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Article Title: Hog Cholera, Texas Fever, and Frank S Billings: An Episode in Nebraska Veterinary Science

Full Citation: Richard A Overfield, "Hog Cholera, Texas Fever, and Frank S Billings: An Episode in Nebraska Veterinary Science," *Nebraska History* 57 (1976): 99-128.

URL of article: <http://www.nebraskahistory.org/publish/publicat/history/full-text/NH1976VetSci.pdf>

Date: 6/2/2015

Article Summary: In the summer of 1886, Frank S Billings arrived in Lincoln anticipating a position with the University of Nebraska, anxious to tackle the immense problems of the contagious diseases of Nebraska's farm animals. Thus began a short but turbulent relationship between Billings and fellow scientists, stock growers, and state and university officials, bringing both praise and criticism to the university and the state.

Cataloging Information:

Names: Frank S Billings, Rudolf Virchow, D E Salmon, Irving J Manatt, Charles E Bessey, Theobald Smith, H J Detmers, L L Seiler, John Thayer, Julius Gerth Jr, H H Wing, J H Sanders, Norman J Colman, T J Burrill, M Bolton, E O Shakespeare, Henry Wallace, C H Walker, S C Bassett, W L Williams, George Cadwell, James H Canfield, H E Heath, Charles F Manderson, Charles H Gere

Keywords: [Note that a large number of government agencies and organizations were referenced in this article and only those considered most notable are indexed here]: Bureau of Animal Industry (BAI); Patho-Biological Laboratory; Nebraska Agricultural Experiment Station; Nebraska Stock Breeders' Association; Nebraska State Board of Agriculture; *Greenhut vs Pearson*; USDA; *Farmers' Bulletin No. 8*; University of Nebraska; United States Veterinary Medical Association; *American Men of Science*

Photographs / Images: Portrait, Frank S Billings about 1880; Drawing of an attack of Cholera; Drawing of Patho-Biological Laboratory of the State University of Nebraska about 1888; 1899 vaccinating outfit for blackleg in cattle, cost \$5.00; Hog ranch on Goose Creek in Cherry County about 1901

**HOG CHOLERA, TEXAS FEVER,
AND FRANK S. BILLINGS:**
An Episode in Nebraska Veterinary Science

By Richard A. Overfield

In the summer of 1886, Frank S. Billings arrived in Lincoln anticipating a position with the University of Nebraska and anxious to tackle the immense problems of the contagious diseases of Nebraska's farm animals. Thus started a short but turbulent relationship between Billings and fellow scientists, stockgrowers, and state and university officials, a relationship that was to bring both praise and criticism to the university and to the state.

Billings was already a well-known medical veterinarian, and few Americans at that time could equal him in training, particularly in microbiology. Born in Massachusetts in 1845, he was the first American to graduate from a German veterinary school, the Veterinary School and Medical Department in Berlin, where he studied from 1875 to 1879. He added to his knowledge of new pathological techniques during 1879-1881 and 1883-1885 as a special student of the leading German pathologist, Rudolf Virchow. Before journeying to Nebraska, he had been pathologist for the New York Polyclinic Medical School, and he had gained national attention by taking a group of boys from Newark, New Jersey, who had been bitten by rabid dogs to Paris for treatment by Louis Pasteur.¹

Exciting developments then were occurring in medicine. In the 1870's, the germ theory of disease became a topic of study in the United States, and a small number of microbiologists began to solve the details and difficulties associated with the theory.

Potentially the germ theory could provide a systematic explanation for disease, and for agriculture it could lead to preventives or cures for such costly animal disorders as pleuropneumonia, tuberculosis, Texas fever, and hog cholera. Frank Billings was a leading advocate of the germ theory of disease, and by the 1880's he, among others, had largely converted the new professional veterinarians to the theory.²

The problems of diseased animals, while not new, were of increasing importance to Nebraskans and other stockgrowers by the 1870's and 1880's. The livestock industry was rapidly expanding and the railroad and new urban markets made contagious diseases an interstate and even an international concern. By the mid-1870's the United States Department of Agriculture (USDA) estimated that animal losses in the United States approached \$100,000,000 annually, and in response the national government began organizing work in veterinary medicine and hiring researchers. This effort was formalized with the creation of the Bureau of Animal Industry (BAI) in 1884, yet by 1886 scientists had not eliminated any of the major contagious diseases of concern to stockmen.³

Continued outbreaks of hog cholera attracted Billings to Nebraska. He first approached university officials and congressmen from Nebraska in 1886 about using their influence to persuade the BAI to hire him to study cholera in their state. Unable to convert the bureau's chief, D. E. Salmon, to his plan, Billings moved with his family to Lincoln anyway, feeling university and state officials were interested enough to finance his work.⁴ When Billings had visited Lincoln earlier in the year, the Board of Regents of the university indicated that they wanted a veterinarian, and in June they authorized Chancellor Irving J. Manatt "to arrange with Billings for the introduction and conduct of experiments and other service looking toward the establishment of a department of veterinary science."⁵ This marked the beginning of the Patho-Biological Laboratory, a pioneering venture in which a state institution hired a full-time researcher to study contagious diseases of domestic animals.

Established at the university farm, Billings moved at once to uncover the secrets of animal disorders. Firmly convinced of the bacterial nature of hog cholera and Texas fever, Billings followed the newly-formulated procedures of identification of the microorganisms involved and clarified some of the difficulties



Frank S. Billings, about 1880. (Courtesy University of Nebraska-Lincoln Archives)

encountered for the past decade by investigators. At this time, what researchers looked for in bacterial diseases was the presence of the microorganism in the fluids of the animal before decomposition began. They then tested the suspected microorganism by growing a pure culture, inoculating an animal with the pure culture, and producing the same disease as obtained naturally. Thus the tests required a proper identification of the germ responsible, post-mortem appearances in the diseased parts of the animal, and transmitting the disease from pure cultures. Each of these tests posed serious problems. Investigators, for example, when consistently finding more than one bacteria present in the diseased organs, as usually happened, had difficulty determining which was the primary cause of the disease and which were merely accompanying or secondary factors. In many cases the number of post-mortems were few on which descriptions were based. When inducing the disease from a pure culture, proper techniques were still primitive and involved problems of culture mediums, contamination, and methods of hypodermic injections. In addition, terminology was lacking to communicate to others what one was examining, and there were no standards as to what characteristics were important in describing bacteria.⁶

Despite these complications, within one year Billings claimed to have discovered the basic nature of the two most dreaded diseases of the area, hog cholera and Texas or Southern fever. Reporting to the regents in December 1887, Billings stated that "during the past summer I was enabled to completely work out the germ cause of Texas fever and the whole nature of that disease as it had never been done before and this leaves nothing further to be done." He had accomplished this, he claimed, at the expense of only \$200. In addition, he believed that he had found a preventive vaccination for hog cholera to be "absolutely possible."⁷ Dean Charles E. Bessey, director of the Nebraska Agricultural Experiment Station and one of America's leading botanists, was more cautious in his report to the regents regarding Billings' work. He stated that "while it is still too early to venture an opinion as to the results [of the hog cholera experiments], I am warranted in saying that it is one of the most important labors ever undertaken by the University."⁸

The claims of Billings regarding the nature of hog cholera and Texas fever immediately brought him into conflict with other

investigators, particularly D. E. Salmon and Theobald Smith of the BAI. Salmon had worked for the USDA since 1879 and was chief of the BAI since its creation. Smith was a graduate of Cornell University, as was Salmon, and was largely responsible for conducting the research of the BAI.⁹ Like Billings, Salmon and Smith far surpassed most Americans at this time in their knowledge of pathological methodology and likewise were firm adherents to the germ theory of disease.¹⁰ When Salmon began his study of hog cholera in the early 1880's, there were numerous conflicting claims as to which microorganism caused the disease. As Salmon continued, he believed the contradictory findings of different investigators resulted from attributing the various symptoms and bacteria found to one disease. He had proof, he claimed, that the swine diseases in the United States, Germany, and England were different diseases instead of one, and in 1885 he announced, in his multiple disease theory, that there was not one hog cholera in the United States but two, which he differentiated as hog cholera and swine plague. Salmon expanded on these claims during the next several years.¹¹

The multiple disease theory of hog cholera ran counter to and largely ignored the studies of Billings. The Nebraska scientist Billings believed that if any work other than his own deserved recognition it was that of H. J. Detmers of Ohio and not that of Salmon. Billings attacked not only the scientific findings of Salmon and the BAI, but more particularly he criticised the general operations of the agency. In references to the "Salmonica College of Veterinary Scalawags" and the "Bureau of Animal Idleness," Billings charged that the government had been negligent in its pursuit of contagious diseases. With the facilities and money available, the BAI should have solved more of these problems. After all, he claimed to have solved the questions of hog cholera and Texas fever in a little over one year when the USDA had been working for nearly a decade without success. The basic problem, according to Billings, was that the BAI had incompetent men who monopolized governmental spending on research even when they were unable to produce results. The bureau, Billings claimed, was afraid to hire competent men such as himself because they could expose the wasted public money and by revealing the baseless scientific claims could deprive the bureau's scientists of their anticipated fame. Billings deemed it his duty as a scientist and as a citizen to expose these deceptions

in public science. Thus began a bitter fight between Billings and Salmon that dominated the veterinary field for the next six years and completely obscured the work of Billings throughout the remainder of his career.¹²

Salmon countered that the "unreasonable" and unceasing attacks resulted from his refusal to hire Billings as a special agent of the bureau to investigate swine disease in Nebraska in 1886, and there seems to be much truth to his claim. Not only had Salmon and the USDA not hired Billings, but they asserted that their reason was that they could obtain a better man.¹³ To Billings this was not possible. He acknowledged no superior in the United States in the areas of microbiology and pathology, and he recognized his professor, Virchow, as his only superior in the world. He passed off Pasteur, for example, as a man "who mistakenly is thought to be an authority in bacteriology."¹⁴ Billings had the training and the knowledge, but he lacked the proper judgment to take advantage of his abilities. He was unable to recognize that anyone could differ with him on a technical question except for ignorance, incompetence, or irrationality. For example, he stated: "I have given you the true light so far as hog cholera is concerned. I know this! I challenge the world to prove me wrong."¹⁵ If Salmon believed there was a better man in America for the job, then to Billings, obviously Salmon was not being truthful in giving this as his reason, or if truthful, then obviously Salmon was too incompetent to hold the important position of chief of the BAI. The inability of Billings to acknowledge legitimate differences of opinion prevented him from ever gaining from criticism, and this was a weakness that continually restricted his abilities. Billings did not try to discern why research findings of others differed but only why the other person was wrong.

Billings moved quickly to convince both veterinarians and stockmen of the validity of his research. He addressed conventions of the Nebraska Stock-Breeders' and the Nebraska Short-Horn Breeders' Associations and presented papers to veterinarian societies in Massachusetts, Illinois, Indiana, New Jersey, Iowa, and Kansas. He put his early findings on hog cholera into print in 1887 in the leading professional journal, the *American Veterinary Review*, and followed in 1888-1889 with fuller studies.¹⁶

Locally, in addition to two bulletins issued by the State



AN ATTACK OF CHOLERA

One of the familiar attitudes assumed when the hog is affected with cholera. When this far along, not many cases of recovery are observed.

Drawing is from Charles William Burkett, The Farmer's Veterinarian (Orange Judd Company: New York, 1914), 182.

Agricultural Experiment Station on hog cholera and Texas fever, Billings used the Lincoln *Daily Nebraska State Journal*, edited by Regent Charles H. Gere, and the *Nebraska Farmer* to advance his scientific claims and his case against Salmon.¹⁷ L. L. Seiler, who served briefly as editor of the *Nebraska Farmer* and later as a contributor to the *Rural World* and the *Iowa Homestead*, became a leading proponent of the pathologist. Seiler made Billings an associate editor of the *Farmer* and opened its pages to his caustic attacks on the BAI. Billings wrote almost weekly articles on the hog cholera dispute during the fall of 1887, some under his own name and some as if written by an interested and impartial third party who always concluded that the facts supported Billings.¹⁸ In courting public support for his views, the doctor continually acknowledged Nebraska taxpayers, the Board of Regents, and the State Board of Agriculture for their support, although he always indicated that final solutions to the problems of disease required additional money and facilities.¹⁹

In building a popular backing in Nebraska, Billings also quickly antagonized a number of persons. Foremost were Governor John Thayer and State Veterinarian Julius Gerth, Jr. Gerth, having only recently come to Nebraska from New Jersey where he and Billings had been friends, conducted one of the early field tests intended to verify the effectiveness of hog cholera inoculation. Using vaccine obtained from Pasteur, Gerth found his inoculated hogs were not immune, and he concluded that the

process was a failure.²⁰ Various American pathologists, including Billings and Salmon, criticised Gerth for numerous improper procedures.²¹ Despite the criticism of his methodology, Gerth and the Live Stock Sanitary Commission reported to the governor and Legislature that inoculation was unreliable and that it was too expensive to be practical even if a vaccine were discovered. They recommended, therefore, that the state use the older methods of killing diseased animals, quarantine, and disinfection to fight hog cholera.²²

This report by the state veterinarian came in December, 1886, during Billings' first year at the University of Nebraska. Billings responded by announcing to the public that hog cholera "can be almost absolutely prevented by means of artificial inoculation."²³ Billings added that he had conducted enough tests to have this confidence and that he needed only a "major test" to finally confirm his method.²⁴ In the fall of 1887, Gerth reopened the issue publicly and challenged Billings to "put up or shut up" regarding his claims and to conduct his "major test" under the surveillance of a committee appointed by the State Board of Agriculture and a representative of the BAI.²⁵ Yet the test never materialized at this time. Billings argued that the Legislature had delayed the experiment station appropriations and the expected funds were not available. Billings offered to commence the test if the Live Stock Sanitary Commission would pay for it, but Gerth denied Billings' claim that his department's money could be used in such a way or that experiment station funds were unavailable.²⁶

Other than the issue of inoculation, it was surprising that Billings objected to Gerth's methods of combating cholera. All through 1887 Billings had asserted that inoculation was only one part of a comprehensive program to combat the disease, and at this time he still had serious reservations about his method of using live germs for inoculation. He stated that "no matter how efficacious inoculation may be, I am still of the opinion that the practical method to prevent hog cholera will be separation, isolation, and quarantine."²⁷ He advocated extensive controls to contain local infection, such as rigid controls over the transportation of diseased animals and over contaminated pens, streams, and burial places. Where the disease already existed, he wanted rigid state and national quarantines, veterinary inspectors, and improved sanitary practices by farmers. While

Gerth seemed to support these same measures, Billings asserted that in his report to the governor and the Legislature all that the state veterinarian recommended as necessary was "stamping out," that is, killing the diseased animals, having the state compensate the owners for losses, and a quarantine which Billings believed was too short to cover the incubation period of the disease. Basically, Billings' objection was their difference of opinion regarding inoculation.²⁸

On this question Billings had strong professional support as well as strong opposition. Many veterinarians regarded inoculation as the most promising solution to cholera even if they believed adequate knowledge was presently unavailable. Related to their disagreement over cholera, Billings publicly alleged that Gerth's actions were responsible for an outbreak of Texas fever within the state, and he added that Gerth had misused public money, was illegally appointed state veterinarian, and knew nothing about animal diseases.²⁹

During 1888 other opposition emerged within the state against Billings.³⁰ The editorship of the *Nebraska Farmer* transferred from Seiler to H. H. Wing, a professor of agriculture in the University of Nebraska. Wing removed Billings as associate editor and demoted him to the status of a regular contributor.³¹ Within three months Wing dropped Billings from even that role. This move to ease out Billings from the *Nebraska Farmer* was significant. Along with Wing most of the new regular contributors were professors of the Industrial College at the university, including its dean, Charles Bessey. In July, 1888, H. E. Heath became editor, and the *Farmer*, which had been an avenue second only to the *Lincoln State Journal* for Billings to broadcast his ideas, now became an outspoken critic of the pathologist. For example, when outbreaks of hog cholera occurred during the fall, 1888, the editor of the *Farmer* queried: "Where is Billings? He should be at once conveyed to the scene and read one of his articles to the sick hogs. It will certainly have some effect on them."³²

Another point on which Billings' enemies rallied was the expense of the patho-biological laboratory. Since he had been at the university, Billings had pushed hard for more equipment, assistants, and laboratory rooms.³³ During his stay, he was able to control about one-third of the budget of the State Agricultural Experiment Station.³⁴ The leading support for continued



Patho-Biological Laboratory of the State University of Nebraska, about 1888. Drawing is from Nebraska Agricultural Experiment Bulletin No. 4.

spending on the patho-biological laboratory came from the Nebraska Swine Breeders' Association and the regents led by Charles H. Gere. Nevertheless, the counter movement gained momentum. An attempt to discredit hog cholera inoculation involved a bill in the Legislature that provided compensation for farmers in Surprise, Nebraska, who claimed their hogs died from inoculation. When this attempt failed, opponents moved to persuade the Legislature to cut off funds to the laboratory which would result in ousting its director. Gerth, the *Nebraska Farmer*, Governor Thayer, the *Omaha Bee*, and the *Omaha Daily Herald* were responsible for generating most of the opposition outside the university and Chancellor Irving J. Manatt apparently was the main force within.³⁵ While admitting that the expenses would be worthwhile if the research led to reduced losses from animal diseases, by 1889 Billings' critics stressed that concentrating so much of the small budget of the experiment station in the patho-biological laboratory was not justified unless other scientists confirmed the result. Billings' colleagues likewise seemed to feel that the present budgets slighted their own research interests and agricultural problems other than animal pathology.³⁶

The confusion resulting from the various claims and charges in the cholera controversy left veterinarians and farmers alike in a quandary as to which scientist was correct. Microbiology and pathology were in early stages of development and their practitioners still lacked the means to evaluate the results of research findings. Thus within the profession, both Salmon and Billings had strong support. Among the agricultural community, the influential *Breeder's Gazette*, after early opposition, generally supported Billings against the BAI, and the criticism of Billings by the *Nebraska Farmer* brought the editors of the two journals at one another's throats. J. H. Sanders of the *Gazette* charged that the attacks by Heath in the *Farmer* were attacks on science that threatened to cut short the early gains of providing agriculture with a scientific base.³⁷ Heath replied that he was not against science, but that he wanted "to see something better than ponderous tomes of abuse of other men as proof of his [Billings'] greatness."³⁸ Heath reflected the growing feeling of many agriculturalists in the controversy between Billings and the BAI. They would leave the scientific questions of discovery and the cause of disease to the scientists, but they were interested in

the question of inoculation and prevention. The editor of *Colman's Rural World*, for example, apologized to his readers for another article by Billings and suggested a "truce until one or the other can produce something of practical utility."³⁹ Heath repeated this view, stating:

Let us have more practical benefits and less wind from all quarters on this hog cholera question. . . while both [Billings and Salmon] have wrangled for two years over a germ invisible to the naked eye, neither has apparently accomplished a thing but draw their salaries.⁴⁰

The pressure from Heath, Gerth, and other dissidents finally forced Billings to conduct public tests. In October, 1888, agreeing that all the apparent discoveries claimed by Billings needed verification, the Board of Regents appropriated funds to cover the expenses. The results of these tests disappointed Billings but, as usual, were contradictory. Of 120 hogs in Falls City inoculated with Billings' vaccine, over 100 died; at Surprise, 614 animals were treated with similar results. According to his opponents, the vaccine not only failed as a preventive but was deadly.⁴¹ Billings tried to ignore these tests, claiming they were a "prematurely forced question as far as the actual experiment was concerned." He pointed out that stockmen at Gibbon had inoculated between 200-300 hogs with the same vaccine used at Surprise and none had even taken ill. The only explanation that one could draw, he claimed, was that cholera was already present at Falls City and Surprise before the inoculation had time to take effect. He asserted that successful inoculation was still not far off and that only pressure on the regents had forced him to proceed with the tests before he was ready.⁴²

The *Nebraska Farmer* showed little sympathy for Billings, however, stating that "he has made sweeping claims for his virus and theory and cannot blame those who have been so 'severely roasted' by his flowing pen and sarcastic tongue if they push him to the wall."⁴³ The *Omaha Daily Herald* took advantage of Billings' situation by noting that "according to the latest reports at hand, the hog offered a choice between cholera and vaccination by Dr. Billings had better take to the woods."⁴⁴

By late 1888 Salmon recognized that he could no longer avoid the threat posed by Billings to the reputation of his bureau. He admitted that "unfortunately the confidence of American stock-owners in scientific work in general, and in that of this department in particular, has been shaken by violent attacks which originated with a Professor in the University of

Nebraska." Salmon also angrily denounced the Nebraska State Agricultural Experiment Station for assisting Billings by publishing for all the world to read "a bulletin [*Swine Plague*] of over 400 pages, the greater part of which is devoted to misrepresenting and distorting the statement in the reports of this Bureau and in laying claims to discoveries which are by no means demonstrated, but which it is asserted disprove the work of this Bureau." Finally Salmon asserted that "one of the Regents of the University of Nebraska [Gere] and a Professor in the University of Ohio [Detmers] have made similar assertions, and more recently it is reported that the National Swine-Breeders' Association has passed a resolution asking that the Commissioner of Agriculture provide for an independent investigation of this subject."⁴⁵ Billings was creating too great a stir, and he had too many adherents for the BAI to ignore.

Accordingly, Commissioner of Agriculture Norman J. Colman agreed to a request by Salmon to establish a commission of "disinterested, competent specialists" to clear himself and his bureau of the "slander."⁴⁶ The commission included professional pathologists T. J. Burrill, M. Bolton, and E. O. Shakespeare. Both sides opened their laboratories and their records to the commission, and the general feeling of interested observers was that fairness and expert knowledge assured a settlement of this important but "ungentlemanly" dispute.⁴⁷

As months passed and Salmon and Billings continued their "acid criticisms," the agricultural press grew restless waiting for the commission to report. In Nebraska Billings' friends and supporters seemed particularly anxious. They believed that from the general indications of the commission during its visit to Lincoln, Billings assuredly was going to win.⁴⁸ The editors of the *Nebraska Farmer* maintained that they would be the first to praise Billings if the commission confirmed his work but that they were becoming increasingly skeptical of the investigation. The secretiveness of the commissioners when they had been in Lincoln bothered them. Also, they believed the commissioners had only seen one side of the situation in Nebraska by spending their time at the patho-biological laboratory instead of investigating the many reported cases of hogs sick from Billings' vaccine. They also implied that the commissioners had allowed Billings to woo them unfairly: "The learned professors," they asserted, "were here as servants of the people and investigators

of hog cholera as well as the excellent brands of choice wines the doctor is said to keep in his cellar."⁴⁹

When the commissioners finally reported in August, 1889, they supported the multiple disease theory of Salmon and discounted any claims to the discovery of hog cholera bacteria by either Detmers or Billings.⁵⁰ While they found some faults with both, they also favored the methodology of Salmon and the BAI to that of the Nebraskan. Despite the apparent victory of Salmon, the commission report failed to end the dispute over hog cholera.⁵¹ A prime example was a review of the swine plague commission report in the *Journal of Comparative Medicine*, one of two professional journals in American veterinary medicine.⁵² The reviewer, after comparing the writings of Billings and the BAI, "line by line and word for word," explained:

We are enabled to say that all of Dr. Billings' charges, sweeping and severe as they are, are true and just, and we can not understand how the committee appointed to investigate the special question involved, could fail to make the same examination, to arrive at the same result, and to publish that result in calm judicious language, not as a matter of justice to Dr. Billings, or of criticism of Dr. Salmon, but as a positive duty to science. Regarded from this point of view, the report of that committee is the most disappointing document of the kind we have ever seen.⁵³

The reviewer concluded:

The report unfortunately, and reluctantly we say it, in view of the very high esteem in which we in common with others, hold the eminent pathologists of the committee which made it, betrays its nature in almost every line as a whitewashing report. It does not venture to touch on most of the disputed points. The one vital issue it discusses, it discusses as Salmon's mouthpiece, pure and simple.⁵⁴

Where many persons faulted the commission was its disregard for the question of preventive inoculation. This was particularly true of agricultural interests. The *Breeder's Gazette*, for example, observed that while the "disputes between germ-hunters" was evidently settled, that aspect of the dispute did not greatly interest stockgrowers anyway. Considering sanitation and quarantines as unsatisfactory methods of prevention, the *Gazette* regarded inoculation as the best hope for success in combating cholera. To the *Gazette*, Billings, at least, was pursuing this problem and apparently nearing success, whereas the BAI, having conducted tests for five years, apparently was abandoning inoculation as an impractical solution.⁵⁵ Henry Wallace, editor of the Iowa farm newspaper, *Homestead*, reiterated the view of the *Gazette* in a letter to Salmon: "I may as well say to you frankly that the practical results of the investigations of the Bureau of Animal Industry with reference to hog cholera have not warranted any great hopes

on the part of the swine growers of America." It was this failure, Wallace believed, that encouraged stockmen to look with such hope to Billings and to maintain confidence in him. Wallace concluded that the commission report only compounded the displeasure with the BAI—"it seemed a whitewashing affair."⁵⁶

Regarding the inoculation question, the swine plague commissioners objected to Billings' work, but they left an opening for his supporters by stating that a safe, practical serum for inoculation was possible and added that "we have reason to believe that the threshold of such an important discovery has already been crossed!"⁵⁷ Drawing from this statement, the *Breeder's Gazette* surmised: "It is but the barest justice to record in this connection that if these bright hopes be ever realized the credit of the discovery must largely be ascribed to Dr. Billings and the State of Nebraska, which provided him the field and encouraged his investigations."⁵⁸

In Nebraska the inconsistent results of Billings' inoculation attempts likewise confused the results of the swine plague commission report. C. H. Walker, former president of the Nebraska Stock Breeders' Association, concluded from "almost daily" letters which he had received that the commission report "is a great disappointment to the hog growers of the country." Walker testified that he would "let the doctors fight" over the multiple disease theory, but he had been using vaccine prepared by Billings, and "it is remarkable that my hogs exposed to the severest test resist both death and disease while those that have not been inoculated take the disease and die."⁵⁹ Walker attributed the failures of inoculation largely to carelessness and to not using the vaccine under the conditions prescribed by Billings.⁶⁰

Threatening to resign since mid-1888, Billings either succumbed to the pressure or saw greater potential elsewhere. Blaming Salmon and his allies for making continued worthwhile research impossible in Nebraska and citing insufficient financial support, the doctor left the University of Nebraska in August, 1889, bringing the work of the patho-biological laboratory to an end. On leaving Nebraska the pathologist organized Billings and Company in Chicago.⁶¹ The new company produced hog cholera vaccine for commercial sale, and Billings continued his research on animal and human diseases. By this time Billings claimed that he had successfully inoculated thousands of hogs, and to

support the reputation of his company, he offered thirty of his "cholera-proof" hogs to any livestock commission, experiment station, or breeder who would subject them to the "severest possible exposures" of the disease.⁶² Within one year, however, Billings and Company declared financial failure and shifted from vaccine production to the hog feeding business in Davenport, Iowa. Here the company intended to continue inoculation as proof of its effectiveness. By the end of 1890, Billings again changed his plans, transferred his business interests and the rights to his inoculation procedure to his partner, and joined the faculty of the Chicago Veterinary College.⁶³

While uncertainty continued regarding the value of Billings' research and particularly his experiments with hog cholera inoculation, his opponents within the veterinary profession voted to expel him from membership in the United States Veterinary Medical Association, the major American veterinary society, for his "unprofessional" attacks upon Salmon and for a caustic letter criticising the executive committee of the association. In addition the committee on diseases of the association went against Billings and supported the conclusions of the swine plague commission and the findings of Theobald Smith on Texas fever.⁶⁴

Billings was not without his supporters within and without the profession, however, and in Nebraska during 1889 and 1890,



*1899 vaccinating outfit
for blackleg in cattle.
Cost, \$5.00.*

such influential organizations as the Nebraska Swine Breeders' Association and the Nebraska Improved Stock-Breeders' Association kept pressure on the Legislature to renew the research program of the Patho-Biological Laboratory.⁶⁵ Particularly dramatic was his election to the presidency of the Nebraska Swine Breeders' even though he resided outside the state.⁶⁶ Among the agricultural press the *Breeder's Gazette* continued to stress the potential greatness of Billings. The *Gazette* had lamented the doctor's intended retirement from research, and in summarizing his varied work with animal diseases it had stated that his work on inoculation "ranks him with Jenner and Pasteur."⁶⁷ Professional and state veterinary societies continued to praise the pioneer work in animal pathology by the state of Nebraska and by Billings.⁶⁸ The Indiana Association of Veterinary Graduates, for example, made Billings an honorary member for his findings which they stated "have been the only investigations of merit made in these United States," and they requested that the state of Nebraska rehire him.⁶⁹ Billings also received the applause of many persons who for reasons having nothing to do with disease were upset with the USDA. They believed that the leaders of the USDA were unjustly harassing their critics, such as Billings.⁷⁰

Within Nebraska the friends of Billings busily agitated for his return. They energetically countered the claims that inoculation was unsuccessful. For example, the *Nebraska Farmer* used the unsuccessful inoculation of hogs at Table Rock by S. C. Bassett to justify supporting the recommendation of the BAI that farmers not practice inoculation in its current stage of development. Bassett, a leader in the State Dairymen's Association and a member of the Nebraska State Board of Agriculture, quickly corrected the account. He had inoculated over 1,000 hogs with the same vaccine as used at Table Rock and only in that one instance did any get sick or die. In fact, Bassett claimed, he had inoculated over 10,000 hogs using Billings' procedures, and he had been protecting his own animals since early 1888, all without any significant problems. Not only did Bassett use the prestige of his name and position to support Billings in the press, but he persuaded the Pawnee County Farmer's Institute to petition the Legislature to renew the pathological research at the State Agricultural Experiment Station.⁷¹

Billings also acted on his own behalf with the Nebraska public



Hog ranch on Goose Creek in Cherry County, about 1901. (Solomon D. Butcher Collection)

by continuing his attacks against Salmon in the newspapers and by personal appearances before livestock associations.⁷² When the Legislature ignored the requests for the renewal of the patho-biological laboratory in 1890, Governor Thayer reported receiving over 800 letters in protest, and Gere berated the Legislature in the pages of his *State Journal*. What made this agitation in favor of Billings even more immediate was an outbreak of hog cholera, more devastating than during the past few years.⁷³

In 1891 the supporters of Billings had their way. The Legislature reinstated the patho-biological laboratory, and the regents rehired the controversial pathologist. In taking the action the regents committed \$10,000 from the experiment station

fund, and in addition to an increased salary for Billings, they provided an assistant, a chemist, and an equipment fund which was lavish by experiment station standards.⁷⁴ Billings remained at the University of Nebraska for only two years, two years that proved as turbulent as his earlier tenure. He continued his hectic pace of research and writing on a wide variety of animal diseases, particularly cornstalk disease, Texas fever, and lumpy jaw.⁷⁵

Most of Billings' work on cornstalk disease had been during his first stay in Nebraska. Cornstalk disease affected cattle, and veterinarians had offered three possible explanations of the malady. The first was that cattle contracted the disease by eating smut found on cornstalks; the second, that cattle ate too many cornstalks which resulted in compacted stomachs; and the third, that bacteria rather than smut on the cornstalks was eaten by cattle. With his strong inclination toward bacterial causes of disease, it was not surprising that Billings advanced the third explanation. In fact, he claimed in 1889 to have discovered the particular bacteria involved in the disease.⁷⁶

Billings had worked on the nature of actinomycosis or lumpy jaw since 1890.⁷⁷ Because men as well as cattle were susceptible to this fungal disease, the resulting controversy was whether men could contract the disorder from diseased cattle, particularly from eating meat of such an animal. Billings sided with those veterinarians who believed that lumpy jaw was not contagious and that it was safe to eat the non-affected parts, that is, all but the head of the animal.⁷⁸ Many cattlemen enthusiastically supported this view when fighting with stockyard officials who refused to market animals suffering from this infirmity. In a case in point, the important court trial of *Greenhut vs. Pearson* arose when the livestock commissioners of Illinois condemned 125 cattle afflicted with lumpy jaw. The cattle interests questioned the legitimacy of government inspection and condemnation, and Billings testified against the commission in a contest that evoked bitter feelings among professional veterinarians.⁷⁹ In the process of the trial, W. L. Williams, a veterinarian on the side of the commission, recorded some interesting comments on the character of Billings:

Complaining of illness, the cross-examination was made very brief, and mainly directed toward showing his [Billings] egotism. He asserted that he had made the infectious diseases of animals his sole study for a number of years, day and night. He was quite

positive that he knew a *great deal* about infectious diseases of animals, more than all other scientists on the American continent, and admitted that before coming upon the stand that he had asserted he was "the Jesus Christ of infectious diseases in America."⁸⁰

Upon his return to Nebraska, defense of and attacks against his inoculation procedure for hog cholera intensified. Immediately, the doctor began providing free cholera vaccine to the stockmen of the state, and during the last four months of 1891 he reported inoculating 3,000 hogs without any problems.⁸¹ In his support the Iowa Swine-Breeders' Association followed the Nebraska breeders in endorsing his work.⁸² Foreign opinion regarding the controversy, which at this time still carried more credibility than American, remained divided but more in favor of Billings. Many leading investigators in England, France, and Germany still opposed Salmon's multiple disease theory and judged the work of Billings to be more reliable.⁸³

In the midst of this confusion, the BAI arranged another test of Billings' work in hope of confirming the opinions of the swine plague commission, and this test considered only the issue of inoculation. Faced with a severe outbreak of hog cholera, a local committee of the Farmer's Alliance in Illinois looked for help. The state experiment station and the USDA both held to the belief that sanitation and quarantine were the only safe and practical procedures to follow. Dissatisfied with this answer, the committee invited Billings to Illinois for a lecture and a demonstration of his inoculation methods, and they sent one of their members, George Cadwell, to Nebraska to learn the procedures. When Billings went to Illinois, the BAI countered by sending an agent there also to issue a challenge. The BAI proposed a test of three lots of hogs; one-third Billings was to inoculate, one-third the BAI, and the remainder to serve as the control group. Claiming that he could never expect fairness from the BAI in any test, Billings refused to participate. The local committee, under pressure by the BAI agent, Billings claimed, decided that Cadwell should replace Billings in the test since the Nebraskan had personally instructed him. The test started in late November, 1891, at Ottawa, Illinois, with Cadwell and the government agent each inoculating 18 hogs. The results were as the BAI predicted; 10 of the BAI's hogs died, 12 of Cadwell's, and 14 of the control. Salmon boasted that the test proved the ineffectiveness of inoculation and reasserted that farmers should stop listening to the claims of Billings.⁸⁴

As with the swine plague commission, challenges soon negated the validity and apparent conclusiveness of the Ottawa test. Being unable to obtain inoculum from a mild infection as instructed, Cadwell had requested that the test not proceed. The local committee, however, supposedly again following the instructions of the BAI, told Cadwell to continue with whatever virus was available. The high death rate in Cadwell's hogs, Billings asserted, was thus predictable and not really a true test because the test violated the basic instructions of his method. To add force to the claim, Cadwell publicly verified Billings' cries of foul play.⁸⁵ The results of the Ottawa test, therefore, varied according to the observer. Billings' opponents claimed it proved his dishonesty and the impracticality of inoculation, while his supporters believed it proved the dishonesty of the government. Some less partisan observers reacted much as did the editor of the *Breeder's Gazette*. He stated that while the test and other reported failures showed that Billings had not yet solved all the problems related to inoculation, still too much evidence of success existed to believe that he was not close to a final solution.⁸⁶

The situation grew more confused as testimonials relating successful use of Billings' inoculation continued to become public. Also Billings received an unexpected vote of confidence at this time for his inoculation from a visiting scientist of the BAI, F. E. Parson. When Billings asked the BAI to designate Parson as an authorized representative to study thoroughly the work of the Nebraska patho-biological laboratory, the BAI denied the request.⁸⁷

The BAI struck again at Billings in 1892 by issuing *Farmers' Bulletin No. 8*. In it the Salmon forces restated their objections to inoculation and presented a collection of testimonials by farmers who had unsuccessfully tried hog cholera inoculation.⁸⁸ Also at this time Senator Algernon S. Paddock of Nebraska confronted Secretary of Agriculture Jeremiah M. Rusk with charges made by some of his constituents, including a state senator and a member of the State Board of Agriculture, that the USDA was unjustly harassing Billings and preventing the Nebraska Agricultural Experiment Station from carrying out its functions. Secretary Rusk, in denying the charges stated that Billings was attempting to "stir up" the citizens of Nebraska by making them believe that the secretary and his department were enemies of

American farmers. "If the state of Nebraska wishes to continue this kind of a man in such a conspicuous position, paying him \$3600 per year and allowing him to expend two-thirds of her Experiment Station funds, I suppose she has the power to do so," Rusk asserted, but he concluded that Billings "is a discredit and a disgrace to Nebraska."⁸⁹

The Ottawa test and the subsequent efforts by Rusk and Salmon to have Nebraska officials silence him pushed Billings to another public defense of his actions and his scientific achievements. In the nearly 300 pages of *Inoculation, A Preventive of Swine Plague, with the Demonstration that the Administration of the Agricultural Department Is a Public Scandal: An Exposure*, Billings was near his best as an antagonist. His choice of language and the personal abusiveness which had dominated most of his writings against Salmon were more controlled, but it was nonetheless sharp and biting. He presented his side of the controversy more by using quotations from letters and newspaper and journal editorials and this gave the presentation an aura of impartiality. The collection revealed the widespread support for Billings' work or, more possibly, the widespread displeasure with the USDA.⁹⁰

During his encounter with Secretary Rusk, Billings retained the support of many influential people. Elected as their president, members of the Nebraska Improved Live Stock Breeders' Association vigorously defended his importance during their 1892 meeting. At the same meeting Chancellor James H. Canfield told the stockmen that the work of the patho-biological laboratory warranted \$50,000 for a building and equipment in addition to an increased annual appropriation.⁹¹ In addition a committee of the National Association of Expert Judges of Swine, after an investigation of "several hours," endorsed the work of Billings, recommended that the state of Nebraska spend more money on the research of the laboratory, and labeled the *Farmers' Bulletin No. 8* "so misleading as to make it unsafe to accept many of its conclusions."⁹² Again the *Breeder's Gazette* repeated its support of Billings and asserted that other states should follow the lead of Nebraska in providing public laboratories to study animal diseases.⁹³ Regardless of their feelings for or against Billings, professional veterinarians, in general, agreed that Nebraska was a leader at this time in providing for original research in veterinary science.⁹⁴

Despite continued support, as during his first stay at the university, Billings' opponents did not ease up on criticism of his work, and he remained unsettled and discouraged with the situation in Nebraska. While not as publicly vocal, there were persons within the university who still believed he was not a good scientist. J. S. Kingsley, for example, shortly after leaving Lincoln for a teaching position in the East, wrote his former dean and colleague, Charles Bessey, and enquired: "How does the hog cholera crank get along . . . ? It is one of the recompenses that I shall not have to be associated with him." Kingsley, who with Bessey was an associate editor of the *American Naturalist*, a leading journal in the natural sciences, added that "I have just shut his [Billings'] articles out of the *Naturalist*."⁹⁵

Publicly, the most constant and severe critic of Billings remained the *Nebraska Farmer*. The editor of the *Farmer* continued to assert that he was not opposed to Billings but only to his unfounded claims, particularly regarding hog cholera. While denying Billings' charge that it was an "organ" of the USDA, the *Farmer* declared that the support for Billings was superficial, and that while quite vocal, only a small group of Nebraskans supported the pathologist. It believed, for example, that only a "clique" had maneuvered Billings into the presidency of the Improved Live Stock Association and that the majority of members as well as farmers and stockmen in general in Nebraska did not support him. Later in 1892 the *Farmer* charged that Billings had "crowded himself and his inoculation scheme on the Nebraska Dairymen's Convention."⁹⁶ Apparently discouraged by the continued controversy and feeling his enemies had again turned the Legislature against him regarding appropriations, Billings resigned from the university in May, 1893.

After leaving the University of Nebraska for the second time, Billings remained a public figure for several more years and then slipped into relative repose. He taught occasionally for the Chicago Veterinary College and then moved to Massachusetts, where he conducted a private medical and veterinary practice until his death in 1912.⁹⁷ He engaged in several more controversies during the 1890's, the most significant of which involved the tuberculin test and the German and British quarantines against American cattle suspected of having Texas fever and pleuropneumonia.⁹⁸ In the latter case the *Breeder's*

Gazette led an attempt to maintain the scientific respectability of Billings among the professional veterinarians. While journal references to Billings declined markedly after 1893, the *Breeder's Gazette* continued to refer to him as the leading American investigator of hog cholera and Texas fever and as the scientist who was most loyal to the interest of American stockgrowers. The *Gazette* in 1895 still maintained that Billings had been mistreated and that politics and not scientific failures accounted for his departure from Lincoln. The USDA, with "falsehoods and slander," lamented the *Gazette*, had "poisoned" the agricultural press and stockmen and "with the aid of its political roustabouts in several states drove Billings from the experiment station in Nebraska and closed his laboratory apparently forever."⁹⁹ Thus, when German officials stated that they would not accept the findings of the BAI regarding the health of American cattle but were willing to submit the issue to Billings, the *Gazette* insisted that Billings was the best man to persuade the Germans to remove the beef embargo. Despite these efforts, by the mid-1890's Billings was not a man around whom most professional veterinarians and scientists could rally. His reputation was too tainted and uncertain, and the attempt to bring him back into the national limelight was short-lived.¹⁰⁰

The Salmon-Billings controversy, like Billings himself, slipped into obscurity after 1893. As neither side could produce conclusive evidence or practical results, most observers either accepted one side of the argument or pushed aside the issue as unsolvable with current knowledge and techniques. In such a situation Billings was bound to lose in the long run to the power, prestige, and widespread influence of the USDA. By the mid-1890's, professional veterinarians generally accepted the multiple disease theory regarding hog cholera and were inclined to accept the authority of the BAI over that of any individual.¹⁰¹ While no more successful at this time than Billings in solving the puzzles of hog cholera and Texas fever, the BAI bolstered its scientific image by its work with other animal diseases. To win, Billings needed conclusive scientific or practical verification of his findings and this never came.

Later research proved the BAI correct and Billings wrong regarding the cause and nature of Texas fever, but in regard to hog cholera, subsequent findings showed both parties to be short of an understanding. Within a decade research attributed the

cause of hog cholera to a virus, a concept of disease unknown during the earlier work of Salmon and Billings.¹⁰² The bacteria of Salmon and Billings merely became accompanying or secondary factors in cholera.

In the case of hog cholera inoculation, the viral concept explained many of the failures and particularly the inability of early researchers to obtain consistent results. What they believed were pure cultures were not. Billings, like Salmon, so completely saw the virtues of the bacterial theory of disease that he too quickly attributed the causes of unknown diseases to bacteria. While such assumptions opened the way to the successful control of many contagious diseases, in the cases of hog cholera and Texas fever the pursuit of bacteria led to many dead ends. Yet the repeated failures of men such as Billings and Salmon made the concept of virus easier to accept. After all many persons had great difficulty believing something like bacteria could cause disease; the imagination had to stretch even further to conceive of something that could cause a disease as deadly as hog cholera yet was so small that it could not be seen with the best microscopes available. Regarding inoculation, Billings was wrong in many respects; nevertheless, the BAI by the mid-1890's reversed its earlier objections and turned to developing vaccines as the best hope for combating cholera. Although the many problems encountered during the next twenty to thirty years in developing a successful vaccine made the failures of Billings and the BAI excusable, they do not excuse the long and wasteful verbal battle that so damaged the prestige of veterinary science during the 1880's and 1890's. On the other hand, without the constant pressure of Billings and his supporters, the BAI probably would not have diverted its attention to inoculation as soon as it did.

The contributions of Billings to veterinary medicine and pathology thus were paradoxical. Although his actions led to his discharge from the United States Veterinary Medical Association, he was a strong supporter of improving professional standards. He helped lead the move to require a three-year college course for veterinarians, to raise the difficulty of these courses, and particularly to make medicine and agriculture scientific. In line with his belief that the United States needed more original research and better facilities for research and education, Billings conceived a bill introduced into Congress by

Senator Charles F. Manderson of Nebraska to establish a national patho-biological laboratory.¹⁰³ In Nebraska, Billings always opened his laboratory to students and professional veterinarians who were interested in research and in need of proper facilities. Because he was well known, attention was drawn to these needed changes. Yet his criticism of the USDA, while much of it was valid and constructive, opened the government scientists and scientific agriculture in general to criticism from all sides.

The two-edged sword which Billings flayed likewise affected the university and its scientific and educational work in Nebraska. While promoting educational reform, original research, and practical scientific application on the one hand, public controversy—on which Billings thrived—opened the university to criticism from those persons who believed that any money spent on universities and science was wasted. Billings publicly denounced any element that opposed increased appropriations for the patho-biological laboratory, and his insulting manner often made the defense of scientific expenses by university officials more difficult. In attempting to secure more money for his research, Billings claimed that aside from his own work the University of Nebraska had never accomplished anything of value for the farmers of the state. Not only did such statements unjustifiably debase the work of his colleagues, but again he provided fuel to the anti-university element within the state.¹⁰⁴ Yet, from the standpoint of the livestock press, what Billings or at least the University of Nebraska was doing was outstanding, and the initial thrust Billings gave to the study of contagious diseases, particularly hog cholera, was continued very ably by his successor, A. T. Peters. Thus Frank S. Billings was, and still remains, a perplexing individual to understand. His scientific career was one of great promise but of contradictory results. It seems only fitting that the 1906 edition of *American Men of Science*, the last year in which Billings was honored by his inclusion, listed the one activity by which Billings approached the pinnacle of fame and the other by which he fell so tragically: "chief subjects of research;—diseases of domesticated animals; research in progress;—ethics."¹⁰⁵

NOTES

1. *The Journal of Comparative Medicine and Surgery*, VII (1887), 147-148; J. McKeen Cattell (ed.), *American Men of Science: A Biographical Directory* (New York, 1906), 29; J. F. Smithcoors, *The American Veterinary Profession: Its Background and Development* (Ames, Iowa, 1963), 348-349, 398-402. Published work by Billings before coming to Nebraska included *The Relation of Animal Diseases to the Public Health and Their Prevention* (New York, 1884); "Tuberculosis from Anatomical, Etiological, and Preventive Standpoints, with Especial Reference to Pathisis Pulmonum," *The Journal of Comparative Medicine and Surgery*, VII (1886), 62-101; "Rabies in the Dog and Its Relation to Rabies in Man," *ibid.*, 161-189.

2. Paul F. Clark, *Pioneer Microbiologists of America* (Madison, Wisconsin, 1961), 50-65, 121-123, 179, 327; Charles Edward Amory Winslow, *The Conquest of Epidemic Disease* (New York, 1967), 193-346; William G. Rothstein, *American Physicians in the Nineteenth Century* (Baltimore, 1972), 261-281; Smithcoors, *American Veterinary Profession*, 341-480; B. W. Bierer, *A Short History of Veterinary Medicine in America* (East Lansing, Michigan, 1955), 47-79; U. G. Houck, *The Bureau of Animal Industry of the U. S. Department of Agriculture: Its Establishment, Achievements and Current Activities* (Washington, D.C., 1924), 21-38, 156-167, 304-317.

3. Houck, *Bureau of Animal Industry*, 2, 21-23; T. Swan Harding, *Two Blades of Grass: A History of Scientific Development in the U. S. Department of Agriculture* (Norman, Oklahoma, 1947), 148-154.

4. Frank Billings to C. H. Gere, June 12, 1886, Papers, Board of Regents, University of Nebraska Archives, Lincoln, B6.F55; *Daily Nebraska State Journal* (Lincoln), September 18, 1887 (hereafter cited as *State Journal*).

5. *American Veterinary Review*, XI (1887), 102-103 (hereafter cited as *AVR*).

6. *Report of the Commissioner of Agriculture* (1878), 321-443 (1879), 365-420; D. E. Salmon, "Our Animal Plagues and the Means of Controlling Them," *Proceedings of the Society for the Promotion of Agricultural Science* (1882), 71-75; D. E. Salmon, "The Nature and Prevention of Hog Cholera," *ibid.* (1886), 57-61; Billings, "The Nature of the American Swine Plague," *AVR*, XI (1887), 294-301, 354-358, 408-414, 450-456; Billings, "The Etiological Moment in American Swine Plague," *ibid.*, 55-66, 124-137, 163-170, 258-265.

7. Billings to Gere, June 12, 1886, University of Nebraska Archives, Lincoln.

8. Nebraska Agricultural Experiment Station, First Annual Report (1887), 12 University of Nebraska Archives, Lincoln.

9. *Breeder's Gazette*, December 30, 1886, 872-873.

10. W. J. C., "Daniel E. Salmon, D.V.M.," *Journal of Comparative Medicine and Surgery*, VIII (1887), 257-262.

11. The names applied to hog cholera were quite confused and varied during this period. Billings, for example, generally used the term "swine plague," and there were three or four other names commonly used in the veterinary literature at this time. The situation was particularly confusing after Salmon's multiple disease theory when Billings' "swine plague" was Salmon's "hog cholera" and Billings did not recognize the existence of Salmon's "swine plague." Throughout this paper the name hog cholera is used to cover all the various diseases that were commonly associated with that term in the 1880's and 1890's. *Report of the Commissioner of Agriculture* (1885), 476-521 (1886), 603-686; *Breeder's Gazette*, November 11, 1886, 705-706; D. E. Salmon, "Nature and Prevention," 58-61; "Bacteriology—Hog Cholera," *AVR*, XI (1887), 431-432; D. E. Salmon, "Hog Cholera and Swine Plague—Their Nature and Prevention," *ibid.*, 363-366; D. E. Salmon, "Hog Cholera," *ibid.*, XII (1888), 6-20; D. E. Salmon, "The Present Condition of the Investigation of Swine Diseases," *Proceedings of the Society for the Promotion of Agricultural Science* (1888), 66-68; D. E. Salmon, "Hog Cholera, Its History, Nature and Treatment," *Report of the Bureau of Animal Industry* (1889); *AVR*, XIII (1889), 102-103.

12. *State Journal*, September 14, 18, 1887; *AVR*, XI (1887), 93-95; *Breeder's Gazette*, November 14, 1888, 499. In addition the various writings by Billings on hog cholera referred to in footnotes 6 and 16 have numerous references to Salmon and the BAI.

13. *Breeder's Gazette*, December 30, 1886, 872.

14. *Nebraska Farmer* (1887), 462.

15. *Ibid.*, 464.

16. Billings, "Nature of Swine Plague;" Billings, "Etiological Moment;" Billings, "Hog Cholera: A Sure Means for the Prevention of the Disease Discovered," *AVR*, XI (1887), 23-30; Billings, "Bacteriology, Hog Cholera and Texas Fever," *ibid.*, 334-337; Billings, "Southern Cattle Plague and Yellow Fever, from the Etiological and Prophylactic Standpoints," and "Swine Plague," *Bulletins* 3, 4, *Nebraska Agricultural Experiment Station, Annual Reports and Bulletins*, I (1887-8); Billings, *The Southern Cattle Plague [Texas Fever] of the United States* (Lincoln, Nebraska, 1888); Review by Billings of Theobald Smith, "Swine Plague, Its Causes, Nature and Prevention," *AVR*, XII (1888), 381-382; Billings, "Original Investigations of Cattle Diseases in Nebraska", *Bulletins* 7-10, *Nebraska Agricultural Experiment Station, Annual Reports and Bulletins*, II (1889); *AVR*, XI (1887), 49-52, 294, 331, 418, 568, XII (1888), 477; *Breeder's Gazette*, February 17, 1887, 250, February 29, March 28, 1888, 212, 306, 309.

17. *State Journal*, September 17, 18, 22, October 5, 9, 1887, December 21, 1888.

18. *Nebraska Farmer*, (1887), 411-676 *passim*.

19. *Ibid.*, 462-464; Billings, *Southern Cattle Plague*, 72.

20. *Breeder's Gazette*, March 18, 1886, 382-383.

21. *Ibid.*, April 1, June 3, 10, 1886, 455, 693-694, 727-728, 764, 800-801, 838; D. E. Salmon to Charles Bessey, March 22, April 6, 1886, General Correspondence, 1886-1887, Bessey Papers, University of Nebraska Archives, Lincoln.

22. *State Journal*, September 28, 1887; *Nebraska Farmer* (1887), 537-541, 580, 674-676, 695-697, 735-737, 758-761.

23. *State Journal*, January 20, 1887.

24. *Ibid.*, January 22, February 9, 1887.

25. *Ibid.*, September 28, 1887; *Nebraska Farmer* (1887), 483.

26. *State Journal*, October 2, 1887.

27. *Ibid.*, October 9, 1887; *Nebraska Farmer* (1887), 541.

28. *AVR*, XI (1887), 410-414, 450-456; *Nebraska Farmer* (1887) 537-541, 580, 674-676, 695-697, 735-737, 758-761, (1888), 23; *Breeder's Gazette*, February 29, 1888, 214.

29. *State Journal*, October 5, 1887; *Nebraska Farmer* (1887), 562, 613-614, 513-518; Billings, *Southern Cattle Plague*, 53.

30. *State Journal*, December 24, 1888; *Breeder's Gazette*, October 31, 1888, 438.

31. This change began with the December 29, 1887, issue.

32. *Nebraska Farmer* (1888), 891. Other instances of criticism in *Nebraska Farmer* are (1888), 874, 894, 925, 938.

33. Inventory of Instruments, etc. in Patho-Biological Laboratory, April 18, 1887, Papers, Board of Regents, B6.F58, University of Nebraska Archives, Lincoln.

34. *Nebraska Agricultural Experiment Station, Annual Reports and Bulletins*, I-II (1887-1889).

35. *Breeder's Gazette*, October 31, 1888, 438; Billings, *Inoculation, A Preventive of Swine Plague, with the Demonstration that the Administration of the Agricultural Department is a Public Scandal: An Exposure* (Lincoln, 1892), 290-291. Hereafter cited as *A Public Scandal*; Robert N. Manley, *Centennial History of the University of Nebraska*, I (Lincoln, 1969), 104-105.

36. *Nebraska Farmer* (1889), 160; Nebraska Agricultural Experiment Station, First Annual Report (1887), 12-14, 17, University of Nebraska Archives, Lincoln.

37. *Breeder's Gazette*, October 31, 1888, 438-439, August 28, 1889, 194; *Nebraska Farmer* (1888), 954, (1889), 588, 630.

38. *Nebraska Farmer* (1888), 925.

39. Quoted in *ibid.*, 1034.

40. *Ibid.*, 925.

41. *Ibid.*, 891, 955, 1034; *State Journal*, December 26, 29, 1888; *Omaha Daily Herald*, December 6, 8, 9, 19, 27, 1888. Hereafter cited as *Herald*.
42. *Nebraska Farmer* (1888), 1051; *State Journal*, December 10, 16, 1888; *Herald*, December 15, 18, 21, 1888.
43. *Nebraska Farmer* (1888), 1051.
44. *Herald*, December 9, 1888.
45. *Breeder's Gazette*, December 5, 1888, 586.
46. *AVR*, XII (1888), 436-437; *Nebraska Farmer* (1888), 1017; *State Journal*, December 14, 1888.
47. *Breeder's Gazette*, 664-665; *AVR*, XII (1888), 482-485; *State Journal*, January 11, 1889.
48. *State Journal*, July 31, 1889.
49. *Nebraska Farmer* (1888), 1050, (1889), 70, 324.
50. *Ibid.* (1889), 556, 558, 559.
51. *Ibid.*, 572-573; 829, 865; *Breeder's Gazette*, August 21, 1889, 170-171.
52. *The Journal of Comparative Medicine and Surgery*, X (1889), 396-404.
53. *Ibid.*, 399
54. *Ibid.*, 400.
55. *Breeder's Gazette*, September 4, 1889, 218.
56. Quoted in Billings, *A Public Scandal*, 76-77.
58. *Ibid.*
57. *Breeder's Gazette*, August 14, 1889, 146-147.
59. *Ibid.*, October 23, 1889, 389.
60. *Ibid.*; *AVR*, XIII (1889), 144, XIV (1890), 7.
61. *Breeder's Gazette*, June 20, 1888, 615, May 8, 1889, 503; *AVR*, XII (1888), 237.
62. *Breeder's Gazette*, October 16, 1889, 362, January 15, August 6, 1890, 57, 86.
63. *Ibid.*, August 20, December 17, 1890, 118, 464.
64. *AVR*, XIV (1890), 388-389, 446-449, 404-409; D. E. Salmon, "Report on Inoculation as a Preventive of Swine Diseases," *ibid.*, 67-76; *The Journal of Comparative Medicine and Veterinary Archives*, XII (1891), 644-645.
65. *Breeder's Gazette*, February 27, 1889, 231, February 26, April 16, 1890, 198-200, 363.
66. *Ibid.*, February 26, 1890, 194, 198.
67. *Ibid.*, December 17, 1890, 464.
68. *Ibid.*, June 18, 1890, 556, December 9, 23, 1891, 422, 473; *AVR*, XIV (1890), 210, 754; Nebraska Agricultural Experiment Station, Third Annual Report (1889), 15, University of Nebraska Archives, Lincoln.
69. *AVR*, XIV (1890), 754.
70. *Breeder's Gazette*, January 11, March 21, 1888, 34-35, 284-285; *Comparative Medicine*, X (1889), 396-404, XII (1891), 240.
71. *Nebraska Farmer* (1890), 41, 108, 121; *Herald*, December 18, 1888.
72. *Breeder's Gazette*, February 26, 1890, 198, February 4, 25, 1891, 90, 153; *Nebraska Farmer* (1890), 162.
73. *Nebraska Farmer* (1890), 386, 450, 862, 899.
74. *Breeder's Gazette*, April 15, June 10, 1891, 290, 454; *AVR*, XV (1891), 63; *Comparative Medicine*, XII (1891), 240-241; Nebraska Agricultural Experiment Station, Sixth Annual Report (1892), 26, University of Nebraska Archives, Lincoln.
75. *Breeder's Gazette*, July 27, 1892, 54; Billings, "The Cornstalk Disease," *ibid.*, November 21, 1894, 340; Billings, "A Consideration of Actinomyces as to Its Nature and Relation to the Public Health," *Comparative Medicine*, XIII (1892), 269-294, 358-373; Billings, "The Etiology of Southern Cattle Plague—Texas Fever," *ibid.*, 467-486, 526-527, 613-629, 676-692.
76. *Breeder's Gazette*, January 15, February 5, August 6, 1890, 50, 85, 124; G. A. Johnson, "Cornstalk Disease," *AVR*, XIV (1890), 671-673; H. F. Spencer, "Corn Stalk Disease," *Comparative Medicine*, XIII (1892), 83-84; Henry G. Pyle, "A Bacterial Disease of Animals," *ibid.*, 218-222.
77. *Breeder's Gazette*, March 19, August 6, 1890, 85, 267-268.

78. Billings, "A Consideration of Actinomycesis."
79. *AVR*, XV (1891), 548-553; W. L. Williams, "Veterinary Sanitary Science. Actinomycesis Bovis," *ibid.*, XVI (1892), 607-612; Olof Schwarzkopf, "The Committee-Report on Meat Inspection and Actinomycesis," *ibid.*, 9-13; Williams, "National and International Meat Inspection," *ibid.*, 129-134, 498; Williams, "Actinomycesis in Relation to Meat Inspection," *Comparative Medicine*, XIII (1892), 351.
80. Williams, "Veterinary Sanitary Science," 610.
81. *Breeder's Gazette*, August 5, 1891, 82; *Nebraska Farmer* (1891), 574.
82. *Breeder's Gazette*, December 9, 1891, 422.
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105. Cattell, *American Men of Science*, 29.