. BIOTERROR, ANTHRAX, AND THE NATIONAL ANIMAL HEALTH NETWORKS

On September 11, 2001, television videos of the burning of the two towers of the World Trade Center in Lower Manhattan blocked television programs at 9 a.m. The north tower had been hit by American Airlines flight 11 and the south tower by United Airlines flight 175. By mid-afternoon the Pentagon had been attacked by American flight 77, and United flight 93 had crashed in a

Pennsylvania field. All had been bound for California, the long flight chosen by terrorists because the planes would be heavily fueled to inflict maximum damage. On the news that evening there was audio of the break-in of the terrorists on flight 93, with pilot Jason Dahl shouting, "*What are you doing?*," and then garbled messages and screams. The audio stream was never repeated—retracted and never again used. The massive response by the military and the federal, state, and local governments would take weeks to get us back to relatively normal life. A nationwide shutdown of all air traffic in the U.S. stranded friends in strange places.

The October 3 headline in the *Des Moines Register* was "NATO Ready to Fight With U.S.," with subheads of "Group Cites 'Clear Proof' Against bin Laden" and "Wary Iowans Back Immigration Curbs." The issue also contained the veterinary school dean's article "Iowa Should Lead Fight Against Agroterrorism." It pointed out our vulnerability to agroterrorism and what we needed to do in the way of prevention: "improve grass-roots diagnostic systems such as the centers at Iowa State—the Veterinary Diagnostic Laboratory and the Plant Disease Clinic—that would likely be the first to detect agents of agroterrorism."

BEGINNING SEPTEMBER 18, 2001, one week after the World Trade Center attack, letters containing anthrax spores were mailed to several news media offices and two U.S. senators, killing five people and infecting seventeen others. The ensuing FBI investigation was one of the largest and most complex in the history of law enforcement.

The first set of letters had a Trenton, New Jersey, postmark dated September 18, 2001. Five letters, one each to the offices of ABC, NBC, and CBS, one to the *New York Post*, and one to the *National Enquirer* in Florida. Two more letters were mailed from the Trenton address three weeks later on October 8 to Senators Tom Daschle from South Dakota and Patrick Leahy from Vermont—the first was opened by an aide; the Leahy letter was mistakenly sent to an address in Virginia. Although the letters had been postmarked in Trenton, they had been mailed from a box at 10 Nassau Street near Princeton University.

The Florida letter was the first to kill; the journalist Robert Stevens died on October 5. Two postal employees at the Brentwood Station in Washington, D.C., were next, and then a Vietnamese immigrant in the Bronx and a ninety-four-year-old widow in Oxford, Connecticut, died. Autopsies were conclusive: all had died of inhalation anthrax.[22]

Material in the two sets of letters differed. The first contained a brown crumbly material that resembled Purina Dog Chow; the second, a dry powder consisting of pure spores. Both letters contained fictitious return addresses and misleading notes. The return addresses were to 4th Grade, Greendale School, Franklin Park, New Jersey 08552; there was no such school and no such zip code. The note in the first letter read: "0-0-11, THIS IS NEXT, TAKE PENACILIN NOW, DEATH TO AMERICA, DEATH TO ISREAL, ALLAH IS GREAT." The manhunt began with full force.[23]

The FBI soon announced that all of the powdery material found in the letters had been derived from a strain of *Bacillus anthracis* known as the Ames strain. Years previously, the Fort Detrick labs had received cultures from all over the Midwest and Southwest and had established one of the more virulent ones, which they labeled the Ames strain, as a standard. It had been mailed to more than sixteen laboratories in the U.S., as well as to sites in Canada, the United Kingdom, and Sweden.

Then, an irresponsible article in a Florida newspaper stated that the offending bacterium had been produced in "a laboratory in Ames, Iowa." The reaction of the communications media was immediate and intense. At Iowa State, the veterinary school dean's office was immediately swamped with television, radio, and newspaper people telephoning, e-mailing, and showing up at the college.

What did Iowa State know about the Ames strain? Where were anthrax cultures stored? Who had stolen it? In the next week the College of Veterinary Medicine did seven television interviews, one with *CBS Evening News*, as well as 107 press releases and over 30 radio interviews. Articles appeared in the *New York Times*, *Chicago Tribune*, *Los Angeles Times*, and the *New Yorker* magazine.

The next information released was that the Ames strain of anthrax had been sent from a veterinary laboratory in Iowa to the Army biodefense lab at Fort Detrick, Maryland, and then on to research facilities in the United States and Europe—and that somewhere along the trail, a terrorist had obtained the Ames strain and used it to attack humans. For a week, Iowa State University was in daily contact with the FBI, Iowa Department of Health, and Governor Vilsack's office. The governor announced that the College of Veterinary Medicine would be constantly protected by the Iowa National Guard.

College authorities could not validate the information in the news. It was true that Professor Allen Packer had sent Iowa cultures of *Bacillus anthracis* to Fort Detrick during and after World War II. Professor James Roth had records of the Department of Veterinary Hygiene and Public Health, but the characteristics, dates, and times did not match with those that had been sent by the FBI. Furthermore, records of the Iowa Veterinary Diagnostic Laboratory did not reveal a match with FBI information.

The Iowa National Guard established an around-the-clock guard over the veterinary school campus in Ames to guard against theft of anthrax bacilli. The costs of the military duty would be assessed to the veterinary school budget, an enormous sum that could not be paid. After appropriate phone calls, neither the FBI nor the CDC wanted the cultures, and both gave permission for Iowa State University to destroy the anthrax collection, which was done on October 10 and 11, 2001. It provoked some criticism, but the university no longer kept current strains, and those that had been archived had been sent by Professor Packer to Fort Detrick and were in the U.S. Army Medical Research Institute of Infectious Diseases—the USAMRIID—collection.

A month later, the history of the Ames strain was elucidated by the FBI. It had not originated in Iowa but in Texas and had taken a circuitous route to the dying patients. The Ames strain had come from a part of Texas where anthrax was endemic and ranchers and veterinarians were savvy on how to deal with it. In 1981 veterinarian Michael Vickers, who ran the Las Palmas Veterinary Hospital in Falfurrias, had done a necropsy on a seven-hundred-pound Beefmaster cow that had died within hours of becoming ill. He had done an autopsy in open pasture, twenty miles south of Hebbronville in Jim Hogg County. Suspecting anthrax, Vickers removed tissue from the heifer.

To confirm his diagnosis, Vickers had put samples of tissue into plastic bags and sent them by bus to the College Station diagnostic lab. The cow carcasses were immediately burned to prevent scavengers from spreading the disease. The College Station lab cultured the samples and within forty-eight hours found anthrax bacteria and called Vickers. The lab also answered a request it had received six months earlier from Army researchers at Fort Detrick for cultures of *Bacillus anthracis*. The shipping room of the diagnostic lab reused a small box that had come to College Station from the National Animal Disease Center in Ames—without removing the return label.

When Fort Detrick received the package from Texas, the anthrax bacteria were sub-cultured, identified, and typed. It turned out to be a highly virulent strain and the culture was added to the Fort Detrick laboratory anthrax collection. It was recorded as the "Ames strain" because it had been shipped to Fort

Detrick in a used box still bearing the old return label from the U.S. Department of Agriculture lab in Ames, Iowa.

After what the public saw as far too long and after several false suspects had been cleared, FBI investigators focused on Bruce Ivins, a scientist at the Fort Detrick Army Biological Laboratory. But in July, Ivins had killed himself with an overdose of acetaminophen. With DNA evidence leading to a vial of anthrax spores in his lab, federal prosecutors declared Ivins to be the culprit and the case was closed.

A study of the investigation by the National Academy of Sciences, *Review of the Scientific Approaches Used During the FBI's Investigation of the 2001 Anthrax Letters*, was released in 2011 that cast doubt on the government's conclusion that Ivins was the perpetrator. Richard Spertzel, the veterinarian who led the U.N. biological weapons inspection of Iraq, wrote that the powder material used could not have come from Ivins's lab since Fort Detrick did not make or use anthrax bacilli in powdered form and did not have the technology to weaponize anthrax with silica.

Early on it was believed that the powder material had been weaponized. That is, it had been prepared in pure spore form with silicates added (which injure the lung tissue in a way that promotes bacterial spore formation and enhances the disease). But elaborate tests with electron microscopy and metal assays did not reveal sufficient amounts or quality of silicates in the powders saved from the letters. Investigators also found no evidence of bentonite in the powder—bentonite was the signature component of Iraq's anthrax weapons. White House spokesman Scott Stanzel, a native of Sac City, Iowa, disputed reports that the anthrax powder sent to the Senate had contained bentonite (silica and aluminum are the major ingredients of bentonite).

Biological weapons have serious limits. The most likely antihuman biological agents, anthrax and smallpox, are difficult to produce and so dangerous that they pose serious hazards for those who would use them. Most technical means for delivery are ineffective—biological agents degrade on storage, and military missiles and high-flying aircraft for aerosolizing pathogens are not sufficiently accurate or effective. Perhaps the biggest problem for bioterrorists is that time is required for disease to develop and spread in animal and human populations, time that allows for diagnosis and intervention with vaccines and antibiotics. None of this matters in the face of a determined enemy, though, especially one who is dedicated to the destruction of Western civilization.

THROUGHOUT NORTH AMERICA, the anthrax attacks highlighted a need for modern veterinary research and diagnostic facilities to protect livestock. Current ventilation and plumbing systems could not deal with anthrax, brucellosis, and other dangerous zoonotic agents. Modern biosecure diagnostic laboratories and housing for new information technology that could connect with national networks were required for rapid responses. One by one, the major veterinary research institutes and diagnostic laboratories scrambled to build new facilities that would include secure laboratories that could handle dangerous pathogenic agents. Cornell University completed an impressive new facility in 2001, with space for two hundred professional scientists and an amended mandate from the State of New York to add diseases of zoo and wild animals and other environmental pathogens to its diagnostic protocols.[24] The Texas Veterinary Medical Laboratory, which had opened in College Station in 1967, was expanded to meet the new threats to the state's livestock industry.

New technology and biosafety rules made new microbiological research laboratories expensive and risky. Few universities were willing to spend the money to modernize: the University of Georgia, pushed by microbiologist John Bowen and Dean David Anderson, developed a concept and gained $100 million in state funds to build a BL3 safety level laboratory on the Athens campus; plagued by construction errors, the building did not pass BL3 biosafety tests, leaving it in limbo until an astonishing rescue in the next decades. Tests required for federal approval of BL3 status created extraordinarily high pressures and vacuums in the building—so high the air would be sucked through miniscule pores in concrete—making it difficult for inexperienced architects and construction workers to achieve the necessary goals.

The University of Georgia Animal Health Research Center was dedicated in July 1996, but there had been catastrophic problems in construction and threats from university business managers to tear down the building. Dean Keith Prasse and succeeding dean Sheila Allen kept going with Bulldog persistence until problems were overcome and the BL3 unit was approved. Prasse and Allen hired experts in infectious diseases and vaccine technology. It took over a decade, but the first BL3 labs were commissioned in 2005. Today, as investigations on influenza, rabies, and tuberculosis have been highly productive, funding for the Animal Health Research Center has increased fourfold—an achievement rarely matched by such vision, perseverance, and dedication to high science. It was a long and expensive learning process, but in the end it worked and would make the University of Georgia a focus for global zoonotic plagues.

A major nationwide stimulus for expansion of diagnostic centers was the increased funding offered by the USDA's Animal and Plant Health Inspection Service. Its response to bioterror was to create the National Animal Health Laboratory Network, a partnership with national and state laboratories to facilitate the early detection of and response to (and recovery from) emergency animal diseases. The network has fourteen level 1 laboratories[25] and over sixty lower-level partners that are federal, state, and university labs. The major concerns in peacetime are foot-and-mouth disease, classical swine fever (hog cholera), avian influenza, Newcastle disease of birds, chronic wasting disease (zombie disease) of deer and elk, and scrapie. But in a bioterror attack, the capacity to focus on the issue at hand is required for rapid emergency response.

Effective barriers appeared to be in place. Governmental oversights at federal, state, and local levels were operating, but the rules of the game keep changing. A massive, uncontrolled outbreak of a foreign zoonotic disease in livestock would soon be economically devastating.[26] There is no zero risk when global commerce is coupled with a worldwide network of informed terrorists armed with modern information technology and dedicated to murder and economic destruction of the U.S. Higher security requires greater technological commitment. Scientists have to ask the right questions, identify the most critical problems, provide adequate solutions, and keep the public informed. Iowa learned much about the costs of mass depopulation programs in the avian influenza outbreak in 2015; it was an expensive struggle to dispose of millions of dead young chickens, laying hens, and turkeys by burying, incinerating, or composting infected carcasses in improvised landfills and composting sites.

As a response to potential agroterrorism threats after the World Trade Center bombing, James Roth at Iowa State University developed the Center for Food Security and Public Health to focus on information and training.[27] Funded largely by the USDA to train staff employees, it filled an important niche in public health planning. About the same time, he started the Institute for International Cooperation in Animal Biologics (IICAB) to deal again with training and cooperative ventures in commercial production of vaccines and biological drugs. The Center for Food Security and Public Health at Iowa State was dedicated to keeping the public alert and informed as a critical part of food safety. The world traveler who surreptitiously bypasses immigration inspections, the bus tour guide who advises his group when reentering the U.S. on ways to hide meat and vegetables from agriculture border inspectors, the cattle buyer who moves cattle from state to state to avoid inspection—all of these raise our risk from zero.

Today, a major threat is African swine fever, a great plague closely resembling hog cholera—classical swine fever—in its rapid onset, hemorrhages, and rapid lethality. In the first year, lost exports could cut pork receipts by nearly half—closing one-quarter of Iowa producers and costing the U.S. pork producers $8 billion. A million pigs are moved daily in the country, and during the ten-day incubation period of African swine fever, pigs would be transported to new sites. Perpetuation of the disease would drive costs to many times that; if the disease gets into wild pigs, it might last forever. Mass depopulation of pigs entails enormous expense. Euthanized animals must be composted on site since infected carcasses cannot be transported on roads that pass other producers and landfills cannot accept infected materials.

THE NATIONAL ECONOMY TOOK A HIT at the end of 2001. The Enron scandal broke and was one of the best-known examples of corporate fraud and corruption. The Enron Corporation was an American energy company that provided electricity and natural gas services and had been named by *Fortune* magazine as America's Most Innovative Company for six consecutive years. But its financial condition had been sustained by an institutionalized, systematic, and creatively planned accounting fraud. Before it was over, investors had lost over $15 billion. The national effect rippled through the economy right down to veterinary practices and to the budgets of veterinary institutions.[28] The economic downturn drove state legislatures to look closely at unique solutions to economic lethargy—venture capital, startup incubators, and tax reductions as incentives for small businesses. Modern, biosecure research labs are required for the public's safety against the threat of foreign animal disease. Reports of animal plagues, even though false, have a destructive impact on the stock market. From the *Des Moines Register*, March 14, 2002: "Corn futures fell sharply Wednesday on the Chicago Board of Trade amid rumors—denied by the U.S. Department of Agriculture—of foot-and-mouth disease in some Kansas cattle."

Then another recession—which started in December 2007 and lasted until June 2009—slammed support for education before it had recovered from the previous recession. The federal government increased tax credits for education and poured millions of dollars into college enrollment subsidies, including Pell Grants to subsidize college for low income families. But with tax revenues plunging, states cut funding for higher education, and colleges responded by raising tuition and spending less on educating students. Veterinary student debt was rising to ominous heights—potential starting salaries were incompatible with gigantic student loans. The opportunity costs of college education were out of whack and were shifting the economic origins of those enrolling in veterinary schools.

FOR FIFTY YEARS, THE NATION'S premier laboratory to study dangerous animal microbes that were foreign to the United States was the Plum Island Animal Disease Center. Now the buildings and their elaborate ventilation and airflow systems were out of date. Worse, the center had no capacity to safely handle biosafety level 4 microorganisms such as anthrax and Ebola virus. Rethinking the plans to renovate Plum Island, planners decided on an entirely new facility in a more accessible location.

The plans were that the new facility be named the National Bio and Agro-Defense Facility—NBAF for short—and that operations would be under the new Department of Homeland Security. A group of twenty-nine sites considered for the new laboratory was whittled to six in 2008: the University of Georgia in Athens; the Texas Research Park in San Antonio; the Umstead Research Farm in Granville County, North Carolina; the Flora Industrial Park in Madison County, Mississippi; the Kansas State University campus in Manhattan, Kansas; and the Plum Island Center site in New York. The final decision, published in the *Federal Register* on January 16, 2009, was Manhattan, Kansas. The State of Kansas had donated land for the new facility, recruited a veterinary expert in African swine fever, Juergen Richt, and provided funds for Kansas State University to build and staff its Center for Excellence for Emerging and Zoonotic Animal Diseases, a name so complex that even its acronym, CEEZAD, is unwieldy.

Construction was delayed by concerns of the continental location. Groups in Kansas and elsewhere had organized to defeat the Kansas State University site, publicizing the dangers of bringing animal disease agents into the heart of the livestock-producing Midwest. The laboratory was to study foot-and-mouth disease, contagious bovine pleuropneumonia, and hog cholera (now named classical swine fever), and the worry was that the location could release these agents into agricultural areas. The Department of Homeland Security paused to do a study and used the National Academy of Sciences to investigate the site location. Completed in June 2012, the National Academy of Sciences report supported Kansas. A ground-breaking ceremony was held on May 27, 2015, with Kansas senator Pat Roberts, Governor Sam Brownback, Agriculture Secretary Tom Vilsack, and Homeland Security's Jeh Johnson. Construction was to begin on campus with the date for transfer of Plum Island operations to Kansas set for 2023. Control of the new laboratory was transferred from the Department of Homeland Security to the Agricultural Research Service in 2019.

40. ANTI-SCIENCE SCAMS AND KEYS TO PROGRESS

Since 2000, commercial, academic, and religious anti-science scams have accompanied the rise in the public's distrust of science. Expansive commercial ventures in animal and human health developed that provided scams for the unwary financier. After retirement from the Veterinary Medical Research Institute, Professor William Switzer, known internationally for research in respiratory diseases of pigs, entered into an arrangement with an entrepreneur to create Mitogenetics LLC, which billed itself as a research and development company focused on biomedical technology "to preserve a healthy lifestyle." Switzer was listed as the company's founder, company director, and chief science officer, but offices were in Sioux Falls, South Dakota, with a businesswoman listed as CEO and president.

According to its website, "Mitogenetics has found therapeutic solutions for mitochondrial and cellular changes used in diseases like type 2 diabetes, obesity, heart disease, hypertension, Alzheimer's disease, and Parkinson's disease—to name a few that have been linked to mitochondrial dysfunction." But it was not true. There were no solutions, nor was there evidence that there might be—there were no laboratories, no research, and no science. A few other scientists located elsewhere were listed, but there were no authentic original scientific publications or any other evidence of innovative science done by Mitogenetics. When the investors' money was gone, Mitogenetics came back for more—but it was too late.

Professor Switzer had been bamboozled into lending his name to a business front that was, at best, a scam to make money for personal gain; at worst, a shell company for other devious activities. The current listing under Buzzfile is that Mitogenetics "primarily operates in the automobile insurance business with $340,000 annual revenue." Turns out, Switzer was following a modern flimflam artist whose modus operandi was *fake it 'til you make it*. But Mitogenetics was minor league—small potatoes in the world of medical scamming.

Elizabeth Holmes zoomed to fame as the youngest female billionaire after dropping out of Stanford at age nineteen to found the company she named Theranos. A "darling of Silicon Valley," she claimed to have created an easy way to test blood just by pricking your finger. She added retired politicos to her board, including George Shultz and Henry Kissinger. Holmes cast a hypnotic spell: her investors included Rupert Murdoch and Betsy DeVos, as well as Steven Mnuchin, big investment banker and secretary of the U.S. Treasury. But her processes were fake and her equipment resembled that in a high school science laboratory. She wasn't selling software but vaporware. When exposed by *Wall Street Journal* reporter John Carreyrou, her company collapsed. Turns out, she was defrauding investors of just under $1 billion on nonexistent technology. Her science directors, having been cheerleaders, not overseers, quietly resigned.[29]

Inappropriate behavior by veterinarians in the federal government can be especially disappointing. Lester Mills Crawford, a veterinary school graduate of Auburn University in 1963 with a PhD degree in pharmacology from the University of Georgia, was appointed commissioner of the Food and Drug Administration by President George W. Bush. Crawford had worked in the Bush election campaign of 2004 and was a member of the National Republican Senatorial Committee and a heavy contributor to Bush's presidential election. A highly trained scientist of great ability, he rapidly worked his way upward in the federal mid-level administrative chain; he had been director of the FDA's Center for Veterinary Medicine, administrator for the Food Safety and Inspection Service at the U.S. Department of Agriculture, and director of the Center for Food and Nutrition Policy. Approved by the Senate Committee on Health, Education, Labor, and Pensions, Crawford was confirmed two weeks later and began as commissioner of the FDA in July 2005. The next spring, Crawford's lawyer announced that he was being investigated by a grand jury over accusations of financial improprieties and false statements to Congress. On October 16, 2006, he was charged by the Department of Justice and the next day suddenly resigned as FDA commissioner. He pleaded guilty to conflict of interest and false reporting of information about stocks he owned in food, beverage, and medical device companies he was in charge of regulating. He was sentenced to three years of probation and fined $90,000.

Here and there, the legitimacy of scientific medical research has been discredited by scams that preyed on science for profit or by professors who cooperated with these scams—modern bogeymen who finagle for professional advantage but foul their own nests. Plagiarism, the appropriation of another person's ideas, results, or words without giving appropriate credit, is the most common form of research misconduct in academia. It often appears among scientists as citation plagiarism—also called "citation amnesia" or "bibliography negligence"—the negligent or willful failure to appropriately credit others and prior discoveries so as to give the impression of priority.

Data dredging or cherry-picking—looking for and giving inappropriate emphasis to findings that seem most interesting—is a wily falsification scheme used in nutritional and agricultural studies, where large sets of data are required. Brian Wansink, once one of the nation's most respected food researchers, was forced to resign from Cornell University when most of his published papers were retracted by the *Journal of the American Medical Association*. His downfall began when he reported that the calorie count in *Joy of Cooking* had gone up 44 percent since the first edition in 1936 and that the change was related to the obesity epidemic; the publisher asked statisticians to review the studies. Turns out, Wansink had used data dredging, or p-hacking, the process of running exhaustive analysis on data sets to tease out subtle signals that might otherwise be unremarkable. His studies were riddled with errors, data inconsistencies, and evidence of fraud. Gregarious and narcissistic, Wansink had never learned the rules of proof and integrity. He had been born in Iowa and had extraordinary academic credentials: an MS from Drake University in journalism and a PhD from Stanford in marketing, as well as faculty stints in economics at Dartmouth, Illinois in Champaign, and the Wharton School at Pennsylvania. But he was a journalist and marketer, not a scientist.

The most serious examples of academic scamming arise from the fabrication and falsification of results—such as making up or "dry labbing" results and reporting them—a form of research misconduct in which scientists manipulate research processes or change or omit data so that the research is not accurate. In 2009, the Department of Biomedical Sciences in the College of

Veterinary Medicine at Iowa State recruited Michael Cho and his team of HIV/AIDS research scientists from Case Western Reserve University in Cleveland. Dong-Pyou Han, a Korean member of the team, reported that he had detected antibodies in rabbits given an experimental HIV vaccine—the first ever evidence that an HIV vaccine might work.

Others could not confirm his work, and the funding agency, the National Institutes of Health, insisted that other labs pursue the issue using Han's reagents and serum to detect the antibodies. In early 2013, scientists at Harvard University, trying to validate Han's work, found the antibodies in Han's sera; they also found something else—human proteins. Following through, they discovered that human antibodies had been added surreptitiously to the rabbit serum specimens. The rabbits had not responded to the HIV vaccine; human anti-HIV antibodies had been added to the rabbit serum to make it appear as if they had. Iowa State University and the NIH investigated immediately.

Han confessed to his misdeeds, resigned, and left town. Unfortunately for him, Iowa's Senator Grassley, the Senate watchdog over medical science misdeeds—unhappy with the NIH's light punishment—was not about to let Han get off scot-free and, pursuing the issue, forced a criminal investigation. In 2014, Han was arrested, tried, found guilty, and sentenced to five years in prison and ordered to return $7.2 million to the NIH. A spokesman for NIH was quoted in the *New York Daily News* as having called it the "worst case of research fraud he'd seen in two decades at the agency." In the end, administrators had failed, their academic greed trumping a careful decision that a medical school HIV hotshot was an inappropriate choice for a cramped veterinary school. Clueless about cutting-edge science, naive about misconduct, and lackadaisical in leadership, the professors in charge had been dazzled by the $19 million in federal funding for the project, but no one was attending to details.

A LESSON ON THE IMPACT of anti-science threats comes from the perpetual turmoil in the Middle East, an intriguing paradox in cultures. In the dark ages of medieval Europe, Arabic scholars held on to the possibilities of truth, rationality, and tolerance while these were being destroyed in Europe. In the tenth century, an Arab philosopher and optics physicist, Ibn al-Haytham—he had discovered that vision occurred in the brain, not the eye—proposed that the scientific method must "search for truth, not support of opinions" and that science must function through observation, measurement, creative experiment, and conclusion. In the next three hundred years, others in the Muslim world emphasized the importance of subjecting contrarian views to the test of evidence and rational analysis.[30] Ibn al-Awam, an Andalusian Arab in Seville, wrote *Kitab al-Filaha* (*Book of Agriculture*), with four chapters on livestock, including diseases of horses and cattle.[31] But then, slowly, the Arabic world entered its own dark ages.

By the 1980s, Egypt had been one of the most heavily endowed recipients of American aide for agriculture and veterinary medicine from the Agricultural Research Service. Operating through the Food and Agriculture Organization of the United Nations in Rome, Americans had helped Egypt build a useful system of universities. Veterinarians, young and old, were intelligent and well-educated. Their universities in Cairo and Asyut published Egyptian veterinary journals, and they owned a great heritage. Yet, somewhere along the line, the great ancient libraries of Alexandria and Baghdad had disappeared, and with them their heritage of tolerance and rational thought.

These bright young veterinary scientists in Egypt were not being productive in the Western sense, and their system seemed hampered by zealots in their Muslim culture. Scientific productivity is strikingly low in many Arab Gulf states, despite the investment of enormous sums of money. This low output of scientific papers and patents is perpetually linked to failures of acceptance of the central core of universal values that any modern society must possess: the search for truth, rational thought, creativity, and analysis of contrary views. The Muslim world of over a billion people is, in many countries, flush with cash yet perpetually retarded in the search for stable and permanent economic growth by its social intolerance, lack of science values, and failure to use rational, evidence-based decision-making processes.

In 2008, Ismail Serageldin, director of the Library of Alexandria in Egypt, in a remarkable treatise on Muslim science, wrote: "Throughout the Muslim world, we are witnessing an increasingly intolerant social milieu that is driven by self-appointed guardians of religious correctness, who inject their narrow interpretation of religion into all public debates. Rejecting rationality or evidentiary approaches, they increasingly force dissenting voices into silence and conformity with what they consider acceptable behavior."[32]

Muslim zealots are paralleled in the U.S. by battles of religious zealots over creationism and evolution. Supporting religious scamming, a disturbing editorial by a member of the *Des Moines Register*'s Reader Advisory Board appeared on January 7, 2006. Covered by the headline "Evolution Disciples Dodge Facts, Implications of Intelligent Design," the writer had turned truth on its head, suggesting that facts belong to creationists and faith to science, telling us about scientists whose "faith in evolution prevents them from admitting there is very little evidence to support its grand claims . . ." From there, he proceeded to a series of illogical and downright silly conclusions. Equally disturbing at the same time was a discussion with students on the Iowa State University campus by Robert Vander Plaats, a candidate for lieutenant governor of Iowa. He was proposing that intelligent design, a revisionist version of creationism, be taught in the public schools "alongside of the theory of evolution."

Intelligent design was a loosely veiled façade whose goal was the teaching of science based on biblical values. The objectives were to falsify science and manipulate public opinion in order to lead the political process to control what science is taught. The creationist curse seemed to disappear, but perhaps it was once again transferred to anti-vaccination activism. Although they will not survive, these anti-science scams require vigilance. Serageldin writes: "The future can be bright, but it requires a commitment to fight for the values of science and to reject obscurantism, fanaticism, and xenophobia."[33]

Over the past decade the internet and social media have changed the rules of how grifters play the game. They speed people to like-minded combatants, giving them an impression of stronger validation than really exists. "What people find on the web 'creates a whole new permission structure, a sense of social affirmation for what was once unthinkable,'" writes Frank Bruni of the *New York Times*. He continues, quoting from a *New Yorker* article that deconstructs the 2016 election: "The capacity to disseminate misinformation, to will conspiracy theories, to paint the opposition in wildly negative light without any rebuttal—that has accelerated."[34] Suspicion becomes certainty. It is the era of the confidence game. Google, Facebook, and Twitter have served to elevate the abilities of the con artist—one can sign on to enter a behavior modification loop, which is the con. At any rate, that is what virtual reality expert Jaron Lanier says in his book *Ten Arguments for Deleting Your Social Media Accounts Right Now*.

Nationwide, college professors were shocked by a 2017 Pew Survey. Asked if colleges were having a positive or negative effect on America, 58 percent of Republicans and conservative-leaning independents said negative—up from just 37 percent two years previously. Even worse, a Gallup poll found that only 44 percent of all Americans had a "great deal" or "quite a lot" of confidence in the country's colleges and universities, while 56 percent had only "some" or "very little." In past decades, one encountered academic bashing—references to "half of what you learn in college is wrong," "those who can, do; those who can't, teach," and all the old standby references to ivory towers. But these surveys revealed something far more ominous.

In the late 2010s, we moved into a politically divisive era that took us backward in culture. Too high a percentage of the population was persuaded that razzmatazz, bullying, bigotry, and even lying were lesser evils that could supersede logic, law, and common sense in the pursuit of political goals. Lying was viewed simply as a marketing tool to move the public into an anti-science stance. The position of science advisor to the president was abandoned, and the National Academy of Sciences, originated by Abraham Lincoln to provide critical scientific information for national leaders, was not used effectively.

In the name of efficiency, new schools of veterinary medicine have appeared that replace microscopes with digitized photographs and virtual reality programs that have no serious connection to how science is done. Some fear that the century-old tradition of the educated veterinarian understanding, speaking, and doing science may be over.[35] The problem is that the virtual in virtual reality is a lie. It uses marvelous technology to teach in seconds by pressing a button what professors of past generations took days to teach using microscopes, real specimens, multilayered diagrams, unretouched photographs, and contact with laborious anatomical dissections and clinical analysis of living animals. Those methods were often inefficient, time-wasting, and boring, especially in the hands of a tired and aging professor. Yet the danger in the digital approach is that, for many students, a connection to reality is virtually lost. Limiting education to the dazzle of virtual reality has led in some institutions to the concept that students do not need experiences offered by diagnostic laboratories, research centers using cutting-edge technology, and veterinary hospitals controlled by professional educators.

The keys to avoiding all this intellectual vandalism that poisons science and education lie in who we elect to lead our government, what regulations are begun to prevent internet misdemeanors, and how effectively we teach science to our offspring—keeping leadership rigorously embedded in long-term realities and not diluted in the name of cost savings or religious bigotry, or to please helicopter parents or student audiences.

Science education has to be an integral part of the nation's economic creativity and inventiveness, an economic engine for biotechnology in food safety, livestock animal health, and animal modeling for the life sciences. It provides the high-quality, authoritative research data that is required for national policy decisions. To fail opens society to agenda-driven misinformation by zany cults and even careless political leaders. In every generation science somewhere does fail, sometimes in devious ways. The dangers that arise from all this are deferred and vastly underrated.

The truth is, despite the defects in our system, we are educating a new generation of problem solvers that understands both the seemingly unlimited capacity of computers as well as the weaknesses in digital communication. For these inquisitive students the study of science is fulfilling, and they understand its power for good. In the few years allotted for college, problem solving is perfected as the graduate's most powerful tool. In most veterinary schools, students do learn to apply discretionary judgment in making fine distinctions among alternative possibilities and to draw valid conclusions from a unique set of observations. In the end, they will combine objectivity and rational thought to determine the best path to a successful clinical outcome. They understand that great plagues will continue and that to survive, we must be tethered to science. The arc of history vacillates but always bends to truth.

APPENDIX I

Transportation Pathways Spread Disease

The stimulus for livestock production in the Great Plains came from an extraordinary gift, an Act of Congress on May 15, 1856. To entice entrepreneurs to build tracks across Iowa, railroad companies were given four million acres—alternate sections of land for each prospective railroad, for a distance of six miles from the right-of-way. The increasing need to reach California and the Pacific Coast by rail had driven this federal economic stimulus. The plan was to cross the Mississippi River into Iowa with construction of bridges at Burlington, Davenport, Lyons (north of Clinton), and Dubuque and to join a railroad extending westward. Transcontinental railroad surveys and construction dominated the economic energy of North America in the late 1850s. Abraham Lincoln was employed as a lawyer by the Rock Island Railroad in its battle over Mississippi River bridges; in the South, Jefferson Davis was the director of the 1853 Pacific Railroad Survey that headed west through Texas.

In the Midwest, the Chicago and North Western Railway was the winner of the race to build tracks to connect Chicago with the Union Pacific in Omaha. Its construction company used the pretentious name Iowa Central Air Line Railroad, which, when that company went broke, reorganized as the Chicago, Iowa and Nebraska Railroad. The *Fifth Annual Report of the Iowa State Agricultural College* in February 1864 reported that "the Chicago, Iowa and Nebraska Railroad is complete and in running order from Clinton in Clinton Co. to Cedar Rapids in Linn Co., a distance of 82 miles. The Cedar Rapids and Missouri River Railroad, a continuation of the Chicago, Iowa and Nebraska Railroad, is completed and in running order to a point west of Cedar Rapids ninety-two miles and will be completed to the Des Moines River at Boonesboro, 123 miles (from Cedar Rapids) by the first of November, 1864." Pushing westward in Iowa, tracks of what had become the Chicago and North Western Railway arrived in Council Bluffs in January 1867. The bridge to connect to the Union Pacific Railroad in Omaha was completed in March 1872.

Starting in Omaha in the summer of 1865, the Union Pacific Railroad moved west across the flat prairie at a record pace of 10 miles per day. In December 1866, it bridged the North Platte River after completing 240 miles of track that year. The Union Pacific Land Grant had given it ownership of 12,800 acres of rich Nebraska farmland per mile of finished track, and advertisements in the East and in Europe flooded immigrants into the state. In 1870, the Union Pacific was offering rich Nebraska farmland for $5 an acre with a 10 percent discount for cash. The Kansas Pacific Railroad, competing for transcontinental railway land, operated a long-distance line in Kansas in the 1870s. Tracks began on the mainline west in 1869 from Kansas City, reached Salina in 1869, and on to Denver. Opening of the markets for cattle, sheep, and hogs in Chicago was a major stimulus to the livestock industry and a big-time cause of "shipping fever" and other infectious diseases.

Expansion of the American railroad industry—it quadrupled in the four-year period from 1879 to 1882—increased immigration and created economic prosperity. As cattle and swine increased, infectious plagues appeared that were debilitating. The rising wealth of livestock was hindered by the heavy economic impact of Texas cattle fever, hog cholera, anthrax, and shipping fever—all made more dangerous by the increasing efficiency of the railroads and the massive concentration of livestock in the new stockyards in Chicago, Kansas City, and Fort Worth. As the Union Pacific Railroad heading west from Omaha reached Cheyenne, settlements expanded into western Iowa and into the new state of Nebraska. Railway shipment to markets in Chicago forced cattle into close contact, perpetuating infectious diseases. As the Kansas Pacific Railroad moved west from Kansas City to Abilene and on to Denver, infectious diseases began to ravish livestock in the Great Plains.

APPENDIX II

North American Degree-Granting Veterinary Schools

School	Year Founded	Year of First Graduating Class	Number of Graduates	Year Closed[1]
Veterinary College of Philadelphia	1852	Unknown	Unknown	1870
Mexican National University, San Jacinto Hospice	*1853*	*Unknown*		—
Boston Veterinary Institute	1854	1854	Unknown	1860
New York College of Veterinary Surgeons[2]	1857	1867	291	1899
Ontario Veterinary College, University of Toronto	*1862*	*1866*		—
Veterinary Institute of Chicago	1864	1864	Unknown	1869
Montreal Veterinary College, McGill University	1866	1869	268	1903
Cornell University, Ithaca[3]	1868	1871	4	1893
American Veterinary College, New York City[2]	1875	1876	628	1899
Columbia Veterinary College	1877	1879	80	1884
Iowa State College (University), Ames	*1879*	*1880*		—
Northwestern Veterinary College, Minneapolis	1881	1885	3	1890
Harvard University	1882	1886	128	1901
Chicago Veterinary College	1883	1884	2,387	1920
University of Pennsylvania, Philadelphia	*1884*	*1887*		—
Ohio State University, Columbus	*1885*	*1887*		—
Université de Montréal	*1886*	*1887*		—

Continued

School	Year Founded	Year of First Graduating Class	Number of Graduates	Year Closed[1]
University of South Carolina, Columbia	1888	1891	1	1891
Baltimore Veterinary College	1889	1891	1	1891
Detroit College of Medicine, Veterinary Department	1890	1892	35	1898
Iowa Veterinary College, Des Moines	1890	1892	13	1894
University of Minnesota Veterinary Department	1891	None	0	1995
Kansas City Veterinary College	1891	1892	1,789	1918
Kentucky State College, Department of Veterinary Medicine	1891	1894	1	1895
Ohio Veterinary College, Cincinnati	1891	1892	67	1892
Indiana Veterinary College	1892	1893	884	1896
McKillip Veterinary College, Chicago	1892	1897	1,212	1920
National Veterinary College, Washington, D.C.	1892	1893	64	1898
New York State Veterinary College at Cornell	*1894*	*1897*		—
United States College of Veterinary Surgeons	1894	1895	419	1927
Queen's University, Veterinary Department	1895	1897	9	1899
University of California, Veterinary Department	1895	1897	10	1899
Grand Rapids Veterinary College, Michigan	1897	1898	586	1918
Western Veterinary College, Kansas City	1897	1898	178	1908
San Francisco Veterinary College	1899	1900	330	1918
New York-American College of Veterinary Surgeons[2]	1899	1899	127	1913
Cincinnati Veterinary College	1900	1903	410	1920
University Veterinary College	1902	1902	53	1906
Kansas State College, Manhattan	*1905*	*1907*		—
St. Joseph Veterinary College, Missouri	1905	1908	414	1923

School	Year Founded	Year of First Graduating Class	Number of Graduates	Year Closed[1]
West Virginia University, Veterinary Department	1905	1910	4	1912
Alabama Polytechnic Institute (Auburn)	*1907*	*1909*		—
Colorado State College (University), Fort Collins	*1907*	*1909*		—
George Washington University, Washington, D.C.	1908	1911	100	1918
Michigan State College (University), East Lansing	*1909*	*1913*		—
Southwestern Veterinary College	1909	1912	23	1916
Terra Haute Veterinary College, Indiana	1909	1911	145	1918
New York State Veterinary College at New York University[2]	1913	1922	71	1922
Arkansas Veterinary College	1913	1916	25	1921
Agricultural and Mechanical College of Texas, College Station	*1916*	*1920*		—
University of Georgia, Division of Veterinary Medicine	1918	1921	70	1933
North Dakota Agricultural College, Fargo	1919	1922	12	1919
Middlesex Veterinary College, Boston	1944	1944	30	1949

Italics indicates school is still in operation.

[1] Data from Archives of the American Veterinary Medical Association and Louis A. Merillat and Delwin M. Campbell, "State Education," in *Veterinary Military History of the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation* (Kansas City, MO: Haver-Glover Laboratories, 1935), 409–22.

[2] New York College of Veterinary Surgeons; American Veterinary College, New York City; New York-American College of Veterinary Surgeons; and New York State Veterinary College at New York University are the same institution.

[3] See New York State Veterinary College at Cornell. The Agriculture College at Cornell University taught veterinary courses in 1868 and awarded the DVM degree but did not have a formal veterinary school with clinical teaching.

APPENDIX III

Six New Land Grant Veterinary Colleges, 1900–1920[1]

STATE COLLEGE OF WASHINGTON, COLLEGE OF VETERINARY MEDICINE; first graduating class, 1902. Inaugurated in the fall of 1899. Dean: Sofus Bertelson Nelson, DVM, Iowa State College 1889. In 1908 the veterinary hospital was erected, and in 1909 the classroom and laboratory were added for $85,000. Number of graduates: 1902, 2; 1903, 0; 1904, 2; 1905, 4; 1906, 2; 1907, 3; and 1908, 5.

KANSAS STATE COLLEGE, DIVISION OF VETERINARY MEDICINE; first graduating class, 1907. Authorized in 1905 and began operation in September of the same year. Director, Division of Veterinary Medicine, School of Agriculture: Francis S. Schoenleber (1905–1917). Deans: R. R. Dykstra, DVM, Iowa State College, 1905 (1917–1948); E. E. Leasure (1948–1964); R. L. Kitchell (1964–1964). Buildings: Veterinary Hall, 1907 ($70,000); Veterinary Hospital, 1923 ($110,000). Number of graduates: 1907, 7; 1908, 4; 1909, 11; 1910, 7; 1911; 12; 1912, 19.

COLORADO STATE COLLEGE, DIVISION OF VETERINARY MEDICINE; first graduating class, 1907. Established in April and opened in September of 1907. Deans: George H. Glover, DVM, Iowa State College, 1885 (1907–1934); I. E. Newsom (1934–1935+). Building: Veterinary Hospital, 1909 ($65,000). Number of graduates: 1909, 2; 1910, 20; 1911, 7; 1912, 12; 1913, 9; 1914, 8.

ALABAMA POLYTECHNIC INSTITUTE, SCHOOL OF VETERINARY MEDICINE; first graduating class, 1909. Established and began operations in 1907. Dean: C. A. Cary, DVM, Iowa State College, 1887 (1907–1935). Buildings: Anatomy and Postmortem, 1922 ($17,000); Laboratory, 1923 ($35,000); Surgery, 1923 ($20,000). Number of graduates: 1909, 5; 1910, 8; 1911, 14; 1912, 11; 1913, 12; 1914, 14.

MICHIGAN STATE COLLEGE, DIVISION OF VETERINARY MEDICINE; first graduating class, 1913. Established by an Act of the Michigan State Board of Agriculture on October 21, 1909; the school began operation the next year. Deans: Richard P. Lyman, VS, Harvard University (1910–1919); Frank Chamberlain (1920–1923); Ward Giltner (1923–1947). Buildings: Clinic, 1914 ($25,500); Anatomy and Pathology, 1931 ($100,000). Number of graduates: 1913, 1; 1914, 2; 1915, 10; 1916, 6; 1917, 9.

TEXAS AGRICULTURAL AND MECHANICAL COLLEGE, SCHOOL OF VETERINARY MEDICINE; first graduating class, 1920. Established in 1916 and began operation the same year. Dean: Mark Francis, DVM, The Ohio State University (1916–1937). Number of graduates: 1920, 4; 1921, 6; 1922, 3; 1923, 2; 1924, 2; the numbers for the next decade ranged from 1 to 5.

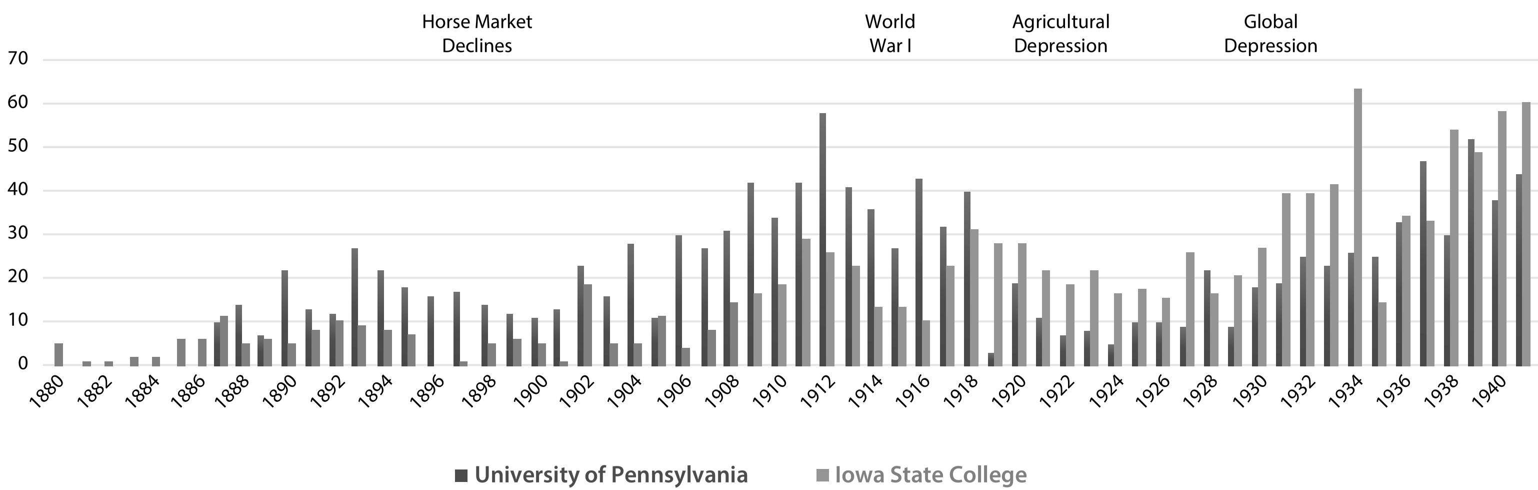
APPENDIX IV

Graduates in Rural and Urban Veterinary Schools

Peaks and valleys developed in veterinary school enrollment and graduation numbers in rural and urban schools. At Penn in Philadelphia, the decline in enrollment and graduation numbers was striking during World War I. Vacillations in the economy and war were having much the same impact as they had in the colleges in rural Iowa, Ohio, and Kansas.

The first enrollment decline in the 1890s was tied to an unprecedented decline in horse values; it was more severe in Iowa and led to discussions of closing the school. Because of the "panic of the '90s," no veterinary student graduated in 1896. The depression in 1912–1913 was thought by C. H. Stange to be due to increased requirements for admission, but it was more likely associated with the transient recession in 1910–1911. The small peak in 1918 was caused by the closing of several private veterinary schools during and after World War I, and the valley in 1920–1926 was due to the aftermath of the war and the resulting agricultural depression. (See graph that follows.)

DIVISION OF VETERINARY MEDICINE GRADUATES PER YEAR, 1880–1941



Number of veterinary school graduates from rural Iowa and urban Pennsylvania from 1880 to 1941. Numbers declined in three periods: the 1890s, 1914–1916, and the 1920s.

APPENDIX V

Military Training for Veterinarians in World War II

Veterinary Reserve Officers' Training Corps units had been established at four veterinary colleges in 1920–1921: Iowa State College, Kansas State College, The Ohio State University, and Cornell University. Enrollment steadily increased, then declined, and ROTC units were disbanded in 1935 (they were reinstated in 1948 when ROTC veterinary units were established in six schools). Veterinary officers had to come from newly trained graduates that enlisted in the Corps.

By 1940, all regular Veterinary Corps officers had competed the annual two-phase course of military indoctrination: nine months total at the Medical Field Service School, Carlisle Barracks, Pennsylvania, and at the Army Veterinary School, Army Medical Center, Washington, D.C. Beginning November 1940, great numbers of veterinary officers were being ordered to active duty to the Meat and Dairy Hygiene Course at the Chicago Quartermaster Depot.

Training of Veterinary Corps officers during World War II was part of the medical training system of wartime courses that varied from the Special Graduate Course in Clinical Pathology (conducted by the Medical Corps) to the Refresher Course in Forage Inspection (conducted by the U.S. Department of Agriculture). Veterinary officers were often assigned to special service schools outside of the Medical Department: a dozen attended the Chemical Warfare School at Edgewood Arsenal, Maryland, and twelve were assigned to the Army Chinese Language School at the University of California, Berkeley.

The Medical Department Laboratory System, developed in the Medical Corps for World War II, included training centers dedicated to the Veterinary Corps. The U.S. Army Veterinary School at the Army Medical Center, Washington, D.C., served as the parent for outlying laboratories: Fort Sam Houston, Texas; Fort Mason, California (general depot); the Medical Department Equipment Laboratory, Medical Field Service School, Carlisle Barracks, Pennsylvania; and the Veterinary Research Laboratory, Aleshire Quartermaster Remount Depot, Front Royal, Virginia (relocated in 1945 to Fort Robinson and in 1947 to the Army Medical School, as inactive).

Major wartime research projects developed for the Veterinary Corps in the mid-1940s were equine influenza, equine periodic ophthalmia, equine infectious anemia, and, in 1945, studies on the effectiveness of drugs against parasites. Additional projects were done in collaboration with veterinarians at the Armed Forces Institute of Pathology: canine filariasis, cereal mites in dog food, and canine leptospirosis. Special animal disease research projects were farmed out to universities, including Newcastle disease and fowl plague to Harvard, with civilian scientists C. A. Brandley and E. L. Jungherr.

The first of an extensive network of Naval Medical Research Units—with the appellation NAMRU—was established in 1944 at Rockefeller University in New York City, with the virologist Thomas Rivers as commanding officer. By the end of the war, veterinary laboratories had also been organized in all major theaters of war: European (England, Paris, Darmstadt, and Reykjavik), North African and Mediterranean (Cairo), Central and South Pacific (Hawaii), Southwest Pacific (Australia and New Guinea), and China-Burma (Chabua, Assam; New Delhi, Calcutta). NAMRU-3 in Cairo, one of the largest and most effective, was destined to employ a series of veterinarians assigned to investigate diseases of Middle Eastern livestock.

APPENDIX VI

Animal Models of Cancer

Russian veterinarian Mstislav Novinsky reported in 1878 that he had successfully transplanted transmissible venereal tumors of the external genitals from one dog to another. Common in dogs worldwide, they grew on the penis and vulva and were transferred during mating. His discovery lay dormant for a century before this "one of a kind" tumor was shown to have originated from a precursor coyote, wolf, or ancient dog and to have survived in nature for over two thousand years as an allograft—not through passage of a causal organism, but as a self-perpetuating graft of tumor cells from one dog to another.

By the 1930s, comparative pathologists were revealing secrets about cancer. Of little interest to the public or to most physicians, the results were critical in our understanding of how cells become cancerous. Rabbit papilloma virus, the first mammalian DNA tumor virus, was reported by Richard Shope, an Iowan working at the Rockefeller Institute. Studying this endemic disease of wild cottontail rabbits in the Great Plains, Shope showed that the warty growths were transmitted through skin abrasions with infective debris.

At the University of Nebraska, Carl Olson had published his landmark studies on papilloma viruses as a cause of cancer: he had discovered that bovine papilloma virus, when infecting a superficial wound on the horse, did not cause papillomas but a common connective tissue tumor in the skin of the horse called equine sarcoid, a nasty fibrous tumor on the legs of the horse. Olson later reported that the same virus caused cancer in the bladder of cattle, and Scottish veterinarians reported that intestinal cancers in cattle could be produced by bovine papilloma virus. Decades later, medical virologists' findings that papilloma viruses caused cancers of the human genital system were touted as incredible discoveries.

Cancer in animals was intriguing to scientists but not viewed as having much clinical importance. How cancer was caused was an enigma. As astonishing as it seems, the early studies on transmissible cancers in chickens, frogs, and rabbits had been largely ignored by the public and generated an inappropriate lack of attention by most clinical oncologists. Scientists working in the large rodent colonies dedicated to experimental research had for years seen naturally occurring tumors in older mice. Mammary gland tumors were common in old female mice, and scientists began investigating the genetics of breast tumors and how they could be transmitted—by transplantation among hybrid mice.

In 1936, geneticist John Joseph Bittner, working at Jackson Memorial Laboratory, reported that a milk factor causing mammary tumors was transmitted in the mother's milk: mice of low mammary tumor strains nursed by mothers of high cancer strains developed a high incidence of mammary tumors; conversely, mice of high cancer strains suckled by foster mothers of low cancer strains developed only a few tumors. These mammary tumors were discovered to be transmitted maternally and to have caused female offspring to develop mammary cancer. Bittner, born in Meadville, Pennsylvania, received a PhD from the University of Michigan with a thesis on the genetics of transplantation of breast tumors in hybrid mice. Working at the Jackson Laboratory where his milk factor research was done, he moved to the University of Minnesota for two decades before his death in 1961.

In 1939, Baldwin Lucké, a medical pathologist holding an appointment with Evan Stubbs in the veterinary school at the University of Pennsylvania, reported the first cancer-causing herpesvirus—the frog renal adenocarcinomas virus. This herpesvirus not only caused cancer of the kidney in leopard frogs, its life cycle involved a unique phenomenon in animals—temperature-dependent tumor growth. When virus from tumor-bearing frogs was released in the spring from the frog's urine into the water, it infected newly developing frog eggs and tadpoles. Cancers then appeared in the third summer of the frog's life, and many grew large enough to kill the frog. The "summer tumor" cancer cells did not produce virus but did contain the quiescent viral genetic material. If the frog was not killed by autumn, tumor growth stopped at hibernation. As the tumor cells ceased their growth cycles in cold weather, the latent herpesvirus genetic material was activated and the cells began to produce virus. The growing virus killed the tumor cells by lysis. But in spring, when hibernation ended, the virus was released into the urine and expelled into the pond water to begin the cycle again by infecting the new eggs and tadpoles.

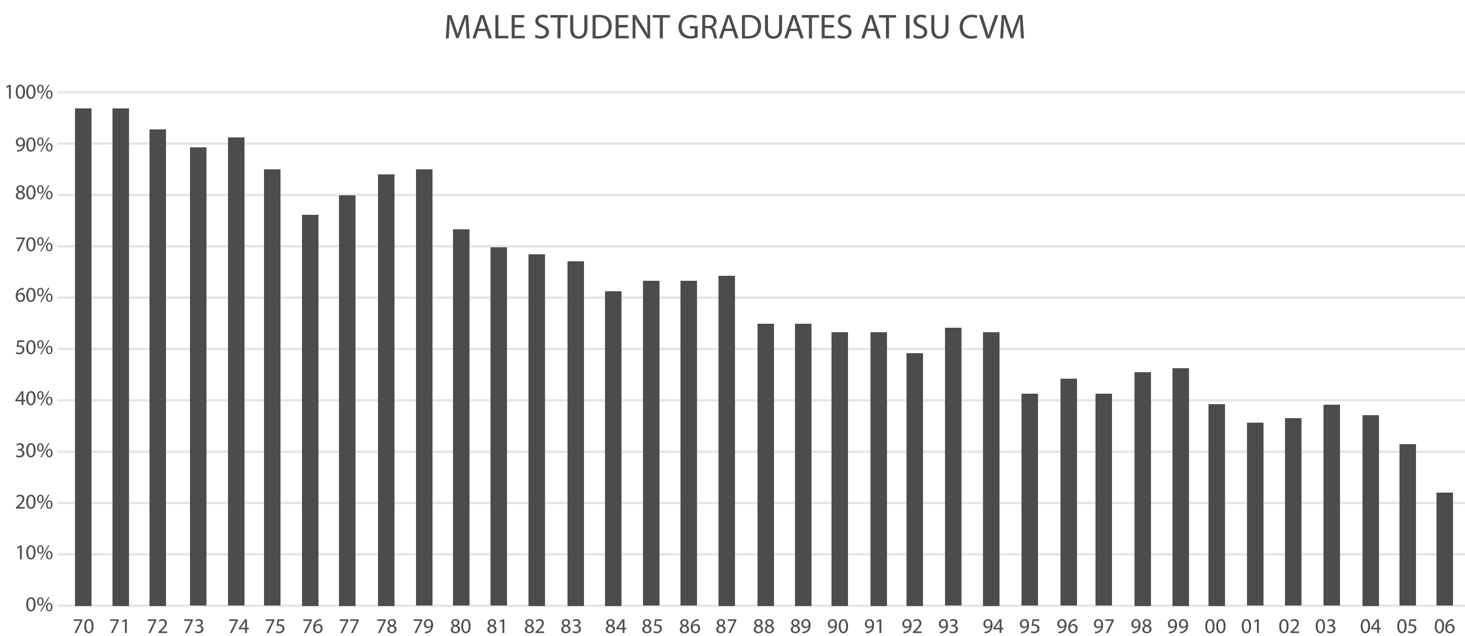
APPENDIX VII

Shift in Gender in Veterinary Students

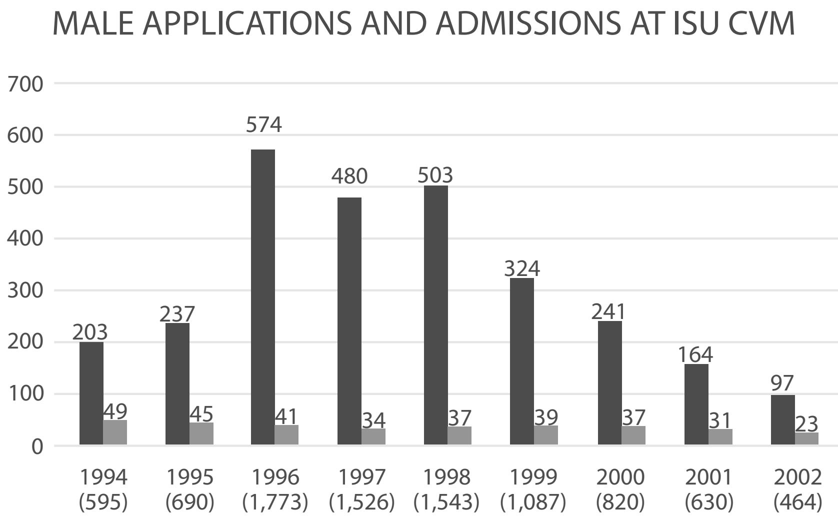
The trend of increasing women graduating from the College of Veterinary Medicine at Iowa State University began in the 1960s; genders reached equivocal numbers in 1992. In the later 1990s the number of male admissions to veterinary medicine declined slowly, even though male applications rose, and then declined to small numbers. (See graphs that follow.)

In the 2002 graduating veterinary class at Iowa State University, only two listed employment as Large Animal (neither working in Iowa). Twelve listed General Practice/Predominantly Large Animal (with four in Iowa and eight out of state) and four listed General Practice/50:50 (one in Iowa).

By 2000, women were assuming major administrative responsibilities in academia. Shirley Johnston was the first dean of a veterinary school in the United States—at Western University of Health Sciences, which admitted its first class in 2002. Soon to follow were Sheila Allen, University of Georgia, and Joan Hendricks at the University of Pennsylvania. Lisa Nolan, an expert in *E. coli* infections, was dean of the veterinary schools at Iowa State and, seven years later, the University of Georgia.



Decline in male students graduating from the College of Veterinary Medicine at Iowa State University from 1970 to 2006. Bars represent percentage of male graduates.



Number of male applicants (black) and male admissions (gray) in Iowa State University College of Veterinary Medicine, 1994–2002. Figure in parentheses is the total number of male and female applicants.

NOTES

PART I. PROLOGUE

1. Sherburne F. Cook, *The Indian Population of New England in the Seventeenth Century* (Berkeley: University of California Press, 1976), 29–35; Kathleen J. Bragdon, *Native People of Southern New England, 1500–1650* (Norman: University of Oklahoma Press, 1996), 20–23.

2. John S. Marr and John T. Cathey, "New Hypotheses for Cause of an Epidemic Among Native Americans, New England, 1616–1619," *Emerging Infectious Diseases* 16 no. 2 (February 2010): 281, https://doi.org/10.3201/eid1602.090276.

3. David H. Fischer, *Champlain's Dream: The European Founding of North America* (Simon & Schuster, 2008). The plentiful native American tribes of coastal New England had made intimate and often hostile contacts with George Weymouth as he explored and fished in the early 1600s. The French, under Champlain, made three annual trips to New England in 1604–1608. All resulted in hostile skirmishes with dead on both sides and ample opportunity for rats with leptospirosis to move onto land. "Indian disease" appeared soon after these skirmishes and in a few years decimated the tribes in eastern Massachusetts.

4. Francis Baylies, *A Historical Memoir of the Colony of New Plymouth* (Boston: Hilliad, Gay, Little, and Wilkins, 1830).

5. Louis A. Merillat and Delwin M. Campbell, *Veterinary Military History of the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation* (Kansas City, MO: Haver-Glover Laboratories, 1935); P. A. Koolmees, "Epizootic Diseases in the Netherlands, 1713–2002," in *Healing the Herds*, ed. K. Brown and D. Gilfoyle (Athens: Ohio University Press, 2010), 19.

The word *veterinary* may have originated from the Latin adjective *veterinarus*; it may have a Celtic origin, from *vieh* (cattle) and *teeren* (to be sick).

6. The first note on a horse in Plymouth was in William Bradford's *On Plymouth Colony*: On September 8, 1642, sixteen-year-old Thomas Granger, who had been tried and convicted, was hanged for "buggery" with a horse. Invoking Leviticus 20:15, officials killed all the animals and buried them in a pit in the presence of young Tom before he was hanged. It was a brutal time. Fifty years later, the Salem witch trials involved over

two hundred accused of all manner of witchcraft and ended with nineteen executed by hanging and one by being pressed; five died in jail. Some historians have explained the frenetic and agitated behavior of the accused on ergotism—the disease from eating rye and other grains contaminated with a potent fungal toxin that affected the brain.

7. Jacques Labessie de Solleysel included the anatomy of the horse and a dictionary of terms used in the cavalry in his book of 1664. Filled with errors, the English translation by Thomas De Grey, *The Compleat Horse-Man, and Expert Ferrier* (London: Thomas Harper, 1651), is reported to have set back English horse health care for a century. See Fairman Rogers Collection, University of Pennsylvania, https://www.library.upenn.edu/collections/special-notable/groups/fairman-rogers-collection.

In the 1700s, books by horse masters appeared in France: *La parfait connaissance des chevaux* by Saunier in 1734; a general anatomy of the horse in 1733 by Captain Sieur de Garsault, horse master to Louis XV; *Le nouveau parfiat maréchal* in 1739; and *Elémens de cavalerie* by Guérinière in 1740.

8. W. Henderson, "Two Successful Cases of Tetanus," *The Veterinarian* 2 no. 15 (1829): 95.

9. "Royal Veterinary School of Toulouse," editorial, *The Veterinarian* 1 (November 7, 1828): 146.

10. Howard H. Erickson, "Eclipse and the London Veterinary College," *Veterinary Heritage* 37 no. 2 (October 2014): 52.

11. Mr. Langworthy, "Grievances of the Veterinary Profession," *The Veterinarian* 2 no. 14 (1829): 66, 67; Mr. Brown, "On the Practice of Uncertified Veterinary Surgeons," *The Veterinarian* 2 no. 15 (1829): 99.

12. U.S. Department of Agriculture, *Nineteenth Annual Report of the Bureau of Animal Industry for the Year 1902* (Washington, DC: U.S. Government Printing Office, 1903), 345.

13. Donald R. Hopkins, *The Greatest Killer: Smallpox in History* (Chicago: University of Chicago Press, 2002).

14. Variolation was an ancient procedure reported from India, Turkey, and China (by snorting ground smallpox scabs). Brought to England from Constantinople, it was first recorded in 1721. Variolation was introduced in Boston during the smallpox epidemic of 1721 when the Puritan minister Cotton Mather (who had defended the Salem witch trials) pressed physician Zabdiel Boylston to inoculate people; 287 people received smallpox pustule material and 3 died. Reverend John Williams campaigned against the procedure, citing the Bible (Matthew 9:12 [King James Version]: "They that

be whole need not a physician, but they that are sick") to support his view that variolation violated the laws of nature.

15. Edward Jenner, *An Inquiry Into the Causes and Effects of the* Variolae vaccineae, *A Disease Discovered in Some of the Western Counties of England, Particularly Gloucestershire, and Known by the Name of the Cow Pox* (London: 1798), 3.

16. Edward Jenner was born in 1749 in Berkeley, and at the insistence of his father, the vicar of Berkeley, was variolated as a child. Young Edward was apprenticed at age fourteen to a surgeon in Chipping Sodbury. He earned the MD degree from the University of St. Andrews in 1792.

17. Jenner, *An Inquiry Into the Causes and Effects of the* Variolae vaccineae.

18. Jenner, *An Inquiry Into the Causes and Effects of the* Variolae vaccinae, 2, 28, 46, 75. Jenner's interest in animal diseases did not end with cowpox; he was the first to describe canine distemper and a pox disease of the feet of horses.

19. Dorothy Porter and Roy Porter, "The Politics of Prevention: Anti-vaccinationism and Public Health in Nineteenth-Century England," *Medical History* 32 (1988): 321; Robert M. Wolfe and Lisa K. Sharp, "Anti-vaccinationists—Past and Present," *British Medical Journal* 325 (August 24, 2002): 430, https://doi.org/10.1136/bmj.325.7361.430.

Parliament's Vaccination Act of 1853 mandated compulsory vaccination against smallpox and led to the London Society for the Abolition of Compulsory Vaccination and its journal, the *Vaccination Inquirer*. In 1879, after a visit to New York by England's leading anti-vaccinationist, the Anti-Vaccination Society of America was founded. Using court battles and demonstrations in state legislatures, anti-vaccinationists succeeded in repealing compulsory vaccination laws in several states, including Illinois, Indiana, Minnesota, and Wisconsin. After smallpox outbreaks in Britain during 1872–1873 and the U.S. in the 1880s, the anti-vaccinationists quietly went underground.

20. O. Charnock Bradley, *History of the Edinburgh Veterinary College* (Edinburgh: Oliver and Boyd, 1923), 14. Christened the Royal (Dick) School of Veterinary Sciences in 1951, Dick's school is now renowned for its modern academic buildings in the Edinburgh Science Triangle and its ties to cutting-edge science at the Moredun Foundation Laboratories (most recently for the cloning of Dolly the sheep).

21. Bradley, *History of the Edinburgh Veterinary College*, 25, 28, 29.

22. Dick's career included an appointment as veterinary surgeon in Scotland for Queen Victoria, serving as editor of a scientific journal, *The Veterinarian*, for twelve years, and providing inspiration for dozens of students. Four other schools arose from the legacy of Professor Dick: James McCall, the first dean at the Glasgow Veterinary

College; Albert E. Mettam, the Royal Veterinary College of Ireland in Dublin; William Williams, the New Veterinary College, a competitor in Edinburgh (that moved to become the veterinary school in Liverpool); and the University of Sydney's veterinary school through James Douglas Stewart. C. P. Lyman founded the Veterinary Department of Harvard University. Joseph Hughes from the Glasgow Veterinary College with A. H. Baker, a graduate of McGill University, founded the Chicago Veterinary College.

Dick became increasingly cantankerous as he aged, and a ferocious competition with former student John Gamgee led to the establishment of the competitive Edinburgh New Veterinary School. Gamgee was responsible for James Law becoming one of the pioneer veterinarians in the U.S. at Cornell University.

23. As quoted in Horatio Hale, "The Klamath Nation," *Science* 19, no. 465 (1892): 7; "Obituary: Rudolf Ludwig Karl Virchow," *American Veterinary Review* 26 (1902): 644.

24. Nadine Chevallier-Jussant, "Henry Toussaint and Pasteur: Rivalry Over a Vaccine," *History of Science and Medicine* 44, no. 1 (2010): 55.

25. Pierre Victor Galtier (1846–1908) was a veterinarian and professor of pathology and infectious diseases at the National Veterinary School of Lyon. He graduated valedictorian of his class in 1873, winning the Grand Prix Bourgelat. Known for his work on immunization of cattle against rabies, Galtier was elected to the Académie Nationale de Médicine in 1901. Asked by the Nobel Prize committee at the Karolinska Institute in Stockholm to submit his records in consideration for nomination for 1908, he died in April and was not nominated.

26. Pierre Galtier, "Rabies Inoculation Experiments to Preserve Herbivorous Animals From Rabies After Rabid Dog Bites," in *Proceedings of the Academy of Sciences in 1888*, vol. 106 (Paris, 1888), 1189.

27. Jean Joseph Henri Toussaint, born in the Vosges area of France, graduated from the Royal Veterinary College in Lyon and accepted a professorship in anatomy, physiology, and zoology at the Toulouse Veterinary School.

28. W. D. Tigertt, "Anthrax," *Journal of Hygiene* 85, no. 3 (1980): 415.

29. "Statistics," *American Veterinary Review* 3 (1879): 41–43.

30. Adolph Koch (1840–1924), Robert Koch's older brother, farmed in Keystone, Benton County, Iowa. Educated in agricultural science at the University of Göttingen, he worked as a ranch manager for five years in Uruguay. In 1869 he returned to Germany, then emigrated in 1871 to Iowa, settling on a farm near Luzerne and then in Keystone. Arnold Koch (1847–1922), Robert Koch's younger brother, lived in St. Louis, Missouri. Mrs. Robert Koch was the actress Hedwig Freiberg and was his second wife.

PART II. FARRIER TO VETERINARIAN

1. An act of the Second Continental Congress that created the Continental Army included provision for a quartermaster general to head a department to purchase replacement horses and mules. *Remount* refers to the provision of fresh horses for military purposes to replace those killed or injured in war; the facts were that far more horses died of disease than were killed or injured in battle.

2. J. F. Smithcors, "The Contributions of Benjamin Rush to Veterinary Medicine," *Journal of the History of Medicine and Allied Sciences* 12, no. 1 (1957): 14.

3. The Philadelphia Society for Promoting Agriculture first advocated for veterinary education. Three members, Benjamin Rush, MD, James Mease, MD, and Richard Peters, pursued a formal institution. Judge Peters practiced law and was a reporter for the U.S. Supreme Court. At Belmont, his estate on the Schuylkill River, he entertained Benjamin Franklin and George Washington—both members of the society. Physician Mease published the first record of Texas cattle fever in the U.S., based on his experience with the disease in Pennsylvania. In New England, there were similar moves afoot. The Massachusetts Society for Promoting Agriculture played a role in keeping interest in veterinary science alive.

Robert Jennings, a graduate of the Pennsylvania Medical College, first proposed the idea of a formal veterinary college in Philadelphia and, through the help of two faculty members, secured subscriptions of $40,000. The state legislature of Pennsylvania granted them a charter on April 15, 1852. Jennings, placed at the head of the institution, arranged for a regular course of lectures on veterinary medicine to begin in the fall of 1853. Announcements were circulated, and although inquiries were received, there were no students. In the spring, Jennings accepted the chair of veterinary medicine at the Ohio Agricultural College in Cleveland. When this institution failed in 1857, he returned to Philadelphia and renewed his efforts to establish a veterinary school. For 1859–1860, two students were secured. The Philadelphia Society for Promoting Agriculture granted support and rooms to the Veterinary College of Philadelphia, but the school was suspended in 1866.

4. Walter R. Borneman, *Polk* (New York: Random House, 2008).

5. Howard H. Erickson, "The Boston Veterinary Institute 1855–1860: Its Establishment, Pioneering Founders, Officers, and Graduates," *Veterinary Heritage* 38 (2015): 62.

6. Louis A. Merillat and Delwin M. Campbell, "Veterinary Service of Civilian Population," in *Veterinary Military History of the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation* (Kansas City, MO: Haver-Glover Laboratories, 1935), 129.

7. J. Horsburgh, "American Veterinary Practice," *The Veterinarian* 27 no. 317 (May 1854): 252–53.

8. E. L. Moseley, "The Cause of Trembles in Cattle, Sheep and Horses and of Milk-Sickness in People," *Ohio Naturalist* 6, no. 4 (1906): 463. See also C. Dwight Marsh, *Trembles*, Farmers' Bulletin (U.S. Department of Agriculture, 1929).

9. David C. Duffy, "Land of Milk and Poison," *Natural History* 99 no. 7 (July 1990): 4; G. W. McCoy, "Milk Sickness: Milk and Its Relation to Public Health," *National Institutes of Health, U.S. Hygienic Laboratory* no. 56 (1909): 217.

10. R. A. Bishop and A. Van Der Valk, "Wetlands," in *Iowa's Natural Heritage*, ed. Tom C. Cooper and Nyla S. Hunt (Des Moines: Iowa Natural Heritage Foundation and Iowa Academy of Science, 1982). The tallgrass prairie bridged the Midwest and the Great Plains, extending from northern Illinois through Iowa, Minnesota, and Missouri to the eastern parts of Kansas and Nebraska and down through central Oklahoma to East Texas.

11. Dorothy Schwieder, Thomas Morain, and Lynn Nielsen, *Iowa Past to Present: The People and the Prairie* (Ames: Iowa State University Press, 1989).

12. Ergot caused ergotism in humans, known as Holy Fire or St. Anthony's Fire from the burning sensations in the skin in the early stages of gangrene. Hospitals to treat this single disease began in France; Europe had three hundred of these specialty St. Anthony hospitals that operated until 1777. Pharmaceutical companies developed the ergot toxins as arterial constrictors to treat postpartum hemorrhage in humans. In 1918 Arthur Stoll with Sandoz Pharmaceuticals isolated ergotamine, which was effective in treating migraine headaches.

13. *The Horseshoer*, Technical Manual 2-220. War Department Technical Manual prepared under the direction of the chief of cavalry, March 11, 1941. Supersedes TM 2140-15, November 1, 1926.

14. Louis A. Merillat and Delwin M. Campbell, "Early Army Veterinary Service," *Veterinary Military History of the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation* (Kansas City, MO: Haver-Glover Laboratories, 1935), 121.

15. F. C. Madison, communicated by K. F. Hensinger, "An Epidemic Among Horses at Fort Randall, Nebraska, 1856," translated from *Deutsch Zeitschrift für Tiermedizin*, 1877, 101, and published in *American Veterinary Review* 3 (1880), 173–75. This was the first report of selenium toxicity, later called alkali disease, and the only veterinary report noted for twenty years.

16. *Regulations and Instructions for the Field Service of U.S. Cavalry in Time of War* (Philadelphia: J. B. Lippincott, 1861), 14.

17. L. Z. Saunders, "From Osler to Olafson: The Evolution of Veterinary Pathology in North America," *Canadian Journal of Veterinary Research* 51, no. 1 (1987): 1.

Andrew Smith's college affiliated with the University of Toronto in 1897, becoming the Ontario Veterinary College. When Smith retired in 1908, the Ontario government acquired his interest in the college and placed it under the Department of Agriculture and moved it to Guelph in 1922; it became a college in the University of Guelph in 1964.

18. L. Z. Saunders, "Some Pioneers in Comparative Medicine," *Canadian Veterinary Journal* 14, no. 2 (1973): 27.

19. Saunders, "Some Pioneers in Comparative Medicine," 27. William Osler was born in 1849 at Bond Head, Ontario, at the edge of the great Canadian forest that began a few miles west of Toronto. Influenced early in life by a theologian who was "an ardent naturalist and microscopist," his changing interests moved him from theology, to natural science, and to medicine—progressing through Trinity College and a small private medical school. After graduating MD, Osler studied in England and then at pathological institutes in Berlin and Vienna. Returning, he wrote: "Virchow himself performs a post-mortem on Monday morning making it with such care and minuteness that three or four hours may elapse before it is finished"; and about Vienna, "it is absolutely painful to attend post-mortems here, they are performed in so slovenly a manner, and so little use is made of the material." Virchow reinforced Bovell about comparative medicine.

20. W. Osler, "Verminous Bronchitis in Dogs," *The Veterinarian* 50 (1877): 387.

21. William Osler and A. W. Clement, "An Investigation Into the Parasites in the Pork Supply of Montreal," *Canada Medical and Surgical Journal* 11 no. 6 (1883): 325.

22. The hog cholera outbreak Osler studied was an epizootic in a herd of three hundred pigs near Quebec in 1877. Osler precisely described the clinical disease, gross and histological pathology, and experimental transmission using blood and lymph node plasma and by feeding infected intestines. He wrote that the absence of bacteria in many cases indicated the cause was not bacterial. Despite this, there is no mention of Osler in the current Dunne's *Diseases of Swine*, which attributes D. E. Salmon and Theobald Smith with first recognizing hog cholera as a distinct disease.

23. W. Osler, "On the Pathology of So-Called Pig-Typhoid," *Veterinary Journal and Annals of Comparative Pathology* 6 (1878): 400.

24. B. W. Bierer, *A Short History of Veterinary Medicine in America* (East Lansing: Michigan State University Press, 1955).

25. Born in Lawrence, Massachusetts, in 1857, Clement was educated in public schools, spent two years at Harvard in a premedical course, and graduated DVS from McGill University Montreal Veterinary College in 1882. After three years with Osler, he left for Europe for two years, spending periods in Berlin with Koch and Virchow, at the Pasteur Institute, and at the veterinary school in Alfort. Returning to Montreal, he left shortly to work in the Johns Hopkins Hospital laboratory and as a consultant with the USDA Bureau of Animal Industry on pleuropneumonia and to author *Veterinary Post-Mortem Examinations*. Socially active in hunt clubs, Clement played critical roles in organizing veterinary laws in Maryland and as an officer in the American Veterinary Medical Association, where he was president in 1897–1898. He died in Johns Hopkins Hospital after five weeks of "complications of disease." "Obituary: Albert W. Clement," *American Veterinary Review* 25 (1901): 65 (see editorial, p. 7).

26. William H. Welch and A. W. Clement, "Remarks on Hog Cholera and Swine Plague," in *Proceedings of the Thirtieth Annual Convention of the United States Veterinary Medical Association* (Chicago, 1893), 206.

27. F. T. Daubigny, "The Teaching of Veterinary Science in the Province of Quebec," *Journal of the American Veterinary Medical Association* 18 (1924): 14.

28. Victor-Théodule Daubigny was born in France in 1836 the son of a farmhand, worked in a notarial office in Hérouville, married, and then farmed with his wife's parents before opening an insurance office. In 1872 he sailed from Liverpool to Quebec, taking a train to Montreal—leaving his wife and four children in France. His wife died in childbirth the next year.

29. Louis-Philippe Phaneuf, "Victor Théodule Daubigny," *Dictionary of Canadian Biography*, http://www.biographi.ca/en/bio/daubigny_victor_theodule_13E.html; see also Louka J. Beaudry, "François-Théodule Daubigny," *Dictionary of Canadian Biography*, http://www.biographi.ca/en/bio/daubigny_francois_theodule_16E.html; J. Brian Derbyshire, "Pioneers of Canadian Veterinary Medicine," *Veterinary Heritage* 34 no. 2 (2011): 33.

30. Hans Kurath, *A Word Geography of the Eastern United States* (Ann Arbor: University of Michigan Press, 1949).

31. Hamlin Garland, *Main-Travelled Roads* (Boston: Arena Publishing, 1891).

32. C. Trenton Boyd, "The Lost History of American Veterinary Medicine: The Need for Preservation," *Journal of the Medical Library Association* 99, no. 1 (2011): 8.

33. Merillat and Campbell, "Veterinary Service of Civilian Population," 129.

34. Matthew Schaefer, "Fairchild, David Sturgis," *The Biographical Dictionary of Iowa*, accessed February 12, 2017, http://uipress.lib.uiowa.edu/bdi/DetailsPage.aspx?id=111.

35. David Blistein and Ken Burns, *The Mayo Clinic: Faith, Hope, Science* (New York: RosettaBooks, 2018).

36. When the Civil War ended, William Mayo set up his practice in downtown Rochester, returning periodically to Bellevue Hospital in New York for seminars, surgical demonstrations, and autopsies. His extraordinary dedication in seeking new science and treatments after a destructive tornado in Rochester, and his compact with nuns to use their dormitory buildings for a hospital, were the seminal events in the beginning of one of the great medical institutions of the world.

37. Samuel Hahnemann, *The Homeopathic Medical Doctrine*, trans. Charles H. Devrient (Dublin: W. F. Wakeman, 1833).

38. J. F. Smithcors, "Veterinary Homeopathy," *Modern Veterinary Practice* 43 (1962): 37–42.

39. F. Humphreys, *Manual of Dr. F. Humphreys, for the Administration of Medicine and Cure of Disease* (New York, 1890), 130.

40. James F. Smithcors, *The American Veterinary Profession: Its Background and Development* (Ames: Iowa State University Press, 1963), 210.

41. Contagious pleuropneumonia was highly contagious but required cow-to-cow contact. It had first arrived in the U.S. in 1943 in a cow imported on an English ship. Caused by *Mycoplasma mycoides*, a small and delicate primitive bacterium that did not survive in the environment, it succumbed to eradication programs; the last case was in New Jersey in 1892—the first big success in animal disease control of the USDA.

42. U.S. Department of Agriculture, *First Annual Report, The Year 1884, Bureau of Animal Industry* (Washington, DC: Government Printing Office, 1885).

43. Joseph Bushman was commissioned later in the war to serve in the Quartermaster Corps's horse and mule recruiting facility at Giesboro Depot along the Potomac River. After the war, Bushman lectured on horse diseases; he was the first veterinarian to lecture at the new Kansas State Agricultural College.

44. Philip M. Teigen and Leon Z. Saunders, "This 'Sorrowful War': A Veterinary Surgeon in the 1862 Shenandoah Valley Campaign," *Veterinary Heritage* 27 no. 2 (2004): 29; From Argos (Utrecht), Dr. Asche-Berg, "Veterinair sachliches von Amerika: hauptsächlich aus dem Conföderations-Krieg 1861 und 1862," *Magazin für die gesamte Thierheilkund* 29 (1863): 17; Katie Reichard and Amelia Grabowski, "Every Man His Own Horse Doctor," National Museum of Civil War Medicine, August 30, 2017, https://www.civilwarmed.org/animal/; Phil Gast, "Veterinary Care During the Civil War: Quacks and a Few Good Men (Part 2)," *The Civil War Picket* (blog), September 14, 2013, http://civil-war-picket.blogspot.com/2013/09/veterinary-care-during-civil-war-quacks.html.

45. Louis A. Merillat and Delwin M. Campbell, “Meet General Grant,” in *Veterinary Military History of the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation* (Kansas City, MO: Haver-Glover Laboratories, 1935), 93.

46. H. J. Detmers, “Investigation of Southern Cattle Fever,” in *First Annual Report of the Bureau of Animal Industry for the Year 1884* (Washington, DC: Government Printing Office 1885), 426.

47. David M. Morens and Jeffery K. Taubenberger, “An Avian Outbreak Associated With Panzootic Equine Influenza in 1872: An Early Example of Highly Pathogenic Avian Influence?,” *Influenza and Other Respiratory Viruses* 4, no. 6 (2010): 373, https://doi.org/10.1111/j.1750-2659.2010.00181.x; J. Law, “Influenza in Horses,” in *Report of the Commissioner of Agriculture for the Year 1872* (Washington, DC: Government Printing Office, 1874), 203; A. J. Williams, “Analogies Between Influenza of Horses and Influenza of Man,” *Proceedings Royal Society of Medicine* 17 (1924): 47.

48. Rush Shippen Huidekoper, “Infectious Diseases: Influenza,” in *Special Report on Diseases of the Horse*, ed. Leonard Pearson, et al., rev. ed. (Washington, DC: U.S. Government Printing Office, 1942), 479.

49. Ulysses G. Houck, *The Bureau of Animal Industry of the United States Department of Agriculture: Its Establishment, Achievements and Current Activities* (Washington, DC, 1924).

50. Williams, “Analogies Between Influenza of Horses and Influenza of Man,” 47.

51. D. E. Salmon, *The United States Bureau of Animal Industry, at the Close of the Nineteenth Century, 1884–1900* (Washington, DC: 1901).

52. Alfred C. True, *History of Agricultural Education in the United States, 1785–1925* (Washington, DC: U.S. Government Printing Office, 1919), 152.

53. Keith R. Widder, *Michigan Agricultural College: The Evolution of the Land Grant Philosophy, 1855–1925* (East Lansing: Michigan State University Press, 2005).

54. *Bulletin of the Iowa Agricultural College*, 1871.

55. True, *History of Agricultural Education in the United States, 1785–1925*, 152.

56. *Second Biennial Report of the Board of Trustees of the State Agricultural College and Farm to the Governor of Iowa, and the Thirteenth General Assembly, January 27, 1868* (Des Moines, 1868).

57. *Addresses Delivered at the Opening of the Iowa State Agricultural College, March 17, 1869* (Davenport, IA: Gazette Printing, 1869), 6.

58. *Third Biennial Report of the Board of Trustees of the State Agricultural College and Farm to the Governor of Iowa, and the Thirteenth General Assembly, January, 1870* (Des Moines, 1870).

59. C. H. Stange, *History of Veterinary Medicine at Iowa State College* (Ames: Iowa State College, 1929), 5.

60. Fritz Volkmar, "Henry Johnson Detmers, 1833–1906: A Biographical Sketch and Character Study," *Journal of the American Veterinary Medical Association* 32 (1933): 617.

61. L. Z. Saunders, "Virchow's Contributions to Veterinary Medicine: Celebrated Then, Forgotten Now," *Veterinary Pathology* 37 (2000): 199, https://doi.org/10.1354/vp.37-3-199.

62. Illinois Industrial University (now the University of Illinois) established a professorship of veterinary science in 1868 and appointed a graduate of the Royal Veterinary College London, F. W. Prentice, to teach agriculture students. Lectures were on entomology, physiology, and veterinary science. There were weekly horse clinics; sick animals were brought in and treated free of charge.

63. Kansas State Agricultural College originated from a Methodist Episcopal Church effort called Bluemont Central College that opened for classes in 1860. When Kansas was admitted as a state in 1861 and the Morrill Act passed in 1862, the trustees of Bluemont Central College offered their building to the Kansas Legislature. It was christened February 1863 as Kansas State Agricultural College.

64. Student notes from Iowa State University Special Collections and Archives.

65. Louis H. Pammel, "Dr. H. J. Detmers" in *Prominent Men I Have Met*, vol. 2 (Ames: Iowa State College, 1927), 36.

66. Northwestern Veterinary College operated in Minneapolis from 1881 to 1890 under the direction of veterinarian C. C. Lyfords; its records have not been found. Complicating the issue is a scam called Northwestern Veterinary College that advertised in Minneapolis in the next century. See N. S. Mayo, "Northwestern Veterinary College," *American Veterinary Review* 47 (1915): 247.

67. "Necrology: Olaf Schwarzkopf," *Journal of the American Veterinary Medical Association* 16, no. 1 (1923): 668.

PART III. PIONEERING VETERINARY EDUCATION

1. James Law, "Cornell University and Veterinary Education," *American Veterinary Review* 1 (1877): 365. Law noted the European outbreak of rinderpest in 1865 had been eliminated in one week by Germany, who had but one-third of the livestock of the U.S. but five state-supported veterinary schools (in Berlin, Hannover, Munich, Dresden, and Stuttgart), while England, with half the livestock of the U.S. and private veterinary schools, took fifteen months of parliamentary dithering at a cost of $40 million. His point was that the U.S. farmers had lost $20 million from hog cholera that year.

2. Louis A. Merillat and Delwin M. Campbell, "Private Veterinary Education," in

Veterinary Military History of the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation (Kansas City, MO: Haver-Glover Laboratories, 1935), 315; Ann N. Greene, "The Now-Opprobrious Title of 'Horse Doctor': Veterinarians and Professional Identity in the Late Nineteenth-Century America," in *Healing the Herds: Disease, Livestock Economies, and the Globalization of Veterinary Medicine*, ed. Karen Brown and Daniel Gilfoyle (Athens: Ohio University Press, 2010).

3. "Veterinary Education in New York State," editorial, *American Veterinary Review* 47 (1915): 661. New York College of Veterinary Surgeons and American College of Veterinary Surgeons amalgamated and under New York Laws of 1913, chapter 676, became the New York State Veterinary College at New York University. No appropriation was asked, and in the opening session classrooms were provided in the medical school building of New York University.

4. Louis A. Merillat and Delwin M. Campbell, "Organized Veterinary Medicine," in *Veterinary Military History of the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation* (Kansas City, MO: Haver-Glover Laboratories, 1935), 449.

5. C. H. Stange, *History of Veterinary Medicine at Iowa State College* (Ames: Iowa State College, 1929).

6. Isaac P. Roberts, "How I Came to Be a College Professor in 1869," in *Autobiography of a Farm Boy* (1916; Binghampton, NY: Vail-Ballou Press, 1946).

7. M. Stalker, Correspondence to the editor dated August 5, 1877, *American Veterinary Review* 1, no. 2 (1877): 257.

8. A. Liautard, "History and Progress of Veterinary Medicine in the United States," *American Veterinary Review* 1 (1876): 5.

9. J. McEachran "On Sanitary Measures," *American Veterinary Review* 1 (1876): 51.

10. A Veterinarian, "The Veterinary Department of the University of Iowa and Its Critics," *American Veterinary Review* 3 (1880): 408.

11. M. Stalker, Correspondence to the editor dated February 13, 1880, *American Veterinary Review* 3 (1880): 496–97.

12. Liautard retired and returned to France in 1900. His journal continued, but in 1919 the name was changed to *Journal of the American Veterinary Medical Association*.

13. Frank S. Billings, *The Relation of Animal Diseases to the Public Health, and Their Preventions* (New York: D. Appleton, 1884), 210.

14. L. H. Pammel, "Dr. Millikan Stalker," in *Prominent Men I Have Met*, vol. 1 (Ames: Iowa State College, 1926), 29; Stange, *History of Veterinary Medicine at Iowa*

State College, 39. For many years Stalker was the state veterinarian and had very close connections to livestock producers. He was responsible for the first Veterinary Practice Act in the state that established educational requirements for practicing veterinary medicine and for the law creating the Office of the State Veterinary Surgeon that was passed in 1884.

15. M. Stalker, "Investigation of the 'Loco' Plant and Its Effects on Animals," in *Third Annual Report of the Bureau of Animal Industry for the Year 1886* (Washington, DC: Government Printing Office, 1887), 271; M. Stalker, "Report of the School of Veterinary Science," in *Eleventh Biennial Report of the Board of Trustees of the Iowa State Agricultural College and Farm, Made to the Governor of Iowa, for the Years 1884 and 1885* (Des Moines, 1885), 16.

16. Stalker, "Report of the School of Veterinary Science," 21; *First Annual Report of the State Veterinary Surgeon of the State of Iowa, for the Year Ending June 30, 1885* (Des Moines, 1885), 10.

17. Stalker, "Report of the School of Veterinary Science," 19.

18. *First Annual Report of the State Veterinary Surgeon of the State of Iowa, for the Year Ending June 30, 1885* (Des Moines, 1885), 26–27.

19. D. S. Fairchild, "Recollections of First College Physician," in *The Alumnus of Iowa State College*, November 1925, 145.

20. David Fairchild married Wilhelmina Conrad Tattersall of High Forest, Minnesota, in 1870. Their son, David Sturgis Fairchild Jr., born the next year, graduated from the short-lived Drake Medical College in the Class of 1897 and entered the Army to serve as a brigade surgeon in the Philippines under Douglas MacArthur.

21. Stange, *History of Veterinary Medicine at Iowa State College*, 52.

22. Fairchild, "Recollections of First College Physician," 145.

23. Stange, *History of Veterinary Medicine at Iowa State College*, 8.

24. Stange, *History of Veterinary Medicine at Iowa State College*, 12.

25. Professors Fairchild and Bessey were in the founding group of the Iowa Academy of Science; Bessey was its first president, from 1876 to 1884. At Iowa State, Bessey published an innovative textbook of botany that combined morphology, physiology, and systemic botany using German methods. C. H. Stange credited Bessey with a very large place in the instruction of veterinary students at Iowa State College.

26. C. J. Marshall, "The Start: 1884–1901," in *History of the School of Veterinary Medicine of the University of Pennsylvania* (Philadelphia: Veterinary Alumni Society, 1935).

27. Rush Shippen Huidekoper was descended on his father's side from a Netherlands

immigrant and on his mother's side from Edward Shippen, the first mayor of Philadelphia. William Shippen, a signer of the Declaration of Independence, was one of the founders of the Medical Department of the University of Pennsylvania. Huidekoper's impact was national: he was on the faculty of the American Veterinary College and, later, professor of anatomy at the New York College of Veterinary Surgeons. He died in Philadelphia as a result of an operation for pleurisy arising from pneumonia.

28. R. S. Huidekoper, "Address on the Opening of the School of Veterinary Medicine at the University of Pennsylvania," *Journal of Comparative Medicine & Surgery* (January 1885).

29. Norton Strange Townshend was born in Northamptonshire, England, in 1835 and emigrated to Avon, Ohio. He earned the MD at Columbia University in New York City and returned to practice medicine and farm in Ohio. Hired by Adonijah Welch, he moved to Ames, Iowa, in 1869 and left the next year for his farm and to work with the Cleveland Association for the Investigation of Science and Its Application to Industrial Pursuits. His career as professor at Ohio State was from 1873 to 1892; he died in Columbus three years after retiring and was buried in the Protestant Cemetery in Avon.

30. Norton S. Townshend papers, William L. Clements Library, Ann Arbor, Michigan; Richard Compton, *A Legacy for Tomorrow, 1885–1985: The 100 Year History of the College of Veterinary Medicine at The Ohio State University* (Columbus: The Ohio State University, 1984); A. C. True, *History of Agricultural Education in the U.S.* (Washington, DC: U.S. Government Printing Office, 1919), 152; N. S. Townshend, "Veterinary Science—Its History and Values," *Family and Fireside* 11 (September 1, 1881).

31. Quoted in H. C. Dethloff, "Mark Francis and Veterinary Medicine in Texas, 1880–1936," *Journal of the West* 27, no. 1 (1988): 40.

32. Quoted in Dethloff, "Mark Francis," 40.

33. Ellis P. Leonard, *A Cornell Heritage of Veterinary Medicine, 1868–1908* (Ithaca, NY: New York State College of Veterinary Medicine, 1979).

34. J. F. Smithcors, "USVMA—The First Quarter Century," in *The American Veterinary Profession: Its Background and Development* (Ames: Iowa State University Press, 1963) 333–34.

35. Louis A. Merillat and Delwin M. Campbell, "Clinical Veterinary Medicine," in *Veterinary Military History of the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation* (Kansas City, MO: Haver-Glover Laboratories, 1935), 300.

36. M. R. Trumbower, "Ergotism Among Cattle in Kansas," in *First Annual Report of the Bureau of Animal Industry for the Year 1884* (Washington, DC: Government Printing Office, 1885), 310.

37. Frank S. Billings, "The Etiology of Southern Cattle Plague—Texas Fever," *Journal of Comparative Medicine and Veterinary Archives* 13, no. 7 (1892).

38. National Research Council (US) Committee on the National Needs for Research in Veterinary Science, *Critical Needs for Research in Veterinary Science* (Washington, DC: National Academies Press, 2005), 16.

39. D. E. Salmon, "The Plague in Kansas," *American Veterinary Review* 8 (1888): 112; "Investigations of Hog-Cholera," in *Third Annual Report Bureau of the Animal Industry for the Year 1886* (Washington, DC: Government Printing Office, 1887), 20.

40. Louis Pasteur reported in 1883 that the cause of a French hog disease, *rouget* (he was actually working with hemorrhagic septicemia), was a bacterium and immediately produced a vaccine for the disease—it failed to protect against hog cholera. Two years later, Loeffler reported from Germany the discovery of a bacterium that caused *rouget du porc* (he was dealing with swine erysipelas). Salmon, working with hog cholera, named the disease swine plague, and the bacterium he isolated produced a fatal systemic disease that was not hog cholera (it was today's salmonellosis).

41. R. A. Overfield, "Hog Cholera, Texas Fever, and Frank S. Billings: An Episode in Nebraska Veterinary Science," *Nebraska History* 57 (1976): 99.

42. Louis A. Merillat and Delwin M. Campbell, "State Veterinary Education," in *Veterinary Military History of the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation* (Kansas City, MO: Haver-Glover Laboratories, 1935), 377.

43. B. W. Bierer, *A Short History of Veterinary Medicine in America* (East Lansing: Michigan State University Press, 1955), 72.

44. Merillat and Campbell, "State Veterinary Education," 377; Frank S. Billings, *The Southern Cattle Plague (Texas Fever) of the United States*, Nebraska Agricultural Experiment Station Bulletin (Lincoln, NE, 1888), 10.

45. W. L. Williams, "Maladie du Coit," *American Veterinary Review* 12 (1888): 295.

46. Originally from New England, the Niles family moved to a farm in Marshall County, Iowa, from Rock County, Wisconsin. William finished grade school in a one-room schoolhouse in Edenville. In the winter of 1882–1883, a country school in Eden Township employed him as its teacher. In the spring of 1884, he enrolled in veterinary medicine at Iowa Agricultural College. The next year his younger brother, Edwin Preston Niles, followed.

47. "The History of Veterinary Medicine in South Carolina," accessed December 10, 2020, http://animalpetdoctor.homestead.com/History4.html.

48. Sam Hendrix, *The Carey Legacy: Dr. Charles Allen Cary: Father of Veterinary Medicine at Auburn and in the South* (Montgomery, AL: Donnell Group, 2018).

49. The Board of Trustees of Iowa Agricultural College appropriated $10,000 for two buildings for the "Veterinary Department" on June 18, 1884. A few rods to the southwest of the veterinary hospital, a two-story frame structure was built for basic sciences. Called the Sanitary Building, it was abandoned by veterinarians in 1893 when basic science instruction moved to the third floor of the new Agriculture Hall; for a time, it was the College Hospital and then the Music Building. Both were torn down in 1926 to make way for the Memorial Union.

50. Stange, *History of Veterinary Medicine at Iowa State College*, 14.

51. Paul Fischer was educated at The Ohio State University; he was awarded the BAgr degree in 1891 and an MVD in 1892. Fischer was an assistant to Detmers after graduation and instructor in veterinary anatomy and surgery. He visited veterinary schools in Hannover, Berlin, and Dresden and spent three months in the bacteriology laboratory of Robert Koch. Fischer returned to Ohio to teach bacteriology and horseshoeing. In 1895 he moved to Utah as professor of agriculture and veterinary science at the State Agricultural College in Logan.

52. Fairchild, "Recollections of First College Physician," 145.

53. Fairchild, "Recollections of First College Physician," 145.

54. Stange, *History of Veterinary Medicine at Iowa State College*, 76; Louis Amos Klein et al. History of the School of Veterinary Medicine of the University of Pennsylvania (Philadelphia: University of Pennsylvania Veterinary Alumni Society, 1935), 157; College Commencements section, American Veterinary Review 18 (1894): 123–26.

55. Wilbert Harriman was also the coach of the Iowa State Agricultural College baseball team. In the fall of 1892 when the baseball season was over, the team looked for new outlets and, settling on the new rugby football that had become popular in the East, they organized a group of "elevens." On November 3, 1892, the Iowa State Agricultural College held its first organized football game. The opponent was tiny State Centre. "*The I.A.C.-State Centre game was very enthusiastic*," the *Ames Intelligencer* reported, and there had been "*bruises and bloody noses*." The game ended in a 6–6 tie.

56. Stange, *History of Veterinary Medicine at Iowa State College*, 71.

57. Pammel and Stalker produced a bulletin on disease in livestock caused by *Crotalaria* species of plants. Rattle weed contained several pyrrolizidine alkaloids that attacked the liver to cause locoism. The disease was confusing because liver damage was delayed; it was sometimes weeks before signs of liver failure appeared. Horses would become progressively dull and wasted as products of dying liver cells accumulated in the bloodstream and were being deposited in the eyes and brain—yellow in the whites of the eyes, and head pressing, a sign of "hepatic encephalopathy" as bilirubin passed into the brain.

58. As quoted in Stange, *History of Veterinary Medicine at Iowa State College*, 16.

59. F. S. Billings, "Trichinae," *American Veterinary Review* 5 (1881): 497.

60. "American Veterinary College," editorial, *American Veterinary Review* 15 (1891): 526.

61. *Proceedings of the United States Veterinary Medical Association, Session of 1896* (Philadelphia, 1896), 79.

62. The Bureau of Animal Industry had a critical interest in veterinary education. As no one regulated scientific competences in veterinary schools, the BAI assumed a role as a federal regulator of veterinary education in 1884, the same year it placed veterinary inspectors in the Civil Service System. To be eligible for employment, the applicant had to be a graduate of a veterinary college that satisfied the requirements for curriculum set out by the BAI. The program continued until 1961, when it was given to the American Veterinary Medical Association.

63. Howard H. Erickson and Susanne Whitaker, "Private Veterinary Colleges in the District of Columbia: C. Barnwell Robinson's United States College of Veterinary Surgeons," *Veterinary Heritage* 42 (2019): 15; Susanne Whitaker and Russell W. Currier, "Private Veterinary Colleges in the District of Columbia: Daniel E. Salmon's National Veterinary College and Its Successors," *Veterinary Heritage* 42 (2019): 1.

64. The National Veterinary College continued to operate as the veterinary department of Columbian University, and then as the George Washington University (the renamed Columbian University) School of Veterinary Medicine. It ceased operations altogether in 1918 when the secretary of agriculture forbade federal veterinarians from teaching in veterinary schools in the District of Columbia. Salmon retired from the BAI in 1905 and spent six years as the director of the Veterinary School of the University of Montevideo in Uruguay. He died on August 30, 1914, in Butte, Montana.

65. "Society Meetings: Iowa Veterinary Medical Association." *American Veterinary Review* 23 (1899): 51.

66. "Society Meetings: Nebraska Veterinary Medical Association," *American Veterinary Review* 23 (1899), 151.

67. Historical records, so dedicated to names and places, are strangely blank for this time. The faculty list for 1900–1901 shows McNeil and Klein as professors, Stalker only as a "lecturer" with no dean identified. Stalker appeared as lecturer until 1908–1909, when he disappears from the list, and Stange is listed as professor and dean.

68. In his later life, true to his Quaker heritage, Stalker was known as a philanthropist, philosopher, and peace activist. In the *Des Moines Mail and Times* of August 18, 1906, Alice Carey Wight editorialized in a full-page piece with the headline "Dr. Stalker's Work for Peace" and the subheading "The Distinguished Man Who Has Contributed to

the International Peace Conference and the Lake Mohonk Meeting Going to Milan, Italy Next." Stalker had attended and spoken at an International Council of Peace Conference in Luzerne. When home, he brought to the Iowa Legislature a resolution, passed by both houses, as an expression of the people of Iowa, upholding President Roosevelt in his appointment of three members to The Hague Tribune. Only one other state, Massachusetts, had done so. As a result of his work, Stalker had been invited to the Fourteenth Annual Arbitration Conference at Lake Mohonk, New York, and then to the peace conference in Milan.

69. Louis A. Merillat and Delwin M. Campbell, "Attempts to Improve Army Veterinary Services by Legislation," in *Veterinary Military History of the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation* (Kansas City, MO: *Haver-Glover Laboratories*, 1935), 213.

70. Veterinarians Corcoran and Treacy, "Army Veterinary Service," *American Veterinary Review* 22 (1898): 472.

71. Rush S. Huidekoper, "Army Veterinary Service," *Journal of Comparative Medicine and Veterinary Archives* 20, no. 9 (1899): 537.

PART IV. LIVESTOCK AND VETERINARIANS GO WEST

1. Mazyck P. Ravenel, "An Unusual Result Following Anthrax Vaccination and a Lesson," *American Veterinary Review* 46 (1915): 634.

2. Bernice L. Hausman, Mecal Ghebremichael, Philip Hayek, and Erin Mack, "'Poisonous, Filthy, Loathsome, Damnable Stuff': The Rhetorical Ecology of Vaccination Concern," *Yale Journal of Biology and Medicine* 87, no. 4 (2014): 403.

3. David E. Lilienfeld, "The First Pharmacoepidemiologic Investigations: National Drug Safety Policy in the United States, 1901–1902," *Perspectives in Biology and Medicine* 51, no. 2 (2008): 188.

4. The Missouri Valley Veterinary Association offices were in Leavenworth, Kansas. The founding president, Sesco Stewart, dean of the Kansas City Veterinary College, was an 1885 Iowa Agricultural College graduate and in 1902 the first president of the AVMA from west of the Mississippi River.

5. Louis A. Merillat and Delwin M. Campbell, "Organized Veterinary Medicine," in *Veterinary Military History of the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation* (Kansas City, MO: Haver-Glover Laboratories, 1935), 470.

6. In 1865, the Union Stock Yard and Transit Company had converted marshland in South Chicago to a massive stockyard, and similar companies were being built in

Kansas City, Omaha, Denver, and Fort Worth. By the end of the Civil War, five railroads had been constructed into Chicago. Coupled with closure of the north-south transport of livestock on the Mississippi River during the Civil War, the railway expansion provided new opportunities and routes to eastern markets for produce of midwestern farmers.

7. Louis A. Merillat and Delwin M. Campbell, "Private Veterinary Education," in *Veterinary Military History of the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation* (Kansas City, MO: Haver-Glover Laboratories, 1935), 315.

8. Merillat and Campbell, "Private Veterinary Education," 315.

9. Howard H. Erickson, "The Indiana Veterinary College (1892–1924): Its Background and Contributions to Veterinary Medicine," *Veterinary Heritage* 40, no. 1 (2017): 3.

10. Deborah Blum, *The Poison Squad: One Chemist's Single-Minded Crusade for Food Safety at the Turn of the Twentieth Century* (London: Penguin Press, 2018).

H. W. Wiley studied medicine at Indiana Medical College and chemistry at Harvard, then became the first chemistry professor at Purdue University in 1876. In 1881 he began investigating food purity at the request of the Indiana State Board of Health and revealed that 90 percent of maple syrup bottles were fakes, that honey was diluted sugars, and that some beekeepers were not even keeping bees. Political pressure from beekeepers caused Purdue trustees to discipline Wiley, and he left to become chief of the USDA's Division of Chemistry in 1883.

11. Louis A. Merillat and Delwin M. Campbell, "Army Food Inspection," in *Veterinary Military History of the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation* (Kansas City, MO: Haver-Glover Laboratories, 1935), 591.

12. C. H. Stange, *History of Veterinary Medicine at Iowa State College* (Ames: Iowa State College, 1929), 53.

13. Stange, *History of Veterinary Medicine at Iowa State College*, 53.

14. *Twenty-Third Biennial Report of the Iowa State College of Agriculture and Mechanic Arts Made to the Governor of Iowa for the Biennial Period July 1, 1906 to June 30, 1908* (Des Moines, 1908), 18.

15. W. J. Lentz, "The Halt: 1901–1907," in *History of the School of Veterinary Medicine of the University of Pennsylvania* (Philadelphia: Veterinary Alumni Society, 1935).

16. Leonard Pearson was born in Elkhart, Indiana, on August 17, 1868, of parents with Puritan ancestry. His two brothers were highly successful: Edward was a civil engineer and president of the New York, New Haven and Hartford Railroad and Raymond

was president of the University of Maryland; there were two sisters, Anna and Julia.

17. Richard Compton, *A Legacy for Tomorrow, 1885–1985: The 100 Year History of the College of Veterinary Medicine at The Ohio State University* (Columbus: The Ohio State University, 1984).

18. Compton, *A Legacy for Tomorrow*.

19. L. Z. Saunders, "From Osler to Olafson: The Evolution of Veterinary Pathology in North America," *Canadian Journal of Veterinary Research* 51, no. 1 (1987): 1.

20. W. H. Lowe, "Animal Hospital for Teaching Students Human Medicine," *American Veterinary Review* 32 (1907): 437.

21. Charles Aleen Cary graduated from Iowa Agricultural College (BS in agriculture, 1885; DVM, 1887). He practiced veterinary medicine in Keokuk, Iowa, and served as assistant Iowa state veterinarian. Cary was appointed professor at South Dakota Agricultural College in Brookings in 1889 and moved to Auburn in 1892 to be the first professor of veterinary science at Alabama Agricultural and Mechanical College. Short periods of study were spent at the University of Missouri with Paquin in 1890 and at the Koch laboratories in Berlin in 1892.

22. D. Salmon, "Foot-and-Mouth Disease," in *Nineteenth Annual Report of the Bureau of Animal Industry for the Year 1902* (Washington, DC: U.S. Department of Agriculture), 391. First recognized in the U.S. in 1838, foot-and-mouth disease had continued with "more or less" prevalence until 1886, when it disappeared only to be reintroduced in 1894 and again in 1896. The economic impact was severe, with local quarantines and international bans on trade with affected areas.

23. Marion Dorset had graduated from the University of Tennessee in 1893 and had earned an MD degree earned in 1896 by taking night classes from George Washington University. He accepted a position with the Bureau of Animal Industry and had worked on the biology and chemistry of the tuberculosis bacillus.

24. Vivian D. Wiser, Larry Mark, and H. Graham Purchase (eds.), *100 Years of Animal Health, 1884–1984* (Beltsville, MD: Associates of the National Agricultural Library, 1986), 30.

25. R. R. Dysktra, *Veterinary Medicine in Kansas* (Kansas Veterinary Medical Association, 1953).

26. C. Wood, "Science and Politics in the War on Cattle Diseases: The Kansas Experience, 1900–1940," *Agriculture History* 54, no. 1 (1980): 82.

27. R. G. Elmore and Howard H. Erickson, *A Century of Excellence: Kansas State University College of Veterinary Medicine* (Virginia Beach, VA: Donning, 2005), 86; W. M. Burson, "Veterinary Activities in Georgia," *American Veterinary Review* 39 (1911): 429.

28. The Iowa State Biological Laboratory report for 1915 on the conference held at Iowa State College for the purpose of implementing the new serum and virus method shows BAI chief Alonzo E. Melvin as chairman. In attendance were Drs. Niles and Dorset; faculty members C. F. Curtiss, the dean of Agriculture, and C. H. Stange, dean and director of the Iowa Experiment Station in Ames; former dean John H. McNeil from Trenton, New Jersey; and concerned veterinarians throughout the country. The attendance list read like a Who's Who of veterinary science in land grant colleges of the Midwest: F. S. Schoenleber, Kansas; A. T. Peters, Nebraska; J. W. Conaway, Missouri; M. H. Reynolds, Minnesota; R. A. Craig, Purdue; C. E. Marshall, Michigan; Paul Fischer, Ohio; and R. R. Dinwiddie, Arkansas. A hot topic at the meeting dealt with checks for antiserum purity.

29. Louis A. Merillat and Delwin M. Campbell, "State Veterinary Education," in *Veterinary Military History of the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation* (Kansas City, MO: Haver-Glover Laboratories, 1935), 398.

30. Merillat and Campbell, "State Veterinary Education," 377.

31. The U.S. Department of Agriculture committee to investigate veterinary schools was A. M Farrington, Bureau of Animal Industry; Paul Fischer, Ohio state veterinarian; Joseph Hughes, Chicago Veterinary College president; R. P. Lyman, AVMA secretary; and Tait Butler, North Carolina state veterinarian. The committee classified schools as Class A: Chicago Veterinary College, Indiana Veterinary College, Iowa State, Kansas State, Kansas City Veterinary College, New York-American, New York State, Ohio State, San Francisco, Washington State, and Pennsylvania; Class B: Cincinnati, Grand Rapids, McKillip, United States; Class C: Colorado State, Ontario, St. Joseph, and Western.

32. Stange had been born in Cedar County, where he had gone to German grade school and graduated from Lowden High School in 1896; he graduated from Iowa State with his DVM in 1907.

33. J. F. Smithcors, *Evolution of the Veterinary Art* (Kansas City, MO: Veterinary Medicine Publishing, 1957); J. F. Smithcors, *The American Veterinary Profession: Its Background and Development* (Ames: Iowa State University Press, 1963), 556.

34. Richard P. Lyman (ed.), *Proceedings of the American Veterinary Medical Association* (Lansing, MI, 1911), 99.

35. Merillat and Campbell, "State Veterinary Education," 391.

36. F. W. Beckman, "Veterinary Education Comes Into Its Own in the West," *American Veterinary Review* 42 (1912): 88.

37. Correspondence: Crocker to Benbrook: 1918. E. A. Benbrook papers collection, Iowa State University Library Special Collections.

38. Stange, *History of Veterinary Medicine at Iowa State College*, 28. Academic departments established in 1912 at Iowa State College: Murphy was head of Anatomy and Histology, with two senior assistants; Dimock of Pathology and Bacteriology, assisted by Murray and two senior students; Bemis of Surgery and Obstetrics, assisted by Nelson; and Bergman of Physiology and Pharmacology, assisted by Judisch. Stange would be head of the Department of Practice and, by virtue of being dean, would be head of the veterinary section of the Iowa Agricultural Experiment Station. The list of veterinary colleges accredited by the USDA Bureau of Animal Industry (and approved for civil service examination) included eight state-supported schools in Alabama, Colorado, Iowa, Kansas, New York (at Cornell), Ohio, Pennsylvania, and Washington. The eight private schools approved were in Chicago (Chicago and McKillip Veterinary Colleges), Cincinnati, Grand Rapids, Indianapolis, Kansas City, New York (New York-American Veterinary College), and San Francisco.

39. "William Wallace Dimock, 1880–1953," editorial, *Journal of the American Veterinary Medical Association* 123 (1953): 353. William Dimock was born in Tolland, Connecticut, received the BS degree in agriculture from the University of Connecticut and the DVM from Cornell University. He spent four years in Cuba at the National Cuba Experiment Station and was granted an honorary DVM degree by the University of Havana in 1908 and made honorary professor there in 1944. Dimock was president of the AVMA and a member of the American Association for the Advancement of Science.

40. Correspondence: Crocker to Benbrook: 1918.

41. Correspondence: Crocker to Benbrook: 1918.

42. Edward A. Benbrook was born in South Orange, New Jersey, in 1892 and graduated from high school there. Awarded the VMD degree from the University of Pennsylvania in 1914, he remained as an instructor in veterinary pathology for one year, being mentored by Crocker, and then accepted a position to teach veterinary science to agriculture students at Oklahoma A&M College. He was to work to establish a veterinary school, but despite his effort, the Bureau of Animal Industry did not issue Oklahoma A&M a permit to grant the DVM degree and start a veterinary a school.

43. David Pfeiffer, "'Tony's Lab': Germ Warfare in WWI Used on Horses in the U.S.," *Prologue Magazine* 49, no. 3 (2017), www.archives.gov/publications/prologue/2017/fall/tonys-lab.

44. John C. Gordon and Steen Bech-Nielsen, "Biological Terrorism: A Direct Threat to Our Livestock Industry," *Military Medicine* 151 (1986): 357; Vincent Barras and Gilbert Greub, "History of Biological Warfare and Bioterrorism," *Clinical Microbiology and Infection* 20 (2014): 487, https://doi.org/10.1111/1469-0691.12706.

45. Mark Wheelis, "Biological Warfare at the 1346 Siege of Caffa," *Emerging Infectious Disease* 8, no. 9 (2002): 971, https://doi.org/10.3201/eid0809.010536; Erhard Geissler, *Biologische Waffen—nicht in Hitler's Arsenalen. Biologische und Toxin-Kampfmittel in Deutschland 1915–1945* (Münster: LIT Verlag, 1999).

German agents were involved in agroterrorism in other countries. Dilger's boss, Captain Rudolf Nadolny, shipped anthrax and glanders organisms to the German embassy in Bucharest for Bulgarian agents who were collaborating with Germans to infect animals in Romania (bound for Russia), a program that ended in 1916 when Romania declared war on Austria-Hungary. To disrupt Norwegian reindeer from ferrying British supplies across northern Norway to Russia, German agents attempted to attack with bioweapons. Other attacks were planned for Spain, Argentina, and Romania.

46. Herbert Hoopes, "Report of an Anthrax and Black Leg Outbreak," *American Veterinary Review* 46 (1915): 325.

47. Dan Manatt and Bryce T. Bauer, "In 1918, an Iowa Governor Banned Foreign Languages," *Des Moines Register*, May 23, 2018.

48. When Dean Stange established the Department of Veterinary Investigation, the plan was to build a new research unit on the open southwest segment of the new Veterinary Quadrangle, the only space left unconstructed when the quad was built. But there was no money in the budget, and Schern was given rooms in the basement of the southeast unit, the Veterinary Physiology Building.

49. Stange, *History of Veterinary Medicine at Iowa State College*, 34.

50. Merillat and Campbell, "State Veterinary Education," 377.

51. After the war the Army Veterinary Service Laboratory was moved to Washington, D.C., as part of the Army Medical School and given permanency as the U.S. Army Veterinary Laboratory. The School for Meat and Dairy Inspectors in Chicago had trained eighty-two veterinary officers and ninety-six enlisted men. It was not disbanded as other military schools were demobilized but continued to instruct veterinarians in the Regular Army. Moved to Washington, D.C., as the Army Veterinary School, it became part of the Army Medical Center.

PART V. ASCENDANCE

1. The National Veterinary College changed names in 1896 when it merged with Columbian University (which changed its name to George Washington University), but ceased operations in 1898. The George Washington University School of Veterinary Medicine opened in 1908 but closed in 1918.

2. "Enrollment of Veterinary Students," editorial, *Journal of the American Veterinary*

Medical Association 13 (1922): 537. In the fall session of 1921, there were 975 students enrolled in the BAI-approved veterinary schools in the U.S. and Canada. Schools established in the previous century had high numbers: Ontario, 88; Iowa, 94; Ohio, 106; Pennsylvania, 30; New York State at Cornell, 75; and New York State at New York University, 23. The newer state veterinary schools were lower: Colorado, 82; Georgia, 21; Kansas, 71; Michigan, 21; Texas, 14; and Washington State, 23. The three agricultural colleges offering a two-year veterinary medicine program and a degree were in the single digits: North Carolina, 0; North Dakota, 6; and Oklahoma, 4. Two private schools had increased numbers by accepting students from private schools that had closed: Indiana, 137; and St. Joseph in Missouri, 102.

3. Veranus A. Moore, "The Veterinary Curriculum," *Journal of the American Veterinary Medical Association* 15 (1922): 283.

4. W. A. Evans, "Why Health Departments Are Interested in the Tuberculosis Eradication Campaign," *Journal of the American Veterinary Medical Association* 13 (1922): 683.

5. E. D. King Jr., "Tuberculosis Contracted by a Family From a Tuberculous Cow," *Journal of the American Veterinary Medical Association* 15 (1923): 763.

6. Flurin Condrau and Michael Worboys, "Epidemics and Infections in Nineteenth-Century Britain," *Social History of Medicine* 20, no. 1 (2007): 147–58, https://doi.org/10.1093/shm/hkm001.

7. Louis A. Merillat and Delwin M. Campbell, "Private Veterinary Education," in *Veterinary Military History in the United States: With a Brief Record of the Development of Veterinary Education, Practice, Organization and Legislation* (Kansas City, MO: Haver-Glover Laboratories, 1935), 315; E. L. Stubbs, "The Advance 1907–1934," in *History of the School of Veterinary Medicine of the University of Pennsylvania, 1884–1934* (Philadelphia: Veterinary Alumni Society, 1935), 72.

8. C. H. Stange, *History of Veterinary Medicine at Iowa State College* (Ames: Iowa State College, 1929), 87. The first use of tuberculin to diagnose tuberculosis in Iowa cattle was done by Niles on the McHenry farm in Denison. The test was based on a rise in body temperature in infected cattle as a response to the subcutaneous injection of tuberculin. A bulletin on bovine tuberculosis published in 1895 by Stalker and Niles emphasized the importance that milk could "convey the disease to humans." Niles includes his records of the test on fifty herds in Black Hawk, Kossuth, Story, Boone, Page, Harrison, Sac, Wapello, and Floyd Counties.

9. Carl Frank Schlotthauer was a pioneer in laboratory animal medicine, the first to hold an academic professor position in the discipline. On October 21, 1959, Schlotthauer was accidentally shot and killed while hunting duck with his best friend and neighbor,

famed Mayo medical pathologist Malcolm B. Dockerty. See J. R. Wright Jr., "The Prince Edward Island-Mayo Clinic Connection: Malcolm B. Dockerty and Lewis B. Woolner," *Archives of Pathology and Laboratory Medicine* 138 no. 3 (2014): 420, https://doi.org/10.5858/arpa.2013-0156-HP.

10. Leo Landis, "The Real 'Footloose': Iowa's Bans on Jazz Dancing in the 1920s," March 18, 2020, *Des Moines Register*, https://www.desmoinesregister.com/story/life/2020/03/18/footloose-iowa-history-state-had-bans-jazz-dancing-1920-s/2867127001/.

11. Edward Jenner, "Observations on the Distemper in Dogs," *Medico-Chirurgical Transactions* 1 (1809): 265.

12. "What Is Canine Distemper?," editorial, *Journal of the American Veterinary Medical Association* 15 (1923): 715.

13. M. Bresalier, "Making Flu: British Medical Sciences and the Definition of a Virus Disease," *The Guardian*, July 8, 2013; R. Carver and J. Skehel, *Distemper and Influenza at Mill Hill*, 2000, Mill Hill Essays, Medical Research Council, archived at https://web.archive.org/web/20010427070905/http://www.nimr.mrc.ac.uk/millhillessays/2000/influenza.htm.

14. In 1931, physician Richard E. Shope published a paper in the *Journal of Experimental Medicine* from the Rockefeller Institute showing that a combination of a virus and bacteria produced swine influenza. The discovery spurred the search for a human influenza virus at Britain's National Institute for Medical Research, where two experienced virologists, Smith and Andrewes, using nasal washings and gargling fluids from sick patients, inoculated several animal species—mice, rats, guinea pigs, pigs, horses, and monkeys—without reproducing disease. Failing, they turned to Laidlaw and Dunkin's ferret model. Andrewes had caught influenza, and Smith dripped his nasal material into two ferrets, which developed influenza. Their report of the discovery of human influenza virus on July 8, 1933, in the *Lancet* was sensational. Mice were used worldwide in 1934 to work with influenza, and in 1940 the virus was shown to grow in chick embryos. In 1947 the National Institute of Medical Research was designated a World Influenza Center by the World Health Organization.

15. Interferon was discovered by Alick Isaacs and Jean Lindenmann in 1957 at Mill Hill. Working with chemist D. C. Burke and electron microscopist Robin Valentine, they discovered that heat-inactivated influenza virus, when placed on membranes of the chick embryo, induced an interfering protein that spread to and protected normal cells.

16. Jill Lepore, "In 1929, Parrot Fever Gripped the Country," *New Yorker*, June 1, 2009.

17. Karl Friedrich Meyer earned his veterinary degree from the University of Zurich in 1909, taught pathology at the University of Pennsylvania for three years, and was a

scientist at the University of California (both Berkeley and San Francisco) from 1914 to 1974, where he played a major role in the School of Public Health. He grouped the abortion-causing bacilli together, naming the new genus *Brucella* after his friend Bruce.

18. K. F. Meyer, B. Eddie, and I. M. Stevens, "Recent Studies on Psittacosis," *American Journal of Public Health* 25 no. 5 (1935): 571, https://doi.org/0.2105/ajph.25.5.571. Meyer's studies on epidemiology showed that the disease could be carried by canaries, finches, and other pet birds. The causal agent was independently identified by scientists in England, Germany, and the U.S. and was so small it was thought to be a virus. Meyer persisted in studies, discovering that the causative agent grew in embryonating chicken eggs and was a tiny bacterium now termed *Chlamydia psittaci*.

19. The Hygienic Laboratory of the U.S. Public Health Service began as a bacteriology laboratory to support infectious diseases in the Marine Hospital Service in 1887. (The Marine Hospital Service became the Public Health Service in 1912).

20. Veterinary faculty, Iowa State College, 1929 (fall). Two sources have identified the figures as follows. Front row (*left to right*): David F. Anderson, pharmacist; H. L. Foust, Anatomy; E. A. Benbrook, Pathology and Bacteriology; H. H. Dukes, Physiology and Pharmacology; I. A. Merchant, Pathology and Bacteriology; F. E. Walsh, Medicine; Paul F. K. Purwin, Veterinary Investigation; S. H. McNutt, Veterinary Investigation; C. D. Lee, Diagnostic Laboratory (Pathology). Back row (*left to right*): M. A. Emmerson, Anatomy; C. H. Covault, Medicine; W. A. Aitken, Surgery; H. E. Biester, Veterinary Investigation; C. D. Rice, Pathology and Bacteriology; W. H. Chivers, Surgery; C. H. Stange, dean; Charles Murray, Veterinary Investigation; H. D. Bergman, Physiology and Pharmacology; F. D. Patterson Jr., Veterinary Investigation; W. F. Guard, Surgery. Absent: Dixon, Fowler, Schwarte, Sloss.

21. Ival Merchant was awarded the PhD degree in veterinary bacteriology in 1933 under the direction of D. Charles Murray; the title of his thesis was *A Study of the Corynebacteria Associated With Diseases of Domestic Animals*. Spending the school year of 1933–1934 at Yale University in the College of Medicine's School of Public Health, he received the CPH degree. Returning to Iowa State, he was promoted to associate professor, and on the retirement of Dean Murray in 1943 he was made professor and head of the Department of Veterinary Hygiene. Merchant played important leadership roles in veterinary public health. He was an organizing member of the National Board of Veterinary Public Health and chairman of its Committee on Education.

22. One herd, which had been sold surreptitiously, was found west of Moscow, in Muscatine County, and was tested promptly. Throughout the day, after the arrest,

farmers submitted their herds to the test without offering opposition to the National Guardsmen. Lenker was charged with selling cattle that were under quarantine, and with contempt. Although there were other farm blockades, sanity started to prevail.

23. Alan L. Olmstead and Paul W. Rhode, *Arresting Contagion: Science, Policy, and Conflicts Over Animal Disease Control* (Cambridge, MA: Harvard University Press, 2015).

24. "Iowa Basic Sciences," Edward Antony Benbrook Papers, RS 14/7/12, Special Collections Department, Iowa State University Library.

25. Lea Rosson Delong, *Christian Petersen, Sculptor* (Ames: Iowa State University Press, 2000), 47–48. Campus sculptor Christian Petersen's proposal was for a large continuous bas-relief depicting progress in veterinary medicine. From his notes the scenes depicted the following: inspection of a cow for foot-and-mouth disease; smallpox vaccine—two figures kneeling over a calf turned on its back to extract vaccinia fluids from its underside; a dominant panel depicting a man overpowering an animal, an incarnation of the centaurs on the pediments of the Parthenon—representing "protection of the human through the production of diphtheria and tetanus antitoxin from the blood of the horse"; men vaccinating a hog against hog cholera. The final scene depicts surgery on a dog, representing research on animals leading to medicine for humans and animals: "the protection of both humans and animals with rabies vaccine prepared from the spinal cord of rabbits and sheep; at extreme right a scientist making a microscopic examination of the brain for rabies."

26. O. H. V. Stalheim and W. M. Moulton, "Brucellosis" in *100 Years of Animal Health, 1884–1984*, ed. Vivian Miser, Larry Mark, and H. Graham Purchase (Beltsville, MD: Associates of the National Agricultural Library, 1987), 42.

27. Stange, *History of Veterinary Medicine at Iowa State College*, 29.

PART VI. DUTY REQUIRED

1. M. H. McMillan, "Horses for Food: Observation of Slaughter at Iowa Plant," *The Veterinary Student* 7 no. 1 (1944): 29.

2. David L. Seim, "The Butter-Margarine Controversy and 'Two Cultures' at Iowa State College," *Annals of Iowa* 67 (2008): 1.

3. Seim, "The Butter-Margarine Controversy," 1.

4. Vaylord Ladwig, "Anthrax in Iowa: Several Outbreaks Reported in Central Iowa," *The Veterinary Student* (Fall 1943), 79. After twenty-six years practicing veterinary medicine in Sac City, Iowa, Ladwig joined the faculty at the University of Illinois College of Veterinary Medicine as director of the Large Animal Clinic. He was the founder

and first president of the American Association of Swine Practitioners, established an endowed award, the Ladwig Honor Student Award, and received many citations as an outstanding teacher.

5. Frederick D. Patterson, *Chronicles of Faith: The Autobiography of Frederick D. Patterson* (Tuscaloosa: University of Alabama Press, 1991). Frederick Douglass Patterson, named after the African American leader, was orphaned at the age of two when both parents died of tuberculosis. He received his secondary education at Prairie View Normal School in Texas—now A&M University—which had been established in 1876 as Alta Vista Agricultural and Mechanical College of Texas and became a land grant institution with the Morrill Act of 1890. Edward Evans was the first president (and eighth principal) of Prairie View in 1948.

6. The first faculty of veterinary medicine at Tuskegee Institute included three graduates of Kansas State College: Theodore S. Williams (Pathology), Lloyd B. Mobiley (Anatomy), and Thomas G. Perry (Small Animal Medicine). Other graduates of Kansas State College moving to Tuskegee included Eugene W. Adams (KSC 1944), Raymond C. Williams (KSC 1946), Walter C. Bowie (KSC 1947), and Earl H. Brown (KSC 1947).

Theodore S. Williams was appointed head of the Department of Pathology and Parasitology at Tuskegee. When Evans resigned to become president of Prairie View College in 1946, Williams was appointed dean. Williams had practiced in Kansas City, taught on the faculty of Prairie View College, and inspected meat for the USDA in Des Moines. After his appointment as dean, Williams spent one year at Iowa State College to obtain his MS degree; he returned to teach the first class at Tuskegee in 1946.

7. Barton J. Bernstein, "The Birth of the U.S. Biological-Warfare Program," *Scientific American* 256 no. 6 (1987): 116.

8. Bernstein, "The Birth of the U.S. Biological-Warfare Program," 116.

9. Dan Crozier, "Commission of Epidemiological Survey," in *The Histories of the Commissions*, U.S. Army Medical Department, Office of Medical History, last modified August 10, 2009, https://history.amedd.army.mil/booksdocs/historiesofcomsn/section3.html.

10. Everett B. Miller, *United States Army Veterinary Service in World War II* (Washington, DC: Office of the Surgeon General, Department of the Army, 1961); Maria Goodavage, *Soldier Dogs: The Untold Story of America's Canine Heroes* (New York: Dutton/Penguin, 2012); Michael G. Lemish, *War Dogs: Canines in Combat* (Washington/London: Brassey's, 1996).

11. Patrick E. Tyler, "China Villagers Recall Horrors of Germ Attack," *New York Times International*, February 4, 1997.

12. Keiichi Tsuneishi, *The Germ Warfare Unit That Disappeared: The Kwantung Army's*

731st Unit, trans. Scitran (Tokyo: Kaimei-sha, 1981), 140. The Soviets pushed the U.S. to cooperate in their international trial for Unit 731 prisoners. But in Japan, the U.S.-led International Military Tribunal for the Far East had begun its work for the trials of Tōjō and other Japanese Class A war criminals and had other plans for scientists who had been involved in biological warfare in the postwar world. Not found in the newspapers was that the Americans had captured several escaping officers from the Japanese biological warfare unit, including Professor Naitō and the camp director, General Ishii.

13. Peter Williams and David Wallace, *Japan's Secret Biological Warfare in World War II* (New York: The Free Press/Macmillan, 1989).

14. Arvo T. Thompson, *Report on Japanese Biological Warfare (BW) Activities, 31 May 1946*, Army Service Forces, Camp Detrick, Frederick, Maryland.

15. Thompson, *Report on Japanese Biological Warfare (BW) Activities*.

16. Aman Agarwal and Daksh Gopalani, *Unit 731: Perpetrator of the Asian Holocaust*, accessed November 12, 2020, https://44479808.weebly.com. Ryōichi Naitō had been third in command in Unit 731. Like many of the Unit 731 scientists, he moved as civilians in the National Institute of Health and other Japanese medical facilities after the war. Naitō founded Japan Blood Bank, an Osaka-based pharmaceutical company that changed its name to Green Cross Corporation; it was one of five Japanese firms in the Green Cross scandal that in 1984 were accused of killing many citizens from marketing HIV-contaminated blood components for hemophiliacs. Naitō died in July 1982.

17. Seiichi Morimura, *The Devil's Gluttony* [*Akuma no hoshoku*; in Japanese], 1981.

18. Edward Hooper, "Stanley Plotkin," in *The River* (Boston: Little Brown, 1999), 547. Information on vivisection extracted from a report to U.S. officials. See also "British Television," documentary, *20/20*, ABC, December 7, 1985.

19. David Peace, *Occupied City: A Novel* (New York: Alfred A. Knopf, 2010). [Justin Cartwright, "Tokyo Vice," review of *Occupied City*, by David Peace, *New York Times*, March 21, 2010, Sunday Book Review, BR 18.]

20. Howard H. Erickson, "Josiah Wistar Worthington: World War II POW," *Veterinary Heritage* 37, no. 1 (2014): 31.

21. Kenneth B. Thomson, *A Case of Treason: The Traitor of Corregidor* (Altamonte Springs, FL: Thomson, 2018).

22. Harry L. Foust, "The Educational and Training Provisions of the So-Called 'G.I. Bill,'" *The Veterinary Student* 7 (1945): 228.

23. Albert Schatz and Selman A. Waksman, "Effect of Streptomycin Upon *Mycobacterium tuberculosis* and Related Organisms," *Proceedings of the Society of Experimental Biology and Medicine* 57, no. 2 (1944): 244.

24. W. H. Feldman, H. C. Hinshaw, and F. C. Mann, "Streptomycin in Experimental

Tuberculosis," *American Review of Tuberculosis* 52 (1945): 269. William Hugh Feldman, a Scottish immigrant to western Colorado, entered Colorado Agricultural College in 1913, and on graduating in 1917 he joined the faculty to teach pathology and bacteriology. In 1927, after graduate work in pathology with A. S. Warthin at the University of Michigan, Feldman joined the Institute of Experimental Medicine at the Mayo Clinic. In 1932 he published *Neoplasms of Domestic Animals*, and six years later, *Avian Tuberculosis Infections*. His portraits of Nobel laureates and other eminent people reside today in the National Library of Medicine. He was president of both the International Association of Medical Museums (which later became the International Academy of Pathology) and the American Association of Pathologists and Bacteriologists.

25. H. Corwin Hinshaw Papers, 1925–1994. American Philosophical Society Library.

26. Donald F. Smith, *Middlesex Veterinary College: A Short-Lived Experiment in Meritocracy*, Perspectives in Veterinary Medicine, Cornell University College of Veterinary Medicine, October 24, 2013, https://hdl.handle.net/1813/46043.

27. David Ropeik, "The Rise of Nuclear Fear—How We Learned to Fear the Radiation" (guest blog), *Scientific American,* June 15, 2012, https://blogs.scientificamerican.com/guest-blog/the-rise-of-nuclear-fear-how-we-learned-to-fear-the-bomb/.

28. R. J. Smith, "Scientists Implicated in Atom Test Deception," *Science* 218, no. 4572 (1982): 545, https://doi.org/10.1126/science.11643806.

29. Smith, "Scientists Implicated in Atom Test Deception," 545.

30. *Steve Canyon* was a long-running adventure comic strip about an all-American, easygoing adventurer in the U.S. Air Force during the Korean War. The cartoon revolved around Cold War intrigue and the patriotic responsibilities of American citizens. The artist, Milton Caniff, had connections in the Washington, D.C., area. He was intensely patriotic and had great insight into Air Force maneuvers—it helped that he was close friends with those who had an inside track about military planning.

31. Christopher Pala, "Anthrax Island," *New York Times Magazine*, January 12, 2003, 36.

32. The Armed Forces Institute of Pathology's series on human cancer, the standard of the day, included two books on cancer in animals. Over the next two decades, experts in medical pathology arose in hospitals of cities and state universities, and the AFIP lost its prominence. A victim of the Base Realignment and Closure program of 2005, it shut its doors on September 15, 2011. Operations were replaced by a new Joint Pathology Center at the Forest Glen Annex in Silver Spring, Maryland. Walter Reed Army Institute of Research was housed in the garrison command of Walter Reed Army Medical Center from 1953 to 2008.

PART VII. TRANSFORMATION

1. R. W. Horne, S. Brenner, A. P. Waterson, and P. Wildy, "The Icosahedral Form of an Adenovirus," *Journal of Molecular Biology* 1, no. 1 (1959): 84, https://doi.org/10.1016/S0022-2836(59)80011-5.

2. Barbara K. Watson and Albert H. Coons, "Studies on Influenza Virus Infection in the Chick Embryo Using Fluorescent Antibody," *Journal of Experimental Medicine* 99, no. 5 (1954): 419, https://doi.org/10.1084/jem.99.5.419.

3. Harry Rubin was born in New York City in 1926. Earning his DVM at Cornell University, he worked with the Agricultural Research Service on the Mexican foot-and-mouth disease outbreak, at the U.S. Public Health Service Virology Laboratory in Montgomery, Alabama, and in the Virus Laboratory at the University of California, Berkeley.

4. In 1939 a Swiss research chemist, Paul Müller, testing chemicals for insecticidal properties, had discovered the extraordinary effectiveness of DDT. It was highly toxic to insects, insoluble in water, and of low toxicity to mammals, and by 1941, the Swiss were using the compound successfully to combat the Colorado potato beetle. By 1948, when Müller received the Nobel Prize for his discovery, DDT was used throughout the world.

5. In 1934 a physician, bitten by a normal-appearing rhesus monkey while engaged in polio research, had developed neurologic signs and died from encephalomyelitis. Albert Sabin, producer of the ultimate polio vaccine, isolated a virus at autopsy he called B virus from its source, Patient B. In 1949 Sabin again isolated B virus at autopsy from the brain of a second physician in which there was no bite, simply monkey saliva that had contaminated a minor cut on his finger. As research on polio using rhesus monkeys increased, the number of reports of fatal human B virus rose. The third fatal case was a veterinarian. Apparently, the professionals caught on to the danger since all succeeding cases were in animal handlers or technicians.

6. The Primate Centers are Wisconsin (Madison), California (Davis), Washington (Seattle), Yerkes (Atlanta), Tulane (Covington), Southwest (San Antonio), and Oregon (Beaverton). Contributions of veterinary scientists were many throughout the early life of the centers. At the California Primate Research Center, James Moe and colleagues documented that the lung disease in the developing fetuses of rhesus monkeys caused by the new adenoviruses could be prevented by immunization.

7. Ralph Brinster was born in New Jersey, graduated from Rutgers College of Agriculture, and earned his VMD and PhD degrees at the University of Pennsylvania.

8. Winston Malmquist was the most senior (and most prominent) veterinary virologist hired when the National Animal Disease Laboratory opened. Malmquist graduated

from Iowa State College with the DVM degree in 1944 and worked in the Rockefeller Laboratory in Kenya. He discovered a new diagnostic test for viruses based on the ability of certain viruses to clump red blood cells into visible red spots. In Iowa he developed cell culture systems to isolate leukemia viruses from cattle.

Martin Van Der Maaten graduated from Iowa State College in 1956 and spent two years at the Army Biological Laboratories at Fort Detrick. Returning his father's practice in Orange City, Iowa, he then joined the Veterinary Medical Research Institute in Iowa for a PhD in virology.

9. Students sharing the intellectual environment at The Ohio State University at the time were Charles Capen, John Shadduck, and Edward Hoover, who would become science leaders, passing their concept of inquiry on to the next generation of Krakowka, Perryman, Wolfe, Jacoby, Fowler, Bishop, Rohovsky, Wiesbrode, and others whose careers were to have such a great impact on veterinary science.

10. E. A. Hoover, G. J. Kociba, W. D. Hardy Jr., and D. S. Yohn, "Erythroid Hypoplasia in Cats Inoculated With Feline Leukemia Virus," *Journal of the National Cancer Institute* 53, no. 5 (1974): 1271, https://doi.org/10.1093/jnci/53.5.1271. Important scientists who clarified the pathogenesis and clinical spectrum of feline leukemia virus diseases at Ohio State include Lance Perryman (immunosuppression) and Stanley Snyder (fibrosarcoma).

11. William David Hardy Jr. graduated DVM from the University of Pennsylvania in 1966. He worked at the ASPCA's Henry Bergh Memorial Hospital in New York City and then at Memorial Sloan Kettering Cancer Center for twenty-four years. In 1975, working with Lloyd Old, he started a cancer center at the Animal Medical Center.

12. Max Essex and Phyllis J. Kanki, "The Origins of the AIDS Virus," *Scientific American* 259, no. 4 (1988): 64; Myron Essex Papers, 1949–1996, Harvard University Library, Francis A. Countway Library Center for History of Medicine.

Myron "Max" Essex was born in Coventry, Rhode Island, and received the DVM degree from Michigan State University in 1967 and a PhD from the University of California, Davis, in 1970. He spent his career at the Department of Microbiology in the Harvard University School of Public Health. Essex holds ten honorary doctorates, fifteen patents, and the Lasker Award.

13. The U.S. secretary of agriculture, Ezra T. Benson, appointed the site committee as Dan Collins, president of the American Cattlemen's Association (chair); Wilbur Plager of Iowa, president of the National Swine Growers; Ted Byerly, deputy administrator of ARS (secretary); and Van Howeling, a USDA employee. The site list was narrowed to nine schools of veterinary medicine: Iowa State College, Michigan State College, U. of

Wisconsin, Texas A&M, Kansas State, U. of Georgia, U. of Missouri, Oklahoma State College, and Colorado State College. On Sunday, July 1, 1956, the committee visited Ames, Iowa, and toured the college's research facilities, business areas, and three potential building sites. Unique in the bid of Iowa State College was three hundred acres of land acquired through the State Legislature's Interim Committee by Iowa State president Hilton that would be deeded to the USDA.

14. William A. Hagan was born and educated in Fort Scott, Kansas, and received the DVM from Kansas State Agricultural College in 1915 and MS from Cornell University in 1917. In 1925 he took a graduate course in infectious diseases at the Robert Koch Institute for Infectious Diseases in Berlin. During a leave of absence from Cornell, Hagan was an assistant in the Department of Animal Pathology of the Rockefeller Institute for Medical Research at Princeton in 1921–1922 and three years later was appointed a European Fellow of the International Education Board. See "The New Dean," editorial, *Cornell Veterinarian* 22 (1932): 211.

15. Chester A. Manthei was born in Michigan, went to veterinary school at Michigan State University in the 1940s, and moved to the USDA's Beltsville research program. His work on bovine brucellosis revealed the unique persistence of bacteria in infected herds: individual cows with chronic infection had intermittent bacteremia and antibody levels—a cow negative for bacteria and antibody one month may have antibodies and *Brucella abortus* in her bloodstream the next. This discovery provided an accurate assessment of herd infection and laid the groundwork for eradication of brucellosis from cattle.

16. William Mengeling changed focus to vaccines against porcine parvovirus and porcine reproductive and respiratory virus. Both are dangers for feral swine—five million of them—progeny of pigs introduced in North America in the fifteenth century and of escaped wild boars, and of hybrids of the two. They caused over $1.5 billion in damage annually and were a constant danger for domestic pig producers.

17. Harley Moon earned the DVM and PhD degrees from the University of Minnesota. He spent a year at the Brookhaven National Laboratory in New York and taught veterinary pathology at the University of Saskatchewan. Moon was the fourth director of the National Animal Disease Center from 1988 to 1995 and later the director of the Plum Island Animal Disease Center. Elected to the National Academy of Sciences in 1991, he served as chairman of the National Research Council's Board on Agriculture and Natural Resources; their study on biological threats to agricultural plants and animals was done early in the early 2000s to assess the nation's strengths and weaknesses

in preventing bioterrorism against crops and livestock. In 2002 Moon moved to a faculty position at Iowa's Veterinary Medical Research Institute, with an endowed chair in veterinary medicine at Iowa State University, and retired two years later.

18. *Review of Technological Advancements Leading to the Complete Eradication of Brucellosis: Hearing Before the Subcommittee on Livestock, Dairy, and Poultry of the Committee on Agriculture, House of Representatives, One Hundred First Congress, First Session, September 23, 1989, Stillwater, OK* (Washington, DC: Committee on Agriculture, 1989), 12, 62.

19. Norman F. Cheville, Dale R. McCullough, and Lee R. Paulson, *Brucellosis in the Greater Yellowstone Area*, (Washington, DC: National Research Council, 1998). National Academy studies were traditionally done with a team of experts, usually twelve or more, that developed a study over a year's time. Because the sponsor was in a hurry, this was to be a trial study with only two lead scientists. There were objections to the principal investigator. A letter appeared in the June 20 issue of *Science* stating that he was "a longtime employee of USDA, which has threatened to decertify the safety of Montana beef because the wandering Yellowstone bison are infected with brucellosis." The next week's issue had a response from an executive officer of the National Research Council defending the appointment and pointing out that one of the critics cited was in a law firm that had brought two lawsuits based on the Federal Advisory Committee Act against the National Academy of Sciences.

20. Richard E. Dierks, Frederick A. Murphy, and Alyne K. Harrison, "Extraneural Rabies Virus Infection," *American Journal of Pathology* 54, no. 2 (1969): 251.

21. Xiaoyue Ma et al., "Rabies Surveillance in the United States During 2017," *Journal of the American Veterinary Medical Association* 253, no. 12 (2018): 1555, https://doi.org/10.2460/javma.253.12.1555.

22. E. L. Stubbs, "Fowl Pest," *Journal of the American Veterinary Medical Association* 21 (1926): 561.

23. R. C. Shope, "Swine Influenza. II. Filtration Experiments and Etiology," *Journal of Experimental Medicine* 54, no. 3 (1931): 373; B. C. Easterday, D. O. Trainer, B. Tůmová, and H. G. Pereira, "Evidence of Infection With Influenza Viruses in Migrating Waterfowl," *Nature* 219 (1968): 523, https://doi.org/10.1038/219523a0.

24. Charles H. Campbell, Bernard C. Easterday, and Robert G. Webster, "Strains of Hong Kong Influenza Virus in Calves," *Journal of Infectious Diseases* 135, no. 4 (1977): 678, https://doi.org/10.1093/infdis/135.4.678.

25. R. G. Webster, C. H. Campbell, and A. Granoff, "The 'in Vivo' Production of 'New' Influenza Virus. 1. Genetic Recombination Between Avian and Mammalian Influenza

Viruses," *Virology* 44, no. 2 (1971): 317, https://doi.org/10.1016/0042-6822(71)90263-7; B. C. Easterday and B. Tumova, "Avian Influenza Viruses," *Advances in Veterinary Science Comparative Medicine* 16 (1972): 201.

26. Congress transferred ownership of the Front Royal Remount Station to the U.S. Department of Agriculture in 1909. It operated a beef research station (in cooperation with Virginia Polytechnic University), which closed in 1973. Lying vacant for months, the thirty-two-hundred-acre campus was transferred to the SCBI.

27. Steven J. Dinsmore and Mark D. Smith, "Mountain Plover Responses to Plague in Montana," *Vector Borne and Zoonotic Diseases* 10, no. 1 (2010): 37, https://doi.org/10.1089/vbz.2009.0046.

28. Kuldeep Dhana et al., "Duck Viral Enteritis (Duck Plague): A Comprehensive Update," *Veterinary Quarterly* 37 (2017): 57, https://doi.org/10.1080/01652176.2017.1298885.

29. Lars Karstad, *Daylight in the Swamp: Autobiography of a Wildlife Veterinarian* (Author, 1980).

30. Veterinarians who were pioneers in wildlife disease research included Gary A. Wobeser in Saskatoon, David Hunter in California, Tom Thorne in Wyoming, and Frank Hayes and Vic Nettles of the Southeastern Cooperative Wildlife Disease Study in Georgia.

31. E. S. Williams, "Chronic Wasting Disease," *Veterinary Pathology* 42, no. 5 (2005): 530, https://doi.org/10.1354/vp.42-5-530.

32. R. Scott Nolen, "Ticks Responsible for Most U.S. Vector-Borne Diseases," *Journal of the American Veterinary Medical Association* 256 (2020): 286, https://www.avma.org/javma-news/2020-02-01/tiny-ticks-big-threat.

33. Coronaviruses cause disease in mice, rats, rabbits, ferrets, and chickens. Mouse hepatitis virus and rat sialodacryoadenitis virus have been used as models of human disease. Bat-transmitted paramyxoviruses include Nipah virus from pigs in Malaysia in 1998–1999 and Hendra virus from horses and trainers along the East Coast of Australia in 1994.

34. Raina K. Plowright et al., "Transmission or Within-Host Dynamics Driving Pulses of Zoonotic Viruses in Reservoir-Host Populations," *PLoS Neglected Tropical Diseases* 10, no. 8 (2016), https://doi.org/10.1371/journal.pntd.0004796.

35. Arinjay Banarjee et al., "Bats and Coronaviruses," *Viruses* 11, no. 1 (2019): 41, https://doi.org/10.3390/v11010041.

36. J. T. Stamp et al., "Further Studies on Scrapie," *Journal of Comparative Pathology* 69 (1959): 208, https://doi.org/10.1016/s0368-1742(59)80026-6. The Moredun Institute

was an Animal Disease Research Association Station that concentrated on sheep diseases. J. T. Stamp led a team that reproduced scrapie in sheep by passing filtered scrapie brain tissue from one sheep to another.

37. Björn Sigurđsson, director of the Keldur Institute for Experimental Pathology at the University of Iceland, first proposed the concept of slow viruses. He first described visna in 1954 in Karakul sheep imported from Germany; his research centered on maedi/visna virus, which caused chronic neurologic (visna) and respiratory (maedi) disease in sheep and goats.

38. William J. Hadlow, "Kuru Likened to Scrapie: The Story Remembered," *Philosophical Transactions of the Royal Society B* 363 (2008): 3644, https://doi.org/10.1098/rstb.2008.4013.

39. Beth Williams studied at the University of Maryland (BS), Purdue University (DVM), and Colorado State University (PhD). She married Tom Thorne, a wildlife biologist—both moving to the University of Wyoming in Laramie—and continued work in chronic wasting disease. Tom Thorne became a noted wildlife expert who headed the restoration of the black-footed ferret.

40. Stanley B. Prusiner, *Prion Biology and Disease*, 2nd ed. (Cold Spring, NY: Cold Spring Harbor Laboratory Press, 2004).

PART VIII. EPILOGUE

1. Timothy Curry and Lynn Shibut, "The Cost of the Savings and Loan Crisis: Truth and Consequences," *FDIC Banking Review* 13 (2000): 26.

2. R. G. Elmore and Howard H. Erickson, *A Century of Excellence: Kansas State University College of Veterinary Medicine* (Virginia Beach, VA: Donning, 2005).

3. William Switzer and his progression of graduate students, including Richard Ross, Robert Duncan, John Maré, and Hank Harris, tackled the problem head-on. In the next decade they would investigate atrophic rhinitis and pneumonia caused by *Mycoplasma hyopneumoniae*, *Mycoplasma hyorhinis*, and *Bordetella bronchiseptica*.

4. Richard Ross had pushed for a new a cutting-edge containment facility for research on infectious diseases of large animals; the Healthy Livestock Initiative, a legislative funding body dedicated to animal health and production animal medicine; instructional teaching systems and information systems for the Department of Veterinary Clinical Sciences; and the Veterinary Diagnostic Laboratory, including development of computer-assisted instructional software and an expanded graduate program in swine medicine.

5. At California-Davis, an impressive research program was established. During the

period, Deans Frederick Murphy and Bennie Osburn were both scientists who saw a clear path to success for their institution. At Texas A&M University, John Shadduck was successful and similar changes occurred as with Robert Marshak at Penn, Donald Smith at Cornell, and Keith Prasse at the University of Georgia.

6. Linda C. Cork, "Veterinarians and the Institute of Medicine," *Veterinary Pathology* 50 (2013): 946.

7. Peter Doherty was a graduate of the University of Queensland with a PhD from Edinburgh. He had returned home to Australia to the John Curtin School of Medical Research to investigate how lymphocytes protect against viral infection. Doherty discovered how a special subset called T-lymphocytes attack and destroy cells that have been infected with viruses. For attachment to virus-infected cells, the T-killer cell had to recognize two components on the surface of the infected cell: a protein from the virus and a unique protein complex called the major histocompatibility complex (MHC for short). Doherty discovered how the MHC recognizes the virus and displays its proteins on the cell's surface in a way that the virus-infected cell can be recognized by roving killer T cells. Veterinary and medical scientists began to provide new models for how diseases worked.

8. Craig W. Hedberg et al. "An Outbreak of Thyrotoxicosis Caused by the Consumption of Bovine Thyroid Gland in Ground Beef," *New England Journal of Medicine* 316 (1987): 993, https://doi.org/10.1056/NEJM198704163161605.

9. Aleen Cust, hiding her gender, enrolled in the New Veterinary College in Edinburgh, Scotland, in 1894 under the name of A. I. Custance. The Royal College of Veterinary Surgeons denied her application for registry in 1897 so that she was unable to list herself or practice as a veterinarian. Born in Tipperary, she returned to Ireland to work as an assistant to a veterinarian.

10. Archives of the *Journal of the American Veterinary Medical Association* show the first college-educated female veterinarians in the United States to be Mignon Nicholson, graduated from McKillip Veterinary College in 1903; Elinor McGrath, from Chicago Veterinary College in 1910; and Florence Kimball, from Cornell University in 1910.

11. In the rural Midwest, Kansas State College led with women graduates Helen Richt in 1932 and Louise Sklar in 1933. Mary Knight Dunlap (who founded the Association for Women Veterinarians in 1947) finished at Michigan State College in 1933, and Ida Mae Dodge was the first woman to graduate in veterinary medicine from The Ohio State University in 1936. The University of Pennsylvania voted to admit women to veterinary school in 1933, and five years later Mary Josephine Deubler graduated VMD.

12. N. Cheville, "The Shift in Gender of Veterinary Students," *Gentle Doctor* 16

(2002): 2; Howard H. Erickson, "Pioneer Women in Veterinary Medicine, Their History and Where They Studied," *Veterinary Heritage* 35, no. 1 (2012): 7.

13. M. Meselson et al., "The Sverdlovsk Anthrax Outbreak of 1979," *Science* 266 (1994): 1202, https://doi.org/10.1126/science.7973702. Matthew Stanley Meselson was a molecular biologist at Harvard University; he had worked with Henry Kissinger in the Nixon administration to convince President Nixon to renounce biological warfare. In 1980 he was appointed consultant to the Central Intelligence Agency on anthrax and in 1992 led the team that investigated the outbreak in Sverdlovsk.

14. Ken Alibek and Stephen Handelman, *Biohazard: The Chilling True Story of the Largest Covert Biological Weapons Program in the World—Told From the Inside by the Man Who Ran It* (New York: Random House, 1999). See book review: William A. Haseltine, "Incubating Bioweapons," *Science* 285, no. 5430 (1999): 1019, https://doi.org/10.1126/science.285.5430.1019.

15. Ken and Handelman, *Biohazard*; Haseltine, "Incubating Bioweapons."

16. A. A. Abramova and L. M. Grinberg, "Pathologic Anatomy of Anthracic Sepsis: Materials of the Infectious Outbreak in 1979, Sverdlovsk (Microscopic Findings)," *Arkh Patol* 1 (1993): 18; David H. Walker, Olga Yampolska, and Lev M. Grinberg, "Death at Sverdlovsk: What Have We Learned?" *American Journal of Pathology* 144 (1994): 1135.

17. D. L. Huxsoll, W. C. Patrick III, and C. D. Parrott, "Veterinary Services in Biological Disasters," *Journal of the American Veterinary Medical Association* 190, no. 6 (1987): 714.

18. Jerry Jaax and Nancy K. Jaax, "An Ebola Filovirus Is Discovered in the USA: Reston, Virginia, USA, 1989," *Veterinary Heritage* 39, no. 1 (2016): 16. Nancy Jaax was a resident in veterinary pathology at USAMRIID in 1979 and began work with Ebola virus in 1983. She was the chief of the Pathology Division at Aberdeen Proving Ground in Edgewood, Maryland, where she worked with chemical warfare agents. Nancy and Jerry Jaax, graduates of Kansas State University, were both career officers in the U.S. Army Veterinary Corps. They worked in research planning in the Provost's Office at Kansas State University. Both were instrumental in winning the national competition for the National Bio and Agro-Defense Facility to be placed in Kansas.

19. *West Nile Virus Outbreak: Lessons for Public Health Preparedness*, United States General Accounting Office Report to Congressional Requesters, September 2000, https://www.gao.gov/new.items/he00180.pdf.

20. *West Nile Virus Outbreak: Lessons for Public Health Preparedness* (Washington, DC: U.S. General Accounting Office, 2000); K. E. Steele et al., "Pathology of Fatal West Nile Virus Infections in Native and Exotic Birds During the 1999 Outbreak in

New York City, New York," *Veterinary Pathology* 37, no. 3 (2000): 208, https://doi.org/10.1354/vp.37-3-208; Richard Preston, "West Nile Mystery," *New Yorker*, October 18 and 25, 1999, 90 and 107.

21. *West Nile Virus Outbreak*, 4.

22. J. A. Jernigan et al., "Bioterrorism-Related Inhalational Anthrax: The First 10 Cases Reported in the United States," *Emerging Infectious Diseases* 7 (2001): 933, https://doi.org/10.3201/eid0706.010604.

23. Peter J. Boyer, "The Ames Strain: How a Sick Cow in Iowa May Have Helped to Create a Lethal Bioweapon," *New Yorker*, November 12, 2001, 66.

24. Cornell University Veterinary School began offering a veterinary diagnostic service in 1912. In 1970 the New York State Legislature enacted a law authorizing the agriculture commissioner to contract with Cornell to operate an official state veterinary diagnostic laboratory. In 2001 the law was amended to include zoo and wild animal populations for evidence of human pathogenic microorganisms. It was a new modern facility for two hundred professionals whose work extends into food safety and the environment, including units as diverse as Quality Milk Production Services and Department of Environmental Conservation.

25. The National Animal Health Laboratory Network Level 1 laboratories are in these locations: *West:* Davis, Calif.; Pullman, Wash.; Fort Collins, Colo.; College Station, Tex. *Midwest:* Ames, Iowa; St. Paul, Minn.; Columbia, Mo.; Lansing, Mich.; Reynoldsburg, Ohio. *South:* Kissimmee, Fla.; Athens, Ga.; Raleigh, N.C. *East:* Ithaca, N.Y.; Harrisburg, Pa.

26. National Research Council, *Chemical and Biological Terrorism: Research and Development to Improve Civilian Medical Response* (Washington, DC: National Academies Press, 1999).

27. James Roth is a Distinguished Professor of Iowa State University, a member of the National Academy of Medicine, and a recipient of the American Association of Veterinary Medical Colleges Senator John Melcher, DVM, Leadership in Public Policy Award. Senator Melcher was an Iowa State College of Veterinary Medicine graduate of 1950.

28. Bethany McLean and Peter Elkind, *The Smartest Guys in the Room: The Amazing Rise and Scandalous Fall of Enron* (New York: Portfolio/Penguin, 2004).

29. John Carreyrou, *Bad Blood: Secrets and Lies in a Silicon Valley Startup* (New York: Alfred A. Knopf, 2018).

30. Bernard Lewis, *What Went Wrong: The Clash Between Islam and Modernity in the Middle East* (New York: Perennial/HarperCollins, 2003).

31. D'Ibn-al-Awam, *Le Livre de L'Agriculture*, trans. J.-J. Clément-Mullet (Paris: Albert L. Herold, Successeur, 1864).

32. Ismail Serageldin, "Science in Muslim Countries," *Science* 321, no. 5890 (2008): 745, https://doi.org/10.1126/science.1162825.

33. Serageldin, "Science in Muslim Countries."

34. Frank Bruni, "I'm O.K.—You're Pure Evil," June 17, 2017, *New York Times*, https://www.nytimes.com/2017/06/17/opinion/sunday/im-ok-youre-pure-evil.html.

35. Robert R. Marshak, "The Vanishing Veterinarian-Scientist?," *Journal of the American Veterinary Medical Association* 237, no. 7 (2010): 775, https://doi.org/ 10.2460/javma.237.7.775; R. R. Marshak, "Veterinary College Accreditation," *Journal of the American Veterinary Medical Association* 242, no. 7 (2013): 912, https://doi.org/10.2460/javma.242.7.912.

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Norman Cheville is dean emeritus of the College of Veterinary Medicine at Iowa State University. He received his DVM from Iowa State (1959), PhD from the University of Wisconsin (1964), and the honorary Doctor Honoris Causa degree conferred by the University of Liège. Dr. Cheville worked at the U.S. Army's biological laboratory at Fort Detrick, Maryland, and for three years at the University of Wisconsin. He moved to the National Animal Disease Center as chief of pathology in 1964 and the Brucellosis Research Unit in 1989, where he led a team that developed a new vaccine for bovine brucellosis. Dr. Cheville spent a sabbatical leave at the National Institute for Medical Research in London studying the immunology of viral infections. Appointed chair of Veterinary Pathology at Iowa State University in 1995, Dr. Cheville was a principal investigator for the National Academy of Sciences study "Brucellosis in the Greater Yellowstone Area" (1998). He also served on the National Research Council studies "Dynamics of Ungulates of the Northern Range" and "Critical Needs for Research in Veterinary Science." His honors include the Pfizer Excellence in Bovine Research Award, 1999; Distinguished Member, American College of Veterinary Pathologists, 1999; Outstanding Achievement Award, USDA, 1991; Distinguished Scientist Award, USDA, 1990; and the Alumni Merit Award, Iowa State University, for outstanding contributions to human welfare and professional accomplishment, 1978. Dr. Cheville has published over two hundred papers and seven books, including multiple editions of *Cell Pathology*, *Ultrastructural Pathology*, and *Introduction to Veterinary Pathology*.