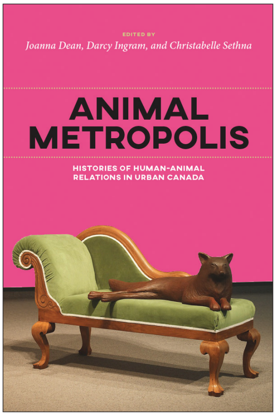

ANIMAL METROPOLIS: HISTORIES OF HUMAN-ANIMAL RELATIONS IN URBAN CANADA

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Species at Risk: *C. Tetani*, the Horse, and the Human

Joanna Dean

The agonizing death of an Ottawa man was noted on 11 September 1885:

> Mr Jno Crabtree, of the firm Robertson and Crabtree, builders, Ottawa, died at his residence on Tuesday morning last week under particularly distressing circumstances. Some ten days ago while laying a brick floor in a new building a nail accidentally penetrated his great toe. Nothing serious was anticipated at the time, but on Tuesday last lockjaw set in, which terminated in his death after suffering intense agony from tetanic convulsions.[1]

Crabtree was one of innumerable individuals whose death from lockjaw, or tetanus as we now know it, was recounted in the pages of late nineteenth-century newspapers. The accounts followed a similar narrative arc, beginning with a minor wound, typically a rusty nail or splinter, or a kick from horse. Then there was a momentous lull – "nothing serious was anticipated at the time." The lull could last three days, or twenty-one, but usually about eight days after the injury the first symptoms of lockjaw appeared, and then culminated in the horrific denouement of tetanic convulsions.

Crabtree's death can be traced back to the number of horses employed in Canadian cities in the 1880s. Many horses carried the spores of

Clostridium tetani in their intestines and distributed them liberally into the urban environment in their manure. We might trace Crabtree's death to the horses hauling people and goods on the streets of Ottawa; his death might be traced to the horses that turned the pugmills mixing the clay for the brick floor he was laying, or it might be traced to one of the horses working on his construction site. It might have been any of one these horses, or a horse that was long gone. *C. tetani* spores lurked in urban soil for many decades.[2] A deep injury left to fester, like that caused by the nail piercing Crabtree's toe, created the anaerobic conditions for the dormant tetanus spores to become active, and release their deadly toxin.

This chapter looks at the three species that produced lockjaw in the city: the bacilli, the horse, and the human. In an attempt to foreground the bacilli, and bring the horse into the picture as a sentient, if not agential, being, it considers them as part of an assemblage or, to use Gilles Deleuze and Felix Guattari's original French term, *agencement*. In agencement, the human is not at the centre but is one part of an interactive whole. As Vinciane Despret explains, "Each living being renders other creatures capable (of affecting and of being affected) and they are entangled in a myriad of rapports of forces, all of which are 'agencements.'"[3] The story of the tetanus bacilli's trajectory through the equine and human bodies provides a window into the entangled animal world of Canadian cities.[4] Agencement is an idea that emphasizes movement and becoming, and this chapter follows *C. tetani* from the streets and into the Connaught Laboratories on the outskirts of Toronto, where a new concatenation of bacilli, horse, and human was put in place with the production of antibodies for human use from the blood of tetanus horses.[5] Photographs distributed by the Connaught Laboratories accustomed the public to the new agencement of laboratory animal, scientist, and bacilli. Photographs made the invisible bacilli visible, and the unnatural natural, familiarizing the readers to the new uses to which animals were put, especially the intimate role of the horse as the "heroic" donor of biomedical products.

The agony of lockjaw

Before the discovery of the bacilli as the causative agent, lockjaw was understood as an inexorable sequence of symptoms: a narrative. The story line was set with Hippocrates' account of a ship captain's death: "The master of a large ship mashed the index finger of his right hand with the anchor. Seven days later a somewhat foul discharge appeared; then trouble with his tongue – he complained he could not speak properly." At this point lockjaw was diagnosed: "His jaws became pressed together, his teeth were locked, then symptoms appeared in his neck; on the third day opisthotonos [spasms] appeared with sweating. Six days after the diagnosis was made he died."[6] The horrors of the lockjaw narrative, in various permutations, run through the long history of intimate connections between human and horse. It was most commonly associated with the battlefield, where the assemblage of horse, human, mud, and weapon led to deep, unwashed wounds that were fertile ground for the bacilli.

The most famous Canadian death by lockjaw was that of Lord Sydenham, governor general of British North America, who died in 1841 after falling from his horse in Kingston in front of the Parliament buildings. His demise was made the stuff of political drama by historians like Adam Shortt and Archibald MacMechan. It is said that Sydenham composed a speech while in the agonies of the disease: his last thoughts were on the state he had served so well.[7] Working-class men and youth were more typical victims, and their deaths were described in newspapers in spare but harrowing narratives that stressed the suspense of the lull, and the pain of the death.

> John Marek, a young man who resided in Streator, died at his home there this week in great agony from lockjaw. Several days ago he received a slight scratch on the cheek from a wire, but the little mark did not appear serious and no attention was paid to it. The latter part of the week it began to pain and physicians were called but they could afford no relief. Sunday morning lockjaw resulted and within a few hours death relieved the young man of his sufferings.

Death by lockjaw was not common, but the stories were widely disseminated as sensational filler for the columns of newspapers across North America. Children often suffered; death came from the most innocent of childhood activities, and the stories recount the familiar trajectory with chilling specifics.[8]

> DIED OF BLOOD POISONING
> Orlo B. Dicken of the South Side Dies Sunday Morning
>
> Orlo B. Dicken, the five year old son of Mr. and Mrs. Charles Dicken, died at their home on the south side Sunday morning of lockjaw, after an illness of twenty-four hours. The boy went barefoot on Thursday and accidentally stepped on a rusty nail, inflicting a severe wound. As it did not pain him greatly, he said nothing about it to his parents and they were not informed of his condition until Saturday when lockjaw set in. The best of medical attendance was secured but proved of no avail. It was even found impossible to pry the boy's jaws apart to insert food.
>
> MAY DIE OF LOCKJAW
> Water Street Boy Suffering Intense Pain in Water Street Hospital
>
> A fourteen-year-old boy named Talon, living on Water Street, was taken to the General Hospital suffering from a severe attack of tetanus or lockjaw. But slight hopes are held out for his recovery by the hospital staff and he is suffering from severe spasms. The lad was playing about ten days ago when he got a piece of glass in his right foot. The injury was attended to but symptoms of tetanus showed themselves yesterday and the lad was immediately moved to hospital for treatment. He is a delicate lad and apparently unable to stand severe pain.[9]

Horses were also known to suffer from lockjaw. Most North American horse-care books devoted a page or two to the disease. As Everett Miller notes, "They related how the disease would occur in the horse which was newly shod (nail prick), lamed (picked up nail) operated on (docked, nicked, gelded) or severely wounded, and seven to ten days later the horse would exhibit signs such as closed jaws, flared nostrils, cocked ears, and opisthotonos (stretched out muzzle, rigid neck, and back muscles and set tail) and a sawhorse like stance." *The Canadian Horse and His Diseases* (1867) noted that lockjaw was not uncommon in Canada, especially in the summer, and described the equine agony: "A horse laboring under this awful disease is one of the most pitiable objects we can look at. He stands with his legs wide apart, like four posts, to support his body; which, from the head to the tail, is rigid and quivering."[10] Newspapers carried occasional accounts of equine lockjaw, usually recounting the deaths among the equine elite of well-loved carriage horses and expensive racing horses.

> FAITHFUL HORSE DIES OF LOCKJAW
>
> The sorrel horse which has done such faithful service for Mr. M.G. Willis for so many years, and has been such a familiar object on the streets, was taken with lockjaw Wednesday and died Thursday. When Mr. Willis was mayor this good, old, reliable horse knew just when nine o'clock came every morning and stood ready to convey his owner to the office to transact his official business. Mr. Willis had used him as a driving horse for a number of years.[11]

The medical care provided for horses and humans was similar, and similarly ineffective. The abundance of folk remedies, such as smoke or copper pennies on the wound, testify to the inability of regular physicians to furnish any real assistance.[12] Fluids and nourishment had to be forced through the clenched jaws. The horse might be fed a liquid mash through closed teeth; the humans soup or oatmeal. Any nervous stimulation set off the convulsions, so horses were to be kept in a dark, quiet stable, people in a muffled room. If the patient could be nursed through the bout, then recovery was possible. Death came from exhaustion, respiratory failure due to convulsions, or the direct action of the toxin. The fatality rate for horses was 80 per cent; survivors would take weeks or months to recover. Among humans, the spasms could continue for weeks, and full recovery could take months. Even today the case fatality rate in the United States is 13 per cent.[13]

Nineteenth-century lockjaw narratives were the product of a particular assemblage of inert and sentient entities: the unprecedented numbers of horses on city streets, the heavy application of their manure to suburban gardens and fields, the wide use of metal tools capable of slicing into human flesh, and the number of human and equine bodies susceptible to the potent toxin. Until the 1880s the critical agent, the bacilli, coursing through the various animal bodies, was unknown and invisible.

“That Awful Microbe”

In the 1880s *Clostridium tetani* emerged in European laboratories, made apparent by its impact on the bodies of small animals. In 1884 Antonio Carle and Giorgio Rattone injected pus from a fatal human case of lockjaw into the sciatic nerve of a rabbit to produce the typical symptoms of lockjaw in the animal. The disease was then transmitted from this rabbit to other rabbits. That same year Arthur Nicolaier injected soil into animals and produced lockjaw. In 1886 *C. tetani* came into view when a spore-forming bacillus was observed in human exudate: rod-shaped with a terminal spore at one end, the bacterium is often compared to a drumstick or tennis racket. In 1889 the spores were shown to be resistant to heat, and to germinate into the vegetative (and toxin-producing) state if placed in anaerobic conditions. The toxin, tetanospasmin, was produced in 1890.[14]

Laboratory research turned lockjaw, a disease that had been identified clinically with a set of symptoms, into tetanus, a disease associated with a bacillus.[15] The discoveries were disseminated rapidly, if with variable accuracy, in the North American daily press.[16] A Canadian nursing text published in 1893 said of tetanus: “formerly thought to be nervous in origin we now know is peculiar kind of bacillus species found most often in garden earth, manure or putrefying fluids, the poison being conveyed by the earth or dirt that is carried into the wound.”[17] As scientists discovered the presence of spores in soil, and the anaerobic conditions necessary for *C. tetani*’s proliferation, it became clear why deep wounds caused by rusty nails and dirty tools were particularly dangerous, and why careful cleaning of the wound would reduce the likelihood that tetanus would develop.

A French scientist, Aristide Verneuil, drew the connection between horses and *C. tetani*. In an article entitled “That Awful Microbe,” the *Toronto Daily Mail* reported in 1888: “The microbe theory seems destined to be held responsible for all the ills that flesh is heir to. M. Verneuil a French scientist . . . asserts that the hitherto respected horse is responsible for the lockjaw microbe and that it is from the docile and useful animal that man ‘catches’ the disease.” Verneuil’s evidence was epidemiological: “the greatest proportion of cases of tetanus being those of stablemen, coaches and grooms.”[18] The medical journal *Canada Lancet* provided the details in June 1889. Verneuil had examined 380 cases of lockjaw, of which 222, or 58 per cent, were among those working with horses. Other victims, like the three doctors in his list, were discovered on investigation to care for their own horses. In the face of evidence of earth or dirt causing the disease, Verneuil argued that the earth acted as an intermediate agent.[19] News of Verneuil's association of the horse with lockjaw travelled quickly, possibly because his epidemiological studies confirmed existing anxieties about human–animal intimacy. The *Canada Health Journal* cited his work in an article on the "Diseases of Domestic Animals: Their Relation to the Human Family and Hygiene." The *Ottawa Journal* linked the faithful horse with the dread disease in 1900: "When the silent and swift automobile glides through Ottawa's streets and the horse is used only for pleasure lockjaw will be an almost unknown disease, says a well known physician."[20]

We now understand that all mammals can carry tetanus, although the horse is the most susceptible. The number of horses in the city, the prodigious amount of manure produced per horse, and the wide distribution of this manure suggest that horse manure was the likely source of much, if not all, urban lockjaw at the turn of the century. Horses were essential to the functioning of the modern city, and their numbers had been increasing as the railway brought more goods needing distribution into the city. The Canadian census indicates that almost two thousand horses lived in Toronto in 1871, one for every 28 human residents; by 1891 there was one for every 25 humans. The number of horses continued to rise, but the proportion of horse to human dropped dramatically in the 1890s when the electric streetcar replaced the horse-drawn streetcar. There was only one horse for every 62 people in 1901, though this rose again to one to every 51 in 1911.[21] At the same time as their numbers were growing, draft horses nearly doubled in size to meet the growing demand for muscle.[22] Horses are recalled with fond nostalgia today, but they occupied a more complicated and more prosaic place in the nineteenth-century imaginary. Many owners cared deeply about individual horses, admiration for the fire horses was almost universal, and the very public suffering of carthorses met with sympathy. But the forced intimacy and the smells, occasional unruliness, and sheer massive sweaty animality of the labouring beast also produced distaste bred of too close a familiarity. Manure was the biggest problem. Each horse produced roughly five tons of manure a year, much of it distributed along city streets, where it was ground into a fine choking dust in the summer and churned into the muddy streets in the spring and fall. As Joel Tarr has shown, the smell and filth was only tolerated because of the necessity of the horse to urban transportation.[23] Other domestic animals, such as pigs and cows, had been removed from most Canadian cities by the end of the nineteenth century.[24] Pet dogs were regulated through muzzles, leases, and licensing, and stray dogs were eradicated from cities because of the threat of rabies.[25] Horses, however, were absolutely critical to the functioning of the modern city, and although the management of the manure was debated and regulated, the horse remained on the streets. Until the advent of the electric streetcar in the 1890s, and then the widespread adoption of the internal combustion engine after the First World War, there was quite simply no other way to move goods from train station to store, or carry people from place to place.

Producing Antitoxin

The first steps in combatting *C. tetani* involved a more intimate rather than a more distant relation with the horse. In 1890, Shibasaburo Kitasato and Emil Adoph von Behring injected sub-lethal doses of tetanus toxin into rabbits and demonstrated the prophylactic action of the resulting antitoxin. (Terminology has changed: what was initially called an antitoxin, and subsequently an antibody, is now called tetanus immune globulin, or TIG. The terminology used here – antitoxin, bacilli, germ – is that of the period.) Two years later von Behring immunized sheep and horses to produce commercial quantities of antitoxin. Horses were injected with gradually increasing doses of tetanus toxin over a number of weeks or months and built up high levels of antitoxin in their blood. This antitoxin was extracted from the blood, purified, and injected into a human, where it provided temporary immunity. A similar process produced diphtheria antitoxin.

A young Canadian doctor brought the new immunological science to Toronto. John Gerald FitzGerald, a graduate of the medical school at the University of Toronto, studied bacteriology at Harvard, and then at the Pasteur Institute in Paris and the University of Freiburg. He developed a close relationship with Dr. William H. Park, the director of the New York City Health Department's Laboratories, during postgraduate studies. He returned to the University of Toronto in 1913 as an assistant professor of hygiene, and immediately began producing Pasteur Preventative Treatment for rabies, derived from the spines of infected rabbits, at the provincial laboratory. His main interest, however, was in combatting diphtheria, the leading cause of death for children under the age of fourteen, and he built a stable in his assistant's yard on Barton St. to house five horses, named Crestfallen, Surprise, Fireman, and J.H.C. and Goliath, for the production of diphtheria antitoxin.[26] FitzGerald subsequently received university funding for a serum institute modelled on the Pasteur Institute: the Antitoxin Laboratory's three goals were, like those of the Pasteur Institute, to prepare and distribute public health serums and vaccines, to conduct research into new biological products, and teach.[27]

The First World War turned FitzGerald's focus from diphtheria to tetanus. Horses and humans fought side by side in the war, and the deep injuries caused by modern explosives led to high rates of tetanus in both species. In the fall of 1914, on the urging of Colonel A.E. Gooderham, chairman of the Canadian Red Cross Society, FitzGerald turned to the production of tetanus antitoxin. With $5,000 in funding from the Department of National Defence, he hired Robert Defries to oversee the immunization of eighteen tetanus horses, housed in the former stables of the Ontario Veterinary College on Temperance Street. The following summer, Gooderham purchased 58 acres of land 12 miles north of the university campus and donated the farm to the university to be used for the production of antitoxins. The province provided an endowment of $75,000, and, perhaps more important, ensured a steady market for the serums.[28] The horses were moved there in 1916, and Connaught Laboratories, with a new central building constructed in an English cottage style, were officially opened with great ceremony in October 1917.

The term "laboratory" is slightly misleading: the Connaught was originally referred to as a farm as well as a laboratory, and might best be understood as a hybrid space, where the animality of the horse met the modern technology of science. Stables dominated. Most of the space on the main floor of the new Connaught building was taken up with twelve wide standing stalls and three box stalls, and a large paddock extended behind the building.[29] Horses were not the only experimental animals housed at the laboratory. A research colony of 500 guinea pigs, for the testing of the antitoxin, were initially to have been accommodated upstairs in the hayloft, calves were kept in one corner for the production of smallpox vaccine, and over time as research expanded many thousands of small mammals – mice, rabbits, dogs, and cats – were also housed on the property.[30] The human technicians were also to have been housed in the same building: at the far end of the loft from the guinea pigs was an apartment provided for the family of the "technical bacteriologist," and an additional bedroom. But horses dominated. The fifteen stalls were inadequate even before the building opened. In addition to tetanus antitoxin, the laboratories used horses to produce anti-meningitis serum, diphtheria antitoxin, anti-pneumococcus serum, and serum for the prevention of gas gangrene, and by 1918 there were, in all, fifty horses for the production of the various serums, housed in an old barn on the property and two temporary stables as well as the laboratory building.[31] The 58 rolling acres provided extensive pastures.

The science took place in the corners of the new building. Tucked into the southeast corner, in one of the smaller rooms, was the laboratory proper with sinks, work tables, sterilizers, and other apparatus. Other laboratories were eventually built on the second floor where the guinea pigs and the bacteriologist were to have been housed. Science and stable met in the northwest corner, where an "operating room" provided for the injecting and bleeding of the horses.

Laboratory reports in the Connaught Archives provide some sense of the experiences of horses involved in antitoxin production. Some early tetanus horses were identified by name (as were all of the diphtheria horses) – Tom and Bert appear in the record book on 21 December 1915 – but very quickly a system of numbers was put in place. A chart, *Report of Tetanus Horses*, for the month ending March 1918, identifies 20 horses, numbered T#1, T#6, T#8, T#17, T#21, and then consecutively T#25 through T#27 and T#29 through T#32 and T#34 through T#42. The horses were injected with gradually increasing amounts of tetanus toxin, and over a few months gradually gained immunity through the production of antibodies. They were then "bled." Large amounts of blood were withdrawn and the antitoxin extracted. A few of the Connaught horses were very productive: horse T#21 had been bled 35 times over three years. Horse T#17 had been bled 30 times. T#1 had been bled 15 times.[32] A second laboratory record, a manual kept by FitzGerald, shows steady bleeding, on a par with that of T#17 and T#21, of horses numbered, more simply, 10, 11, 12, 13, 14, 15, 16, 19, and 20.[33] It appears from this book that about ten tetanus horses were bled every month.

These records show that horses at the Connaught Laboratories routinely had about 6,000 cc of blood removed at a single time, although amounts as low as 2,000 cc and as high as 11,000 cc were recorded. This amount meant that the horses could recover and produce more serum in a month's time. Horses that had reached the end of their productivity as serum horses were bled out. Connaught records show three horses, numbered 11, 16, and 19, being bled out in 1917. The records note of the procedure for number 16: "Large amount of salt solution with sod. citrate run into jugular vein after 4 bottles of blood had been withdrawn total plasma 22,400 [sic]." Tom and Bert appear to have been bled out on 21 December 1915, as they produced 38,000 cc and 14,000 cc respectively. As this record book ends on 22 February 1917, and horses 10, 12, 13, 14, 15, and 20 do not appear in the "Report of Tetanus Horses" for 1918, we can speculate that the other horses had also been bled out as they reached the end of their serviceability.[34] A pamphlet produced a number of years later by the Connaught describes the process: "In a separate room with an autopsy room adjoining, an operating-table is installed. When a producing horse is disposed of, it is anaesthetized and 'bled out' on this table. In other words, as much as possible of its blood is removed and preserved."[35] The procedure was more fraught than this clinical account suggests: one employee, whose memory dates back to the early 1950s, remembers the struggle to strap the horse to the operating table, and hold the horse in place as the table and horse were tilted from an upright position to the horizontal. He recalled holding anesthesia in a rag to the horse's nose. The process may also have been emotionally difficult for technicians who had become familiar with the individual horses. Number 16 is identified by only number until 16 December 1917, the day she was bled out, when she is given a name, Molly, in the laboratory records.

Antitoxin serum was revolutionary in its impact during the First World War, when thousands of men who would have died from minor wounds inflicted on the manure-filled fields of battle were given a series of antitoxin injections. The British military epidemiologist, Sir David Bruce, concluded that the injections reduced the death rate from tetanus from 50 per cent to 19 per cent.[36] More recently epidemiologists have concluded that "anti-tetanus serum undoubtedly prevented life threatening tetanus among several hundred thousands of wounded men, making it one of the most successful preventive interventions in wartime medicine."[37] Much of the credit for protection of the British forces from tetanus infection goes to the Connaught Laboratories. By 25 October 1917, when the laboratories were formally opened, they were producing all of the antitoxins for the second British Army Corps, which included all the men in the Canadian Expeditionary Force.[38] FitzGerald subsequently claimed that over the course of the war they produced one fifth of the tetanus antitoxin required by the British forces, and did it at a fraction of the cost of the commercial laboratories south of the border.[39] (The Department of National Defence had been paying $1.35 for antitoxin from American commercial laboratories, but Connaught Laboratories provided a dose of antitoxin, of high quality, for 34 cents.[40])

Vaccine Farms

There were no national standards for the production of biological products in Canada until 1928, and in the early years the Connaught Laboratories struggled to overcome the controversial legacy of "vaccine farms," where cowpox vaccine had been produced from infected calves under questionable circumstances. A 1917 article on the Connaught Laboratories in the *Contract Record* emphasized that their new stables were hygienic spaces: "One feature of the building is the arrangement to secure sanitary conditions. The walls in the stables and laboratory rooms are lined with glazed brick dado, which can easily be kept clean. All internal angles are coved, so as to avoid dust-catching conditions, and all corners are bull-nosed."[41] A manure trolley removed waste to the outside, and floor level ventilators removed foul air. A similar article, in *Construction*, also emphasized cleanliness and modernity.[42]

Vaccine farms had not been particularly scientific or hygienic locations. The cowpox vaccine was produced from an infected calf: the calf was shaved and scarified with vaccine; five days later large vesicles formed, and when they were considered ripe they were broken and the lymph used to coat ivory "points," sealed with a protective coating of egg white. As Jennifer Keelan has observed, the science of vaccine production was unreliable: bad lymph could cause painful side effects, even (rarely) death, and the protection offered was variable.[43] Canadian vaccine was sourced from the Montreal Cowpox Institute (from 1878) and the Ontario Vaccine Farm (from 1885) as well as from American vaccine farms, such as the New England Vaccine Company.[44] The Ontario Farm was, like the American farms, a private initiative. It was subsidized, and inspected, by the Government of Ontario, but there were ongoing concerns about hygiene, and demands for higher-quality glycerinated vaccine. In 1916, probably in response to these concerns, the Connaught Laboratories purchased the calves and equipment from the Ontario Farm and took over production of the vaccine. The calves were housed separately in one corner of the laboratory building, with their own operating room, a large enamel bath for bathing the calves, laboratories "for vaccine work only," and a separate entrance.[45]

Opposition to smallpox vaccination had been heated. In 1887 Montreal had erupted in riots, and protests took place in Toronto before and after the opening of the Connaught: in 1906, five thousand Toronto residents signed a petition to repeal the mandatory vaccination of schoolchildren, and a second successful campaign was waged in 1919.[46] The antivaccination groups were dismissed by public health officials – in his 1899 annual report Toronto's chief medical officer, Dr. Charles Sheard, called them "ignorant and superstitious" – and historians have, until recently, largely followed suit.[47] Michael Bliss dismissed antivaccinators as, simply, "wrong."[48] Recently historians have been more sympathetic. Katherine Arnup points out that fears of contamination by unhygienic vaccines, opposition to compulsion, and the accusations of class bias in the administration of vaccines in Toronto had some legitimacy. Jennifer Keelan argues from a careful study of the medical literature that the fears of the antivaccinators were often legitimate; she points out that in the early twentieth century science was not the prerogative of pro-vaccinators.[49] Whether historians will remain as sympathetic in the coming years, with new concerns about vaccination levels emerging, remains to be seen.

Much of the public anger was directed at the arrogance of the medical profession and the compulsion involved in mandatory health measures, but there was a distaste, even repugnance, at the use of animal products in human medicine. In *Bodily Matters: The Anti Vaccination Movement in England, 1853–1907*, Nadja Durbach notes: "Anti vaccinators repeatedly characterized vaccine matter as a 'loathsome virus derived from the blood of a brute' which could harbor animal diseases as yet unknown to humans."[50] The original vaccine matter was supposed by some to have come from a horse: "the stinking heels of an emaciated horse in the later stages of phthisis."[51] She describes widespread fears in the 1890s that the calf lymph would cause cow-like tendencies in children. Similarly, in the United States, Dr. J.F. Banton wrote that vaccination introduces a "bio-plasm, death laden – carrying all the vices, passions and diseases of the cow."[52] In 1906 a Toronto school board trustee echoed these concerns, demanding that "the arbitrary pollution of children's bodies in Toronto with animal matter be abandoned."[53]

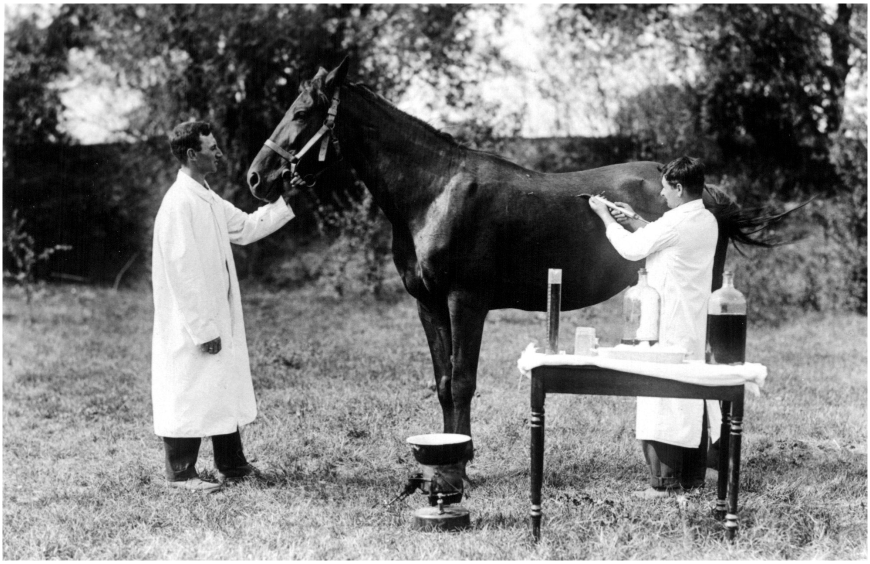
A public health disaster in St. Louis in 1901 heightened anxieties about the animal source of biomedical products. Antitoxin derived from a diphtheria horse called Jim killed several children, and it emerged that he was carrying tetanus. A report published in the *Canadian Journal of Medicine and Surgery* absolved Jim, but blamed the unhygienic conditions of the laboratory for the deaths, citing a *New York Times* editorial: "The business of producing virus and serum . . . cannot be carried on without immeasurable risk to life and health with worn-out horses and sickly calves, nor in dirty stables or improvised annexes to vermin infested barns. Healthy animals, perfect plants constructed and managed under expert supervision, and the assurance of pure cultures with entire freedom from pus organisms are the essential conditions."[54] In response, serum producers began to account for the origins, the history, and the health of their horses, and new standards for serum production were set in the United States.[55]

Distaste for the animality of the vaccine co-existed with concern for the welfare of the calf donor. In 1882 Henry Bergh, the president of the American Society for the Prevention of Cruelty to Animals, had raised the "barbarous and unnatural treatment to which animals are subjected" in his discussion of "the loathsome pestilence" that was vaccine in the *North American Review*.[56] The British *Vaccination Inquirer* wrote in 1895: "The luckless calves must be no longer strapped and fixed and shaved and scarified and poisoned and fastened in their stalls with fourscore aging sores on their bellies, and their tails tied over their backs, lest in seeking alleviation of their miseries for themselves they rupture their vesicles and ruin the stock-in-trade of the virus-mongers."[57] More research is needed to establish the connections, but it appears that antivaccination sentiments contributed to the rise of antivivisection movements in Canada. In 1920, when the Anti Vaccination League of Canada was restructured to become the Medical Liberty League, the antivivisectors created a separate entity, the Canadian Anti Vivisection League. Both movements appear to have collapsed in the 1920s with the success of diphtheria and tetanus antitoxin and the ascendancy of medical science.[58]

In 1906, the *Toronto Star* called for the medical profession to address the antivaccinators' concerns and make the case for vaccination: "If, therefor, medical scientists wish people to retain their faith in vaccination they must keep them constantly supplied with facts and arguments, and be ready to meet the opposition, not angrily, but patiently."[59] A few years later, as the Connaught opened, they did exactly that, providing the public with facts, as well as photographs, to reassure them of the hygiene, health, and happiness of the animals used to produce smallpox vaccine and tetanus and diphtheria antitoxins.

Reassuring the Public

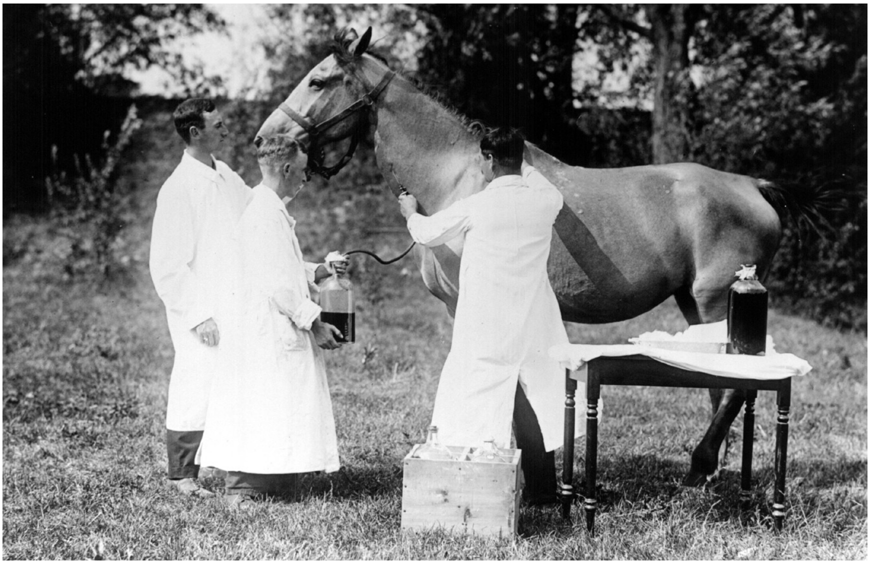
Tetanus antitoxin was not itself controversial but the patriotic production of tetanus antitoxin served to build support for the laboratories' other activities, and accustom readers to the use of animals in the production of biomedical products. On Saturday, 25 November 1916, almost a year before the official opening of the Connaught, an article appeared on the front page of the *Toronto Star* with a headline in red ink, "Anti toxin for Canadian Soldiers All Made at Toronto University," and a subtitle, "STAGES IN ANTI-TOXIN MANUFACTURE ILLUSTRATED FOR OUR READERS," with four photographs of handsome horses and clean laboratories. The article takes the reader through the process of antitoxin production, emphasizing the healthiness, and also the happiness, of the horses, and the scientific and hygienic methods. It first describes the production of tetanus toxin from the bacilli, describing it as a kind of alchemy taking place at the medical school in a "mysterious-looking room with long tables, glass cupboards filled with strange looking flasks and tubes." An accompanying photograph shows a white-coated man sitting at a lab table at the University of Toronto.[60] The scientific origins of the germ are established (the tetanus originated from Washington Laboratories), and the various germs are made familiar through domestic metaphors : tetanus and diphtheria germs are fed veal broth, and the meningitis germ "must, as the doctor said, change its boarding house every other day." Diphtheria,



6.1 "Injecting Toxin." Photographs familiarised the readers to the new uses to which animals were put, especially the intimate role of the horse as the heroic donor of biomedical products. This photograph, "Injecting Toxin," was published on the front page of the *Toronto Star*, 25 November 1916 to promote the war work of the laboratory. It is not likely that the photograph reflects the normal procedures. Acc1076. Courtesy of Sanofi Pasteur Canada (Connaught Campus) Toronto Archives.

tetanus, and meningitis germs are described as fussy children: "germs are very particular and must have things to their taste if they are to grow up to be fine hardy germs." At the end of three weeks, the article explains, each flask holds billions of germs.

The toxins are extracted from the flask and injected into the horse. After a few months, when the horse has accumulated enough "poison counteracting fluid," one to two gallons of blood is taken from the animal. The author is reassuring: "Now most people think that the bleeding causes the horse to suffer. As a matter of fact the horse hardly seems to notice the procedure but stands quietly and patiently while the blood is being taken. Of course, he may feel a little weak, but a good rest and several good feeds soon remedy that." An article published the same month in the Australian *Sydney Herald* makes the same point even more emphatically of tetanus horses at the Danish Serum Institute: "They feel well, and they are so well looked after that even old weak horses, which otherwise would



6.2 “Bleeding a Horse.” This photograph was published on the front page of the *Toronto Star* on 25 November 1916 to promote the war work of the laboratory. It was probably staged for this purpose; horses were normally restrained for this procedure. Acc1080A. Courtesy of Sanofi Pasteur Canada (Connaught Campus), Toronto Archives.

have been used for the manufacture of ‘guliasch’ now live, thrive and increase in weigh and even regain some of the friskiness of their youth.”[61] Accompanying photographs in the *Star* show white-coated scientists “inoculating a horse with tetanus germs” (this was an error: the toxin was injected) and then “drawing off some blood from the animal.”[62] The horses are large handsome creatures. A third photograph in the series, available in the Connaught Archives but not used in the *Star*, depicts a handsome horse with the caption “A Typical Antitoxin Horse.”[63]

The *Toronto Star* then followed the “great bottles of blood” to the laboratories at the University of Toronto, where it reported that the plasma was drawn off, and the antitoxin precipitated, filtered, scraped off, and tied into paper bags to be dissolved into water. Here the reporter strains to make the laboratory procedures familiar, describing paper bags of antitoxin as being “like Christmas puddings ready for boiling.” The final photograph shows a clean white laboratory room with a long line of flasks with paper filters in funnels with the caption “Filtering Anti-Toxin to Ensure its Purity.”[64] The flasks make the invisible antitoxin visible, and the white filter papers remind the reader once again of its purity. The description of the process created distance between the blood and the antitoxin: the red corpuscles were removed, leaving a bloodless yellow serum. As the antitoxin was precipitated, dried, and dissolved, the bloodiness and the horsiness disappeared, leaving only the active agent, the antitoxin. (Enough horse remained, however, to trigger allergic reactions in a percentage of the population.[65])

One year later, J.G. FitzGerald, director of the laboratories, wrote a similar article for the University of Toronto *Varsity Magazine* Supplement describing the opening of the laboratories. He emphasized the contribution made to the war effort, and the honour of their lab being selected as a reliable source for antitoxin. Photographs depict the horses in the new Connaught stables, a scientist in the lab, a horse being bled, antitoxin preparation, and the shipping room.[66] Another collage of photographs positioned prominently above FitzGerald’s desk in the laboratories presents these laboratory images in the context of bucolic photographs of country estate–type cottages and herds of tetanus horses, anti-meningitis horses, and diphtheria horses grazing on rolling meadows.[67]

The following year, his assistant director, Robert Defries, contributed another article to the *Varsity*. His message is much same as in the *Star*: he emphasizes the healthiness of the horses and purity of the toxin.

> In preparing this serum, healthy horses are selected and injected with increasing doses of the lockjaw poison. To obtain this poison, which is one the most powerful known, the germs are grown in a special broth for two weeks. The germs are removed by careful filtering, and the clear broth contains the poison. The poison is so powerful, that less than one thousandth of a drop will kill a small guinea pig. The horse, as the treatment is continued, produces an antitoxin to neutralise the poison, and finally after six or eight months is not in the least affected by very large amounts of the poison. The serum is then obtained from the blood of these horses, at regular intervals, and during the whole treatment the horses maintain good health.[68]

6.3 Photographs distributed by the Connaught Laboratories accustomed the public to the new assemblage of bacilli, laboratory animal, and scientist. They emphasised the hygiene of the laboratory procedures and the health of the horses. Robert Defries, "The War Work of the Connaught and Antitoxin Laboratories, University of Toronto," The Varsity Magazine Supplement (1918), 94-96. Courtesy of Sanofi Pasteur Canada (Connaught Campus) Toronto Archives.

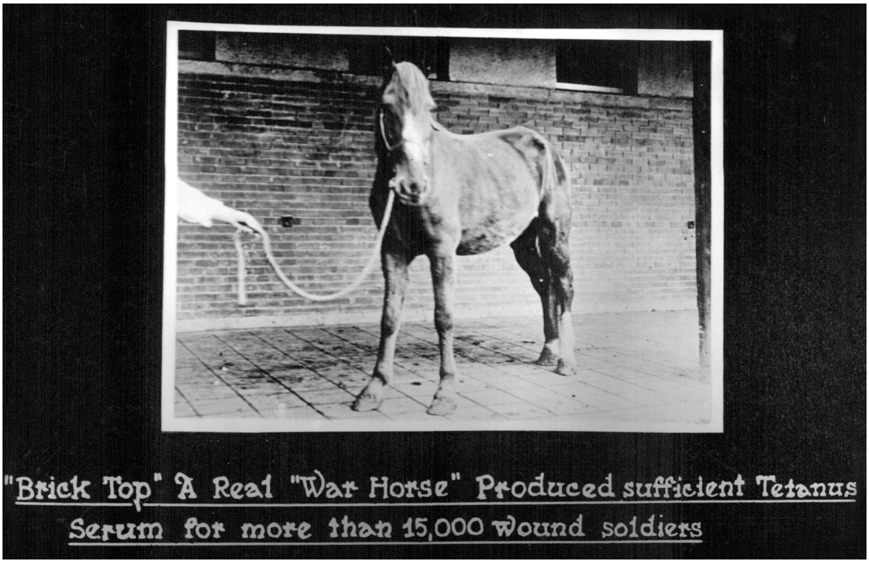
The invisible agents, *C. tetani*, toxin, and antitoxin, are made visible by their containment in gleaming glass flasks in a series of photographs. A photograph titled "Horses During Treatment" shows horses grazing under trees by a stream. "Withdrawing the Serum" shows a horse being bled in a spotless room. "A Ton of Tetanus Antitoxin" shows stacked boxes of antitoxin ready for shipment to the front. The photographs are professionally shot. They make the bacilli visible, the horses' role natural, and the scientists authoritative.[69] The glass flasks in the toxin laboratory contain, and define, the microbe. The antitoxin is made apparent by the rubber tubing running from the horse, the line of bottles labelled Tetanus Serum, and the boxes of antitoxin destined for soldiers in France. They serve to make the new *agencement* of bacilli, horse, and human familiar to readers.

Photographs

The photographs of horses disseminated by the Connaught Laboratories were elements in an emerging iconography of serum production. As Bert Hansen has observed, images of a healthy horse surrounded by white-coated scientists were a common trope of American serum therapy, intended to reassure the reader of the health of the animal, the hygiene of the procedure, and the purity of the final product. He traces their origin to November 1894, when *Scientific American* used three images of serum production that, as Hansen observes, "established the leading visual elements for all the successive depictions": a child being treated, laboratory technicians with glass flasks and tanks, and "docile and dignified horses patiently receiving injections or allowing their blood to be drawn."[70] These images were recirculated by the *New York Herald* in a campaign for the funding of a laboratory and stables for the New York Health Department. As the iconography developed, certain norms emerged. The horses are usually handsome animals, and stand calmly during the treatment, secured by metal railing. The technicians and handlers are white-coated, serious professionals. The glass bottles and instruments shine. The images culminate in a 1950s painting, *The Era of Biologicals,* by Robert A. Thom for the Parke-Davis series Great Moments in Pharmacy, depicting three anonymous technicians in white jackets, pants, and hats drawing blood from two horses.

J.G. FitzGerald had worked with the New York Health Department, and the Connaught campaign echoes that in the *Herald*. The initial photographs in the *Star* were, however, obviously and awkwardly staged. The horse stands on a rough lawn, secured only by a lead rope, and the scientific instruments are perched precariously on a side table on a white cloth. The first photograph, depicting the inoculation of the horse, is the most curious. Robert Defries described toxin injection as a hazardous procedure: "a slip of the injecting needle might result in the death of an operator, for the fatal dose of tetanus toxin for man is an infinitesimal amount," and he explains the precautions taken at the Connaught Laboratories: "Mr. Double developed the technique of injecting the horses and trained his assistants to exercise great care."[71] It seems unlikely that Defries would have authorized an injection of such a toxic agent in these circumstances: without any restraints, outside, where the horse could easily be startled. An article in the *New York Herald* in 1894 showed a "refractory" diphtheria horse strapped down on its side for inoculation, and the classic photograph shows a horse restrained by a stall of iron piping, and several attendants.[72] The second photograph, of the horse being bled, also depicts an unlikely scenario. It shows a full bottle of dark fluids, presumably blood, perched on the narrow table only inches from the horse, well within reach of a good kick, which the horse seems poised to deliver. Were the garden images an attempt to naturalize the procedure? Was the location necessitated by the lack of appropriate indoor spaces in 1916? Were the existing buildings on the Connaught property too barn-like, too unhygienic to be featured in a newspaper story whose intent was to reassure? The photograph used in FitzGerald's subsequent 1917 article is a classic serum horse photograph. The photograph is cropped to show only the horse's head and flank, restrained by iron pipes, and two men in white coats holding tubing of blood. Defries's 1918 collage also shows a much more likely image of a handsome horse restrained by iron piping in bright, clean, large windowed operating room, a safe and hygienic location for the inoculating and bleeding of horses.[73]

At the conclusion of Defries's article, however, is a separate, and somewhat incongruous photograph of an ungainly little horse, with the caption: " 'BRICK TOP.' A REAL WAR HORSE. Has supplied sufficient serum for 15,000 soldiers in his four years of service." Brick Top is awkwardly posed beside the brick wall of the stable on a dirty tile floor. His hipbones are



6.4 “Brick Top: A Real War Horse.” Photograph from Connaught Laboratory photo album. Acc0708A. Courtesy of Sanofi Pasteur Canada (Connaught Campus) Toronto Archives.

visible and his coat dull. His handler stands off camera, loosely holding the lead rope.[74] Brick Top also appears in two Connaught photo albums. Brick Top is such an unlikely candidate that the only explanation for his selection as a poster boy for the laboratory is that Brick Top was actually the horse that produced serum for 15,000 soldiers. There is no record of a Brick Top in the laboratory records, where most of the tetanus horses were identified by number, but it is possible he was T#17, who had at this point been bled 35 times over the course of three years.[75] The decision to give Brick Top a name, and a personality as a war hero, was typical of the equine serum narrative. In the United States, Dan, “the retired fire horse,” was given credit for saving 100,000 soldiers.[76] In his ordinary heroism Brick Top may have served as a stand-in for the maimed and worn veterans of the First World War.[77]

The serum horse imagery was intended to reassure the public of the health of the horse, the hygiene of the facilities, and the naturalness of the procedure. The awkwardness of the early Connaught photographs, and the transition to the image of the iconic serum horse, reveals the work

6.5 "Seeing her true friend. An Antitoxin producing horse at the Connaught Laboratory Farm." Color Lantern Slide. Ags020. Courtesy of Sanofi Pasteur Canada (Connaught Campus), Toronto Archives.

underlying this image. The tetanus horse images were later used in a colourized lantern slide on diphtheria horses, with photographs of beautiful horses and pretty children, and such headings as "Jack and Tom have produced Antitoxin for 3 years, saving many children's lives," and "Seeing her true friend. An Antitoxin producing horse at the Connaught Laboratory Farm."[78] The photographs build on much older, heroic, narratives of war horses and fire horses. They work with animal welfare narratives, like *Black Beauty*, to show animals in willing service to mankind. These ideas become woven into new narratives of science and modernity.

Canadians no longer live in terror of lockjaw. The assemblages described in this chapter no longer exist. We do not have horses, humans, and *C. tetani* jostling one another on city streets; nor do we have horses, scientists, and germs circulating through laboratory spaces. In 1927, scientists developed the tetanus vaccine. The weakened toxins in the vaccine induced the recipient to develop their own antibodies, conferring long-term immunity, and making antitoxin necessary only for the rare unvaccinated victim. The vaccine was widely available by 1938, just in time for the next world war, and it is now a routine part of childhood and adult immunization.[79] Curiously, the narratives and visual images continued to circulate long after the bacilli was defeated. The serum horse, like the fire horse, continues to serve as a potent image of animals in heroic service to humankind.

Notes

1 *Huron Expositor*, 11 September 1885.

2 Other species also shed tetanus spores, but the horse was the animal that did so most prolifically in the late nineteenth-century city.

3 Vinciane Despret, "From Secret Agents to Interagency," *History and Theory* 52, no. 4 (2013): 37. Although most of the literature in animal studies literature uses the English translation, "assemblage," this chapter follows Vinciane Despret and John Phillips in using Deleuze and Guattari's original French term *agencement*. Assemblage evokes a static collection of things, and does not fully capture the interactive and evolving nature of Deleuze and Guatarri's model. See John Phillips, "Agencement/assemblage," *Theory, Culture & Society* 23, nos. 2–3 (2006): 108–9, and Gilles Deleuze and Felix Guattari, *A Thousand Plateaus*, trans. B. Massumi (Minneapolis: University of Minnesota Press, 1987).

4 The story of tetanus has largely gone untold, as historians of immunological medicine have focused upon the parallel history of diphtheria, which Terra Ziporyn calls the darling of the bacteriological revolution. See Ziporyn, *Disease in the Popular American Press: The Case of Diphtheria, Typhoid Fever, and Syphilis, 1870–1920* (New York, Westport, CT, and London: Greenwood Press, 1988). See also Evelynn Maxine Hammonds, *Childhood's Deadly Scourge: The Campaign to Control Diphtheria in New York City, 1880–1930* (Baltimore and London: Johns Hopkins University Press, 1999).

5 I would like to thank Sanofi Pasteur Limited (Connaught Campus) for access to the records in their archives, and the invaluable assistance of archivist Christopher Rutty.

6 J.M.S. Pearce, "Notes on Tetanus (Lockjaw)," *Journal of Neurology, Neurosurgery, and Psychiatry* 60 (1996): 332.

7 Archibald MacMechan, *The Winning of Popular Government: A Chronicle of the Union of 1841* (Toronto, 1920), reprinted in *The Chronicles of Canada, Volume VII: The Struggle for Political Freedom*, ed. George Wrong and H.H. Langon, 235. See also Adam Shortt, *Lord Sydenham* (Toronto: Morang,

1908), 340: "Yet in the intervals of his suffering he continued, with characteristic fortitude, to devote himself to his duties, public and private." Even the dispassionate account of Sydenham's life in the *Dictionary of Canadian Biography* notes the agony of his death. Phillip Buckner, "Thomson, Charles Edward Poulett, 1st Baron Sydenham," *Dictionary of Canadian Biography*, http://www.biographi.ca/en/bio/thomson_charles_edward_poulett_7E.html (accessed 17 December 2015).

8 Statistics for the incidence of tetanus prior to the twentieth century are not available. The focus in this chapter is on generalized tetanus, which produced the classic symptoms of lockjaw. Neonatal tetanus was not understood at the time to be the same disease. See Sally G. McMillen, "No Uncommon Disease: Neonatal Tetanus, Slave Infants, and the Southern Medical Profession," *Journal of the History of Medicine and Allied Sciences* 46, no. 3 (July 1991): 291–314. See also Stephen J. Kenny, "'I can do the child no good': Dr. Sims and the Enslaved Infants of Montgomery, Alabama," *Social History of Medicine* 20, no. 2 (August 2007): 223–41. There are two other rare types of tetanus: localized tetanus and cephalic tetanus.

9 "DIED OF BLOOD POISONING: Orlo B. Dicken of the South Side Dies Sunday Morning," "MAY DIE OF LOCKJAW: Water Street Boy Suffering Intense Pain in Water Street Hospital," *Ottawa Citizen*, 3 August 1899.

10 Everett B. Miller, "Comparative Medicine: American Experience from Equine Tetanus – From Benjamin Rush to Toxoid," *Bulletin of the History of Medicine* 57, no. 1 (1983): 141; D. McEachran and Andrew Smith, *The Canadian Horse and His Diseases* (Toronto: J. Campbell 1867), 152. "Tetanus or Lockjaw in Horses," *The Canada Farmer* 3, no. 2 (15 January 1866): 23, describes how to treat a horse.

11 See accounts of horses' deaths in *The Canada Farmer*, 1, no. 11 (15 June 1864): 165, and "Disease of Horses and Cattle," *The Canadian Gentleman's Journal and Sporting Times* 7, no. 385 (10 January 1879): 1, and *The Illustrated Journal of Agriculture* 4, no. 7 (November 1882): 106. The last article describes the loss of a valuable team of draft horses and calls for the removal of nails from city streets. One article lists the causes of equine death, in cases with insurance in New York over five years, with tetanus coming 7th with 37 causes. *The Monetary Times, Trade Review and Insurance Chronicle* 24, no. 38 (20 March 1891): 1155.

12 See, for example, recommendations for smoke in the wound in "A Cure for the Most Dangerous of Wounds," *Northern Messenger* 24, no. 19 (20 September 1889): 3; "Cure for Lockjaw," *The Canadian Mute* 7, no. 18 (14 June 1889); and in *Newcastle Farmer* 3, no. 3 (November 1948). A warning against the use of cobwebs in wounds was published in "Death in the Cobweb," *The Northwest Review* 15, no. 51 (26 September 1900): 3. A tarnished copper penny was advised in "Remedy for Lockjaw," *The British American Cultivator* 2, no. 3 (March 1846). The *Journal of Agriculture and Horticulture* 2, no. 19 (1899): 4511, published in

Montreal, recommended salt pork on the wound.

13 *Epidemiology and the Prevention of Vaccine-Preventable Deaths*, 13th ed. (May 2015), available through the Centers for Disease Control, http://www.cdc.gov/vaccines/pubs/pinkbook/tetanus.html (accessed 17 December 2015).

14 *C. tetani* is now known to produce two exotoxins: tetanospasmin, which is one of the most potent toxins known and causes the symptoms of lockjaw, and tetanolysin, the function of which is still unknown.

15 Andrew Cunningham and Perry Williams, eds., *The Laboratory Revolution in Medicine* (Cambridge, UK: Cambridge University Press, 2002). For another perspective, see Morten Hammerborg, "The Laboratory and the Clinic Revisited: The Introduction of Laboratory Medicine into the Bergen General Hospital, Norway," *Social History of Medicine* 24, no. 3 (2011): 758–75.

16 Terra Ziporyn tracks the inconsistencies in media accounts of diphtheria in *Disease in the Popular American Press*.

17 Isabel Robb, *Nursing: Its Principles and Practice for Hospital and Private Use* (Montreal: W. Briggs, 1893), 435–36.

18 "That Awful Microbe," *Toronto Daily Mail*, 27 February 1888, 4. The story was attributed to the *New York Times*.

19 "The Nature of Tetanus," *Canada Lancet* (June 1889): 310.

20 "Diseases of Domestic Animals, Their Relation to the Human Family and Hygiene," *The Canada Health Journal: A Monthly Magazine of Preventative Medicine* 10, no. 2 (February 1888): 66; *Ottawa Journal*, 25 January 1900. The *Ottawa Journal* story continues: "Tetanus – the lockjaw germ – will, he says, disappear almost completely. It is in fodder that the germ is introduced into cities, and with the elimination of the horse that dread disease, lockjaw, will probably almost disappear." The story goes on build the case against the horse, arguing that in Paris, France, where the new automobile was being adopted, the horse caused more traffic fatalities than the automobile. An American newspaper, *Spokesman Review,* made the point more forcefully in 1913, in "Why Horses Are Among Man's Worst Enemies," *Spokesman Review*, 14 September 1913. For an interesting discussion of the incidence of tetanus in the decades following the disappearance of the horse, see "Tetanus in the United States, 1900–1969, Analysis by Cohorts," *American Journal of Epidemiology* 96, no. 4 (1972): 306.

21 The statistics can be found in the Canadian census. The ratio of horse to human was also high in other Canadian cities in 1891, ranging between 1 to 18 in Ottawa and 1 to 41 in Saint John. Margaret Derry estimates that the world population of horses peaked between 1910 and 1920 at 110 million horses, double the horse population of a century earlier, and four times that of 1720, before the industrial age: Margaret Derry, *Horses in Society: A Story of Animal Breeding and Marketing Culture, 1800–1920* (Toronto: University of Toronto Press, 2006), 47. Derry cites Harold B. Barclay, *The Role of the Horse in Human Culture*

(London: J.A. Allan, 1980), 339. For US statistics see Clay McShane and Joel A. Tarr, *The Horse in the City: Living Machines in the Nineteenth Century* (Baltimore: Johns Hopkins University Press, 2007), 16, and Ann Norton Greene, *Horses at Work: Harnessing Power in Industrial America* (Harvard University Press, 2008), 166. For British numbers see F.M.L. Thompson, "Horses and Hay," in *Horses in European Economic History: A Preliminary Canter,* ed. F.M.L. Thompson (Reading, UK: British Agricultural History Society, 1983). Thompson has calculated that the ratio of urban horse to urban human in England rose from 1 to 30 in 1830 to 1 to 20 in 1900. For a discussion of the many ways that horses powered the modern city, and their impact on urban life, see Joanna Dean and Lucas Wilson, "Horse Power in the Modern City," in *Powering Up: A Social History of Power, Fuel and Energy from 1600*, ed. Ruth Sandwell (Montreal and Kingston: McGill-Queens University Press, 2016).

22 Ann Greene estimates that in the United States the average draft horse increased in size from 900–11,000 pounds in 1860 to 1,800–2,000 pounds in 1880. Greene, *Horses at Work*, 174. Leah Grandy has observed that photographs show noticeably larger horses in the streets of Saint John, New Brunswick, after 1901. Leah Grandy, "The Era of the Urban Horse: Saint John, New Brunswick, 1871–1901" (MA thesis, University of New Brunswick, 2004).

23 Joel Tarr, "Urban Pollution: Many Long Years Ago," *American Heritage Magazine* (October 1971), available at http://www.banhdc.org/archives/ch-hist-19711000.html (accessed 26 January 2015). Toronto's attempts to manage manure are described in P.M. Hall, "Disposal of Manure," Paper read before the Section of Public Officials, American Public Health Association, September 1913. For discussion of stable flies, see Nigel Morgan, "Infant Mortality, Flies and Horses in Later-Nineteenth-Century Towns: A Case Study of Preston," *Continuity and Change* 17, no. 1 (May 2002): 97–132, and Patricia Thornton and Sherry Olsen, "Mortality in Late Nineteenth Century Montreal: Geographic Pathways of Contagion," *Population Studies* 65, no. 2 (2011): 157–81.

24 In Toronto, for example, there were 1,102 dairy cows in 1861, 500 in 1891, and 29 in 1911. Sean Kheraj, "Living and Working with Animals in Nineteenth-Century Toronto," in *Urban Explorations: Environmental Histories of the Toronto Region*, ed. L. Anders Sandberg, Stephen Bocking, Colin Coates, and Ken Cruikshank (Hamilton, ON: L.R. Wilson Institute for Canadian History, 2013), 120–40, esp. 126.

25 For a description of the regulation of dogs in Toronto during this period, see Amanda Sauermann, "Breeding and Exhibition of the Canine Body in Canada" (MA thesis, Carleton University, 2011).

26 In 1914, 443 deaths from diphtheria were reported in Ontario (16.7 per 100,000 population) and 654 in Quebec (31 per 100,000). The story of FitzGgerald funding his laboratory from his wife's dowry is widely told.

27 This account of the early history of the Connaught Laboratories is drawn largely from Robert D. Defries, *The First Forty Years, 1914–1955: Connaught Medical Research Laboratories, University of Toronto* (Toronto: University of Toronto Press, 1968). See also Paul A. Bator and A.J. Rhodes, *Within Reach of Everyone: A History of the University of Toronto School of Hygiene and the Connaught Laboratories, Vol. 1, 1927–1955* (Ottawa: Canadian Public Health Association, 1990), and Paul A. Bator, *Within Reach of Everyone: A History of the University of Toronto School of Hygiene and the Connaught Laboratories, Vol. 2, 1955–1975, With an Update to 1994* (Ottawa: Canadian Public Health Association, 1995); Christopher J. Rutty, "Robert Davies Defries (1889–1975)," in *Doctors, Nurses and Medical Practitioners: A Bio-Bibliographical Sourcebook*, ed. L.N. Magner (Westport, CT: Greenwood Press, 1997), 62–69; Pierrick Malissard, "Quand les universitaires se font entrepreneurs: les laboratoires Connaught et l'Institut de Microbiologie et d'hygiène de l'Université de Montréal, 1914–1972" (PhD diss., Université du Québec à Montréal, 1999).

28 Pierrick Malissard describes multipurpose laboratories as ingenious devices for ensuring research funding. Pierrick Malissard, "Les 'start up' de jadis: la production de vaccins au Canada," *Sociologie et societes*, 32, no. 1 (2000): 93–106.

29 Defries repeatedly states in *The First Forty Years* that the Connaught Laboratory building housed 20 horses, but the floor plan shows only 15 stalls.

30 A full accounting of the assemblage in the Connaught Laboratories should include the humble guinea pig. These small animals would be infected with tetanus, and then given varying doses of antitoxin. The amount required to save the guinea pig would determine the strength of the antitoxin. By the time the building was opened the guinea pig room had been redesignated for future laboratory space, and two neighbouring buildings were cobbled together to house the colony. Defries notes that the colony had thrived in the original Barton Street stable, where it had grown to 500 guinea pigs, but struggled in the new location, and eventually succumbed to a streptococcic infection. It was replaced by a new strain from the Lister Institute in London in 1930. Defries, *The First Forty Years*, 315. Guinea pigs appear once in FitzGerald's laboratory book, when it is recorded that the guinea pig given 450 units of antitoxin lived 8 hours longer than the untreated guinea pig, and the pig given 500 units lived for 88 hours. Record book labelled, "Dept Hygiene, Record Diphtheria and Tetanus Antitoxin Refining. Book 2. Commencing October 12, 1917 Ending Feb 22, 1917," Sanofi Pasteur Limited (Connaught Campus) Archives. A newspaper article on "the humble guinea pig" made no reference to the guinea pig's heroism: "The horse actually supplies the serum but the little pig acts as a meter, in order the mixture may be of the right strength. A group of guinea pigs would be given a fatal dose of toxin, and varying amounts of antitoxin," *The Globe*, 21 November 1925, 14. For background on the standardization of serum, see

Christoph Gradmann and Jonathan Simon, eds., *Evaluating and Standardizing Therapeutic Agents, 1890–1950* (London: Palgrave Macmillan, 2010).

31 Robert D. Defries, "The War Work of the Connaught and Antitoxin Laboratories, University of Toronto," *The University of Toronto Varsity Magazine Supplement* (1918), 94–96.

32 "Report of Tetanus Cases, for the month ending March 1918," Sanofi Pasteur Limited (Connaught Campus) Archives. The chart notes: Toxin Dose; Date Started; No. of Bleedings; Date of Last Bleeding. The earliest horse, T#21, started on April 7, 1915, and had been bled 35 times by March 1918. T#17 started May 31, 1915 and had been bled 30 times; T#1 started January 1916, and had been bled 15 times; T#6 was also started January 1916 and had been bled 17 times; T#25 had been bled 9 times; T#26 had been bled 4 times. Of T#29 through T#34, who had been started 5 or 6 September 1917: T#30 and T#31 had been bled 3 times, T#32 had been bled once, T#29 had not yet been bled. Nor had T#8, who had been started 3 August 1917, or horses T#34 through T#42, started in early 1918, presumably because their antibody levels were not yet high enough. The chart also has a column for General Condition, which is not filled out.

33 Record book labelled "Dept Hygiene, Record Diphtheria and Tetanus Antitoxin Refining. Book 2. Commencing October 12, 1917 Ending Feb 22, 1917," Sanofi Pasteur Limited (Connaught Campus) Archives.

34 There is some confusion in the record book, as horse 11 is bled out on 13 November (10,600 cc) but appears once again in the record book on 28 November, when 9,700 cc is recorded as having been taken. However, horse 11 does not appear again. Horse 19 is bled out on 20 June 20 1917, when 24,800 cc was taken.

35 "Connaught Laboratories, University of Toronto," pamphlet at Sanofi Pasteur Limited (Connaught Campus) Archives. Undated, but the reference to three brick stables (p. 49) dates it after the period under discussion here.

36 David Bruce, "Tetanus: Analysis of One Thousand Cases," Presidential Address, *Transactions of the Royal Society of Tropical Medicine and Hygiene* 11, no. 1 (November 1917): 1–53.

37 P.C. Wever and L. van Bergen, "Prevention of Tetanus during the First World War," *Med. Humani* 38, no. 2 (December 2012): 78–82.

38 "Splendid Gift to the University," *Mail and Empire*, 26 October 1917.

39 *The Globe*, 25 October 1927, 13.

40 Defries, *The First Forty Years*, 24. The lab also supplied the needs of the Armed Services for smallpox vaccine.

41 *Contract Record*, 24 October 1917, 882.

42 *Construction* 11, no. 5 (May 1918). The photographs are attributed to Stevens and Lee, Architects, and a blueprint is included.

43 This description is drawn from Jennifer Keelan's excellent thesis. Jennifer Keelan, "The Canadian Anti-Vaccination Leagues, 1872–1892"

(PhD thesis, University of Toronto, 2004). The process of smallpox vaccine production had changed in the late nineteenth century. In "arm to arm" vaccination with human lymph, lymph was taken from the pustules of cows infected with cowpox and used to initiate a chain of infection that was passed directly from vaccinated child to unvaccinated child. Concerns about sharing human disease through the lymph led to its replacement by the use of vaccine points impregnated with animal lymph. Keelan notes that the history of the shift in methods is still poorly understood. See also Keelan, "Risk, Efficacy, and Viral Attenuation in Debates over Smallpox Vaccination in Montreal, 1870–1877," in *Crafting Immunity: Working Histories of Clinical Immunology*, ed. Kenton Kroker, Jennifer Keelan, and Pauline M.H. Mazumdar (Aldershot, UK: Ashgate, 2008), 29–54.

44 W.B. Spaulding, "The Ontario Vaccine Farm, 1885–1916," *Canadian Bulletin of Medical History* 6 (1989): 45–56. See also Pierrick Malissard, "'Pharming' à l'ancienne: les fermes vaccinales canadiennes," *Canadian Historical Review* 85, no. 1 (2004): 35–62.

45 One photograph in the Connaught collection shows the calf splayed on the operating table, with the white-coated scientist harvesting serum. Photograph Acc1125. Photographs from an album, labelled CAL 1918 album – B3 Smallpox 2 and Smallpox1, show the operating table and enamel bath for the calves. Another, a collage, shows the white-coated technicians "Bathing Calf before Vaccination, "Acc0094. This photograph appears in Robert Defries's 1918 article in the *Varsity Magazine Supplement*, along with photographs with the captions, "Vaccine Unit," and "Feeding the calf after vaccination." Photographs in Sanofi Pasteur Limited (Connaught Campus) Archives. For a discussion of these photographs, see Joanna Dean, "Animal Matter: The Making of Pure Bovine Vaccine at the Connaught Farm and Laboratory at the Turn of the Century," blog post, *Active History,* 2 April 2015, http: http://activehistory.ca/2015/04/animal-matter-the-making-of-pure-bovine-vaccine-at-the-connaught-laboratories-and-farm-at-the-turn-of-the-century/ (accessed 17 December 2015).

46 See Paul Adolphus Bator, "The Health Reformers versus the Common Canadian: The Controversy Over Compulsory Vaccination against Smallpox in Toronto and Ontario, 1900–1920," *Ontario History* 75 (1983): 348–73; Barbara Tunis, "Public Vaccination in Lower Canada, 1815–1823: Controversy and a Dilemma," *Historical Reflections* 9, nos. 1/2 (Winter 1982): 264–278; Katherine Arnup, "Victims of Vaccination?: Opposition to Compulsory Immunization in Ontario, 1900–1990," *Bulletin canadien d'histoire de la médecine* 9, no. 2 (1997): 159–76; Jennifer Keelan, "Risk Efficacy and Viral Attenuation in Debates over Smallpox Vaccination in Montreal, 1870–1877," 29–54, and Christopher J. Rutty, "Canadian Vaccine Research, Production and International Regulation: Connaught Laboratories and Smallpox Vaccines, 1962–1980," 273–300, in *Crafting Immunity*; Heather MacDougall, *Activists and Advocates:*

Toronto's Health Department 1883–1983 (Toronto: Dundurn, 1990), and Keelan, "The Canadian AntiVaccination Leagues, 1872–1892." For earlier, scattered opposition see Barbara Lazenby Craig, "State Medicine in Transition: Battling Smallpox in Ontario, 1882–1885," *Ontario History* 75, no. 4 (December 1983): 319–47; and Barbara Craig, "Smallpox in Ontario: Public and Professional Perceptions of Disease, 1884–1885," in *Health, Disease and Medicine: Essays in Canadian History*, ed. Charles G. Roland (Toronto: Hannah Institute for the History of Medicine, 1984), 230. There are some slight discrepancies between Arnup's account and that of Heather MacDougall in *Activists and Advocates*. MacDougall describes the formation of the Toronto Anti-Compulsory Vaccination League by Dr. Alexander Ross in 1888, and says it re-emerged in 1900 as the Toronto Anti Vaccination League. Arnup describes the league as a national body. She says the league was renamed The Anti-Vaccination and Medical Liberty League in 1920; McDougall refers to this later organization as the Medical Liberty League, which may reflect common usage. For the United States, see Martin Kaufman, "The American Anti-Vaccinationists and Their Arguments," *Bulletin of the History of Medicine* 41 (1967): 463–78, esp. 470–71; James Colgrove, "'Science in a Democracy?' The Contested Status of Vaccination in the Progressive Era and the 1920's," *Isis* 96, no. 2 (2005): 167–91. For Britain see Nadja Durbach, *Bodily Matters: The Anti-Vaccination Movement in England, 1853–1907* (Durham, NC: Duke University Press, 2005), 113.

47 Sheard is cited in MacDougall, *Activists and Advocates*, 123.

48 Michael Bliss, *Plague: A Story of Smallpox in Montreal* (Toronto: Harper Collins, 1991), 212.

49 Durbach is not unsympathetic to the charges by the *Vaccination Inquirer* that "the vaccinators not only come into [the Englishman's home], but they get inside his skin, and invade his veins, so his blood is not his own," *Vaccination Inquirer*, June 1881, 50. Cited in Durbach, *Bodily Matters*, 113.

50 Gibbs, *Our Medical Liberties*, 8, cited in Durbach, *Bodily Matters*, 125.

51 Eadon, *Vaccination*, I, cited in Durbach, *Bodily Matters*, 125. Human-derived lymph was understood to have exposed children to a range of human diseases, notably syphilis.

52 Cited in Kaufman, "The American Anti-Vaccinationists," 471.

53 "Vaccination Optional Now, " *Toronto Daily Star*, 2 March 1906, 7. Cited in Arnup, "Victims of Vaccination," 161.

54 W.R. Inge Dalton, MD, "Responsibility for the Recent Deaths from the Use of Impure Antitoxins and Vaccine Virus," *Canadian Journal of Medicine and Surgery* 11, no. 1 (1902): 36.

55 See, for example, the *Pittsburgh Press*, 3 November 1901. The article says that all the horses from which serums are taken for making diphtheria and other antitoxins are obtained from the fire and police departments. "The majority had been used by the city for some time so it is well known where they come from and what their

associations have been previous to being turned over to the health bureau."

56 H. Bergh, "The Lancet and the Law," *North American Review* 134, no. 303 (February 1882): 161–70. He writes: "In the period of less than one hundred years, millions upon millions of sound and healthy human beings have been inoculated with the most loathsome pestilence, doomed to carry to the grave bodies wasted by consumption, or marred and deformed by scrofula, cancer and innumerable ills." For Canadian antivivisection sentiment, see J.T.H. Connor, "Vivisection and Biomedical Research in Victorian English Canada," *Canadian Bulletin of Medical History* 14 (1997): 37–64.

57 *Vaccination Inquirer*, 1 July 1895. Cited in Durbach, *Bodily Matters*, 144.

58 The discovery of antitoxin has been described by James Turner, Harriet Ritvo, and Susan Lederer as a critical moment in the history of animal welfare movements. As Ritvo says: "Continuing advances in immunology and other areas protected biomedical research from antivivisectionist protest for much of the first part of this century, as did the prestige enveloping the entire scientific enterprise." Harriet Ritvo, "Plus ca Change: Antivivisection Then and Now," *Bioscience* 34 (1984): 626–33, esp. 630; Susan E. Lederer, "Political Animals: The Shaping of Biomedical Research Literature in Twentieth-Century America," *Isis*, 83, no. 1 (1992): 61–79; James Turner, *Reckoning with the Beast* (Baltimore: Johns Hopkins University Press, 1980). See also Nicolaas A. Rupke, ed., *Vivisection in Historical Perspective* (London: Routledge, 1987). Terra Ziporyn notes of diphtheria antitoxin that "few articles about immunization technique failed to reassure the readers that the horses were well treated." Many, she notes, concluded with a dig at antivivisectionists: "the wondrous antitoxin alone, they proclaimed, should end any concerns about the horrors of animal sacrifice." Ziporyn, *Disease in the Popular American Press*, 35.

59 "Vaccination," *Toronto Daily Star*, 7 March 1906, 6. Cited in Arnup, "Victims of Vaccination," 163.

60 This appears to be the room used for toxin production. The large cupboard to the left appears in two photographs of the toxin production laboratory at the Connaught. Photograph CAL 1918, album-B3LAB, Sanofi Pasteur Limited (Connaught Campus) Archives. The article does not distinguish between the "germ" and the spore, saying only that the tetanus germ has been known to live fifty years, and survive boiling.

61 *Sydney Herald*, 22 November 1916. The article continues: "Before the war nobody was sure as to the importance of this serum. Now it is quite certain that the effect of it is wonderful. After having introduced the rule that all wounded are to receive an injection of serum – and it has been introduced, both with the Central Powers as well as the British and French, and it is also being introduced with the Russian army – tetanus has, to all practical purposes, disappeared. Thousands and thousands of human lives have been saved in this manner." A similar feature article in the *New York Times* extolled a

diphtheria horse with this series of headlines in 1895: " 'No. 7' A Valuable Horse. Has Furnished the Health Board with 15 Quarts of Antitoxine. Bought for $10; Worth $5,000. Gaining Flesh While Losing Blood and Does Not Appear to Be at All Dissatisfied in His New Role." *New York Times*, 26 March 1895, p. 3, col. 4. Cited in Bert Hansen, *Picturing Medical Progress from Pasteur to Polio: A History of Mass Media Images and Popular Attitudes in America* (New Brunswick, NJ: Rutgers University Press, 2009), 291.

62 The original photographs are Acc1077A (toxin injection), and Acc1080S (bleeding), Sanofi Pasteur Limited (Connaught Campus) Archives. The text notes correctly that it was the tetanus toxin that was injected, rather than tetanus germs.

63 The third photograph is CAL 1918 Album, Sanofi Pasteur Limited (Connaught Campus) Archives. The photograph does not appear in the *Star* but it has the same background, and is positioned in a photograph album with the photographs used in the Star.

64 A similar photograph is Acc0995, Sanofi Pasteur Limited (Connaught Campus) Archives.

65 British military policy was to give injured soldiers four doses, once every seven days, to keep the level of antitoxin high. Because the first dose could activate an allergy to the horse, the reactions to the second and third doses could be fatal, and the army found that the effectiveness of the antitoxin had to be factored against the allergies it created. Sir David Bruce, "Tetanus: Analysis of 1458 cases, which occurred in Home Military Hospitals during the years 1914–1918," *Journal of Hygiene* 19, no. 1 (July 1920): 1–32.

66 J.G. FitzGerald, Director, "The War-Work of the Connaught and Antitoxin Laboratories," *The Varsity Magazine Supplement*, 3rd ed. (1917), 54–56. The photograph of antitoxin preparation depicts a demonstration table, probably at the opening ceremonies for the laboratory, with a young woman demonstrating the various stages of antitoxin purification.

67 The collage is photograph Acc0094. The collage can be seen above FitzGerald's desk in an early photograph of the laboratory, Acc0690. Sanofi Pasteur Limited (Connaught Campus) Archives.

68 Robt. D. Defries, MD, DPH, Associate Director, "The War Work of the Connaught and Antitoxin Laboratories, University of Toronto," *The Varsity Magazine Supplement*, 4th ed. (1918), 94–96.

69 Kenton Kroker describes the process of making the invisible visible: "Extraction, filtration, cultivation and inoculation produced cultures of microbes of considerable purity, which could be then be viewed with light microscopes and their associated technologies of stains and filters." Kenton Kroker, "Immunology in the Clinics: Reductionism, Holism or Both?," in *Crafting Immunity*, 107–44.

70 "The New Cure for Diphtheria: Drawing the Serum from the Horse," *Scientific American* 71, no. 20 (17 November 1895): 309. Cited in Hansen, *Picturing Medical Progress*, 93. The image recirculated,

appearing in the *New York Herald*, 12 December 1894, and *Leslies Illustrated Weekly*, 17 January 1895.

71 Defries, *The First Forty Years*, 23.

72 "Inoculating a Refractory Horse," *New York Herald*, 17 December 1894, 4. Cited in Bert Hansen, "New Images of a New Medicine: Visual Evidence for the Widespread Popularity of Therapeutic Discoveries in America after 1885," *Bulletin of the History of Medicine* 73. no. 4 (1999): 629–78.

73 Photograph Acc1076, Sanofi Pasteur Limited (Connaught Campus) Archives. See also Plate 38 in Defries, *The First Forty Years*, which shows a new animal operating room, built in 1928, with a large tilt table prominently positioned.

74 Photograph Acc0708C, and Acc0708A, Sanofi Pasteur Limited (Connaught Campus) Archives.

75 One American story was titled "Exfire Horse Saves Many Lives." Dan the retired fire horse had, according to the story, saved 100,000 European soldiers through his serum, and a Dr. Parks was quoted as saying that the example of the horses at Otisville was a consummate example of service which no human ever excelled. *Gettysburg Times*, 3 January 1917, 3.

76 After the war J.G. FitzGerald made an even greater claim for what was presumably another horse: "To have saved the lives of between 20,000 and 30,000 men is a record of which any man might be justly proud, and this is the record of a horse at the farm of the University of Toronto, which is run by the Connaught Research Laboratories."

77 Credit for this observation should go to Ann Greene, at the 2015 annual meeting of the American Society for Environment History.

78 The lantern slide image of a tetanus horse is identified as Ags288, Sanofi Pasteur Limited (Connaught Campus) Archives. It is likely that these were the images were used in promotional lectures given by FitzGerald in 1927. The photographs with the captions quoted are Ags019, Ags020, Sanofi Pasteur Limited (Connaught Campus) Archives.

79 David W. Fraser, "Tetanus in the United States, 1900–1969," *American Journal of Epidemiology* 96, no. 4 (1972): 306–12. Fraser documents a steady decline in the incidence of deaths from tetanus from 1900, and argues: "Decreasing exposure to tetanus spores or improvement in non specific wound care may have had more effect than immunization in lowering tetanus mortality rates over the last 70 years." This is hard to reconcile with what we know of horse populations. Urban horse populations declined with the invention of the electric streetcar in the 1890s, but their numbers continued strong until after the First World War, and the bacilli remained active for a number of years in the soil.