REPORT

OF THE

SECRETARY OF AGRICULTURE

1890

WASHINGTON
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1890

[PUBLIC RESOLUTION—NO. 49.]

Joint resolution providing for the printing of the Agricultural Report for eighteen hundred and ninety.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That there be printed four hundred thousand copies of the Annual Report of the Secretary of Agriculture for the year eighteen hundred and ninety; seventy-five thousand copies for the use of the members of the Senate; three hundred thousand copies for the use of the members of the House of Representatives, and twenty-five thousand copies for the use of the Department of Agriculture, the illustrations for the same to be executed under the supervision of the Public Printer, in accordance with directions of the Joint Committee on Printing, said illustrations to be subject to the approval of the Secretary of Agriculture.

SEC. 2. That the sum of two hundred thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to defray the cost of printing said report.

Approved, September 25, 1890.

TABLE OF CONTENTS.

LIST OF ILLUSTRATIONS.

REPORT

OF THE

SECRETARY OF AGRICULTURE.

DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., October 25, 1890.

To the PRESIDENT:

I have the honor to submit my Second Annual Report as Secretary of Agriculture.

I deem it to be my first duty in making this report to congratulate you and the country at large upon the generally improved outlook in agricultural matters. At no time in the history of this country has there been so much agitation among the farmers as a class as during the period which has elapsed since I had the honor to submit to you my first report. The causes of this widespread agitation have been so varied and so numerous that to attempt to specify them all would be as tedious as it would be unnecessary in a report of this character. I will only refer to such of the most prominent causes as for various reasons seem to require special mention here.

Naturally the first place in this brief enumeration belongs to a depressed condition of agriculture prevailing at the time that you assumed office, the result of a slight but steady diminution of the prices of most of our staple agricultural products, a reduction which had been going on for some years, and which, therefore, has amounted in the aggregate to a considerable percentage of the average crop values. Severely as such a depression must necessarily have been felt by a class who measure even their prosperity by a very moderate standard of profit, it has not been without its good results.

The attention of the country was thoroughly awakened to the farmer's condition, and agricultural matters were very properly made the subject of special consideration by Congress. The subject was discussed in the press, the views of the farmers themselves were made known, and it is gratifying to be able to point out that to-day the cloud which for some years seemed to rest gloomily upon American agriculture has been lightened, while the wise economic legislation already secured holds out still brighter promise for the future. As an earnest of this statement, I subjoin a brief table, showing prices of some of our staple agricultural products to-day and a year ago.

Prices of leading agricultural products at Chicago, October 16.

Articles.	1889.		1890.	
Corn ... per bushel..	$0.30⅞ to	$0.31	$0.50 to	$0.50¼
Wheat ... do	.80⅛	.81¼	1.00	1.00¾
Oats ... do	.18¾	.19¼	.42	.43
Barley ... do	.63	——	.78	——
Flaxseed ... do	1.27	1.27½	1.45½	1.46
Buckwheat ... do	.38	.45	.55	.65
Hogs ... per 100 pounds..	3.85	4.20	3.85	4.50
Cattle, choice ... do	4.00	5.05	4.75	5.30
Sheep, Western ... do	3.50	4.20	3.00	4.60

The recent legislation looking to the restoration of the bimetallic standard of our currency, and the consequent enhancement of the value of silver, has unquestionably had much to do with the recent advance in the price of cereals. The same cause has advanced the price of wheat in Russia and India, and in the same degree reduced their power of competition. English gold was formerly exchanged for cheap silver, and wheat purchased with the cheaper metal was sold in Great Britain for gold. Much of this advantage is lost by the appreciation of silver in those countries. It is reasonable, therefore, to expect much higher prices for wheat than have been received in recent years.

In my last report I ventured to appeal most earnestly for a larger measure of tariff protection for the farming industry. "For all such articles as our own soil will produce, the farmer justly asks that protection which will insure to him all the benefits of our home market." Such was the language with which I concluded my appeal on his behalf. I am thankful to say that it has been in a very large measure heeded; and, admitting to the fullest extent the place to which natural causes are entitled in assigning reasons for the higher prices now prevailing for agricultural products, it is impossible not to see the beneficial influence of the tariff protection awarded to the farmer under the present law. A comparison of the duties under the present law on some of the agricultural products heretofore imported in considerable amounts with the rates of duty imposed on them under the old law will illustrate this in a striking manner.

Agricultural imports, fiscal year ending June 30, 1890, with change in tariff duties.

	Value.	Old duty.	New duty.
Animals and animal products:			
Cattle	$244,747	20 per cent. ad val.	Over one year, $10. Under one year, $2.
Horses	4,840,485	20 per cent. ad val.	$30, or 30 per cent. if value over $150.
Sheep	1,268,209	20 per cent. ad val.	Over one year, $1.50. Under one year, $0.75.
Cheese	1,295,506	4c. per lb	6c. per lb.
Eggs	2,074,912	Free	5c. per dozen.
Wools	15,264,083		
Class 1 (above and below 30c. per lb.)		10c. and 12c.	11 cents.
Class 2 (above and below 30c. per lb.)		10c. and 12c.	12 cents.
Class 3 (above and below 12c. per lb.)		2½c. and 5c	At 13c. per lb., 32 p. ct. Over 13c., 50 p. c. ad val.
Flax	2,188,021		
Straw		$5 per ton	$5 per ton.
Not hackled		$20 per ton	1c. per lb.
Dressed line		$40 per ton	3c. per lb.
Tow		$10 per ton	1½c. per lb.
Barley	5,629,849	10c. per bush	30c. per bush.
Hay	1,143,445	$2 per ton	$4 per ton.
Hops	1,053,616	8c. per lb	15c. per lb.
Tobacco	17,605,192		
Unstemmed (leaf)		75c. per lb	$2 per lb.
Stemmed (leaf)		$1 per lb	$2.75 per lb.
All other		35c. per lb	Stemmed, 50c. per lb. Unstemmed, 35c. per lb.
Potatoes	1,365,898	15c. per bush	25c. per bush.
Wines	8,859,956		
Champagne:			
Bottles between pint and quart		$7 per doz	$8 per doz.
Bottles between half pint and pint		$3.50 per doz	$4 per doz.
Bottles less than half pint		$1.75 per doz	$2 per doz.

We have a strong assurance in the recent increase of values of meat products, and the circumstances which now environ production, of continued prosperity of stock raising. New industries now in process of development will increase the ability of consumers to purchase meats; and better protection of wool will open larger domestic markets, as it has already advanced prices. There is an increasing interest in the production of mutton in the central West, and of early lambs in the populous East, indications of progress that promise increase of profit in sheep husbandry. Of chief interest naturally to the stock raisers of this country are the export trade in animals and their products, and the possibilities of still further relieving our home markets of these products by extending our markets abroad.

THE EXPORT TRADE IN ANIMALS AND THEIR PRODUCTS.

Step by step as it were with the vigorous prosecution of the work of exterminating pleuro-pneumonia and controlling Texas fever, and with a more general appreciation of the benefits derived from a judicious exercise of the powers conferred on this Department, we find a gratifying improvement in the export trade in live animals. The total value of animals and fowls exported for the fiscal year ending June 30, 1890, was over $33,000,000, an increase of something over $15,000,000 as compared with the year previous. The increase in the number of cattle was from 205,786 in 1889 to 394,836 in 1890, while the number of hogs exported increased from 45,128 to 91,148, over 100 per cent. In horses there was a slight reduction of exports, far more than counterbalanced, however, by the large increase in the number of mules exported. In the number of sheep exported there was a decrease.

A very large increase is shown in the export trade in beef and hog products, while in dairy products the export trade in butter was especially gratifying, the figures for 1889 being 15,504,978, and in 1890 29,748,042 pounds. The increase in the value of meat and dairy products exported between 1889 and 1890 was over $32,000,000. At a time when our domestic markets are overcrowded with animals and their products, this increase in the export trade is very encouraging. The prices realized abroad have as a rule been good, and but for the unjust restrictions placed upon both animal and meat products abroad, the increase in the amount exported would have been much greater. Experimental shipments of cattle to Germany and Belgium were made during the year with favorable results, but excessive duties and the quarantine restrictions which were immediately imposed at once destroyed this trade. A careful review of the trade shows how urgent it is that we should secure more favorable regulations in the chief European countries in regard to our exports of animals and animal products. The first step towards the accomplishment of this object was necessarily to secure as far as possible the absolute immunity of our own cattle from disease.

ERADICATION OF PLEURO-PNEUMONIA.

The regulations for the eradication of contagious pleuro-pneumonia have been vigorously enforced during the entire year, and rapid progress has been made. In New York no cases have occurred during the year ending June 30, 1890, except on Long Island. There have been no cases in Maryland since October, 1889. Pennsylvania has remained free from the disease during the entire year. In both Maryland and Pennsylvania constant inspection has been maintained and the complete eradication of the contagion thereby assured. During the two months of May and June, 1890, but 13 affected animals were purchased in the whole infected district as compared with an average of 71½ per month during the preceding ten months. At this writing it would seem that the disease is practically banished from American soil, though the length of time which has elapsed since the last case of the disease was noted by the inspectors has been hardly sufficient to warrant a formal official declaration to this effect.

INSPECTION IN GREAT BRITAIN.

The vigor with which the work of exterminating pleuro-pneumonia was carried on would nevertheless, as far as our export trade was concerned, have been comparatively ineffectual unless simultaneously with its eradication in this country we were able to convince Great

Britain and other European governments of the progress made in ridding the United States of this disease. Early last winter, therefore, I solicited the aid of the State Department in opening negotiations through Minister Lincoln with the British Government, looking to an arrangement which I deemed extremely desirable with a view to putting an end to the frequent allegations that cases of contagious pleuro-pneumonia existed among American cattle shipped to British ports.

The circumstances under which these allegations were made convinced me of the absolute necessity that this Department should be represented at the inspections made of our cattle on landing in Great Britain. Thanks to the cordial co-operation of the State Department and the intelligent activity displayed in the matter by Minister Lincoln, I finally obtained the privilege of appointing veterinary inspectors representing this Department, to be resident in Great Britain, who were to be allowed every facility in participating with the British inspecting officers in the work of inspecting American cattle landed in British ports. As soon as this privilege was secured I appointed three competent officers for this responsible duty and dispatched them to Great Britain in charge of the Chief of the Bureau ot Animal Industry, Dr. Salmon, who remained with them until their duties were clearly defined and the best means decided upon to enable them to carry on their work effectually and in harmony with the British authorities. This transatlantic inspection has been in force for the past two months, and I am happy to be able to state that since it was instituted not a single case has been reported of contagious pleuro-pneumonia among American cattle landed in Great Britain. Indeed, I am now informed that not a single case has been reported by the British authorities themselves since March last.

At the same time that I presented this matter to the attention of the Secretary of State I also placed before him facts bearing upon our meat export trade, showing conclusively the utterly groundless nature of the charges made by other European governments in regard to the unwholesomeness of our meat, but especially of our pork products. I am happy to state that this matter was taken up by the State Department with the same cordiality that characterized its action in regard to our export of live cattle, and that the facts supplied by me to that Department were laid before the foreign governments by our respective ministers so clearly and with such force as will, I am sure, carry considerable weight in the further consideration of this subject by the governments in question.

INSPECTION OF EXPORTED ANIMALS.

The act of August 30, 1890, provides for the inspection of all exported cattle, sheep, and swine. The amount of work required to accomplish this is indicated by the fact that during the year ending

June 30, 1890, the number of these animals exported was as follows: cattle, 394,836 head; hogs, 91,148 head; sheep, 67,521 head. Rules and regulations for this service have been prepared and the inspection is now being made. The necessity of this inspection is shown by the exclusion of American cattle, sheep, and swine from European markets on the plea of the danger that disease will be introduced by them. While this inspection alone might not be accepted as in all cases giving a complete guaranty against the appearance of disease during the voyage, it is an important step in this direction, and will give us the means of knowing officially the condition of the animals as they leave our ports. In connection with the inspection recently established by me at the foreign animal wharves of Great Britain, it will also enable us to trace back animals which may be found affected there, so that the nature of their malady may be determined, and if found contagious the proper measures will be enforced for its eradication.

REGULATIONS REGARDING TEXAS FEVER.

The regulations regarding Texas fever, which went into effect on March 15, though carefully formulated so as to allow the free movement of Southern cattle to market, have been on the whole well observed, and the result has been a marked decrease in the number of cases of Texas fever occurring on farms, in stock yards, or on vessels carrying export cattle. One of the largest buyers and exporters of cattle in the United States reports that, whereas a year ago he dared not buy cattle for feeding or export in the stock yards, but was obliged to go to the farms where he could get evidence that they had not been exposed, this year, on the contrary, he has purchased such animals at the stock yards without fear. Last year his losses from Texas fever, in spite of his precautions in buying, were considerable; the present summer he has not lost one from this cause. He further states that, owing to the immunity from this disease, insurance rates have been reduced from $8 to $3.50 on every $100 worth of cattle, this alone representing a saving of over a million dollars on export cattle. Owing to lack of authority under existing laws, I have, however, been unable in some cases to enforce these regulations, and there is at present no penalty which can be applied in such cases. Owing to such disregard, some cases have occurred of Texas fever imparted to valuable thoroughbred cattle, and these have since died from the effects of the disease.

Proper facilities for separating the two classes of cattle are still lacking at the ports on the Atlantic seaboard, and as a consequence the disease has occasionally appeared among export cattle on their voyage to foreign countries. The influence of this upon the trade is very bad. It is being cited in Great Britain as affording good reason for their continuing the prohibition of the introduction of live cattle from this country. Ample power to compel immediate remedy of this condition of things is therefore urgently needed. If the regulations of this Department can be properly enforced, the appearance of Texas fever in this country outside of the affected areas will be very rare, and not a single case should occur among cattle after leaving our ports. I have therefore suggested amendments to the act establishing the Bureau of Animal Industry, which are now pending in Congress. If enacted, these will fully provide for the prevention of the spread of this and other communicable diseases of animals from State to State or from the United States to foreign countries. These amendments are essential to rendering the work of this Department effectual. If there is to be control of animal diseases at all, it must be so thorough as to prevent their spread, and thus remove foreign objections to our cattle and meats, give confidence to stock owners and shippers, and secure full protection to farmers.

INSPECTION OF PORK PRODUCTS.

It is with great gratification that I have assumed the duties imposed upon me by the passage of the act of August 30, 1890, in which provision is made for the inspection of salted pork and bacon. The unjust war waged upon our pork products by some of the European governments rendered this provision absolutely necessary as a preliminary step towards any action looking to a removal of the obstacles which now impede our export trade in these products. The absence of inspection on this side provoked an argument on the part of the representatives of foreign governments, to which we were really not prepared to reply. It was that no inspection being held by ourselves, while a rigid inspection was conducted by them of American pork products landed in their countries, they were in a position to know better than we ourselves the actual condition of these products. The present law will enable us to warrant the wholesomeness of our pork products under the seal of official inspection. Having then satisfactorily established the injustice of these foreign discriminations, we shall be in a position to demand their withdrawal, or at least to insist upon a retraction of all charges made on the ground of unwholesomeness or impurity. Armed with a certificate of inspection guarantying wholesomeness on the one hand, and with the retaliatory clause wisely interpolated in this law on the other, we shall, it seems to me, be in a position to provide powerful support to further diplomatic negotiations on behalf of American hog products.

MEAT INSPECTION.

In my report of last year I urged the great desirability of a national inspection of cattle at the time of slaughter, and also an inspection of meats, which would enable this Department to guaranty that the animal products exported from this country were untainted by disease, and which would reveal at once the presence of any diseases affecting our meat-producing animals. The call for such inspection was not because of any unusual prevalence of disease, since the animals of the United States are probably at present more exempt from such influences than those of any other nation, but because of the unfounded statements of disease which have been made the pretense for the restrictions and prohibitions which the governments of other countries have enforced against our animals and their products. None of these restrictions upon the sale of our meats have been removed, and it appears from the statements of shippers, confirmed in some cases by the reports of our consular agents, that there is a tendency to make them more stringent and irksome. It is sufficiently evident that any assistance which the Government can properly render to such trade, at a time when our home markets are overstocked as at present, should be freely accorded.

A bill providing for a general inspection law of this character was passed by the Senate September 18, 1890, and has been referred to the Committee on Commerce of the House of Representatives. This bill provides for all necessary regulations, and if passed will enable the Secretary of Agriculture to cause the inspection of animals and meats at slaughter, and to give a guaranty of their wholesomeness and freedom from taint of every kind. Such a law is urgently needed and should be enacted without delay.

QUARANTINE AND INSPECTION OF IMPORTED CATTLE.

Regulations for the quarantine of neat cattle from the countries not located on the American continent continue to be enforced. The period of quarantine—three months—is regarded as amply sufficient under the regulations to prevent the introduction of disease; and no additional restrictions will be imposed, notwithstanding the fact of the restrictions imposed by Great Britain on cattle from this country, and the further fact that pleuro-pneumonia is much more prevalent and widespread in Great Britain than it ever was here.

There has long been danger of the introduction of foot-and-mouth disease by the importation of sheep, swine, and other susceptible animals that have heretofore been allowed to land without either quarantine or inspection; indeed, this disease has several times been brought to this country by cattle from Great Britain, but it has fortunately been detected in time to prevent its dissemination here. Notwithstanding this fact, our sheep have been excluded from Great Britain for more than ten years, owing to the alleged existence of this disease in the United States, where it is never seen except in British cattle that were affected before landing.

I have concluded that the adoption by this Department of regulations for quarantine and inspection of all neat cattle, sheep, and other ruminants, and all swine imported into the United States under the authority given to me by the act of August 30, 1890, is necessary for the full protection of our own live animals. Regulations have accordingly been perfected to carry this provision into effect, and it is believed that the result will be not only to fully protect our herds and flocks, but, in view of the assurances to that effect secured from the British authorities, that it will moreover result in the revocation by the British Government of the regulation excluding our sheep from Great Britain. This inspection and quarantine of all cattle, sheep, and swine imported into the country will add seriously to the work of this Department. During the twelve months ending June 30, 1890, cattle were imported to the number of 30,695; sheep to the number of 393,794; but the figures of the Bureau of Statistics of the Treasury Department fail to give the number of swine imported. Increased duties levied under the present law will no doubt greatly diminish the number of animals imported, although during the year just mentioned 3,935 head of cattle and 16,303 head of sheep were admitted duty free, on the ground that they were imported for breeding purposes.

In this connection I would point out that the average value of the 10,865 horses imported for breeding purposes during the year was but $270 each; that the cattle imported for this purpose averaged but $18.60, and the sheep but $7.26, showing conclusively that by far the greater number of these animals were not of such a character as would improve our native stock, and that they could only be sold in competition with the animals produced by our own farmers. The new law provides "that no such animal shall be admitted free unless pure bred of a recognized breed, and duly registered in the book of record established for that breed." This wise provision will no doubt restrict the importation of animals free of duty to those which have special merit and which will prove beneficial to the agricultural interest.

THE SUGAR INDUSTRY.

Encouraging progress has been made within the past year in the development of an indigenous sugar industry. Under the impetus given by the investigations of this Department, improved processes of manufacture have been introduced on many of the more prominent plantations of Louisiana. In Florida large tracts of swamp land suitable for the cultivation of sugar cane have been reclaimed, and the culture and manufacture of cane have already been begun. In Nebraska a large beet-sugar factory, capable of using 300 tons of beets per day, has been erected with the best approved modern machinery, and is now in successful operation. The finest quality of granulated sugar is produced, which finds a ready local market, thus avoiding all expenses of transportation to and from a distant refinery.

A careful study of the soil and climatic conditions of the country favorable to the production of sugar beets has been made, and those localities in the United States best adapted for this purpose have been pointed out. This area includes a zone of territory extending from the Atlantic to the Pacific, with a breadth of from 100 to 200 miles. It includes parts of the New England States, Northern New York, Northeastern Pennsylvania, Northern Ohio, Indiana, Illinois, Wisconsin, Southern Iowa, parts of Nebraska and the Dakotas, and large portions of the Rocky Mountain plateaux and of the Pacific slope. Within these areas it is confidently believed—and this belief has been verified by actual production of good beets—will be found an adequate acreage for the production of sugar on a large scale, and from beets as rich as can be grown in Europe. It is not an idle prophecy to speak of the production of a quantity of beet sugar in the near future sufficient to supply one half or more of all the sugar consumed in the United States.

The investigations in sorghum culture have also been vigorously prosecuted, and the Department will soon be ready to offer to the sorghum growers of the country a few varieties of that plant which have been already developed to a high degree of excellence as sugar producers. At least one sugar factory in Kansas has been operated the present year with profit to the owners, with an output of three quarters of a million pounds of sugar, demonstrating that with the best agriculture, the best soil and climate, and the best machinery, sorghum sugar may be made at a profit.

Under the fostering provisions of the new tariff bill, it is believed that the patient and laborious investigations of the Department will soon bear fruit and result in the production of our sugar at home. To further secure this end I have established three special experimental stations for the scientific study of the problems underlying the promotion of an indigenous sugar industry; one each for sugar cane, sorghum, and the sugar beet. Through these stations the farmers of the country will be taught the principles of the successful growth of the plants producing sugar, and the manufacturer the best methods of securing in marketable shape the products of the fields. With the administrative changes in the tariff law which I recommend, it is my sincere belief that the efforts of this Department to secure home sugar for home consumption will prove successful.

EFFECTS OF RECENT LEGISLATION.

It becomes my duty to call attention in this report to certain provisions under the tariff law which went into effect on the 6th instant, relating to the bounties on sugar from beets, sorghum, or sugar cane grown within the United States. Under Schedule E, paragraph 231, it is provided that the bounty on sugar, according to the polariscopic test, shall be paid "under such rules and regulations as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, shall prescribe." Paragraph 232 provides that to the same officer, namely, the Commissioner of Internal Revenue, sugar producers shall give due notice as to the place of production, equipment, and an estimate as to the amount of sugar they propose to produce in the current or next ensuing year, and that they shall furthermore apply to the Commissioner of Internal Revenue for a license, accompanied by a bond. Paragraph 233 provides that the Commissioner of Internal Revenue shall issue such license; paragraph 234, that no person not so provided with a license, etc., can receive bounty, and that the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, "shall from time to time make all needful rules and regulations for the manufacture of sugar from sorghum, beets, or sugar cane grown within the United States, or from maple sap produced within the United States, and shall, under the direction of the Secretary of the Treasury, exercise supervision and inspection of the manufacture thereof;" and so on throughout the entire Schedule E, relating to sugar, does the law provide that the entire regulation and control of sugar making in the United States shall devolve upon a subordinate officer of the Secretary of the Treasury.

It seems impossible that the law should have been so drafted, save by an oversight. The entire work relating to the development of the sugar industry in the United States, from the chemical supervision of sugar making established in Louisiana to the sorghum and beet-sugar experiments throughout the country, has been, from the first, part of the work of the Department of Agriculture, under the special supervision of its chief chemist. Under the direction of this officer there have been issued from time to time bulletins of the utmost importance to both growers and manufacturers. They are, indeed, the only official sources of information relating to this important industry issued by the National Government; and during the last session of Congress a special appropriation was made by that body of $50,000, to be expended through the Chemical Division of this Department under my direction, in promoting the cultivation of sugar-making plants and the manufacture of sugar. Moreover, the very essence of the supervision necessary, with a view to an equitable award of bounties, namely, the testing of the sugar by the polariscope, is a strictly scientific operation, coming within the sphere of the Chemical Division, and one with which a considerable experience has made the chief and his assistants thoroughly familiar.

If it is really the intention of Congress to withdraw the "supervision and inspection" of the sugar industry from this Department, such intention should be formally expressed, and the efforts of this Department in relation to this important matter, involving the expenditure of much time, labor, and money, must be restricted to such lines of labor and investigation in connection with this industry as relate directly and exclusively to the sphere of the tiller of the soil. It is perhaps not generally understood that heretofore all the scientific supervision of work done in the various manufactories of sugar throughout the country has been exercised by the Chemical Division of this Department. Officers of this division have been detailed by me for this purpose, and a number of them are so engaged under my orders at the present time. It is unquestionably due to this Department to recognize the fact that whatever improvement has been made in methods of sugar manufacture, and whatever progress has been accomplished in the development of the sorghum and beet-sugar industry, has been due to the scientific investigations conducted under its auspices and the practical application of the results under the supervision of its officers.

Again, under free list, paragraph 482 provides that "any animal imported specially for breeding purposes shall be admitted free." It is further provided, in accordance with a suggestion of my own, that no such animals shall be admitted free unless pure bred, of a recognized breed, and duly registered in a book of record established for that breed. The provisions referred to are followed by the statement that "the Secretary of the Treasury may prescribe such additional regulations as may be required for the strict enforcement of this provision." Even before this Department was an executive department of the Government, its Bureau of Animal Industry had supervision of the importation of live animals into this country, and the head of the Department was held responsible in matters of quarantine of live animals, and for the supervision of the live-stock industry and the contagious diseases of animals. Recent legislation enlarges the powers of this Department, lodging in the hands of the Secretary of Agriculture the control of all importations of animals, whether free or dutiable, imposing upon him the duty of inspecting the same, as he is charged also with the duty of regulating the interstate commerce in live animals and the proper inspection of all live animals exported.

Under those circumstances, the provision I have quoted, making it the duty of another officer to prescribe regulations for the enforcement of the provision admitting animals free under certain conditions, is incomprehensible to me. In section 20 of the said law it is provided—

That the operation of this section—

Prohibiting the importation of neat cattle and hides of neat cattle from any foreign country—

shall be suspended as to any foreign country or countries or any parts of such country or countries, whenever the Secretary of the Treasury shall officially determine and give public notice thereof, that such importation shall not tend to the introduction or spread of contagious or infectious diseases among the cattle of the United States, and the Secretary of the Treasury is hereby authorized and empowered, and it shall be his duty, to make all necessary orders and regulations.

Inasmuch as there is no officer of the National Government whose duty it is to have authentic information as to the existence of diseases among cattle in foreign countries and as to the contagious or infectious character of such diseases, and the probability of the introduction or spread thereof among the cattle of the United States, save only the Secretary of Agriculture, the provision in question which makes it the duty of another officer to declare officially as to such facts is, to say the least, an instance of glaring inconsistency in the law.

REORGANIZATION.

The act providing the necessary appropriations for carrying on the work of this Department became a law but a few months ago, and until this was done I was naturally much hampered in my efforts to carry out fully and thoroughly the measures indicated by me in my last report as essential to an efficient reorganization of the Department. During the past winter and spring I was obliged to do the best I could in this direction under these discouraging circumstances.

Since the 14th of July, when the appropriation act became a law, I have, with such appropriations as Congress saw fit to place at my disposal, pushed the work of reorganization with all possible energy. Under that act several new divisions were created, but as the work for these divisions had already been duly considered and carefully outlined, and as the persons designed to take charge of them were already in the employ of the Department, their reorganization was effected, I may say, immediately on the passage of the law.

A review of the work of the several divisions, which I now have the honor to lay before you, indicates the activity and energy with which the work of the Department has been pushed; and with a well-deserved tribute to the intelligence and good will exercised by all the members of my large force, in the performance of the duties assigned to them, I will now call your attention to the most salient features of the work of each division.

BUREAU OF ANIMAL INDUSTRY.

I have already alluded in this report to the exercise of the administrative powers of this Bureau and the generally satisfactory results which have followed, as well as to the additional powers which are in my opinion needed to make the work absolutely efficient.

INVESTIGATION OF DISEASES.

The scientific investigation of the communicable diseases has been carried on for the purpose of elucidating the many points in connection with the cause and nature of these maladies which must be understood before they can be economically prevented or eradicated. The diseases to which most attention has been given are hog cholera and Southern fever of cattle. With both, discoveries of great importance have been made which are not only of value from a scientific point of view, but which promise important results in the way of prevention and treatment, and will accordingly be treated at length in the report of the Bureau of Animal Industry.

A thorough knowledge of animal plagues is becoming more and more necessary, both because of the great increase in the number of animals in the country and the multiplication of the transportation routes by which contagion may be carried, and also because of the recent legislation already mentioned looking to a Government guaranty that the animals shipped abroad and those from which our meat products are obtained have been unaffected by disease. The excellent results which have already been reached with pleuro-pneumonia and Texas fever demonstrate the possibility of controlling and even eradicating the most virulent diseases when our knowledge of them is sufficient to indicate the proper measures. That the most destructive diseases of swine and other animals will be ultimately controlled or eradicated is almost certain, and to hasten this result the scientific investigations should be maintained and made more comprehensive.

A short time ago, I regret to say, there was an announcement made under the authority of a State official, referring to an outbreak in a Western State, which was characterized as "foot-and-mouth disease." Issued under such auspices it was given extensive publication, but fortunately my attention was called to it at the start, and I immediately telegraphed the governor of the State in question, requesting him to do all that was in his power to repress the spread of a rumor which I felt sure must be groundless, and announcing my intention to have the matter immediately investigated by a competent authority. I at once dispatched one of our veterinary inspectors to the spot and received from him a report confirming my anticipations to the effect that it was not the disease known as "foot-and-mouth disease," and, furthermore, that it was not a contagious disease at all. Immediately on the receipt of this reassuring report, I cabled the facts to our consul-general's office in London, in order that he might make it public there, the unfortunate rumor to which I refer having already been reproduced in British journals.

I desire to emphasize here the danger of giving out statements of this kind without a thorough investigation. Immediate communication with this Department will always find me willing to co-operate in an investigation of this kind, and, until the exact facts are ascertained beyond a doubt, no statement alleging the existence of a dangerous contagious disease should be given to the public. It is no exaggeration to say that the losses to our cattle growers from unfounded rumors of such diseases have been infinitely greater than the actual losses occasioned by the diseases themselves.

COLLECTION AND DISTRIBUTION OF INFORMATION

The information obtained from year to year by the scientific investigation of diseases must necessarily form but a small portion of the existing knowledge on the subject of disease, and must be used in connection with what has been previously acquired in order to give satisfactory results. For this reason I have deemed it of great importance that reliable reports should be issued, treating systematically of the common diseases of animals with special reference to prevention and treatment. Taking these as a basis for comparison with the results of investigations issued annually, the farmer will be enabled at all times to obtain full information in regard to any disease with which his stock may be affected.

The first report of this series on the Animal Parasites of Sheep has recently been issued, and a second report on the Diseases of the Horse is now in press. Other volumes are in preparation and will be issued as rapidly as possible. The favor with which the announcement of these publications has been received shows that they will supply a variety of useful knowledge which has been greatly needed by the agricultural community.

Various lines of investigation are being vigorously prosecuted with the design of showing the actual condition, means of improvement, and future prospects of various branches of the animal industry. A full report on the Sheep Industry is in preparation, well advanced towards completion, and will probably form the first volume of this series. Reports on the American Trotter and the Thoroughbred Horse of the United States will be ready for the press at about the same time. This brief statement of the reports now nearly completed will serve as an indication of the character and scope of this section of the work of the Bureau of Animal Industry.

Last February I received an invitation to attend an interstate convention of cattlemen, to be held the following month at Fort Worth, Texas. Though unable to attend, I was impressed with the character and scope of the work indicated in the call for this meeting, and detailed a special agent of this Department to be present. I also sent a stenographer from this Department, with instructions to take a full report of the proceedings for my information. One of the subjects which was thoroughly discussed at the important convention in question, at which thirteen States were represented, was the urgent necessity to cattle growers for more extended information on the subject of the cattle supply of the country, the condition of the cattle markets, and the relation of quality to price in the cattle marketed. I have given this subject considerable attention, have invited an exchange of views on the subject from prominent cattlemen, and have concluded that an earnest endeavor to secure information of the kind desired must be made by this Department through the Bureau of Animal Industry and its agents. It is merely carrying out the conviction which I have frequently had occasion to express elsewhere, that the peculiar circumstances of our agricultural people and their lack of facilities such as are enjoyed by people whose occupations require them to live in cities, within easy access of all centers of information relating to their business, make it the imperative duty of this Department to supply this lack as far as possible, and I have determined that an earnest effort in this direction shall be made during the coming year.

DAIRY AND POULTRY INTEREST.

In my last report I announced my determination to establish in the Bureau of Animal Industry a special division devoted exclusively to the service of the dairy interest. The act of appropriation, with the changes made in the appropriation for the needs of this bureau, making it possible to carry this determination into effect, was passed so lately that the thorough organization and equipment of an important division of this character has not yet been possible. The present encouraging condition of the dairy interest, its vast extension throughout this country, and the general appreciation of the necessity for the successful conduct of the dairy business, of the strict application to the feeding of dairy cattle of the most scientific principles, and of the application to the business of perfect methods, make necessary the establishment in this Department of a division which shall be in these matters the natural leader. Such a division should moreover be able to extend material benefit to the dairy interests of this country by lending its aid to the extension of our export trade in dairy products and to the development of the manufacture at home of every dollar's worth of dairy products which we consume, an object which will be still further facilitated by the recent increase in the duty on cheese, a product which constitutes almost our entire dairy import.

Regarding the poultry interest, I am inclined for the present to place it in the special charge of the Dairy Division. Even though it may not be essential that this interest should be represented at present by a special division, the magnitude of the interest requires that some one division be charged with its supervision. The poultry products of this country represent in the aggregate a vast sum; and the industry is one which exists, or should exist, on every farm in this country, and which, consequently, interests a larger number of the constituents of this Department than any other single industry. In this connection, I congratulate our poultry raisers on the recent change in the law, which instead of admitting imported eggs free, now levies on them a duty of 5 cents per dozen. The large imports of eggs into this country in past years, which it seems have come not only from our neighbors in Canada but even from across the ocean, amply justify the imposition of this duty.

DIVISION OF CHEMISTRY.

A review of the work of the Chemical Division during the past year shows that it has been carried on with diligence and success. New and commodious quarters have been acquired for the use of the division, and many mechanical facilities have been provided which it was impossible to find in the old quarters in the basement of the main building.

Work in connection with the adulteration of foods has been heartily sustained by Congress, and an increase in the appropriation has been made therefor. This is a work which should have the sympathy of every legislator and the help of every honest man. The adulteration of human food is an evil whose proportions are growing, I am sorry to say, from year to year. It is an evil destined to undermine and destroy health; and its practice not only interferes with the sale of products honestly manufactured, but also casts discredit upon our goods in foreign countries, corrupts morals, and places a premium upon dishonesty. I hope to be enabled, through the Chemical Division, to analyze specimens of every product placed upon our market in competition with pure goods and products of the farm, and the co-operation of Congress in these efforts is earnestly solicited. Investigations during the past year have related particularly to the adulteration of tea, coffee, chocolate, and other table beverages. These results are now nearly ready for delivery to the printer.

These investigations show that the adulteration of such articles is not very extensive, and, except in the case of tea, is easily distinguishable. The most frequent one is the introduction of substances to give additional weight, such substances as will attach themselves readily to the leaves and yet not be easily distinguished by the eye. These substances are mostly of a harmless character, although some of them have been found to be deleterious. In the case of coffee the chief adulterations have been found in the ground coffees, the difficulty of adulterating the berry, whether roasted or unroasted, being so great as to almost exclude this kind of fraud. With the green berry, the chief adulteration seems to be in exposing it to a moist atmosphere that it may absorb moisture and thus increase in weight; but this is a species of fraud which is easily distinguished, since the simple drying of the berry and the estimation of the water contained therein is sufficient to determine whether or not it has been thus exposed.

Extensive investigations have also been made in regard to the adulteration of sugar, molasses, honey, and confections, and the publication of this work will speedily follow that of the work on the adulteration of table beverages.

A thorough study of the materials which prevent the crystallization of the sugar in sorghum juices has also been made, these substances have been identified and studied, and the best methods of removing them from the sorghum juices have been investigated.

Coupled with this work has been the continuation of the experimental station work for the development of varieties of sorghum which are as free as possible from these deleterious substances, and containing as high a percentage of sucrose as can possibly be obtained by years of patient selection of seed and careful cultivation of the cane. Some remarkable results in cultivation of this kind are now on record.

In 1889 four varieties of cane were studied for thirty-five days, giving in that period an average of 14.15 per cent. of sucrose in the juice, 1.15 per cent. glucose, and having a purity coefficient of 77.5. The present year seven varieties of cane, for the same length of time, showed an average of 14.48 per cent. sucrose, .77 per cent. glucose, with a purity coefficient of 76.40. The best varieties of cane this year showed, for fifty-one days, from August 25 to October 15, 15.48 per cent. sucrose, .51 per cent. glucose, with a purity coefficient of 78.36.

It is proposed to continue these culture experiments for the purpose of developing and introducing all varieties of sorghum cane which give any promise whatever of becoming useful. In all, the Department has experimented with about 800 varieties and subvarieties of cane. Many of these, on investigation, proved to be duplicates of others which had come to us under separate names. From this extensive list, after three years of careful investigation, all have been eliminated except ten or twelve distinct varieties which possess the essential qualifications of sugar-producing plants, viz., high sucrose content with a low content of other substances. Work will be continued with these selected varieties until their excellent qualities are rendered permanent by continued selection and by improvement due to careful cultivation. It is believed that the sorghum plant will then be able to compete successfully with the sugar cane and the sugar beet, but only in those localities where soil and climate are best suited for the production of the sorghum plant in its highest perfection.

The investigations so far completed show that the localities in which sorghum can flourish are confined to the semi-arid region of the country, notably beginning in Central Southern Kansas and extending southward indefinitely. The investigations have also shown that sorghum of excellent quality can some seasons be produced in other parts of the country, but the uncertainty of suitable climatic conditions would seem to render it advisable to attempt the production of sorghum for sugar-making purposes only in the localities indicated.

Investigations by the Department in respect to the production of sugar from the sugar beet have also been of the most extensive nature. During the early spring 5,000 packages of sugar-beet seed of the most approved varieties were obtained from European growers and sent to all persons in the country who had applied for them. Arrangements were also made by which the beets, after maturity, could be sent to the Department for analysis. As a result of this arrangement beets have been received from about one thousand different localities in all parts of the country, and these have been analyzed in the laboratory. The results of the analysis are, for the most part, extremely favorable, especially with those varieties which have come from the northern and central portions of the country. It is not uncommon to find beets containing 15 per cent. of sugar, while in exceptional cases the percentage of sugar has risen as high as 20. We have also found many beets of a strictly typical character, combining a perfect shape with the proper weight and a high content of sugar. A typical sugar beet is conical in shape, smooth in its external contour, with a white, solid interior, weighing about 1 pound, and having a content of sugar of about 14 per cent. Many samples of such beets have been received, showing that it is possible to produce in this country sugar beets of the highest type.

In Bulletin No. 27 are given the results of a careful study of the soil and climatic conditions of the country suitable to the production of sugar beets, and a map has been prepared showing a zone within which the most favorable results will probably ensue from the cultivation of the sugar beet. A large beet-sugar factory has been erected at Grand Island, Nebraska, equipped with the most approved modern machinery, and this factory is now working sugar beets at the rate of 300 tons per day. There is every reason to believe that the encouragement which has been extended to the sugar-beet industry, by the investigations of the Department and by act of Congress, will result ere long in the establishment of many additional sugar factories in those portions of the country which the data obtained by the Department show to be best suited for the purpose. When it is considered that 250 beet-sugar factories of the size and capacity of those now in operation in California and Nebraska will be sufficient to make one half of the total sugar consumed in the United States, it is not idle to expect that in the course of a few years a large proportion of the sugar consumed in the United States will be made therein from the sugar beet.

Further investigations of the Chemical Division have had relation to matters more specifically connected with the agricultural experiment stations and the best methods of analysis to be used therein. Investigations have been made of these methods in the laboratory, and they have been carefully compared with other methods, so that the best could be secured. In this work the co-operation of the agricultural chemists throughout the whole country has been enlisted in an organization known as the Association of Official Agricultural Chemists, whose annual conventions are held in Washington under the auspices of the Department of Agriculture and whose proceedings are published as bulletins of the Chemical Division. Bulletin No. 28 of this division, containing the proceedings of the association meeting held in August, is now ready for the press.

DIVISION OF STATISTICS.

The operations of the Statistical Division have been replete with activity in various directions. The necessity of statistics in the work of legislation is becoming more and more imperative, as attested by the demands upon this office during the extended session of the present Congress. The discussion of industrial and economic questions in the halls of legislation, in polemic discussion, in literature and journalism, makes constant demand upon the resources of the Statistical Bureau for the facts of production and distribution, prices of products, wages of labor, development of resources, and status of agriculture.

The year has been somewhat peculiar in its statistical record. An abnormally mild winter, characterized by verdure and vegetable growth until late in the season throughout all but the higher latitudes, was closed with a period of low temperature and frosts, which extended southward to the orange belt of Florida. The effect of conditions so extreme was injurious to all the winter grains and to all the orchard fruits, forecasting the reduction in area of winter wheat which followed, the unequal rate of yield for the breadth remaining, and the unexampled dearth of nearly all kinds of fruits. Even the Pacific coast had an exceptional experience, consistent in its proverbial unlikeness to Atlantic coast conditions, for while the country from the great mountains to the eastern seacoast was singularly mild and summer-like, the Pacific slope was cold and stormy, with heavy rainfall and an unusually late spring.

The spring weather of the East was unfavorable to early planting, being too cool and wet at many points. These conditions were favorable to the hay crop, which is very valuable everywhere, and in the South becoming vastly more important every year as the improvement of farm animals progresses in that region, promising to make stock growing a very prominent rural industry of the cotton belt, which is in many respects peculiarly adapted to profitable extension of the various forms of animal industry.

The great arable crop of the country, corn, has had an unfavorable development. Starting in July with a condition expressed by the average of 93.1, which was less promising than the record of the previous year, but by no means discouraging, the effect of drought reduced the average in sixty days to 70.1; and on the 1st of October, when the crop was matured, the record stood at 70.6, against 91.7, indicating a prospect for 23 per cent. decrease in the rate of yield compared with that of last year. This foreshadows a reduction of something like half a billion bushels of corn. Still there is a fragment of last year's crop remaining, and there will be ample supplies for consumption of high-priced corn. The amount consumed depends much upon price, and the export demand is influenced far more by this consideration than the domestic consumption.

The winter wheat crop was reduced by spring frosts, and the spring wheat in its drier areas by drought, so that the average condition when harvested was expressed by 75.5, against 87.5 last year, indicating a yield materially less than that of 1889, upon a reduced area. The oat crop has met with serious disaster, reducing its product more than 200,000,000 bushels. It has also been a year of partial failure of the potato crop. The reports of condition have been growing worse since July, and as the time of harvesting approached the yield was still further reduced by the prevalence of rot. The Southern crops are generally above an average in production. The cotton crop of last year was the largest ever grown and brings a good price, and the prospect is now good for another large crop. The sugar product is also large, probably the largest grown for many years. Rice, tobacco, and vegetables have generally yielded well, and among the results is a high degree of prosperity in nearly all branches of Southern agriculture.

The despondency which was caused by the low prices of the beginning of the year has already been measurably dispelled by the advance in agricultural values, and good grounds exist for the belief that our farmers are entering upon a new era of profitable culture and general industrial prosperity.

DIVISION OF ENTOMOLOGY.

Though the year has not been marked by any very serious insect injury of a general character, the work of this division has been steady and unremitting. During the past few years the boll worm of cotton (*Heliothis armigera*) has been a source of more than usual damage to the cotton planters, particularly in Texas, Southern Arkansas, and parts of Mississippi and Louisiana, doing more harm than even the cotton worm (*Aletia xylina*). The edition of the fourth report of the U. S. Entomological Commission, treating of the cotton worm and boll worm, is exhausted, and there has been a general demand from the States interested for a supplementary investigation of the pest. Congress appropriated a small sum for this purpose, and the investigation has been begun. Agents of the division have been stationed at College Station, Texas; Pine Bluff, Arkansas; Holly Springs, Mississippi; and Shreveport, Louisiana; and the work of study and practical experiment has been apportioned so as to bring about the best results. The appropriation became available too late in the summer for efficient work, but the work this season will prepare the way for more thorough work next year, and if there is any possible way of giving our planters more effective and practical means of overcoming this enemy than those now at command, I have confidence that the way will be discovered.

During May there was a local outbreak of the army worm (*Leucania unipuncta*) in certain portions of the State of Maryland, and an agent of the division was sent to investigate it. There were some features about this outbreak that appeared abnormal, and the entomologist will consider it in his report in connection with another insect that is often mistaken for the army worm and which is much subject to an epidemic disease, a fact which acquires importance because of the possibility of artificially conveying this disease to the boll worm.

During July and August alarming rumors of the destructive appearance of the Rocky Mountain locust, or western grasshopper (*Melanoplus spretus*), were received from Idaho and Utah, and an agent of the division was sent to investigate them. He found that the locust in question was not the western migratory species, but a comparatively local form known as *Camnula pellucida*, information most reassuring to farmers in the Mississippi Valley. The means adapted to combating this last mentioned locust are identical with those which were found efficacious in the case of the first mentioned. The report of the Entomological Commission, containing the necessary instructions, is unfortunately out of print; but for the benefit of farmers situated in the district threatened by the present pest, I have directed the entomologist to prepare a summary of these instructions for distribution throughout the section of country subject to the present visitation.

Further experiments have been made with the use of hydrocyanic acid gas under tents as a remedy for the red scale. In my last report the statement was made that the cost of this remedy had been greatly reduced by experiments made by one of the California agents, and further experiments have developed means by which the process may be easily rendered more efficacious and the expense still further reduced.

The horn fly of cattle, which attracted so much attention last year, seems to have been much less abundant during 1890, and complaints from stockmen have been comparatively rare. Observations confirmatory of the results recorded in my last report have been made, and late fall and winter observations show that this insect hibernates in the preparatory state in the ground.

The question of the damage of the grape by phylloxera in California has been taken up, and certain vine-growing regions of the State have been visited by an agent, who is making tests and observations.

The division has been appealed to in reference to the possible danger of the importation of the destructive Florida scale insect into California, a matter which has attracted a great deal of attention the past season in the latter State. It seems that frequent accidental importations of these scales, particularly of the purple scale, the long scale, and the chaff scale, have been made; but in no case have the insects become destructive. It is therefore argued by many that the climate of the Pacific coast is not favorable to their increase, while others hold opposite views and are much alarmed. The entomologist is of the opinion that, while there are some grounds for the former belief, we can not exercise too much care in preventing the carrying of these destructive scale insects from one section to another. I have therefore been particularly careful to have the plants received from foreign countries and to be shipped to the different States carefully disinfected before such shipment, as I am very anxious that the Department shall not be the means of further disseminating such noxious species. I earnestly recommend that similar precautions be taken by all nurserymen and horticulturists shipping plants to other States.

In view of the success that has attended the importation of the Australian lady-bird to prey upon the fluted scale in California, public attention has been specially drawn to this manner of destroying injurious insects through the instrumentality of their natural enemies, but success in any instance is not likely to follow without the most complete, thorough, and intelligent direction. The entomologist, fully realizing the importance of this question, has made various efforts during the year, so far as they can be made with the assistance of foreign correspondents equally interested in the subject, to import desired species, and to reciprocate by sending others abroad.

The increased appropriation to this division will justify renewed attention to the subject of bee culture, and plans are being formed to carry on whatever investigations will tend to advance this important industry. The investigations already made under direction of the entomologist had for their object the control of the fertilization of the queen, whereby bee keepers would be able to improve the disposition and the honey-producing qualities of their bees by selection, in the same manner in which the stock breeder and the fruit-grower have for so many years so successfully improved our domestic products. There is reason to believe that this can be accomplished with reference to the bee; but there are many other ways in which the Department can help the bee keeper in investigations on a scale which neither individuals nor associations can afford to pursue. This is especially true in reference to the study and introduction of bee plants from sections of the country or other parts of the world where they are valuable into sections where they are not yet known. This applies also to the introduction of bees known to have desirable qualities, as, for instance, the *Apis dorsata* of Ceylon.

Many other insects of less importance have been carefully studied and figured, notably the rose chafer, concerning which a complete article has been published in the periodical bulletin of the division. The publications of the division have occupied more of the time of the office force than usual. The issue of Insect Life, the periodical bulletin, has been continued, and most encouraging comments concerning the usefulness of this publication are constantly received.

DIVISION OF MICROSCOPY.

The following is a brief abstract of the work upon which the Division of Microscopy is engaged for the current year: Original investigations in the interest of pure food stuffs, including medicinal and food oils and condiments. In food stuffs the skillful use of the microscope is constantly demanded to meet the new methods and combinations practiced in the adulteration of butters, lards, and branded substitutes for butter and lard, as well as in the examination of the various other food products. A microscopical examination of certain lard compounds in relation to the lard bill of the Fifty-first Congress was made by this division for, and at the request of, the House Committee on Agriculture.

The study of economic textile fibers is also a part of the work of the year. The various structural characteristics of textile fibers, which represent their felting properties, in respect to which they greatly differ, will be illustrated.

A further and more comprehensive illustration of our native edible mushrooms, as well as of poisonous varieties, and of those which may be classed as doubtful, is in progress as part of the year's work.

DIVISION OF ECONOMIC ORNITHOLOGY AND MAMMALOGY.

During the past year the work of this division has been continued in the two lines of research mentioned in previous reports.

(1) The work on geographic distribution of species has received as much attention as the means at the command of the division would permit, and considerable progress has been made both in the study of the faunal areas of the country and in mapping the distribution of species.

A report of the work done in Arizona during the summer of 1889 has been published as North American Fauna, No. 3. It gives in detail the results of a biological survey of about 5,000 square miles in the northern part of the Territory, and is accompanied by accurate maps of the forests of the region. The practical scientific value of such a survey is self-evident, and it is hoped that the division may be enabled to extend this work to other and larger areas.

The study and mapping of faunal areas—those fitted by nature for the existence of peculiar associations of animals and plants and consequently for the production of certain crops—has progressed far enough to warrant the issue of a provisional map. Such a map, showing by different colors the principal life areas of North America, has been prepared and accompanies North American Fauna, No. 3.

In order to obtain more complete data respecting the breeding range of various species of birds, a special schedule was prepared and sent out early in the year, and already reports have been received in reply from nearly four hundred localities. These reports contain much valuable information, which is being tabulated and mapped as rapidly as possible.

The most important field work accomplished during the present year has been that done in the Salmon River Mountains in Idaho, under the personal supervision of Dr. Merriam, chief of the division, assisted by Mr. Vernon Bailey and Mr. Basil H. Dutcher, field agents of the division. This work, which is still in progress, has already brought to light many facts of economic and scientific value concerning this almost unknown region, and has resulted in the discovery of several species new to science. Important work has also been carried on in the arid regions of the West, especially in Texas, Wyoming, Utah, and Washington; in the latter State an effort is being made to determine the northern limits of the "basin region."

(2) The economic work of the division, that devoted to the study of species directly injurious or beneficial to agriculture, has been mainly confined to investigations connected with the preparation of four distinct bulletins, namely, (*a*) an illustrated bulletin on hawks and owls, now almost completed, which, it is hoped, will be ready for distribution soon; (*b*) a bulletin on the gophers of the Mississippi Valley, on which work has been continued during the year and much valuable information secured concerning the distribution and ravages of the several species; (*c*) a bulletin on the common crow, already far advanced, and (*d*) a bulletin on crow blackbirds, now well under way. In connection with the work on these bulletins more than eight hundred stomachs have been examined during the past year, while about two hundred more, mainly those of bobolinks and meadow larks, have been examined in response to special requests for information as to the food of these birds.

A little time has been devoted to the collection of published notes by other workers in this little-known field, but the records are so few and so widely scattered that as yet only a beginning has been possible.

In connection with the stomach examinations the utility of the reference collection of seeds has been demonstrated almost daily, and although very considerable additions have been made during the year, this collection is still lamentably incomplete. The facilities for the determination of stomach contents have been materially increased and a competent biological clerk has been added to the force of the division.

More than 4,000 specimens have been sent in for identification by field agents and others, and a large and increasing correspondence has been conducted since January 1, 1890.

DIVISION OF FORESTRY.

Although there is evidence of a growing appreciation throughout the country of the importance of the interests which this division is designed to serve, there is still need that the scope and character of its work be explained and illustrated. The day when forest planting and the application of scientific principles to the management of our natural forest areas will be generally recognized as a necessity, is certainly approaching. While our forest resources are still immense, signs of approaching exhaustion in certain directions are already apparent. Carriage timbers especially are becoming scarce. The scarcity of walnut has long been known, and trade papers are beginning to discuss the difficulty with which first-class white-pine stock can be secured and to note the abundance of culls in the market, a sign that this staple resource, often represented as inexhaustible, must have been considerably reduced.

Without, therefore, entertaining alarming apprehensions of timber famine in the near future, it is a wise policy to keep watch over our forest resources, to show how unnecessary waste can be avoided and the means of economy developed, and to teach those principles by the application of which the natural forests may be so utilized as to recuperate and reforest themselves with valuable timbers, and also to teach how to create new forests artificially. It is the duty of this division, furthermore, to point out the consequences upon water and soil conditions of imprudent and undue deforestation. Although better endowed than formerly by the appropriations for the current year, the Division of Forestry is not yet equipped for field work, or, indeed, for any but scientific investigations that can be carried on in the office or laboratory, or by studies in the natural forests.

The two lines of investigation which will continue to be foremost, and for which the present appropriations insure more effective prosecution than formerly, relate to the life history of our important timber trees and to studies into the relations of the quality of timber to the conditions of its growth. Monographs dealing with the former subject are in hand for publication during the coming winter. The latter investigations will require careful selection of study material, laborious laboratory work, and a large number of tests, and promise to afford results of marked interest to the forester and of great practical value to the engineer, the builder, and indeed to every worker in wood.

During the year there has been published in the interest of forest conservation a very exhaustive report on the experiences of the world in regard to metal ties. This publication is full in mechanical detail, and will serve, it is hoped, to stimulate our railroad managers to give further trial to this substitute for wood material, since it is said to be of improved efficiency and ultimately most economical. Whenever it has been practicable, the chief of the division has been detailed to attend the various forestry conventions and other meetings where it has been believed that interest in forestry matters might be stimulated or advanced.

To accompany distribution of tree seeds, which, to satisfy the demands of the law, is made in small quantities proportionate to the appropriation, a circular giving detailed instructions for handling the seeds was prepared and distributed. It is thought best to restrict the distribution of plant material, as far as possible, to such kinds as are not readily obtainable, or to such as for some other reason are not likely to be tried by the would-be planter, and to engage the experiment stations in the trial of new species rather than leave this work to inexperienced hands. Excepting an importation of Austrian osier rods, which were sent to the experiment stations, only native seeds have been distributed.

RAINFALL EXPERIMENTS.

An amendment to the act of appropriation for this Department was adopted at the last session of Congress placing at my disposal the sum of $2,000 "for experiments in the production of rainfall," it being understood that such experiments were for the purpose of ascertaining whether such a result could be attained by the use of explosives. The difficult and problematical nature of these experiments, and the necessity of undertaking them only under the direction of a person possessing thorough qualifications for conducting the work, has made it thus far impracticable for me to give the matter proper attention. The experiments will, it is expected, soon be inaugurated.

DIVISION OF BOTANY.

As stated last year, two distinct lines of research are carried on by this division—the scientific and the practical. Under the first, gratifying progress has been made in the collecting, classifying, and mounting of plants growing in all parts of the United States, as well as of others secured by exchange or otherwise from foreign countries.

The herbarium of the Department of Agriculture has become of national importance and of great money value, and some of its parts could never be duplicated if lost or destroyed. Its location in the Department building, which is not fireproof, is a source of great anxiety, not only to those who have charge of it, but to the scientific world. The American Association for the Advancement of Science at its last meeting passed a strong resolution urging the Department of Agriculture to furnish fireproof quarters for it.

The Department has lately commenced the publication, in a special series, of the information which it is enabled to gather from study and comparison in the herbarium. This information is embodied chiefly in scientific papers, designed more especially for botanists, and intended to supplement the more practical work of the bulletins. The special series is not a periodical, but numbers are issued as often as sufficient matter accumulates. Three numbers have already been distributed. Nos. 1 and 3 relate to the flora of Southern and Lower California, and No. 2 is a catalogue of Texas plants, which is preliminary to a manual of the flora of that State soon to be published by this Department.

In the collection special note is made of all economic plants. So far as concerns forage plants, bulletins are issued, illustrated by plates, describing their characteristics and value for forage purposes, and setting forth the soils and climate to which they are adapted. During the year two such have been issued, one a new, revised edition of the "Agricultural Grasses of the United States," the other, Bulletin No. 12, entitled "Grasses of the Southwest." Both bulletins have received the highest commendation from farmers and from botanists. They exemplify in the best sense the value of scientific work applied to practical uses.

The experiments undertaken by the Division of Botany with a view to increase the grass production of the arid lands of the West have thus far demonstrated that a decided improvement in this matter is practicable; that the introduction of certain methods of cultivation and of certain forage plants not before used renders possible great advance in the grazing industry of those regions. Congress at the last session, appreciating the importance of the experiments, increased the appropriation therefor, to enable this Department to arrange with all the Western stations for co-operative experiments under our supervision. The chief of the division has about completed an extended tour of the West and South, made for the purpose of arranging the plan of the work and more carefully studying the conditions of soil and climate. The operations at the Government grass station, at Garden City, Kansas, have been very satisfactory, and for that locality the results have been fully equal to our expectation.

DIVISION OF VEGETABLE PATHOLOGY.

Since my last report Congress, in accordance with my recommendation, has made the Section of Vegetable Pathology a division, and it is now thoroughly organized and equipped with an efficient corps of workers in both the field and the laboratory.

A special effort has been put forth during the past year to make the field work as thoroughly practicable as possible, and with this end in view the chief and several of his assistants have spent considerable time making experiments which I believe to be of great practical value. To show the importance of this work I will cite the case of one series of experiments personally conducted by the chief, the results of which are based on very careful records. The remedies used were those whose efficacy have been established by this division, and the object of treatment was a large nursery whose proprietor had offered his entire stock to the Department for experiment. This work extended over two years. The expense involved was a little over $125, and the amount saved was $5,000.

This division was the first agency in this country to introduce the use of fungicides for grape diseases, and it is estimated as a result of its work that nearly five thousand grape growers in all parts of the country treated their vineyards for mildew and black rot in 1890, and the amount of fruit saved in this way will vary from 50 to 90 per cent. of the crop.

In addition to the foregoing, experiments in the treatment of pear, apple, quince, and numerous small fruits have been conducted in New Jersey, Maryland, Virginia, Wisconsin, and Missouri. The diseases of other crops, such as cotton, tomatoes, potatoes, etc., have been under treatment in numerous widely separated localities, each of which was selected as being particularly adapted to the work in hand.

The laboratory work has been pushed forward with vigor, the principal subjects under investigation being peach yellows, the California grape disease, pear blight, cotton diseases, a bacterial disease of oats, and the so-called "rots" of the sweet potato.

The laboratory investigations of the California grape disease have been mainly in the line of bacteriological study of diseased parts of the vine, supplemented by inoculation experiments, with a view to determining the contagious and non-contagious nature of the malady. Numerous facts bearing on this subject have been accumulated, and these will be shortly embodied, together with a result of the field observations and experiments, in a report soon to be published. In May of this year the special agent engaged in this work asked and was granted leave of absence without pay for six months, in order that he might visit France, Spain, Italy, and Northern Africa, in search of information that will aid him in his work.

For many years the vineyards of these countries have been ravaged by a disease which, according to the published account, is very similar to the one in California. It was claimed that within the past two years the disease had almost entirely disappeared from certain portions of Italy, and it was principally to get some definite information in regard to this matter that the agent desired to personally inspect the European vineyards. It is hoped that his investigations will enable him to throw some light on the best means of combating the California trouble, which has already devastated thousands of flourishing vineyards, causing losses almost beyond calculation.

The peach-yellows work is being prosecuted with vigor along practically the same line followed last year. Some important results bearing on the treatment of this disease have been obtained, but as yet they are not sufficiently conclusive to warrant their publication.

The publications and correspondence of the division have assumed such proportions, that to give them the attention they deserve requires about one third of the time of the regular office force. Two special bulletins and four numbers of the Journal of Mycology have been issued since my last report, and the fact that the editions of these are now entirely exhausted is, I believe, a sufficient guaranty of the interest in the work.

DIVISION OF POMOLOGY.

The development of the fruit industry throughout the country and in parts of the country where not long since it was thought no fruits could be grown, has been steady and encouraging. It must not be forgotten in estimating the value of pomological work in the United States that we Americans pay to foreign fruit growers more than $20,000,000 per annum for fruits and nuts which we import. I am convinced that one of the ultimate rewards of scientific pomology will be to see very nearly the whole of this vast sum turned into the pockets of American fruit growers, so wide is the range of climatic variation in different sections of our vast country. To accomplish this result necessitates a special study of and experiment in the study of fruit culture ; and it is my hope that the Pomological Division of this Department will contribute an important share to this great work.

Special agents have been appointed to obtain information regarding fruit culture in their respective localities, and to report to the pomologist as to their wants and resources. A system of reciprocity between the division and the various national, State, and local societies of a pomological nature has been inaugurated. The identification of fruits sent from all parts of this country is becoming more and more useful as a part of the work of this division, and during the past year there has been a very great increase in the number of samples sent for this purpose. It is evident that this portion of the work of this division is highly appreciated by the fruit growers of the country.

I am glad to be able to state that in pursuance of the work of this division, which involves the effort to introduce foreign and untried varieties and species of fruits into this country from abroad, a successful importation was made during the year of the date palm from Egypt and Algeria. Sixty-three trees, representing eleven of the choicest varieties, were received and were found on arrival to be without exception in good condition. This is the first instance of the successful introduction of rooted suckers of any variety of the date upon this continent, a notable event in the pomological history of the country. Their transportation has frequently been attempted, but the plants have never survived the voyage. There are good grounds for anticipating their successful introduction into the arid regions along our extreme southwestern border.

The division has in course of preparation a special report upon nut culture, and it will be based upon the practical experience of those who have already given this subject attention, and such information and advice will be given as may prove of benefit to those who desire to engage in it. Many choice varieties of wild nuts, especially of the chestnut and pecan, have already been discovered in the course of the investigation of the subject, and these will be obtained and placed in the hands of careful experimenters. Choice kinds of the filbert will also be brought from England and placed where it is likely they will succeed in this country.

One of the important features of the work of this division is an investigation of our wild fruits. This investigation should be more thorough than the means at hand enable me to make it, but no field of pomology is more promising of good results than this, and I trust that by enlistiug in the work the cordial co-operation of the various experiment stations throughout the country much good may be accomplished even with the limited means on hand.

SILK SECTION.

I stated in my last report that, in regard to silk culture, the real question to be determined as to the possibility of establishing this industry in the United States is that which concerns the reeling of silk, the conversion of the cocoons into a marketable thread.

While I have looked for assistance in the solution of this problem to the improvement of machinery for reeling silk, I have nevertheless become quite convinced that, even with such machinery perfected, it would be necessary for manufacturers to have some encouragement, either in the shape of a duty on imported raw silk or a bounty for such as might be produced in the United States. The importance of this subject and the desirability of establishing such an industry are beyond dispute, and, as though to strengthen the claim on behalf of home-grown silk, we find a great increase, nearly 25 per cent., in the imports of unmanufactured silk during the last fiscal year over the preceding one; the imports of this product for the fiscal year ending June 30, 1889, being in value $19,333,229, and for the fiscal year ending June 30, 1890, $24,331,867. Under those circumstances I confess that it would be a source of great regret to me to see the abandonment of all efforts looking to the establishment of silk raising in the United States, but I can not but reiterate my conviction that to all the improvement in mechanical devices which American ingenuity can bring about must be added the benefit of legislative encouragement. Should some bill embodying this idea become a law during the coming winter, it will afford me great pleasure to be the instrument for executing it and creating for this industry a brighter outlook than at present exists.

TEXTILE FIBER INDUSTRIES.

The fiber investigations commenced in 1889 have been steadily pursued with encouraging results. Much valuable information has been collected showing the present status of different branches of the fiber industry in this country and in Europe, a portion of which has already been given to the public in Bulletin No. 1 of the fiber series. Since the beginning of the year nearly 400 specimens of fibers and fiber plants have been received, many of them from farmers and others seeking information regarding possible new fiber interests, or exhibiting to the Department results in cultivation, preparation, or manufacture of known fibers.

Among the examples of American flax received by the Department are several fine samples grown in Wisconsin, Minnesota, Iowa, and on the Pacific coast, one of which, from the first named State, is declared by a leading manufacturer to be "good enough for even fine linens." A fine sample was also received from Texas. A beautiful example of linen thread, grass-bleached in New Jersey, demonstrates that this branch of the linen industry can be carried on in the United States as successfully as in Europe; while the entire linen series proves conclusively that even fine flax, in any quantity, can be produced in this country with skill and careful culture. The new tariff law raises the duty on dressed line from 2 cents to 3 cents per pound, and gives to the manufacturer of crash and the coarser linens an immediate additional protection of 15 per cent. ad valorem. This makes an American flax industry possible. The early establishment of large linen factories in this country will assure a market for American-grown flax, and the duty of 3 cents per pound on the dressed line, it is thought, will enable the American grower to produce flax fiber with profit to himself.

As flax culture is a new and untried thing with many farmers, the Department will render all aid in its power toward re-establishing the cultural side of the linen industry. Already there is great interest in new machinery and processes for cleaning flax, and some of these give promise of good results.

Hemp culture has been largely extended in States north of the Ohio River, and a perceptible increase in the employment of native hemp in binding twine (in preference to the higher-priced imported sisal and manila hemps) has been noted. Considerable areas of sisal hemp are growing in Florida, and it is thought that with a little encouragement at the outset sisal hemp might readily be produced within our borders. New Zealand flax is growing in California, from which strong fiber has been experimentally produced. Seeds of this plant, and of the manila hemp plant, have recently been imported and distributed for experiment in southern localities.

Several indigenous plants producing bast fiber, growing throughout the South, are under investigation and will be reported upon when the investigations are completed.

In regard to the ramie industry the chief progress of the year has been in the direction of manufacture rather than that of decorticating machinery, though the interest in this fiber continues.

ARTESIAN WELLS INVESTIGATIONS.

By a provision in the urgent deficiency act, approved April 4, 1890, Congress appropriated $20,000, and directed the Department to investigate the proper location for artesian wells and their use in irrigation in the semi-arid region lying between the ninety-seventh degree of west longitude from Greenwich and the eastern foot-hills of the Rocky Mountains. The area includes the States of North and South Dakota, portions of Montana, Wyoming, Colorado, New Mexico, and Texas lying east of the Rockies and the lower Rio Grande River, with those portions of Nebraska, Kansas, Oklahoma, and the Public Land Strip that are west of the ninety-seventh degree. The appropriation was made available the 15th of April, and by the 20th of that month organization was perfected and field work begun by a large and competent staff of division geologists and field agents working under capable chiefs.

The field and official work was heavy, as the law required a report to be made as early as possible after the 1st of July. The supervising engineer and chief geologist made an intelligent though rapid reconnoissance of the whole field, each of them traveling in doing so about 12,000 miles. The entire field force covered at least 70,000 miles of travel during their work. A report of operations was made on the 22d of August to Congress. The reports of the special agent in charge, of the supervising engineer, the chief geologist, and of the several division geologists and field agents, are accompanied by valuable maps, diagrams, plans, and illustrations drawn from photographs taken for this investigation. Besides the three principal reports, there are four from division geologists, covering the Dakotas, Western Nebraska and Kansas, Eastern Colorado and Southwestern Texas. These contain a mass of valuable data, locating and describing over 1,300 artesian, a large number of bored or gang wells, and several hundred springs, besides presenting important evidence as to the existence of other earth waters in quantities sufficient for economic application to agriculture, when the same can be restored to and distributed over the earth's surface. The reports presented, under the provision of the law of April 4, 1890, are confined directly to the location and availability of artesian waters, all other references and data being incidental. It was found necessary to make for the use of the investigating staff a definition of "artesian water." This was done in the following terms:

To include all subterranean waters, which, on being reached or opened from above, are found to flow to a level higher than the point of contact, and from some permanent and general source rather than from a local and temporary one. All bored wells in which the water rises and all natural waters, such as springs, rising from below, are included in this definition, as artesian in character. These supplies may be divided into positive and negative, the first to include wells the waters whereof flow above the surface of the earth, the second to embrace waters rising with force, but not flowing above.

Taking into consideration the time employed, this series of reports must prove to be of decided economic value. They form a positive contribution to the science of hydrognosy, or the phenomena of earth waters, besides illustrating the possibility of an extensive agricultural utilization of such valuable supplies. A supplementary report relating to earth waters, other than artesian, as defined by this investigation, is now being prepared, under a resolution adopted in June last by the Senate of the United States. This report will deal largely with the evidences of water underlying the river valleys and uplands of the Great Plains region, as under-sheet or underflow, and by percolation, seepage, and drainage.

The brief preliminary reports made to Congress of the artesian wells investigation, resulted in the passage of the following provision of the general deficiency act, approved September 30, 1890:

IRRIGATION INVESTIGATIONS.—To enable the Secretary of Agriculture to continue to completion his investigations for the purpose of determining the extent and availability for irrigation of the underflow and artesian waters within the region between the ninety-seventh degree of longitude and the eastern foot-hills of the Rocky Mountains, and to collect and publish information as to the best methods of cultivating the soil by irrigation, forty thousand dollars: *Provided*, That no part of said sum shall be expended unless the entire investigation, collection, and publication contemplated herein, including the report thereon, can be fully and finally completed and finished before July first, eighteen hundred and ninety-one, without any additional expense, cost, or charge being incurred.

The extraordinary nature of the above proviso made the formulation of plans for carrying out the investigations enjoined upon me under the act a matter of very serious difficulty. Indeed, a too literal adherence to the language of the act, embarrassed as it is with this provision, would make it well-nigh impossible to undertake the work at all. Assuming, however, after due consideration, that the intention of Congress was that these investigations should be continued, I at once proceeded to organize an irrigation inquiry, and to prepare to carry on the work of artesian and underflow investigation as far along toward completion as was possible by the exercise of the utmost diligence within the period provided. At the same time, I felt called upon to instruct the gentlemen in charge that all reports must be completed and handed in on or before the 30th of April, 1891. The date at which the act was approved, and the early period at which I am obliged to call in the reports, necessarily curtail the time available for field service to a few weeks of field activity, and hence curtail the usefulness of this investigation.

Edwin S. Nettleton has been appointed as chief engineer of this department, and Robert Hay as chief geologist. The engineer at once entered on field work in the Dakotas. He is also preparing plans for the prospective utilization in irrigation of the waters of certain artesian wells. These plans are to be the basis for constructing reservoirs, distributory ditches, etc., the cost of which is to be borne by land owners willing to meet the burden of such experiments.

It has been represented to me that underflow waters can be made available for purposes of irrigation by means of pumping at a less expense than that entailed by the building and maintenance of extensive reservoirs, dams, and ditches. Inasmuch, moreover, as the former plan, should it be found equally effective and economical, would place this matter of supply in the hands of the individual land owner, a feature which is in itself favorable to this plan, I have directed the chief engineer to make a special investigation with a view to supplying reliable information on this point, with such details in regard to the relative cost of the work as will substantiate or controvert the representations in question.

In October Prof. Robert Hay proceeded to Northwestern Nebraska, where, being soon joined by the chief engineer, a series of observations were at once made, both investigations moving southward as rapidly as possible, examining Western Nebraska and Kansas, the adjacent section of Colorado, and the important drainage basins of the Canadian and Pecos Rivers within Eastern New Mexico. Levels are being run across this mid-section of the Great Plains, and investigation of the underlying strata, their position and relations to the wells, springs, and other evidences of earth waters, are in progress, the results of which I hope to submit to Congress at an early day. It is hoped by these levels and field investigations to quite definitely locate the sources, nature, and extent of the subterranean water supplies. Similar field work will be continued in the Southwest throughout the winter, and at the earliest date that the season will permit active labors will be resumed along the whole line.

The Irrigation Inquiry Office, under the direction of Special Agent R. J. Hinton, is preparing by my orders a concise but comprehensive progress report on irrigation, its development, and the cultivation of the soil thereby. Monographs and reports will also be made through this office by specialists and experts, who will examine and report on such divisions of the arid region as they are most familiar with. This series of papers will include, among others, monographs on irrigation and water supplies in the mid-plains section, Colorado and Wyoming; the basin division, including Northern Arizona, Utah, and Nevada; the Northwest, or Montana and Idaho, with Oregon and Washington east of the Cascade range; also California and Southern Arizona, and the Valley of the Rio Grande.

AGRICULTURAL EXPERIMENT STATIONS AND OFFICE OF EXPERIMENT STATIONS.

The Office of Experiment Stations serves to connect the agricultural experiment stations in the several States and Territories with each other and with this Department, to bring to them the fruits of accumulated experience, to indicate lines of inquiry, to assist them in co-operative effort and in research, to co-ordinate their work, and to collate and publish the results.

During the past year the work of the office has included correspondence; visiting stations; attendance on farmers' meetings, and conventions of college and station officers; the collecting and indexing of station and other literature; the collection of statistics, and the promotion of co-operation among the stations. A most important part of its business has been the preparation of publications, including a record of the current publications of the stations and of this Department; the proceedings of the Convention of the Association of American Agricultural Colleges and Experiment Stations; organization lists of the stations and colleges; circulars and letters of inquiry and information on topics relating to station work; and, finally, Farmers' Bulletins.

The correspondence of the office is large and has doubled in the past year. It relates not only to the scientific, administrative, and general interests of the stations, but also to numerous and varied problems in agricultural science and practice, and extends to all parts of the world.

The increase in the amount and improvement in the quality of the work of the stations and the establishment of new ones have caused corresponding increase in their publications. The editorial work of the office is consequently enlarged, and the Experiment Station Record for 1890-'91 will include twelve numbers instead of six, as in the previous volume. The Record, with its index, makes it easy to ascertain what the stations are doing in any given line of investigation, what are the main results, and where the published details are to be found. It will thus be increasingly valuable. Further provision for collating and disseminating information is made in the Digest of Station Reports and other technical publications of the office.

Each station distributes its own publications freely in its own State, but can send very few outside, although the results reported would often be equally useful in other States. To provide for the general distribution of such information to the farmers of the whole country a series of inexpensive popular bulletins has been planned. Of the first of these an edition of 50,000 was speedily exhausted, and its statements were widely quoted by the agricultural press. A second bulletin illustrated the results of inquiries pertaining to topics of practical interest. An edition of 150,000 was issued, of which 75,000 were distributed through members of Congress. The nature of these publications led to the name "Farmers' Bulletins." The work and connections of the office are such as to bring to its attention a great amount of information of the highest value to the farmer, and I earnestly hope that the printing fund of the Department may be so enlarged as to enable these popular publications to appear more frequently and in larger numbers than heretofore.

One direction in which the sphere of the office should be enlarged is the collating of the fruits of agricultural inquiry in Europe, where during the past forty years numerous experiment stations and kindred institutions have been studying the laws that underlie the right practice of farming, with results that are constantly increasing in volume and value. Our station workers need this information to enable them to avoid going over old ground and making old mistakes and to suggest to them the most advantageous methods and lines of research. The Department needs it for its own investigations and to enable it to give to the stations the advice and assistance which they desire. So urgent is the need that this work must be undertaken at once, but that in order that it may be carried on effectively and with sufficient thoroughness, an addition to the appropriation for the office is imperatively demanded. Well done, this work would save years of experimental investigations in this country; without it the loss of labor, of money, and of needed information will be great.

Plans have been suggested and are under consideration for coöperative investigations on the soils of the country; fertilizers; sugar-beet culture; dairying; foods and feeding stuffs; the improvement of native grasses, forage plants, and wild fruits, and the introduction and acclimatization of new economic plants, the successful culture of which will substitute home-grown for foreign products. For the most advantageous carrying out of these plans there is need of more frequent visiting of the stations by the representatives of this Department, especially of this branch of it, and of the occasional calling to Washington of the directors and leading workers of the stations for consultation.

A review of the work and condition of the experiment station enterprise in the United States is on the whole decidedly encouraging. During the past year eight new stations have been established, viz., in North and Southeast Alabama, Arizona, South California, New Mexico, North Dakota, Utah, and Washington. Experiment stations are now in operation under the act of Congress approved March 2, 1887, in all the States and Territories except Montana, Washington, Idaho, Wyoming, and Oklahoma. In several States the United States grant is divided, so that 52 stations in 43 States and Territories are receiving money from the United States Treasury. In several States branch or substations have been established. If these be included the number of stations is 70.

These stations with this office expend in all about $785,000 per annum, of which $660,000 is appropriated from the National Treasury. They employ over four hundred persons in the work of inquiry, and are conducting a large amount of research in the laboratory and greenhouse, and of practical experimenting in the field, the orchard, the stable, and the dairy. During the past year the stations have published about 300 reports and bulletins, aggregating about 10,000 printed pages. At a low estimate 3,000 copies of each of these publications have been distributed, making a total of 30,000,000 pages, containing information on agricultural topics, directly disseminated among the people by the stations during one year, and thousands of newspapers and other periodicals have quoted from these publications the results, and to some extent the processes of the experiments described. It is believed that no means for popularizing the teachings of scientific research has yet been devised which in scope and far-reaching effectiveness surpasses this for the diffusion of agricultural science.

A marked feature of the enterprise is the close relation already established between the stations and the farmers. In many of the States members of the station staffs have been either organizers of farmers' institutes or among the foremost workers in them. The calls upon the station officers for public addresses are numerous and increasing. The station correspondence with farmers is very large, and touches almost every topic connected with farm theory and practice. Moreover, the results worked out by the stations are applied and enlarged by farmers who conduct trials upon their own farms on plans indicated by the stations, and the proof thus brought of the capacity of our intelligent farmers for experimenting is most gratifying. In short, the station and the farmer are working together and to the advantage of all concerned.

Another encouraging fact is the aid given the stations by State legislatures, local communities, agricultural associations, and private individuals. From these sources the stations have received during the past year about $125,000 in money, in addition to other gifts of land, buildings, and equipment. This indicates that the generous policy pursued by the General Government is acting already in the case of the stations, as it has done for a longer time in that of the land-grant colleges, as a proper stimulus to generosity on the part of the States, communities, and individuals, and that on the foundations laid by the General Government are to be built large and strong institutions.

The union with the agricultural colleges by which the stations have secured the advantages arising from the use of libraries and laboratories, and from connection with specialists, teachers, and students; the influences exerted by the Association of American Agricultural Colleges and Experiment Stations, and, finally, the earnestness and enthusiasm of the station workers, all conspire to give the promise of constantly increasing usefulness.

DIVISION OF RECORDS AND EDITING.

While this division, like several others, was actually called into existence last July, when the act of appropriation which included a provision therefor became a law, the work was practically done under another division in such a manner as to necessitate no reorganization of the work when it became an independent division. For convenience it will therefore be referred to in this report as a division, even with regard to the work done before it was properly raised to that dignity.

Since my last report this division has transmitted to the Public Printer the manuscript for eighty bulletins, besides supervising the printing of the Annual Report of the Department. With reference to the majority of these bulletins it has also prepared the usual synopses on the plan indicated in my last report, whereby as was anticipated the circulation of the bulletins has not only been greatly increased, but it has been effected far more promptly than was usual heretofore. The advantage of prompt distribution is especially appreciable in regard to the bulletins of this Department, relating as they do to the practical work of agriculture, which itself depends upon times and seasons with such regularity that delay in the distribution of a bulletin of a few weeks or even a few days in some cases may render it unavailable to the farmer for practical use until another season. An effort has been made to exercise greater discrimination in the distribution of bulletins, by which those relating to particular branches of agriculture should reach only those engaged therein. A great waste of bulletins has thus been avoided, and the circle of those who are benefited by the Department bulletins has been enlarged in far greater proportion than the number of copies distributed.

The work of publication of the Department has been much aided by the establishment of the division. Indeed, this work has attained such proportions that it is eminently desirable that there should be one office serving as the channel of all communications between this Department and the Public Printer, and the result has, I believe, been as satisfactory to that official as to ourselves. It is only just that I should here give due credit to the efficient management of the present incumbent of that office for results which have given us during the last twelve months, at an expense slightly less than that of the twelve months previous, publications aggregating in number of copies 1,133,000, as against 566,000 for the twelve months previous. At the same time a due share of the credit for the excellent results and good administration of our printing fund during the past twelve months belongs to the new division. In spite, however, of these advantages, I regret deeply to have to report that for want of a sufficient printing fund useful publications have had to be unduly postponed, while some have had to be abandoned altogether. The amount at the disposal of the Department for the previous fiscal year was $39,235.45, a sum even less than that of the year preceding, which was $40,914.37, and both these years this amount was secured only by obtaining a deficiency appropriation. Notwithstanding the immense increase in the number of divisions over two years ago and the fact that the accumulated experience and efficiency of divisions long established increase the number of publications, the appropriation for the current year is only $40,000, a sum less than that expended two years ago.

The measure of the efficiency of the Department of Agriculture is largely its ability to supply practical, useful information to the public, and I can not but deplore in the strongest manner any policy which shall weaken the power of the Department for good in this its most useful field of labor, because that which is essential to the practical results of every other. To concentrate the time and ability of the chiefs of the several divisions and their assistants upon the investigation of problems with which our farmers have to contend, and when practical results have been obtained to withhold the means of making them public for the benefit of those whom the Department is created to serve, seems to reach the heights of unwisdom.

With regard to the publication work of the future, I have found that it will be necessary to divide the publications of the Department into three classes. The scientific work of the several divisions, for obvious reasons, must be recorded in a form available to the scientist and to the student. Even where no practical results are immediately obtained, the work done is so much accomplished on the way toward them, and the preservation of a record thereof for future reference will save to us needless repetition. Limited editions, therefore, of a series intended to serve as a technical record of the scientific work of the several divisions are needed. A second series, in the form of special bulletins containing the results of investigations and information of value to specialists in agriculture, to be issued in editions considerably larger, must be undertaken for the benefit of those who, without being scientific in any sense of the word, are engaged in some practical department of agricultural work, such as horticulture, dairying, stock raising, etc. In addition to these two series, we have found it desirable to cause the publication from time to time of short practical tracts, inexpensive in form, devoted to some special feature of agricultural work calling for clear, concise instructions, within the comprehension of any person able to read them, and available for immediate distribution in some particular section or to some particular class. The circulation of these bulletins must vary according to the demands of the occasion.

Again, as in the case of this class of bulletins issued through the Office of Experiment Stations, Farmers' Bulletins 1 and 2, it is desired to give in the plainest possible manner the gist of experimental research throughout the country on some one or other of the many important agricultural problems which it is the province of the stations to investigate and solve. To fully cover the field of publication to the extent which I deem absolutely essential to this Department, I have been obliged to name the sum of $60,000 as the minimum amount necessary to carry out my purpose. In this connection I will only add that it is not only unsatisfactory, but seriously prejudicial to the efficiency of the work, to be compelled year after year to formulate plans of publication on an insufficient appropriation, trusting to a deficiency appropriation to supplement it. Many of our publications need six months' careful preparation, and, as I have already pointed out, delay in publication when a bulletin is ready often means a loss of one year's time to the farmers of the country.

DIVISION OF ILLUSTRATIONS.

Considerations in some degree analogous to those which led me to establish a division of records and editing led to my organizing the work of illustrations as a separate division, which, under the competent direction of a single chief, should include all the draughtsmen and engravers employed in the Department. These have been heretofore scattered here and there among the several divisions, and I concluded that better results would follow from the performance of all the work of this character under the direct supervision of a competent artist. Moreover, I am well satisfied that a considerable saving will be effected in the expensive work of illustration by the existence of an officer charged with responsibility for supervising this branch of the work for all the divisions of the Department, thus affording to the chiefs of the several divisions an associate whom they should consult in reference to all contemplated work of this character. The work of this division has been, as it were, but just begun under the new order of things, even sufficient room having been lacking at the time the division was created; and this room has only just been provided, although I regret to say the accommodations, for reasons which I have sufficiently amplified when dealing with the question of the buildings, are far from adequate for the work required of it.

SEED DIVISION.

The distribution of seeds for the year ending June 30, 1890, exceeded in number of packages that of any in former years, although the appropriation for that purpose was the same as that granted in years immediately preceding. This was due to a radical change made in the method of purchasing seeds, and to which allusion was made in my last report, namely, the employment of a special agent, whose sole duty it is to visit personally different sections of the country and inspect, as far as possible, the product of the seeds offered to the Department and to look up such as seem to possess especially desirable characteristics. The result has been so satisfactory that, with an expenditure of money for the purchase of seeds no greater than that of the previous year, the number of packages of seed distributed has exceeded that of the previous year by three quarters of a million, the fact being that the total amount of seed distributed by this Department during the last fiscal year would, at the prices paid during the previous year, have cost the Department $18,000 more than it has. An earnest effort has been made to introduce new and important varieties of seeds, many having been secured for that purpose in foreign countries. I may refer especially in this connection to the Ladoga wheat, Bermuda grass seed and the sugar-beet seed.

I have also continued and enlarged the distribution of seed to State experiment stations, these institutions having obviously the best facilities for giving the seeds a thorough trial and for making such reports regarding the same to the Department as will enable us to arrive at just conclusions as to the adaptability of the seeds to our climate and soil, as to the best methods of cultivation, etc., thus enabling us to accompany further distribution, if such be decided upon, with intelligent and reliable instructions.

DIVISION OF GARDENS AND GROUNDS.

This division is charged with the care of the grounds and conservatories surrounding and attached to the Department buildings. The grounds include some 40 acres, with roadways, walks, trees, etc., to be looked after and kept in order; and in the conservatories and propagating houses are conducted the propagation and culture of economic plants. The distribution of these plants throughout the country, with due regard of course to the climatic conditions favorable to their growth, devolves upon the Superintendent.

The conservatory attached to the Department is a common resort of visitors to the national capital, and I have been impressed with the fact that its educational features have not been as complete as it seems to me is desirable. These conservatories are not only among the finest in the country, but the plants they contain having been selected according to a special design and embracing a very large variety not only of the ornamental, but especially of the economically useful varieties, much useful instruction would result to visitors by the preparation for free distribution of a carefully prepared catalogue, provided with reference numbers and a plan of the greenhouses, so that the several plants could be readily identified. As so large a portion of the conservatories is devoted to plants of economic value, this catalogue should be sufficiently full to explain the value of each plant, as well as the method of cultivation and of the preparation of the commercial product. I have accordingly made arrangements for the preparation of such a catalogue, and am quite satisfied that when completed the work will not only reflect credit upon the Superintendent of Gardens and Grounds, to whom it is intrusted, but will be found of great interest and value to visitors to the conservatories; indeed, it will no doubt have the effect of greatly increasing the number of visitors, especially of those whom it should be the object of all public institutions to serve in a particular manner. I refer to young people in attendance upon our educational institutions.

The plants distributed through this division during the past fiscal year amounted to over 80,000, and included olives, tea, coffee, camphor, strawberries, grapes, both native and foreign, citrus of many species, raspberries, date palms, figs, Japan persimmons, currants, loquats, guavas, pine-apples, black pepper, vanilla, mangoes, and bananas. Reports as to the results obtained with the plants so distributed are encouraging. The culture of the olive is fairly established on the Pacific coast, and it seems likely that it can be profitably established on the Atlantic coast as well, the tree being well adapted to the climates over a wide range in the Southern States. With this end in view, the Department recently imported some of the best selected varieties, which are now being propagated for eventual distribution in suitable localities. There were also distributed some 10,000 cuttings of Smyrna figs of carefully selected varieties, such as furnish the dried figs of commerce.

At present the camphor tree is found well adapted as a shade tree in Florida, where suitable shade trees are a matter of special interest, and many plants have been sent into that State during the past ten years. It is hoped that at some time the plant may be profitably utilized for its commercial products. With the increased demand for camphor, it is believed that the prices for the article would warrant an extension of the plant in some of the Southern States. It has been proved to withstand the climate of the Atlantic coast as far north as Charleston, S. C. It is a hardier tree than the orange, probably nearly as hardy as the olive. To enable those who may desire to experiment with the tree, a quantity of plants will be propagated sufficient for a generous distribution in the near future.

The black pepper, vanilla, cinchona, and the cocoa (*Erythroxylon coca*) are being propagated and have been distributed to some extent. Their success is as yet somewhat problematical, but is possible in some situations in southern Florida, where these plants may obtain permanent foothold.

The importance of this work in the general encouragement of the growth of useful and economic plants is shown by the large amount of imports of fruits, nuts, spices, and vegetable products, which could certainly be much reduced were the cultivation of these plants undertaken, if only in those limited localities where they can be cultivated with assurance of success.

THE WEATHER BUREAU.

Under an act approved October 1, 1890, Congress directed "that the civilian duties now performed by the Signal Corps of the Army shall hereafter devolve upon a bureau to be known as the Weather Bureau, which, on and after July 1, 1891, shall be established in and attached to the Department of Agriculture."

In accordance with this act I have included estimates for the ensuing fiscal year for carrying on the work of the bureau thus created in this Department. I deem it evident from the discussion which attended the passage of this act, and from the wording of the act itself, that in making this transfer of the Weather Bureau to this Department it was the intention of Congress that the work of the bureau should be extended, in so far as might be necessary to a full co-operation of this branch of the service with the work of the several divisions already established in this Department for the benefit of agriculture, without in any way restricting its general scope. In this spirit I have submitted estimates for the coming year on the basis of the wider range of work thus contemplated, and I take the opportunity of expressing here my own conviction that in many ways the work of meteorological observation which this Department will be thus enabled to carry on in conjunction with its other work, will be found of great value to the farming interests of the country. It is indeed self-evident that to complete the study of soil conditions, of animal and plant life, a study of the climatic conditions of our country is indispensable.

REPRESENTATION OF THE DEPARTMENT AT FAIRS, ETC.

In my last report I referred to the fact that there are held in this country annually a vast number of fairs—usually a State or Territorial fair in every State and Territory in the Union, many other large district or interstate fairs, while county fairs are very nearly as numerous as the number of counties in the whole country. It is a very essential part of the duty of this Department to keep itself well informed in regard to the extent and character of the agricultural resources of all sections of the country, and I know of no opportunity for adding materially to this information at so slight an expense of time and money as is afforded by these exhibitions, which bring together in one place samples of all the best that the country can produce.

It is my desire that the representatives of this Department should be found hereafter at all the principal State fairs, under instructions to make a thorough report on the character of the exhibits, and at the same time to avail themselves of meeting, as they will do on such occasions, the leading representatives of agricultural interests, from whom much can be learned as to the wants of the farmers, the nature of their difficulties, and the best manner in which the Department can serve them. Furthermore, I desire to carry this system of representation at the fairs as far as possible, even to include county fairs, by availing myself of the co-operation of the large staff of voluntary correspondents of the Department distributed through all sections of the country, and to whose enthusiastic devotion to the cause of agriculture the Department has already been often and much indebted. It seems to me that by such means a sort of bird's-eye view, as it were, might be obtained of the agricultural resources of the country, with the result of supplying this Department with a vast amount of valuable information which can not only not be secured so easily in any other way, but indeed can not be secured at all except by these means.

Among other services which these representatives could render the Department would be the collection and forwarding to the Department museum samples of the various exhibits which at present are too frequently scattered and lost. This subject naturally leads to a consideration of the necessity for a more frequent interchange of thought between this Department and the agricultural intelligence of the country. I called attention in my last report to the fact that there had been, especially in the past few years in the United States, an enormous development in the agricultural organizations devoted to the farmer's self-improvement. Our dairy associations, our horticultural, life-stock, and kindred societies, have not only multiplied as to number, but to-day are far more active in holding meetings and conventions than they have ever been before. The farmers' institutes are meetings of a general character, attended usually by the best farmers in the sections in which they are held, and bringing together the best agricultural thought and practice. Not only do I deem it to be of the utmost importance, indeed a solemn duty devolving upon this Department, that these meetings and gatherings should be encouraged in every possible way by their representative Department in the National Government, but I conceive it to be absolutely necessary for the intelligent conduct of the work of this Department that it should be frequently represented at such meetings, not only for the encouragement and benefit of those present, but for the benefit of this Department and its division chiefs.

Speaking from my own experience, I am aware that in the large section of country with which I am familiar, from an agricultural standpoint, most important meetings have been held in recent years. Questions of the gravest import to the agriculture of this country have been discussed at these meetings, and yet rarely indeed has there been present any person representing the National Department of Agriculture who could speak for it, and what is still more important, learn for it the views and wants of these people. This is a condition of affairs which calls for immediate remedy, and in so far as the liberality of Congress will enable me to do so, I am determined to provide that remedy. It is only by the closest co-operation between this Department and the agricultural societies—the Granges, the Alliances, etc.,—that the work of the Department can be carried to its highest development and attain its greatest usefulness, and I recommend that a special fund be placed at my disposal for this purpose.

COLUMBIAN WORLD'S FAIR.

The act of Congress approved April 25, 1890, gave national assent to and recognition of the proposition to hold a World's Columbian Exposition in the city of Chicago in the year 1893. The bill provides that there shall be prepared a governmental exhibit. For the purpose of securing harmony of installation and arrangement, it was provided that a board consisting of persons to be designated, one each by the head of each Department, should be formed. In compliance with this law I designated the Hon. Edwin Willits, Assistant

Secretary of Agriculture, as representative of this Department upon the board, and you ratified this nomination and designated him as its chairman. Mr. Willits informs me that doubt upon the part of the accounting officers of the Treasury has already been expressed as to the availability of the funds appropriated by Congress for the work in hand, and at this writing we have an intimation that nothing can be purchased, nothing constructed, nothing exhibited which is not now in the Departments, and that no outside assistance can be employed in any branch of the work of preparation.

In so far as the Agricultural Department is concerned, I say without reservation, it were better to abandon the attempt to make any exhibit than to undertake the task with such limitations. It certainly is not my intention to enter the exposition field in competition with the private, State, or corporate exhibitor, but beyond this field there lies a wide region wherein this Department may operate in illustrating those functions which are peculiarly its own. This Department is instinct with science. A process can not be fully illustrated on a printed page, and this exposition furnishes a rare opportunity, which hardly comes twice in a lifetime, to supplement the publications, at present its only means of communicating with the public, by a spectacular exhibition of current methods of dealing with agricultural problems and processes. If the work devolving upon this Department in connection with this exposition is to be undertaken at all, it must be in such a manner as to guaranty satisfactory results; and in its performance we must be left at liberty to avail ourselves of such material and such expert assistance as we can find adapted to the purpose. I commend the subject to your attention in the hope that any obstacles to effective work now existing may be removed by Congress, and that the work may proceed without delay.

THE MUSEUM.

The needs of the Museum have continued to receive my most thoughtful attention. A marked improvement in the appearance of the exhibit has been effected by its re-arrangement and renovation; and plans have been perfected by which, it is believed, the aid recently granted by Congress will be applied to the best possible advantage. The educational, scientific, and historical interests which would be promoted by a distinctly agricultural museum of suitable character are too generally recognized to need urging at this time. It should be a matter of regret, however, that for the thousands who annually visit us from abroad, impressed in advance with the magnitude and diversity of our agricultural productions, we should have no permanent national collection fitly illustrating the products of our soil. The need of such a collection, moreover, is being keenly felt in investigations prosecuted by this Department.

and involving important economic questions, the solution of which could be materially facilitated and hastened by access to the actual results of cereal growth attained under various conditions of soil, climate, and culture. I deem it a fitting time to suggest that proper foresight on the part of Congress should secure for this Department, after their exhibition at the Columbian Exposition, such available articles relating to the operations of agriculture as shall be worthy of place in a permanent exhibit; and that in the meantime suitable provision be made for the accommodation of the present collection and subsequent accessions.

ADEQUATE BUILDING FACILITIES.

A consideration of the wants of the Museum brings me to the question of adequate building facilities. The want of these is conspicuously illustrated by the unavoidable utilization of a huge, unsightly wooden structure, far inferior to many an exhibition building on a country fair ground, as an agricultural museum; furthermore, the building being made to do service on occasion as a general storage warehouse, and to accommodate not only the silk filature and cocooneries, but a number of offices for which I need hardly say it is most illy adapted. Moreover, its use for this purpose necessitates dividing the force of several divisions, one part of the force being at work in one building and another part in another, a condition of things which is found a serious impediment in carrying on the work. All the more important divisions are suffering grave inconvenience, and important work is unavoidably delayed owing to this condition of things; in fact, a vast amount of time and pains, which might have been profitably devoted to more important work, has to be unavoidably spent in devising ways and means to overcome, or at least to mitigate, the embarrassment and annoyances, amounting to serious obstruction to the work of the Department, entailed by this want of room.

I must therefore renew in the most energetic manner my earnest recommendation that immediate steps be taken to provide this Department with an additional building, suitable for the accommodation of all the laboratory work of the Department, and at the same time of a number of the offices, as well as with fireproof accommodations for the reception of the valuable herbarium and other property of the Department, which it has cost years of labor and large sums of money to accumulate, and which, if they should ever be destroyed, no amount of time and no amount of money could possibly replace.

PROMOTION OF CORN CONSUMPTION IN EUROPE.

I have long been impressed with the necessity of taking measures to promote the consumption of Indian corn in foreign countries. The facility with which we can raise this cereal, its generally low price, and the occasional glut in the home market in years when the yield has been especially large, make an increase in our exports of corn extremely desirable. It is essentially an American cereal, one which can be grown in all parts of this great country, and the area adapted to which is practically illimitable. Not more than 20 per cent. of the crop on an average is moved outside of the county in which it is grown, and to the extent to which this indicates the utilization of the crop for feeding purposes on the farms where it is grown this is well; but when we realize that this fact is due in part at least, especially in years, like the last, of an ample yield, to the absolute want of demand, our home markets being fully supplied, it is certainly a matter of profound regret that there does not exist a foreign demand sufficient to relieve the glut at home, and to secure for our farmers in the West a price which would be adequate at least to save them from loss on the growing of the crop.

During the past ten years our exports have hardly exceeded 3 or 4 per cent. of the total crop. This is due largely to the fact that corn is utilized throughout the greater portion of Europe solely as food for animals, and then only when its very low price tempts the feeders. As a food for human beings it is practically unknown, save in some sections of Southern Europe, while in the greater part of that continent it can not even be grown to maturity. I have recently determined to avail myself of the presence in Europe of Col. Charles J. Murphy, a well-known authority and enthusiast on the subject of the increase of our corn export, who has been commissioned by me to make a report to this Department upon the general subject of the promotion of the use of Indian corn as a human food in European countries. Colonel Murphy's report will be made the subject of a special bulletin as soon as it shall have been received, and will no doubt treat of this important subject practically and well.

REPRESENTATION OF THE DEPARTMENT ABROAD.

I desire to record here very emphatically my conviction that some method must be adopted by which, as occasion requires and without long delays, this Department shall be enabled to send representatives to foreign countries in cases where only personal visits can be relied on to secure much-needed information. The subject of world-wide competition has been dwelt upon at length on so many occasions that it would be purely superfluous to insist here upon the active competition which meets our own farmers in every market where their products are offered for sale. The commercial side of this condition of things is well understood, but it does not seem to be so clearly understood or so well appreciated that there is an intellectual competition which is even more serious than the other, in that it is the basis of the other.

Where wise economic legislation is the cure, the perfection of agricultural methods, which means the maximum of production at the minimum of cost, is the prevention of agricultural troubles. In our pursuit after this perfection we must study the methods of all other countries that attain or approach it in any branch of agriculture. We must be prepared to learn all that is to be learned elsewhere, and then wisely adapt the information so obtained to the conditions of the American farmer. Consequently that information must be acquired by men who are themselves familiar with our own agricultural conditions. This plan, except in so far as it is now offered on behalf of agriculture, is by no means a new or original one. It is but a few years since that a commission of distinguished military officers visited many of the European countries and British India for the purpose of studying the equipment of foreign armies with a view of adapting to our own military service all that might seem to be advantageous. I have understood that the report brought back by these gentlemen was regarded by high authorities as most valuable. In this respect, as in many others, agriculture has not had the fair treatment which, in spite of the fact that it is beyond dispute the most important industry in the country, is, after all, all that it asks for. The suggestion of sending a well-qualified representative abroad purely in the interest of agriculture is cavilled at as a means of affording a pleasure trip to some broken-down professor. It is time that we rose superior to such humiliating and unworthy puerility.

It may be well, perhaps, in this connection to call attention to the fact that we are in this respect far behind the other nations of the world, however disagreeable it may be to confess it. Important gatherings of men devoted to agricultural science, and enjoying by the courtesy of the government under whose jurisdiction they assemble every privilege and facility for gaining information in regard to the agriculture of that country, are constantly being held in various parts of the world, at which representatives of this, the greatest agricultural country in the world, are conspicuous by their absence, and when we are represented it is often by some wealthy amateur enjoying his ease abroad, or, as is sometimes the case, by some enthusiast, who, at a sacrifice of time and money which he can ill afford to spare, manages to attend; but officially this country and this Department are very rarely represented on such occasions. A most notable instance of our omissions in this respect was furnished during the meeting last September of an international agricultural congress at Vienna, in which we had been especially invited to participate by the Austro-Hungarian Government, at which over eleven hundred delegates were present, including distinguished representatives of agricultural interests from every country in Europe, from Japan, from Australia, from India, and from South America, and at which were discussed subjects of profound interest to American agriculture. This was a meeting at which, for many reasons, it was most desirable that the United States, through this Department, should have been officially represented. Unfortunately, for want of adequate provision, the United States alone, of all the leading countries of the world, was absent.

Let me here recall the fact that since I had the honor to assume the office of Secretary of Agriculture I have been visited by gentlemen from Austro-Hungary, Germany, Bavaria, France, Great Britain, Canada, Australia, New Zealand, Japan, and even from one of the native principalities of the East Indies, the official representatives of departments analogous to my own in their native countries, traveling under orders from and under the pay of their respective governments, armed with all the official credentials necessary to secure to them every attention and courtesy necessary to the prosecution of their inquiries. Thus do these countries indicate their willingness to learn whatever we may be able to teach them. Thus do they recognize the fact upon which I have already insisted—that there is an intellectual as well as a commercial competition, to which the old maxim, "Knowledge is power," applies with a force which all must recognize.

In concluding this my second annual report as Secretary of Agriculture, I feel amply justified in expressing my general satisfaction at the condition of agricultural matters in our country. It is true that in many cases the effects of former agricultural depression are still felt, and it is also true that in a vast country like ours there must be at all times more or less depression existing in one section or another and affecting some local interests. Nevertheless, a careful review of the events of the past year and a general survey of the agricultural field to-day betoken marked improvement in the condition of our agriculturists and promise well for their future well-being.

The recognition of agricultural interests in recent national legislation will have the double effect of assuring the farmers of the appreciation of their wants as a class by our public men and of securing to them many beneficial results in the near future. I have also had frequent opportunities of noting with sincere gratification the rapidly growing tendency of our farmers to avail themselves of the work of this Department in its many branches and their constant thirst for more information, not only in regard to the statistics of agriculture, but as to the scientific principles which all are now beginning to recognize as lying at the very foundation of successful agricultural work. That the means for imparting this information exist in this country through the liberality of the National Government on a scale far beyond any that has been attempted in any other country under the sun, is a fact which all must gratefully acknowledge, while this very fact, coupled with the earnest demands for increasing information, it must not be forgotten, adds largely to the burden of responsibility imposed upon this Department and its officers, upon the national legislature, which is responsible for providing it with the means necessary to enable it to satisfy these constantly increasing demands for information and advice, and upon those numerous institutions scattered throughout the country and specially endowed from the National Treasury to labor for the benefit of agriculture.

Much indeed has been done for agriculture in this country. Much more remains yet to be done; but relying upon the results of an earnest co-operation on the part of all the great forces which I have indicated as at work in this behalf, and confident of the cordial support of the people of the United States in all steps taken by the National Government to further the interests of that great foundation industry of agriculture, upon which the future prosperity of the country so essentially depends, I look forward with courage to the work that lies before us in the future and with confidence to the time when, in the high quality of its work as well as in the magnitude of its enterprises, the agriculture of the United States shall not only lead all other industries in this country, but shall be the leader in this great industry of all other countries.

In the hope that together with the people of the United States you may be led to the same encouraging conviction by a consideration of this report, I have the honor to respectfully submit the same.

Very respectfully, your obedient servant,

J. M. RUSK,
Secretary.

SPECIAL REPORT OF THE ASSISTANT SECRETARY

SIR: In accordance with your request, I beg leave to submit the following review of the scientific work of the Department in its relations to practical agriculture, to form a part of the Annual Report of the Department.

Trusting that it may fully cover the object which you had in view, and that its publication may serve to emphasize in the minds of the readers the determined effort in every division of this Department under your administration to conduct all the work in a manner subservient to the best interests of practical agriculture, I have the honor to remain,

Very respectfully, yours,

EDWIN WILLITS,
Assistant Secretary.

Hon. J. M. RUSK,
Secretary of Agriculture.

THE SCIENTIFIC WORK OF THE DEPARTMENT IN ITS RELATIONS TO PRACTICAL AGRICULTURE.

Agriculture to be permanently successful must be founded on, and conducted according to scientific principle. As all legislation not in accordance with fundamental economic laws will sooner or later fail in its beneficent purpose, so agriculture without an intelligent apprehension of its conditions and limitations, without a wise consideration of the laws to which it is subject, without a proper application of every means to enhance its productiveness, will ultimately fail to respond to expectations and will bring disaster to the farmer. Nature can not be cheated, and her implacable laws will surely find out their transgressors. There is a plague-stricken soil as well as a plague-stricken population. Sanitation and vegetation are not accidents: for both there are arts that promote and arts that prevent injury. Science is at the bottom of each.

Science is classified knowledge. This knowledge comes from experience and from investigation. It is as important to know what has been done as to know what it is possible to do. Science arranges the facts of the former in line and finds a law; or it investigates, projects itself into the unknown, and discovers other laws or amplifies those already known. Men who heed these laws avoid mistakes, conserve their energies, and double production.

The practical farmer too often forgets or ignores what he owes to science. He perhaps is sometimes not aware of the obligation. How many farmers, for instance in the temperate zone, would be moved to build a monument to the man or men who invented hay as adapted to modern use? Yet in a large sense hay is a modern discovery, based upon long experiments made in the importation, cultivation, and improvement of grasses till then unknown to the agriculturist. As recently as the sixteenth century the average weight of the bullocks bought for the English navy was less than 400 pounds. For want of hay the sheep were mostly killed in November, and such as were left were, with the oxen, starved through the winter, so that improvement was impossible. The grass experiments, scientific and practical, of the Duke of Bedford and others, made the 2,000 pound bullock possible, by furnishing food for continuous unstinted growth, winter and summer, from birth to maturity. It was by no accident that the few useful grasses upon which are based the live stock and dairy interests in the magnificent proportions of the present time were brought from diverse countries and made subservient to the interests of mankind.

How long it took the world to learn that proper rotation of crops "rests the land" as effectually as fallowing, thereby saving one crop and sometimes two a year; to learn that the increase of live stock on the farm within and under certain conditions increases its fertility; to learn that artificial drainage warms and lightens cold and heavy soils, advancing the harvest by weeks and bringing the subsoil to the relief of the impoverished surface, by which as some one has said we find a new farm under the old one, or as Emerson so graphically says, "by drainage we have gone to the subsoil, and we have a Concord under Concord, a Middlesex under Middlesex, and a basement story of Massachusetts more valuable than the superstructure." These matters were all demonstrated by the application of scientific principles long before adoption by the world at large.

It is perhaps a waste of words to continue a further discussion of what agriculture owes to science. Illustrations multiply as the ever-widening field is traversed. Suffice it to say that to the introduction of scientific methods and processes is due in large measure the elevation of those who till the soil to their present high estate. Science carries intelligence with it wherever it goes, and its wains are freighted with the burdens of increased harvests. In line with this sentiment and in furtherance of the demand of the farmers of the United States, was founded

THE DEPARTMENT OF AGRICULTURE.

As far back as 1822 a strong effort was made to transform the "Mall," some 200 acres, between the Capitol and Executive Mansion, then almost a barren waste, into an experiment farm, in which should be propagated for distribution new and rare seeds and plants. Nothing came of the agitation in that form, but in due time a division was established in the Patent Office to gather facts and disseminate information for the benefit of agriculture, and after a while to purchase new and rare seeds and plants in limited quantities for gratuitous distribution. The demand for better things grew till finally a separate and independent department was set up on 40 acres of the "Mall" which forty and more years before was sought for an experiment farm. With this transfer came enlarged powers and duties. In accord with enlightened progress, the means were given for original, scientific investigation. Several new divisions were created for that purpose, among which chemistry was chief. Since then, from time to time, other lines of inquiry have been added till there is hardly a topic of investigation relating to agriculture, suggested by modern thought, that is not in greater or less degree covered by the work of the Department. Its halls are instinct with science. The chiefs of the divisions and many of their subordinates are eminent in their special lines, and are recognized for their work and their ability the world over as the peers of any like body of investigators, seek where you may.

One of the gratifying features of this development in scientific research is that the practical character of the work has not one whit abated. Much more than one half of the money appropriated is used for the gathering of facts and statistics, for the purchase and distribution of seeds and plants, for the extirpation of contagious diseases of animals, for the introduction of and experiments with forage plants, for the inspection of meats and animals intended for export, and finally, for the dissemination of information. The most abstruse scientific inquiry is tempered by a practical impulse. The best scientific work has for its end the useful and the permanent good of agriculture. Here is exemplified what history again and again shows, that the best and highest scientific work has always been allied with the useful. Men need to be harnessed to facts, theories need to be in touch with realities to produce the best results; truths substantially verified in our experience. At the same time the publications issued by the Department constitute a mass of information the most extensive and varied among the nations of the earth. The annual report, of 400,000 copies, constitutes the largest single edition of any book published. In their practical character, in their scientific worth, and in the promptness of their issue, our publications are the admiration of all representatives of foreign governments accredited to the Department to study its workings and efficiency.

So much it is thought is due to make it clear that in this development the cardinal purpose and duty of the Department is not lost sight of. It remains now to consider in detail the

SCIENTIFIC WORK OF THE DEPARTMENT.

This work may be properly divided into three classes: (1) The experimental; (2) the remedial; and (3) general science.

As a matter of fact this classification is not made by divisions, but largely characterizes the work of all the divisions. The classification is generic, not divisional.

I.—THE EXPERIMENTAL.

This may be subdivided for more clear definition into (1) the empirical, and (2) the economic.

The empirical.—This term empirical is used for the want of a better, though not strictly accurate. By the term is meant that class of experiments which are not popularly considered scientific, though in fact based upon a scientific principle. This work is more fully carried on by the Seed Division, the Horticultural Division, the Pomological Division, and the Botanical Division.

The distribution of improved and valuable seeds and plants is sound policy, because based upon natural law. In a wide sense nature has made her own distribution which all experiments must recognize, and it is the study of the laws of this distribution that constitutes the scientific element of the empirical work, and which renders our definition not strictly accurate. For instance, it was practically a useless waste of funds to distribute cotton seed to the State of Michigan, which was done for a while under the ironclad appropriation that each Congressman should receive his quota of all seeds—an anomaly subsequently rectified. Climatic and other considerations (really scientific) should have their weight in the purchase and distribution. But, within comparatively certain lines, there is a wide field for improvement in quality and product, by the judicious introduction of new varieties and the transfer of valuable ones from one locality and condition to another.

While nature in the broad sense has placed her varieties of vegetable life in the regions to which they are best, and sometimes where they are exclusively adapted, there are some very marked exceptions. For instance, the potato, corn (maize), and tobacco were indigenous only on this continent. Their transfer to Europe has been an untold benefit to its teeming population. The transfer to England, in the seventeenth and eighteenth century, of some of the grasses indigenous in Virginia and Maryland, rendered it in large measure possible to make the hay in abundance, which has been noted near the beginning of this article, and which was the prime cause of the modern development of the cattle industry. The planting of the Eucalyptus tree, indigenous in Australia, has been a boon to treeless Southern California. We need not to be reminded that nearly all our cereals as well as our domestic animals are of European or Eastern origin. These illustrations cover broad lines, but they are sufficient to establish the fact that the securing of new seeds and plants for distribution is a paying investment properly conducted. On the other hand, it is equally as susceptible of demonstration that the distribution of valuable seeds and plants, not new, but well known, from one locality to another, is promotive of a higher and better production. Taken from a locality where they succeed at their best estate, they carry with them to their new home some of the impulse and vitality they took on where they were grown. This is nature's secret at the bottom of the benefits in "change of seed."

Recognizing these facts (based. as has been noted, on scientific reasons), Congress for nearly fifty years has appropriated funds for the purchase and distribution of new and valuable seeds and plants, and has committed the duty of carrying on the work to the Department of Agriculture. While it is conceded that many mistakes have been made and some notable failures have occurred, the fact remains indisputable that great benefits have been conferred upon the agriculture of the United States by the distribution. We can, out of many, give only a few illustrations. Take one from the Seed Division, that of the wheats sent out. Many kinds have been distributed. The most of them appear in the list of those now cultivated, but the number disseminated is of little importance compared with the prominence of some of them in the wheat growing of the present day. The variety which has the widest distribution is the "Fultz," a red winter wheat, which originated in Pennsylvania, and was distributed in 1871 and subsequent years. The area now occupied by it is four times as much as that devoted to any other wheat, and probably occupies one third of the area seeded in winter wheat, producing at least one fourth of the wheat harvest of the country. The next in extent is the "Mediterranean." This was imported by the Department twenty-five years ago and for several subsequent seasons from Marseilles, France, and grown on the islands of the Mediterranean Sea. The next was the "Fife." It is almost as prominent among spring wheats in the proportion of its cultivation as is the Fultz in the domain of winter wheats. It is the great wheat of the Northwest, introduced by the Department. The next and fourth in importance is the "Clawson," so well known in Michigan. Many more might be mentioned, taking a lower rank, but which are leading varieties in many localities. The four named yield nearly or quite one half of our usual crop. Last year the Department distributed seven home varieties and four new imported ones. The home varieties consisted of three new improved ones and four of more than local celebrity, to be transferred to the localities in which they were not grown. Of the four imported two were of Black Sea and Italian parentage, for our Southern States, and two of English and French parentage; all raised in and thoroughly acclimatized to France. It is hoped that out of the four we may find at least one substantial acquisition. They all may prove failures. That is the reason why the experiment is called empirical, having as it does a large element of chance in it, though careful study was made of the strain, of the varieties, and the conditions of production.

So much for the Seed Division, though illustrations too numerous for this article suggest themselves. Let us take one or two from the work of the Horticultural Division. This deals largely, of course, with plants. It first introduced the Russian apple, which has such rare success in the West and North. It introduced the Japan persimmon, which has become so largely cultivated in Florida and California. The celebrated Washington navel orange of California was propagated from a tree growing in the hothouse of this Department. Those who have seen this wonderful orange grow will concur in the statement one repeatedly hears in California, that the introduction of this one variety was worth more to the country than the total cost of the Department of Agriculture. The original plant came from Bahia, Brazil. It took three years and two failures before success was attained, and then only in rearing a single tree, from which has come such a progeny. We can not stop to enumerate the catalogue of fruits and plants and fibers introduced, of the pineapple, olives and figs, dates, and citron. We will stop, however, long enough to speak of the citrons and figs recently imported by the Pomological Division, and of the date palms from Egypt, just distributed in California and Arizona, and upon which great expectations hang.

The Botanical Division is specially charged with the experiments with the grasses and other forage plants. During the existence of the Department the Seed Division gave much attention to the distribution of grass seeds, but it is not till within the last two years that the thorough and exhaustive experiment has been assigned to a division which shall make it a specialty. It is believed that the era which was inaugurated by the English experimenters, heretofore noted, can be repeated; that they did not exhaust the subject; that new grasses and forage plants can be found that will successfully enlarge the list. Another reason for entering upon the work is that the results of the English experiment accrue only to a comparatively small portion of the United States. The conditions south of Virginia and Kentucky and west of the Missouri River are so different that the staple forage plants will not thrive in economic production. The South needs a new line of grasses as much as did England in the sixteenth century, and for substantially the same reason. The Great West, which is developing so rapidly, presents altogether another problem. All the grasses known to us in the North have been practically discarded there and others are supplanting them. The list is at present small, even under irrigation, and the hope is that it may be largely increased; while without irrigation there is as yet no known grass that will succeed under cultivation. Perhaps two thirds and more of that vast territory is not susceptible of irrigation. A considerable portion of this area is covered with native grasses of limited production that close and continuous pasturage destroys, leaving nothing in its place.

It is believed that from those native grasses, from those in Siberia, in India, and in South America, some varieties may be found that shall "stick" and thrive permanently, thereby quadrupling at least the production. It will doubtless take many years to accomplish this. It took England fifty years to develop her grass industry. Long before the expiration of half that time the advancing tide of population will utilize the results of these experiments, if successful, without in any sensible degree affecting the value of the products of the older and more thickly populated States. It is wise statesmanship to anticipate the wants of the future, and to determine how far it is practicable to make homes for the teeming millions to come. The Department of Agriculture is for the whole country, and should canvass the wants of all. The South, if these experiments prove a success, will find in them the means of restoring her sterile acres, and of preventing further depletion of her soil, and at the same time of developing an industry that shall make her more self-sustaining. The West may gradually force back the lines of the desert, and with grass to temper and forest trees to resist, may hope to modify the blizzards.

The economic.—This is the second branch of the experimental work. This characteristic may be found in all, but in a less degree than in the Chemical Division. The most marked feature of this division in this line is its work on the sugar question. This experiment and investigation is one of long standing. A large amount of work was done to determine whether there was sufficient saccharine matter in cornstalks to produce sugar with a profit. It was finally decided that there is not. Then, or in a measure concurrent with the corn experiments, began a long line of tests on sorghum; first, to determine the variety, the richest in saccharine qualities; second, to find the period of maturity productive of the largest yield, and at what stage of its growth the sugar would crystallize most readily, and with least loss in molasses. The cane upon which these tests were made was planted, cultivated, and gathered under the supervision of the division. Both objects were satisfactorily determined, and for a time it looked as though the general production of sugar from sorghum would prove a success, but the price of raw sugar in the market took a large decline, so great that sugar from sorghum could not be economically produced, resulting in the collapse of the new industry, as well as that of the manufacture of glucose, a bastard sugar with which the genuine was adulterated. The experiments continued, however, taking the form of improving cane by careful scientific cultivation and propagation, so that the yield of sugar might be increased, and in determining what localities, if any, were adapted to its economic production. Considerable success has attended the work. The quality of the cane has been sensibly improved, and the regions of highest production pretty well defined; but at this date the promise for a general sorghum-sugar industry does not equal the high hopes of its most sanguine promoters, though it promises to be a success in a restricted locality. The experiment, however, has proved a most valuable one, even where it has failed, worth all and more than it cost, in that it has been demonstrated that sugar in unlimited quantities at a price but little above the cost of foreign sugars can be manufactured, so that in case of national emergency or scarcity abroad our country may be amply supplied with home products.

If the maxim "In time of peace prepare for war," is a good one in a military sense, it is no less so in an economic. A great deal of scientific work has been done in the analysis of the cane, in the study of all the processes of extracting the juice and its manufacture, in the improvement of the machinery and apparatus, in the elimination of waste by new methods and new processes, so that a full knowledge of the conditions and the possibilities of the industry has been obtained. These experiments have not been limited to sorghum cane, but have covered that of the sugar cane of Louisiana. With the latter the improvement is so marked that it is worthy of special note. The industry in Louisiana has been of so long standing that comparisons can be made. It has been proven that by modern processes developed with the coöperation of the division, and in many respects under its direct instruction, the yield of sugar from a given average ton of cane can be raised from 120 to 200 pounds, the difference of 80 pounds being lost in the operation conducted according to the old methods. When the new processes shall be applied by all the cane-sugar producers, an increase of product in the area of present cultivation would be effected to the value of more than $10,000,000 annually. These results from both the sorghum and the cane experiments amply justify the work and the expenditure. These experiments still continue, and in addition, under direction of Congress, he cultivation of the sugar beet, and the manufacture of sugar therefrom, have been taken up. A large amount of the best seed from Europe has been obtained and distributed in the localities supposed to be best adapted to their growth, and analyses of the beets from a wide region of country are being made. At this writing the most flattering hopes are excited from the showing made. The previous work done with sorghum and sugar cane makes the transition to the beet sugar inquiry an easy one, and its solution will be more rapid, intelligent, and satisfactory.

II.—THE REMEDIAL.

Vegetable and animal life are subject to similar conditions. A tree and an animal live essentially on the same elements. They both grow to maturity, and in due time die and decay. Both have their enemies and their diseases. There are diseased cattle and diseased vines. No one speaks of a diseased granite block. It is this life and its conditions, therefore, that has its enemies and its diseases. Anything that saps or stops nutrition is an enemy to life, and may be the cause of disease. Growth stopped, decay begins, and death ensues. Kill the enemies, stay the disease, and life continues to maturity and production. Whatever kills the enemy is a remedy, whatever stays the disease is a cure. Neither adds a particle to the inherent life. Both simply remove obstructions and life goes on. The means and methods of killing the enemies and curing diseases are *remedial*, and a large part of the work of the Department is the study of these remedies. The Division of Entomology is charged with the killing of the animal enemies that attack plant and animal life; the Division of Vegetable Pathology, with remedies for the diseases of plants; the Bureau of Animal Industry, the diseases of animals. We will discuss the work of the last two first.

Manifestly the most logical way is first to find the cause of the disease, then the work of finding a remedy is simplified; the finding of the cause in very many cases suggests the remedy. It is true that experiment often finds a remedy, but with great waste of time and energy if the cause is unknown. What is the cause of plant disease? What is "pear blight?" What is "peach yellow," or "apple scab," or "black rot" in the vine? What is that "vine disease" which goes through a vineyard as a "flame of fire?" What is "rust" in wheat? What is "potato rot?" What is "mildew?" Again, what is the cause of diseases in animals? What is "hog cholera," or "swine plague," or "pleuro-pneumonia," or "Texas fever," or "tuberculosis," or "glanders," or "horse distemper?"

Now, modern science has gone far toward demonstrating that the ultimate cause of all these diseases and many not named is an infinitesimal "germ" or "spore." This germ or spore has a mysterious life of its own that attacks the life of the plant or animal, It attaches itself to the plant, and as a fungus sucks out its vitality. It enters the sap and destroys its nutritious qualities. It enters the blood, and curdles it as it were by its marvelous power of reproduction, till the "issues of life" are spent.

There is, however, a dispute, notably relating to plant diseases, as to whether these germs are the real cause of the disease, whether they are not in fact an effect. Worms, say one side, eat the dead body, not the live; mold takes hold of decaying not living wood. These spores attack only the dead or dying. The disease antedates the attack. Vultures will follow all day long the wounded deer to pounce upon him perhaps before his last expiring breath. So do these minute spores follow the decaying vitality of the seemingly vigorous plant, which is, in truth, moribund. In other words, that this fungus never troubles, or rather thrives on an absolutely healthy vine, but that the vine is in process of decay, though it may not seem so to the eye.

On the other hand, it is as emphatically claimed that it does attack healthy plants; that in the same orchard or vineyard, in the same row, where all grow in the same soil and are in the same condition of apparent health, growth, and vitality, one will be attacked and the other left; that the disease can be produced at will in healthy plants by inoculating the virus, that is the spore, into the sap; which facts would seem to settle the controversy in their favor. Whether it does or not, there can be no question that these spores either are the cause of death or hasten it, so that if they are killed before they have got in their work, the life is in one view saved, in the other prolonged. In either case the remedy is fruitful. The experiments of the Division of Vegetable Pathology fully establish this fact.

This diversity of opinion does not exist to the same extent, relative to the germ or spore existing in animal diseases. It is true, nevertheless, that it is claimed that many of the maladies are caused by the lack of vitality in the subject, by which it is unable to resist the attacks of the germs already in the system; that a healthy body has the ability to keep them in subjection, but any derangement, sometimes a simple cold and the hitherto inert forces take new life, and attack some vital part. It is manifest, however, that this theory will not account for diseases of a contagious type where an epidemic prevails, which travels over lines as well defined as a blizzard, striking down indiscriminately the strong and the weak, the apparently healthy as well as the unhealthy. There is, however, an unsolved mystery in the ways of these unseen messengers of death; one is taken and another is left, even under like exposure and apparently like conditions. If it be proved as claimed, that the causes of these diseases is a living germ, substantial progress has been made. They have form and substance and life, and it is a relief from the terror inspired by the conception that the cause is something intangible as a spirit, impalpable as a ghost, but withering as a blast from the infernal regions. There is hope in the knowledge that these spores are living organisms, for it is almost axiomatic that every living thing can be killed. It may be by some poison, mineral or vegetable, by some substance that destroys the tissue in which it lives, by some parasite harmless to the animal but deadly to the germ, by the frosts of winter, by fire, fumigation and purification, whereby the nests in which it is bred, are wholly destroyed. It is believed that, as the next step, now that the cause is known, science will in time in each case find the remedy that shall kill the germ without killing the animal. It is a matter of some discouragement that up to date we have not been able to exterminate pleuropneumonia except in the destruction of the animal infected, but public attention has been sharply arrested on this point, and some of the ablest men of the world are investigating the problem. In the two divisions under consideration, experts are studying in all their forms and phases these germs or spores that prey upon animal and vegetable life. In the laboratory, in the field, with microscopes, with germ culture, with fungicides, with vaccination of other or similar, but less injurious germs, and in every way that science can suggest, or experiment can blaze the way, remedies are being sought, and in time, as before said, will be found in some form or other, as by Jenner for smallpox, Pasteur for hydrophobia, and Koch for tuberculosis.

The work of these two divisions, however, is not limited to this strictly scientific investigation. In the Division of Vegetable Pathology some of the experiments with fungicides have brought substantial results. A striking example bearing on this point is shown in the method of dealing with black rot of the grape. Before this disease was investigated by the Department, nearly every grape grower had a theory as to the cause of it, but the question of a remedy was entirely beyond the imagination of the most sanguine. By scientific investigations which covered months, it was shown that the disease was due to a microscopic fungus, and that the fungus passed through several stages. The character and life history of the fungus was determined, and this knowledge suggested the remedy which, when applied intelligently, can save the crop. Many farmers and fruit growers who have followed the instructions of the Department this year have saved from 80 to 90 per cent. of their crop, while there was almost a total failure in the portions of the vineyards untreated. Reports of this season's work justify the statement that in this one line more has been saved by the comparatively few who followed instructions than the total expenditure of the division in all lines. The division has had under investigation a large line of plant diseases, chief among which are "peach yellows," "pear blight," "apple and pear scab," "pear and cherry leaf blight," the "California vine disease," "cotton anthracnose," "anthracnose of the hollyhock," a bacterial disease of the oat which is destroying millions of bushels, "rots" of the sweet and Irish potatoes, "mildew" and "anthracnose of the grape." In some the causes are still unknown or obscure. Others are perceptibly yielding to treatment, and there are high hopes of essential success in the near future.

The Bureau of Animal Industry was specially charged in 1886 with the eradication of pleuropneumonia among cattle, which at that time was so widespread and so terribly destructive. With a large force, mainly of veterinary experts, it attacked the disease, and has essentially stamped it out. To form some idea of the work done (and it was essentially scientific in its character), we need only to note the fact that from August 1, 1886, to November 30, 1888, there were inspected by the agents of the Bureau 50,838 herds, containing in all 300,737 cattle; there were found 1,428 infected herds, which contained 5,715 infected animals, and there were made 49,073 post-mortem examinations. Whenever a herd was found infected, or had an infected animal in it, it was at once quarantined, the infected animal slaughtered, and in fact large numbers of animals exposed to the contagion were likewise slaughtered and paid for by the Department. This work enlisted in its service the highest attainable skill in the country; for large interests were at stake, large sums of money expended, and a terrible evil was to be extirpated. That success has been attained is due in a large measure to the scientific work of the Department. In but one or two localities are there now any appearances or suspicions of the disease, and strict quarantine is still being made of all suspected animals. This is necessary for the reason that the germs of the disease may still exist in an undeveloped state, which on some propitious occasion will show itself and begin its devastating work. It is said that notwithstanding large expenditures of money in foreign countries, whence came the disease, nowhere has it been entirely eradicated; so, constant vigilance is required, not only to watch the least symptoms of revival of it here, but to prevent the importation of infected animals.

Entomology.—A large portion of our injurious insects are of foreign origin. We are the asylum of every downtrodden race of men, good, bad, and indifferent, and they bring with them from every clime the diseases and the insects incident to their countries. The result is that we are in number and variety the most pest-ridden country of the world. The Hessians are reputed as bringing with them the Hessian Fly, and it is not discrediting the Hessian soldier to say that the Hessian Fly has done far more harm to the country than did the soldier. George Washington could take him prisoner, but a generation could not capture the fly. The work, therefore, of the Division of Entomology is the most varied of any connected with the Department. When we take into account the fact that there are already listed nearly or quite three hundred thousand varieties of insects, only a small portion, it is true, injurious to agriculture, but a large portion likely at any time to become so by some change of temperature, some change or increase in the humidity of the climate, or some want of its natural source of sustenance, which may precipitate them in countless hordes upon growing fields, the importance of the science of entomology will be so obvious as to lift it into public consideration. A universally effective insect powder would command as ready sale as a well advertised patent medicine. Insects are the scourge of every farmer and fruit grower, and the life-long plague of every thrifty housewife. The work of this division has been so constant in studying their life history and characteristics, and the means of checking their ravages, that it could hardly have failed, if it would, in accomplishing great good for agriculture. The information given as to remedies has been so ample, and the instructions as to methods of application have been so full, that it is needless to specify the particular instances of special benefit. The sum and substance of the instructions is to kill the insect and yet not kill the plant or animal or substance it infects. The experiments in insecticides and their application by spraying machines have been invaluable. These experiments have not been haphazard, but have been guided by scientific discrimination. One illustration will suffice. The persistent efforts of this division to discover a remedy for the ravages of the scale insect among the orange groves of California—ravages which in a short time from their beginning threatened to destroy this most promising branch of agriculture—have been crowned with success. It was due to the efforts of this division that a skilled entomologist was sent to Australia, where he discovered a parasite to the pest, though Australian scientists had denied its existence, and having discovered it brought home a supply for propagation in California. California fruit growers have asserted that the investigations and experiments have saved their oranges.

III.—GENERAL SCIENTIFIC WORK.

The Chemical Division has been conducting an important and fruitful series of tests to determine the extent and character of adulteration of the food, drugs, and liquors offered for sale in American markets, and has made analyses of grasses and cereals, of soils and waters, as occasion has required and the means at hand have afforded opportunity.

The Forestry Division has devoted itself to the study of the life histories of trees, and the distribution and extent of forests, the prevalence and characteristics of varieties of forest growths, and the modifications arising from differences in climate and soil, and to a series of mechanical tests and laboratory examinations to determine more satisfactorily the qualities of our many timbers, grown under different conditions, so that the wood worker and user may more intelligently make his choice of timbers from different localities and for different purposes.

In the Division of Ornithology the whole question of distribution of plants and animals, the food habits of birds and mammals, and the relation of these to agriculture, horticulture, and forestry has been primarily considered, and much valuable fieldwork has already been performed. The results to be obtained can be hardly less important than those already referred to as accomplished and hoped for in connection with the distribution of cereal, vegetable, fruit, and grass seeds by the Department for economic purposes. An accurate survey showing, as regards altitude and latitude, the habitat of any given indigenous species will serve to the scientist as a starting point for the consideration of the multitudinous questions brought to his attention with respect to the adaptability of any given locality to the growth of any given economic plant. In this study the Botanical, the Pomological, and the Forestry Division are contributors.

The Division of Pomology is creating for itself a wide field of usefulness in connection with the study of varieties of fruits and the effect of change from a given climate and soil to another, and the Botanical Division is engaged in a similar work in respect to plants and grasses. The National Herbarium, under the control of the Botanical Division, is winning recognition and approval from the botanists of the world, both by reason of the extent of its collections and the excellence of its system of classification.

The Entomological Division has for its scientific function the collection and classification of insects and the study of the conditions which promote or retard their increase and of their capabilities of usefulness or mischief. The reputation of the division among scientific men was world-wide years ago, and it has suffered nothing in standing or reputation of late years.

The study of the habits of the silkworm is now pursued in the Silk Section, and forms the chief scientific function of the section. The study promises to result in the distribution of the best varieties of the worm.

The Microscopical Division is rendering valuable public service by applying the microscope to the study of food adulteration and the character of textile fibers.

Important scientific work has been performed by a special agent of the Department in relation to the adaptability of some of the most economic fiber plants to growth in different sections of the country, and practical results of the study have been embodied in publications setting forth suggestions as to the best methods of cultivation, decortication, and separation from woods and gums.

Statistical Division and Office of Experiment Stations.—If it be true, as Comte says, that the test of a science is its power of prediction, the highest order of economic science finds full play in the Statistical Division and of agricultural science in the Office of Experiment Stations. It is said that in no one thing did Gladstone in his prime show his wonderful abilities more than in forecasting the production and revenues of England. He reasoned from the known to the unknown. The Statistical Division more than any other considers all the forces that enter into the great and varied agricultural productions in our vast domain, so that intelligence shall decide what to plant, where to plant, and when to plant. The Office of Experiment Stations is charged with the scientific work of comparing, editing, and publishing the results of the experiments made by the experiment stations, and to indicate, from time to time, such lines of inquiry as shall seem most important. It goes without saying that this work calls for the highest scientific qualities. To take a comprehensive view of the work of nearly four hundred independent workers in the scientific field, to properly digest the same for publication, and to suggest lines of work and lines of experiment requires the ablest talent the country can produce. The relations of this Department with the agricultural colleges and experiment stations are and should be very intimate. They were both born of the same impulse. The act to establish a Department of Agriculture (before that it was, as heretofore stated, a division of the Patent Office) was approved May 15, 1862. The act establishing the agricultural colleges was approved July 2, 1862. The act establishing agricultural experiment stations was approved March 2, 1887. The bill to make this Department one of the Executive Departments of the Government was pending at that date before Congress, and had passed the House of Representatives, and finally became an act, approved February 9, 1889. The historian will recognize the significance of this coördinate legislation. It means a movement all along the lines of science applied to agriculture. These colleges and experiment stations are nurseries of applied science.

This article will have failed of its object if it does not satisfy the most skeptical that this Department in applying its scientific work to the wants of the great industry it represents, is fully abreast with the marching columns of this new movement.

REPORT OF THE CHIEF OF THE BUREAU OF ANIMAL INDUSTRY.

SIR: I have the honor to transmit herewith my report, which contains a brief statement of the more important work accomplished by the Bureau of Animal Industry during the year 1890. For many interesting details of the work, and for the reports of agents, inspectors, and other employés, I must refer you to the Sixth Annual Report of the Bureau of Animal Industry.

Very respectfully,

D. E. SALMON,
Chief of the Bureau of Animal Industry.

Hon. J. M. RUSK,
Secretary of Agriculture.

PLEURO-PNEUMONIA.

The year has passed without any discovery of contagious pleuro-pneumonia outside of the districts which were recognized in the last report as infected. The regulations of the Department have been enforced without difficulty, and the progress of the work for the eradication of this plague has been continuous and rapid.

No cases of the disease have occurred in the State of New York except on Long Island. No cases have been discovered in Pennsylvania during the year, although a constant inspection has been maintained. The last case discovered in Maryland occurred in October, 1889, and since that time the State has been free from all evidence of the contagion. The condition of New Jersey as regards this plague has also improved rapidly. No other States have been affected.

The efficiency of the regulations and of the methods employed under them is demonstrated by the fact that for two years there has not been a case of the disease outside of the very restricted areas on the Atlantic seaboard which have from the first been recognized as infected. These regulations are still in force, and with the almost complete eradication of the contagion the danger of any infection extending to other sections has practically disappeared.

WORK IN NEW YORK.

In order to hasten the work on Long Island more radical measures of disinfection were adopted early in the year and in certain cases where the disease had reappeared several times stables were torn down and burned. It also became necessary in order to maintain any respect for the Department regulations that vigorous measures should be adopted to prevent cattle from grazing upon the commons in the infected district. There appeared to be a widespread opinion, fostered by interested parties, to the effect that the Department had no power to enforce its regulations. As the total eradication of the disease could never be accomplished while the cattle of the infected districts were allowed to pasture in common and mingle together on the pastures and highways, it was determined to put a stop to this practice by seizing and slaughtering all cattle found off of the owners' premises without a permit from the chief inspector. The first seizure included over one hundred head of cows, and this was followed by others at short intervals. The owners, however, soon discovered that it was to their interest to abide by the regulations and from that time the disease has rapidly disappeared. There can be no doubt but that these measures, though they appear arbitrary and severe, were the means of bringing speedy success to the work on Long Island, when before their adoption there was reason to fear that the contagion might still linger there for an indefinite time.

From July 1, 1889, to June 30, 1890, there were inspected in New York 17,767 herds, containing 147,988 head of cattle. There were 151,284 animals reëxamined and 34,905 were tagged with numbers and registered upon the books of the Bureau.

There were 128 new herds found affected with pleuro-pneumonia during the year, and these herds contained 2,879 animals, 182 of which were pronounced diseased when the inspections were made. There were purchased for slaughter during the same time 603 affected cattle at a cost of $15,756.37, an average of $26.13; also 2,513 exposed cattle at a cost of $55,744.54, an average of $22.18. The smaller cost of the exposed cattle was due, as in previous years, to the fact that the amount which the owner realized for the carcasses was deducted from the appraised value, the Department paying the balance.

It has been found necessary to disinfect 416 stables, stock yards, or other premises during the year, and also to make *post-mortem* examinations upon 17,109 carcasses of bovine animals, of which 631 were found diseased with pleuro-pneumonia.

The total expenses in New York from July 1, 1889, to June 30, 1890, were $174,952.48, of which $71,500.91 was paid for cattle purchased for slaughter as either diseased or exposed. The remainder constitutes the cost of disinfection, inspection, tagging, registering, supervising the movement of cattle, *post-mortem* examinations, and all the various expenses incident to a work of this character.

WORK IN NEW JERSEY.

In this State the active work has been almost entirely confined to Hudson County. The diseased herds discovered have not been numerous, and both affected and exposed animals have been promptly slaughtered.

From June 30, 1889, to July 1, 1890, there were inspected in New Jersey 8,624 herds, containing 64,108 head of cattle. Of this number 40,305 were reëxamined and 9,780 were tagged with numbers and registered upon the books of the Bureau.

There were 29 new herds found affected with pleuro-pneumonia during the year, and these herds contained 405 animals, 46 of which were pronounced diseased at the time the inspections were made. There were purchased for slaughter during the same time 69 affected cattle at a cost of $1,848.50, an average of $26.79 per head; also 451 exposed cattle at a cost of $10,947.75, an average of $24.27 per head.

It has been found necessary to disinfect 167 stables, stock yards, or other premises, and also to make *post-mortem* examinations upon the carcasses of 10,741 bovine animals, of which 89 were found diseased with pleuro-pneumonia.

The total expenses in New Jersey from July 1, 1889, to June 30, 1890, were $60,828.02, of which $12,896.25 was paid for cattle purchased for slaughter because they were either diseased or had been exposed.

WORK IN MARYLAND.

Although the last case of pleuro-pneumonia was discovered in Maryland in October, 1889, it was deemed best to keep up the inspection for a considerable time in order that there might be a certainty of the complete extermination of the disease. Quarantine restrictions were removed May 1, 1890, but inspections have been continued, and it may now be definitely announced that Maryland is free from the contagion.

From July 1, 1889, to June 30, 1890, there were inspected in Maryland 7,296 herds, containing 71,503 head of cattle. Of this number 8,368 were reëxamined and 10,298 were tagged with numbers and registered upon the books of the Bureau.

There were 2 new herds found affected with pleuro-pneumonia during the year, and these herds contained 28 animals, 2 of which were pronounced diseased when the inspections were made. There were purchased for slaughter during the same time 4 affected cattle at a cost of $99.19, an average of $24.80 per head; also 69 exposed cattle at a cost of $1,115.01, an average of $16.16 per head.

It was found necessary to disinfect 5 stables or other premises during the year and to make *post-mortem* examinations upon the carcasses of 15,109 bovine animals, of which 4 were found diseased with pleuro-pneumonia.

The total expenses in Maryland from July 1, 1889, to June 30, 1890, were $38,558.17, of which $1,214.20 was paid for cattle purchased for slaughter as either diseased or exposed.

THE WORK AS A WHOLE.

Including all the districts in which pleuro-pneumonia has existed there were inspected from July 1, 1889, to June 30, 1890, a total of 33,687 herds of cattle, containing 283,599 animals. Of this number 199,957 were reëxamined, and 54,983 were tagged with numbers and registered upon the books of the Bureau.

There were 159 new herds found affected with pleuro-pneumonia during the year, and these herds contained 3,312 animals, 230 of which were pronounced diseased when the inspections were made. There were purchased for slaughter during the same time 676 affected cattle at a cost of $17,704.06, an average of $26.19 per head; also 3,033 exposed cattle at a cost of $67,807.30, an average of $22.36 per head.

It has been found necessary to disinfect 588 stables, stock yards, or other premises, and also to make *post-mortem* examinations upon the carcasses of 42,959 bovine animals, of which 724 were found diseased with pleuro-pneumonia.

The total expenses of the pleuro-pneumonia work from July 1, 1889, to June 30, 1890, have been $274,338.67, of which $85,511.36 was paid for cattle purchased for slaughter as either diseased or exposed.

The remainder constitutes the expense for inspection, disinfection, tagging, registering, and supervising the movement of cattle, of *post-mortem* examinations, and of all the various expenses necessary to insure the prompt discovery of this plague when it appears in any herd and prevent the further extension of the infection.

The following table gives a résumé of the pleuro-pneumonia work from July 1, 1889, to June 30, 1890, as given in detail above:

	New York.	New Jersey.	Maryland.	Total.
Herds inspected	17,767	8,624	7,296	33,687
Cattle inspected	147,988	64,108	71,503	283,599
Cattle reëxamined	151,284	40,305	8,368	199,957
Diseased cattle found by inspection	182	46	2	230
Post-mortem examinations	17,109	10,741	15,109	42,959
Diseased carcasses found	631	89	4	724
Cattle tagged	34,905	9,780	10,298	54,983
New herds found affected	128	29	2	159
Animals in affected herds	2,879	405	28	3,312
Diseased cattle purchased	603	69	4	676
Exposed cattle purchased	2,513	451	69	3,033
Premises disinfected	416	167	5	588

A résumé of expenditures in the pleuro-pneumonia work for the same period is made below:

Items.	New York.	New Jersey.	Maryland.	Total.
Salaries	$82,386.60	$35,583.31	$30,139.62	$148,109.53
Traveling expenses	12,619.26	10,323.16	6,366.08	29,308.50
Miscellaneous expenses	8,445.71	2,125.30	838.27	11,409.28
Affected cattle	15,756.37	1,848.50	99.19	17,704.06
Exposed cattle	55,744.54	10,947.75	1,115.01	67,807.30
Total	174,952.48	60,828.02	38,558.17	274,338.67
Average for affected cattle	26.13	26.79	24.80	26.19
Average for exposed cattle	22.18	24.27	16.16	22.36

COMPARISONS WITH PREVIOUS YEARS.

The progress accomplished by this work can not be appreciated without comparing the number of new herds found affected during the year, and the total number of cases of pleuro-pneumonia found on *post-mortem* examination with similar data gathered from the reports of preceding years. As all carcasses of animals which have died or which have been slaughtered in the infected districts are carefully examined, we have in the returns of the *post-mortem* examinations the total number of cases of pleuro-pneumonia which have occurred.

The number of cattle and of new herds found affected with pleuro-pneumonia on *post-mortem* examination during the year ending June 30, 1890, as compared with the preceding year is as follows:

States.	Affected cattle.		Affected herds.	
	1889-'90.	1888-'89.	1889-'90.	1888-'89.
New York	631	1,561	128	235
New Jersey	89	302	29	91
Pennsylvania	....	29	....	7
Maryland	4	242	2	46
Total	724	2,134	159	379

The total number of diseased and exposed cattle which have been purchased and slaughtered each year since the work for the eradication of pleuro-pneumonia was commenced is shown by the following table. The figures are for the fiscal year ending June 30.

	1886–'87.	1887–'88.	1888–'89.	1889–'90.	Total.
Diseased	1,342	2,398	1,903	676	6,319
Exposed	1,576	5,345	4,583	3,033	14,537

These tables show a very marked decrease of the disease. There were not half as many new herds found affected in 1889–'90 as in the preceding year, and only about one-third as many affected cattle. The largest number of cattle were slaughtered in 1887–'88, as previous to this the work had not covered the whole of the infected district. Since that time the number slaughtered has been largely decreased each year. The eradication of the disease has been most rapid, however, since April, 1890, the number of new herds found affected and the cases of pleuro-pneumonia found on *post-mortem* examination during the quarter being as follows:

	April.	May.	June.	Total.
Herds affected	13	5	5	23
Animals affected	33	62	9	104

This shows a gratifying improvement over the preceding months of the year, but it is only when we compare the figures for this quarter with those for the first quarter of the year 1890–'91 that we can appreciate the rapidity of our recent progress. The statement for this quarter is as follows:

	July.	August.	September.	Total.
Herds affected	2	4	3	9
Animals affected	2	13	13	28

When we add that during the month of October, 1890, no cases of disease were found it is conclusively shown that we are rapidly nearing the time when pleuro-pneumonia can be declared exterminated from the United States. Until from four to six months have elapsed after the last case of this disease has been found it will be necessary to maintain the same inspection force and to keep up the same vigilant supervision as we now have. Otherwise neither our own people nor foreign governments will be convinced of the complete success of the work.

REGULATIONS CONCERNING TEXAS FEVER.

The losses from Texas fever were so much reduced by the regulations of 1889 that a similar order was issued early in 1890 to take effect March 15. By commencing the supervision at this early date it was hoped that the infection of northern pastures might be entirely prevented and the dissemination of the disease reduced to a minimum. This anticipated relief from the fever was very generally realized, but there were some outbreaks in Kansas which occurred from infection introduced before the regulations went into effect. This was no doubt due to the exceptionally warm winter and could not be foreseen.

The regulations, also, differed from those of 1889 by allowing no cattle from the Indian Territory or from Texas with the exception of the northern part of the Panhandle to mingle with the uninfected cattle. While it is doubtless true that the northwestern portion of the Indian Territory and a considerably larger section of Texas are free from permanent infection, the absence of local laws preventing free driving of dangerous cattle makes it unsafe to allow cattle from such districts to go into the same cars and yards as those from farther north. The full text of the order is as follows:

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., February 24, 1890.

To the Managers and Agents of Railroad and Transportation Companies of the United States:

In accordance with section 7 of an act of Congress approved May 29, 1884, entitled "An act for the establishment of a Bureau of Animal Industry, to prevent the exportation of diseased cattle and to provide means for the suppression and extirpation of pleuro-pneumonia and other contagious diseases among domestic animals," you are hereby notified that a contagious and infectious disease known as splenetic or Texas fever exists among cattle in the following described area of the United States:

All that country lying south and east of a line commencing on the Mississippi River at latitude 36° 30′ north, thence running westward on that parallel of latitude, being the southern boundary of Missouri, to the eastern boundary of Indian Territory, thence running northward to the southern boundary of Kansas, thence westward along said boundary of Kansas to the one hundredth meridian of longitude, thence southward along said one hundredth meridian of longitude to the southern boundary in Childress County in Texas, thence westward along the southern boundary of the counties of Childress, Hall, Briscoe, Swisher, Castro, and Parmer to the eastern boundary of New Mexico.

From the 15th day of March to the 1st day of December, 1890, no cattle are to be transported from said area to any portion of the United States north, east, or west of the above described line except in accordance with the following regulations: *Provided*, That these regulations shall not apply to any cattle taken into or through the State of Colorado for feeding purposes in accordance with the regulations of that State:

First. When any cattle in course of transportation from said area are unloaded north, east, or west of this line to be fed or watered, the places where said cattle are to be so fed or watered shall be set apart and no other cattle shall be admitted thereto.

Second. On unloading said cattle at their points of destination pens shall be set apart to receive them, and no other cattle shall be admitted to said pens, and the regulations relating to the movement of Texas cattle, prescribed by the cattle sanitary officers of the State where unloaded, shall be carefully observed. The cars that have carried said stock shall be cleansed and disinfected before they are again used to transport, store, or shelter animals.

Third. Whenever any cattle that have come from said area shall be reshipped from any of the points at which they have been unloaded to other points of destination the car carrying said animals shall bear a placard stating that said car contains southern cattle, and each of the waybills of said shipment shall have a note upon its face with a similar statement. At whatever point these cattle are unloaded they shall be placed in separate pens, to which no other cattle shall be admitted.

Fourth. The cars used to transport such animals and the pens in which they are fed and watered and the pens set apart for their reception at points of destination shall be disinfected in the following manner:

(*a*) Remove all litter and manure. This litter and manure may be disinfected by mixing it with lime, diluted sulphuric acid, or, if not disinfected, it may be stored where no cattle can come in contact with it until after December 1.

(*b*) Wash the cars and the feeding and watering troughs with water until clean.

(*c*) Saturate the walls and floors of the cars and the fencing, troughs, and chutes of the pens with a solution made by dissolving 4 ounces of chloride of lime to each gallon of water, or disinfect the cars with a jet of steam under a pressure of not less than 50 pounds to the square inch.

The losses resulting yearly to the owners of northern cattle by the contraction of this disease from contact with southern cattle and through infected cars, and by means of the manure carried in unclean cars from place to place, have become a matter of grave and serious concern to the cattle industry of the United States. It is necessary, therefore, that this cattle industry should be protected as far as possible by the adoption of methods of disinfection in order to prevent the dissemination of this disease.

A rigid compliance with the above regulations will insure comparative safety to northern cattle and render it unnecessary to adopt a more stringent regulation, such as the absolute prohibition of the movement of southern cattle except for slaughter during the time of year that this disease is fatal.

Inspectors will be instructed to see that disinfection is properly done, and it is hoped that transportation companies will promptly put in operation the above methods.

Very respectfully,

J. M. RUSK,
Secretary.

It has been found that the regulation requiring a placard to be placed upon the car in which southern cattle are shipped is of little practical benefit, as shippers and others remove these marks in so many instances that this method of distinguishing infected cars cannot be relied upon. Railroad companies have, however, in nearly all cases, stamped their waybills in accordance with the regulations and this has proved sufficient for the identification of cars and cattle.

It will be noticed that the regulations thus far made have not extended east of the Mississippi River. There is no doubt, however, that the Gulf and south Atlantic States are infected with this disease to the same degree as Texas, and there should be the same regulation of cattle coming from them. The traffic has been so light and the difficulties of regulating it have been such that up to the present the attempt has not been made. Before the disease can be entirely prevented it will be necessary that the line of infection shall be drawn to the Atlantic seaboard and that the same rules be enforced east of the Mississippi as were enforced west of it during the last two years. This will prevent the infection of a number of stock yards that during the present year have been centers from which the dissemination of the disease has taken place with cattle bought both for home and for export markets.

On the whole the effect of these regulations has been extremely beneficial. As compared with former years but a small amount of the disease has been reported either in the United States or among cattle shipped abroad. The losses during the ocean voyage have been so much less than usual that insurance is said by shippers to have been reduced over 50 per cent. If this statement is correct it means a saving of over a million dollars to our shippers by this reduction of insurance alone.

Since the danger of shipping export cattle infected with pleuro-pneumonia has been removed a number of English writers have expressed great fear of the permanent introduction of Texas fever into Great Britain by cattle from the United States. This fear certainly must be groundless and one that could arise only through ignorance of the characters of the disease. In the first place, cattle that are sick from this disease do not transmit it to other animals, and consequently affected animals which are landed on the other side may be left out of consideration as carriers of the infection. In the second place, cattle which are shipped by cars or boat lose the infection in about three weeks after leaving their native pastures. If, therefore, the time should come when Texas cattle shall be exported to Great Britain, there would be little danger from them, as it would require fully three weeks, if not longer, to transport them. In the third place, this disease never occurs in our Northern States until the middle of summer after there has been a protracted period of intense heat, the temperature of our spring and early summer being generally insufficient to develop the disease. The summer temperature in Great Britain is probably neither high enough nor is the high temperature continued a sufficient time to allow the development of this fever.

Leaving these facts out of consideration, we should be able to prevent the exportation of any cattle that are infected, or any that are capable of disseminating the infection, by properly enforced regulations which will prevent the mingling of southern and northern cattle in our cars and stock yards. The disease is one of the easiest to prevent of any which affects our domesticated animals, and for that reason we should be able to guard against all danger from it either to our own cattle or those of other countries to which our animals are sent.

The success of the regulations during the past two years has been all that was anticipated. It has not been found difficult to identify cattle from south of the line of infection in Texas by their brands, and railroad companies have, as a rule, been prompt to clean and disinfect their cars. The principal stock-yard companies have also furnished separate pens, which have been maintained with great regard to cleanliness and the proper handling of cattle, and from every point of view it has been demonstrated that the prevention of this disease is practicable without any hardship to those engaged in the cattle traffic. Indeed, it is now asserted that southern cattle bring better prices when sold from the quarantine yards than when indiscriminately mixed with other stock, and for this reason many lots of cattle from just north of the line are sent by choice of the owners to the quarantine yards for sale.

INSPECTION OF AMERICAN CATTLE IN GREAT BRITAIN.

The rapid progress and practically complete success of the work for the eradication of contagious pleuro-pneumonia from the United States removes the cause alleged by foreign governments for the exclusion of American cattle from their countries.

Great Britain for a number of years has maintained an absolute prohibition against the introduction of American cattle into that country, and only permits their reception at the foreign animal wharves, where they are to be slaughtered within ten days after their arrival.

The several governments of the continent of Europe have also enforced a quarantine of from two to four weeks on all American cattle, which has almost entirely prevented shipments from this country.

For a number of years the British authorities have reported the arrival at their ports of American cattle affected with contagious pleuro-pneumonia, and it became, therefore, absolutely necessary that this Bureau should be represented by its own officials at the *post-mortem* examinations made on American cattle at the foreign animal wharves in order that we should determine, to our own satisfaction, whether the lung disease found there was, as they claimed, contagious; and if it were found to be contagious, the affected animal should be traced back to the farm in this country from whence it came. With this object in view the aid of the State Department was solicited in opening negotiations through Minister Lincoln with the British Government looking to such an arrangement. Through the active coöperation of the State Department and the intelligent efforts of Minister Lincoln the privilege was obtained from the British Government of stationing three veterinary inspectors, one at each of the principal animal wharves where American cattle are slaughtered, and who would be allowed every facility in participating with the local officers in the work of inspecting and making *post-mortem* examination on American cattle landed in British ports. As soon as this privilege was secured three competent veterinary officers of the Bureau were dispatched to Great Britain in charge of the Chief of the Bureau of Animal Industry, who remained with them until their duties were clearly defined and the best means decided upon to enable them to carry on their work effectually and in harmony with the British authorities.

This work was commenced on August 16 of the present year, and from that date to November 8, inclusive, there were inspected and *post-mortem* examinations made on 104,296 head of cattle arriving in Great Britain from the United States at the several ports, as follows:

London	43,488
Liverpool	50,342
Glasgow	10,466

No indications of contagious pleuro-pneumonia were found in any of these animals, and on account of the eradication of the disease in this country it is believed that none will be found in the future.

INSPECTION OF EXPORT CATTLE BEFORE SHIPMENT.

The act of August 30, 1890, providing for the inspection of all export cattle, sheep, and swine, has enabled this Bureau to introduce a system of tagging export cattle by means of which it will be possible to determine the section of the country from which any animal has come that may be found at a foreign port affected with any disease. This act also prevents the exportation of any diseased animals. The amount of work required to carry out this inspection may be comprehended by the fact that during the year ending June 30, 1890, the number of animals exported was as follows:

Cattle	394,836
Hogs	91,148
Sheep	67,521

The following rules and regulations under the tenth section of the above named act were prescribed by the Secretary of Agriculture on October 20, 1890:

Order and Regulations for the Inspection of Cattle and Sheep for Export.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., October 20, 1890.

The following order and regulations are hereby made for the inspection of neat cattle and sheep for export from the United States to Great Britain and Ireland and the continent of Europe by virtue of the authority conferred upon me by section

10 of the act of Congress approved August 30, 1890, entitled "An act providing for the inspection of meats for exportation, prohibiting the importation of adulterated articles of food or drink, and authorizing the President to make proclamation in certain cases, and for other purposes:"

(1) The Chief of the Bureau of Animal Industry is hereby directed to cause careful veterinary inspection to be made of all neat cattle and sheep to be exported from the United States to Great Britain and Ireland and the continent of Europe.

(2) This inspection will be made at any of the following named stock yards: Kansas City, Missouri; Chicago, Illinois; Buffalo, New York; Pittsburgh, Pennsylvania; and at the following ports of export, viz: Boston and Charlestown, Massachusetts; New York, New York; Philadelphia, Pennsylvania; Baltimore, Maryland, and Norfolk and Newport News, Virginia. All cattle shipped from any of the aforesaid yards must be tagged before being shipped to the ports of export. Cattle arriving at ports of export from other parts of the United States will be tagged at said ports.

(3) After inspection at the aforesaid stock yards all cattle found free of disease and shown not to have been exposed to the contagion of any contagious disease will be tagged under the direction of the veterinary inspector in charge of the yards. After tagging the cattle will be loaded into cleaned and disinfected cars and shipped through from said yards in said cars to the port of export.

(4) All animals will be reinspected at the port of export. All railroad companies will be required to furnish for the transportation of cattle and sheep for export clean and disinfected cars, and the various stock yards located at the ports of export shall keep separate clean and disinfected yards for the reception of export animals only.

(5) Shippers will notify the veterinary inspector in charge of yards of intended shipments of cattle, and will give to the said inspector when possible the name of the locality from which said animals have been brought and the name of the feeder of said animals, and such further and other information as may be practicable for proper identification of the place from which said animals have come.

(6) The inspector, after passing said cattle and tagging the same, will notify the veterinary inspector in charge of the port of export of the inspection of said animals, giving him the tag numbers and the number and designation of the cars in which said animals are shipped.

(7) Export animals, whenever possible, shall be unloaded at the port of export from the cars in which they have been transported directly at the wharves from which they are to be shipped. They shall not be unnecessarily passed over any highway or removed to cars or boats which are used for conveying other animals. Boats transporting said animals to the ocean steamer must be first cleansed and disinfected under the supervision of the veterinary inspector of the port, and the ocean steamer must before receiving said animals be thoroughly cleaned or disinfected in accordance with the directions of said inspector. When passage upon or across the public highway is unavoidable in the transportation of animals from the cars to the boat it must be under such careful supervision and restrictions as the veterinary inspector may in special cases direct.

(8) Any cattle or sheep that are offered for shipment to Great Britain or Ireland or the continent of Europe, which have not been inspected and transported in accordance with this order and regulations, will not be allowed to be placed upon any vessel for exportation, as they will be deemed under the law to have been exposed to infection so as to be dangerous to other animals.

(9) The supervision of the movement of cattle from cars and yards to the ocean steamer at the ports of export will be in charge of the veterinary inspector of the port. No ocean steamer will be allowed to receive more cattle or sheep than it can comfortably carry. Overcrowding will not be permitted.

(10) The veterinary inspector at the port of export will notify the collector of the port of the various shipments of cattle or sheep that are entitled to clearance papers, and certificates of the inspection of said animals will be given to the consignors for transmission with the bills of lading.

J. M. RUSK,
Secretary.

This work was inaugurated at the various ports of export named in the regulations on or about the 17th of November, and from that date up to the 28th of said month there have been inspected and tagged 12,055 head of export cattle from the different ports, as follows:

Boston	3,703
New York	3,893
Philadelphia	518
Baltimore	2,559
Newport News	1,197
West Point, Va	185

The work of inspecting and tagging at the interior stock yards named in the regulations commenced on or about the 1st day of December, and the entire system as adopted is now in full running order.

INSPECTION AND QUARANTINE OF IMPORTED ANIMALS.

Regulations for the quarantine of neat cattle from the countries not located on the American continent continue to be enforced. The period of quarantine—three months—is regarded as amply sufficient under the regulations to prevent the introduction of disease, and no additional restrictions have been imposed, notwithstanding the fact of the restrictions imposed by Great Britain on cattle from this country and the additional fact that pleuro-pneumonia is much more prevalent and widely spread in Great Britain than it ever was in the United States.

There has long been danger of the introduction of foot-and-mouth disease by the importation of sheep, swine, and other susceptible animals that have heretofore been allowed to land without either quarantine or inspection; indeed this disease has several times been brought to this country by cattle from Great Britain, but it has fortunately been detected in time to prevent its dissemination here. Notwithstanding this fact our sheep have been excluded from Great Britain for more than ten years owing to the alleged existence of this disease in the United States, where it has never been seen except when brought by British cattle that were affected before landing.

In order to avoid any danger of the introduction of this disease from foreign countries into the United States the Secretary of Agriculture, under the provisions of the act of August 30, 1890, prescribed on October 13, 1890, the following regulations for quarantine and inspection of all neat cattle, sheep and other ruminants, and all swine imported into the United States:

Regulations for the Inspection and Quarantine of Neat Cattle, Sheep and other Ruminants, and Swine, Imported into the United States.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., October 13, 1890.

In pursuance of sections 7, 8, and 10 of an act of Congress entitled "An act providing for the inspection of meats for exportation and prohibiting the importation of adulterated articles of food or drink, and authorizing the President to make proclamation in certain cases, and for other purposes," approved August 30, 1890, the following regulations are hereby prescribed for the inspection and quarantine of neat cattle, sheep and other ruminants, and swine, imported into the United States:

(1) With the approval of the Secretary of the Treasury the following named ports are hereby designated as quarantine stations, and all cattle, sheep and other ruminants, and swine imported into the United States must be entered through said ports, viz., on the Atlantic seaboard, the ports of Boston, New York, and Baltimore; on the Pacific seaboard, San Diego; along the boundary between the United States and Mexico, Brownsville, Paso Del Norte, Eagle Pass, Loredo, and Nogales;

and along the border or boundary line between the United States and British Columbia and Canada, through the custom ports in the collection districts of Aroostook and Bangor, Maine; Vermont, Vermont; Buffalo Creek, Niagara, Cape Vincent, Champlain, and Oswegatchie, New York; Detroit, Port Huron, and Superior, Michigan; Minnesota and Duluth, Minnesota; and Puget Sound, Washington.

(2) The word "animals," when used in these regulations, refers to and includes all or any of the following kinds: Neat cattle, sheep and other ruminants, and swine. The words "contagious diseases," when used in these regulations, includes and applies to all or any of the following diseases: Anthrax in cattle, sheep, goats, or swine; contagious pleuro-pneumonia in cattle; tuberculosis in cattle; foot-and-mouth disease in cattle, sheep, goats, and swine; rinderpest in cattle and sheep; sheep pox, foot rot, and scab in sheep; hog cholera and swine plague in swine.

(3) All cattle, sheep and other ruminants imported into the United States from any part of the world except North and South America shall be accompanied with a certificate from the local authority of the district in which said animals have been for one year next preceding the date of shipment, stating that no contagious pleuro-pneumonia, foot-and-mouth disease, or rinderpest has existed in said district for the past year. And all swine imported into the United States from any part of the world except North, Central, and South America shall be accompanied with a similar certificate relating to the existence of foot-and-mouth disease. All such animals shall also be accompanied with an affidavit by the owner from whom the importer has purchased them stating that said animals have been in the district where purchased for one year next preceding the date of sale, and that neither of the above mentioned diseases have existed among them, or among any animals of the kind with which they have come in contact, for one year last past, and that no inoculation has been practiced among said animals for the past two years. Also by an affidavit from the importer or his agent supervising the shipment stating that the animals have been shipped in clean and disinfected cars and vessels direct from the farm where purchased; that they have not passed through any district infected with contagious diseases affecting said kind of animals, and that they have not been exposed in any possible manner to the contagion of any of said contagious diseases.

(4) The foregoing certificate and affidavits must accompany said animals and be presented to the collector of customs at the ports of entry and by him be delivered to the inspector of the Bureau of Animal Industry stationed at said port to allow them to be imported into the United States.

(5) All neat cattle imported into the United States from any part of the world except North, Central, and South America shall be subject to a quarantine of ninety days, counting from date of arrival at the quarantine station. All sheep and other ruminants and swine from any part of the world except North, Central, and South America shall be subject to a quarantine of fifteen days, counting from date of arrival at the quarantine station.

(6) Any person contemplating the importation of animals from any part of the world except North, Central, and South America must first obtain from the Secretary of Agriculture two permits, one stating the number and kind of animals to be imported, the port and probable date of shipment, which will entitle them to clearance papers on presentation to the American consul at said port of shipment; the other, stating the port at which said animals are to be landed and quarantined, and the approximate date of their arrival, and this will assure the reception of the number and kind specified therein at the port and quarantine station named at the date prescribed for their arrival, or at any time during three weeks immediately following, after which the permit will be void. These permits shall in no case be available at any port other than the one mentioned therein. Permits must be in the name of the owner of or agent for any one lot of animals. When more persons than one own a lot of animals for which permits have been issued a release from quarantine will be given each owner for the number and kind he may own, and this release will be a certificate of fulfillment of quarantine regulations. Permits will be issued to quarantine at such ports as the importer may elect, so far as facilities exist at such port, but in no case will permits for importation at any port be granted in excess of the accommodations of the Government quarantine station at such port. Every importer shall, on the day of the shipment from a foreign port, telegraph to the Chief of the Bureau of Animal Industry the number and kind of animals shipped, the vessel on which they are shipped, and the port at which they are to be landed. United States consuls at foreign ports are hereby notified to give clearance papers or certificates for importation of animals only upon presentation of permits as above provided, with dates of probable arrival and destination corresponding with said permits, and in no case for a number in excess of that mentioned therein.

(7) All animals imported into the United States shall be carefully inspected by a veterinary inspector of the Bureau of Animal Industry, and all animals found to be free from disease and not to have been exposed to any contagious disease, except as provided in regulation 5, shall be admitted into the United States. Whenever any animal is found to be affected with a contagious disease, or to have been exposed to such disease, said animal, and all animals that have been in contact or exposed to said animal, will be placed in quarantine, and the inspector quarantining the same shall report at once to the Chief of the Bureau of Animal Industry, who will direct whether or not said animals quarantined shall be appraised and slaughtered, as provided by section 8, of the act under which these regulations are made. All animals quarantined by reason of disease or exposure to disease shall not be admitted to the established quarantine grounds, but shall be quarantined elsewhere, at the expense of the importer, or be dealt with in such manner as the Chief of the Bureau of Animal Industry shall determine.

(8) In case of imported animals proving to be infected, or to have been exposed to infection, such portions of the cargo of the vessel on which they have arrived as have been exposed to these animals or their emanations shall be subjected, under the direction of the inspector of the Bureau of Animal Industry, to disinfection in such manner as may be considered by said inspector necessary before it can be landed.

(9) No litter, fodder, or other aliment, nor any ropes, straps, chains, girths, blankets, poles, buckets, or other things used for or about the animals, and no manure shall be landed excepting under such regulations as the veterinary inspector shall provide.

(10) On moving animals from the ocean steamer to the quarantine grounds they shall not be unnecessarily passed over any highway, but must be placed on cars at the wharves or removed to the cars on a boat which is not used for conveying other animals. If such boat has carried animals within three months it must be first cleaned and then disinfected under the supervision of the inspector, and after the conveyance of the imported animals the boat must be disinfected in the same manner before it may be again used for the conveyance of animals. When passage upon or across the public highway is unavoidable in the transportation of animals from the place of landing to the quarantine grounds it must be under such careful supervision and restrictions as the veterinary inspector may, in special cases, direct.

(11) The banks and chutes used for loading and unloading imported animals shall be reserved for such cattle, or shall be cleansed and disinfected as above before being used for such imported cattle.

(12) The railway cars used in the transportation of animals to the quarantine grounds shall either be cars reserved for this exclusive use, or box cars not otherwise employed in the transportation of animals or their fresh products, and after each journey with animals to the quarantine grounds they shall be disinfected by thorough cleansing and disinfection under the direction of the veterinary inspector.

(13) While animals are arriving at the quarantine stations, or leaving them, all quarantined stock in the yards adjoining the alleyways through which they must pass shall be rigidly confined to their sheds. Animals arriving by the same ship may be quarantined together in one yard and shed, but those coming on different ships shall in all cases be placed in separate yards.

(14) The gates of all yards of quarantine stations shall be kept locked, except when cattle are entering or leaving quarantine.

(15) The attendants on animals in particular yards are forbidden to enter other yards and buildings, except such are occupied by stock of the same shipment with those under their special care. No dogs, cats, or other animals except those necessarily present shall be allowed in the quarantine grounds.

(16) The allotment of yards shall be under the direction of the veterinary inspector of the port, who shall keep a register of the animals entered, with description, name of owner, name of vessel in which imported, date of arrival and release, and other important particulars.

(17) The veterinary inspector shall see that water is regularly furnished to the stock and the manure removed daily, and that the prescribed rules of the station are enforced.

(18) Food and attendance must be provided by the owners of the stock quarantined. Employés of such owners shall keep the sheds and yards clean to the satisfaction of the veterinary inspector.

(19) "Smoking" is strictly forbidden within any quarantine inclosure.

(20) No visitor shall be admitted to the quarantine station without special written permission from the veterinary inspector. Butchers, cattle dealers, and their employés are especially excluded.

(21) No public sale shall be allowed within the quarantine grounds.

(22) The inspector shall, in his daily rounds, as far as possible, take the temperature of each animal, commencing with the herds that have been longest in quarantine and ending with the most recent arrivals, and shall record such temperatures on lists kept for the purpose. In passing from one herd to another he shall invariably wash his thermometer and hands in a weak solution (1 to 100) of carbolic acid.

(23) In case of the appearance of any disease that is diagnosed to be of a contagious nature the veterinary inspector shall notify the Chief of the Bureau of Animal Industry, who shall visit the station personally or send a veterinary inspector, and on the confirmation of the diagnosis the herd shall be disposed of according to the gravity of the affection.

(24) The yard and shed in which such disease shall have appeared shall be subject to a thorough disinfection. Litter and fodder shall be burned. Sheds, utensils, and other appliances shall be disinfected as the veterinary inspector may direct. The yards, fence, and manure box shall be freely sprinkled with a strong solution of chloride of lime. The flooring of the shed shall be lifted and the whole shall be left open to the air and unoccupied for three months.

(25) In the case of the appearance of any contagious disease the infected herd shall be rigidly confined to its shed, where disinfectants shall be freely used, and the attendants shall be forbidden all intercourse with the attendants in other yards, and with persons outside the quarantine grounds.

J. M. RUSK,
Secretary.

[The designation of the ports, named in the foregoing regulations as quarantine stations, was approved by the Secretary of the Treasury on the 16th day of October, 1890, as provided by section 8 of the act of Congress approved August 30, 1890, providing for inspection of meats and animals.]

It is believed that these regulations will not only protect our herds and flocks, but in view of the assurances to that effect received from the British authorities it will probably result in the revocation by the British Government of its regulation excluding American sheep from Great Britain.

The inspection and quarantine of all cattle, sheep, and swine imported into the United States will add largely to the work of this Bureau. During the twelve months ending June 30, 1890, cattle were imported to the number of 30,695 head and sheep to the number of 393,794. The figures of the Treasury Department fail to give the number of swine imported.

The increased duties levied under the present law may greatly diminish the number of animals imported into this country, although during the year just past 3,935 head of cattle and 16,303 head of sheep were admitted duty free on the ground that they were imported for breeding purposes.

INSPECTION OF SALTED MEATS FOR EXPORT.

The act of August 30, 1890, provides "that the Secretary of Agriculture may cause to be made a careful inspection of salted pork and bacon intended for exportation, with a view to determining whether the same is wholesome, sound, and fit for human food, whenever the laws, regulations, or orders of the government of any foreign country to which such pork or bacon is to be exported shall require inspection thereof relating to the importation thereof into such country, and also whenever any buyer, seller, or exporter of such meats intended for exportation shall request the inspection thereof."

This inspection has been assigned to the Bureau of Animal Industry and all arrangements have been made to carry the law into effect. It is too early at this writing to estimate the quantity of meat that the Department will be called upon to inspect under this law, but should the prohibition now enforced by certain continental governments be removed so far as regards inspected meats, as there is now reason to hope, there is no doubt but that the amount will be very large. The regulations adopted for this inspection are as follows:

Regulations for the Inspection of Salted Pork and Bacon for Export.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., September 12, 1890.

By virtue of the authority conferred upon the Department of Agriculture by section 1 of an act entitled "An act providing for the inspection of meats for exportation, prohibiting the importation of adulterated articles of food or drink, and authorizing the President to make proclamation in certain cases, and for other purposes," approved August 30, 1890, the following regulations for the inspection of salted pork or bacon for export, and the marks, stamps, or other devices for the identification of the same, are hereby prescribed:

(1) Whenever any foreign country, by its laws, regulations, or orders, requires the inspection of salted pork or bacon imported into such country from the United States, all packers or exporters desiring to export to said country shall make application to the Secretary of Agriculture for such inspection; also, whenever any buyer, seller, or exporter of such meats intended for exportation shall desire inspection thereof, he shall likewise make application to the Secretary of Agriculture for such inspection.

(2) The application must be in writing, and shall give the name of the packer of such meats, and, if the packer be the exporter, the probable amount of such meats to be exported per week or month for which inspection is requested; the name of the country, or countries, to which such meats are to be exported; the place at which inspection is desired and the date for such inspection. The applicant shall likewise agree to abide by these regulations, and to mark his packages as hereinafter provided.

(3) Every package containing salted pork or bacon which has been inspected must be branded or stenciled both on the side and on the top by the packer or exporter, as follows:

FOR EXPORT.

(*a*) (Here give the name of the packer.)
(*b*) (Here the location and State of the factory where packed.)
(*c*) (Here give the net weight of the salted pork or bacon contained in the package.)
(*d*) (If exported by other than packer, the name of the exporter.)
(*e*) (Name of consignee and point of destination.)

The letters and figures in the above brand shall be of the following dimensions: The letters in the words "for export" shall not be less than three-fourths of an inch in length and all the other letters and figures not less than one-half an inch in length. All letters and figures affixed to the top and sides shall be legible and shall be in such proportion and of such color as the meat inspector of the Department of Agriculture may designate.

(4) The meat inspector of the Department of Agriculture, having, after inspection, satisfied himself that the articles inspected are wholesome, sound, and fit for human food, shall affix to the top of said package a meat inspection stamp, to be furnished by the Department of Agriculture, said stamps bearing serial numbers, and the inspector will write on said stamp the date of inspection. The stamp must be securely affixed by paste and tacks, in such a way as to be easily read when the package is standing on its bottom. Not less than five tacks shall be driven through each stamp, one at each corner and one in the middle.

The stamp having been affixed it must be immediately canceled. For this purpose the inspector will use a stencil plate of brass or copper, in which will be cut five parallel waved lines long enough to extend beyond each side of the stamp on the wood of the package. At the top of said stencil will be cut the name of the inspector, and at the bottom of said stencil will be cut the district in which inspection is made. The imprinting from this plate must be with blacking or other durable material, over and across the stamp, and in such manner as not to deface the reading matter on the stamp; that is, so as not to daub and make it illegible.

The stamp having been affixed and canceled, it must immediately be covered with a coating of transparent varnish or other substance. Orders for stamps must be made by the inspector on the Chief of the Bureau of Animal Industry. The inspector having inspected and found wholesome the contents of said package and affixed the stamp thereon, will issue to the packer or exporter a certificate of inspection, reciting the time and place of inspection, the name of the packer, the name of the exporter, and the name of the consignee and country to which exported. He will also place on said certificate the number of the package. One certificate only will be issued for each consignment and must designate the stamp numbers of all the packages contained in said consignment.

(5) The inspector will enter in the stub of his stamp book the information given by the packer's brand on the package inspected, and will report daily on blank form (*m. i.* 1) the number of stamps issued on each date and all the information required by said blank.

(6) The certificates of inspection will be furnished by the Department of Agriculture and be issued in serial numbers and in triplicate form. The inspector will deliver one copy of said certificate to the consignor or shipper of such meat inspected, one copy he will attach to the invoice or shipping bill of such meat, and the third copy he will forward to the Chief of the Bureau of Animal Industry of the Department of Agriculture for filing therein. He will likewise make a daily report on blank form (*m. i.* 2) of all certificates issued on that date, and fill out said blank with all the information required thereon.

(7) Whenever the inspection of any salted pork or bacon is requested by an exporter or shipper at any other place than where packed, the packages containing such meats are to be opened and closed at the expense of the exporter, and said packages must be branded or stenciled in the same manner and contain the same information as prescribed in the case of inspection for a packer.

J. M. RUSK,
Secretary.

The new duties connected with this inspection of animals and meats, which have been assigned to this Bureau during the last year, will be seen by the above statement to be numerous and responsible. They involve a greatly increased amount of work, but their fulfillment will undoubtedly be of enormous benefit to the country, as they will insure the protection of our live stock from imported diseases and furnish a guaranty to foreign buyers that our meats are wholesome and that our export animals are free from the contamination of any communicable malady.

INVESTIGATION OF REPORTED DISEASES.

During the year the Bureau has been requested to investigate many cases of diseases supposed to be of a contagious nature, including a considerable number of cases of disease supposed by the owners of the animals to be contagious pleuro-pneumonia or foot-and-mouth disease. Careful investigation in every case showed that these suppositions were incorrect and that the affection was either an ordinary sporadic disease, or that it was tuberculosis or some other equally common disorder. There have been no cases of pleuro-pneumonia found except in a small district on Long Island and an equally small district in New Jersey, which has long been infected, but from which the contagion is now nearly or quite eradicated.

There have been several reports of foot-and-mouth disease in the interior of the country from persons who had never seen the European disease known by this name. Investigations have, however, shown in every case that the diagnosis was not justified by the facts, and that the actual disease was of a sporadic nature and not contagious. There has been no real foot-and-mouth disease in the United States since March, 1884, when it was introduced into the Portland quarantine station by cattle from Great Britain. The contagion in this case was disseminated to a small extent outside the quarantine station, but it was immediately recognized and eradicated by prompt measures. With the three months' quarantine to which all bovine animals are subject, and the inspection of all other animals coming into the country, it is next to impossible to introduce foot-and-mouth disease without its being immediately recognized, and it would certainly be impossible for it to reach the interior of the United States without being discovered by the inspectors of the Department of Agriculture.

A recent circular issued by the State veterinarian of the State of Missouri, which was headed, "Foot-and-mouth disease," and which gave a somewhat detailed description of the symptoms of a disease which the State veterinarian thought might be the European foot-and-mouth disease, has excited considerable comment abroad and has been considered by some veterinary authorities as a demonstration of the existence of that disease; but careful investigation made by one of the inspectors of the Bureau demonstrated that the disease was not of a contagious nature, and that it had little, if any, resemblance to the foot-and-mouth disease of Europe. There had been no cattle or other animals taken to Missouri which had been imported from any country where foot-and-mouth disease exists, consequently there was no explanation of the appearance of a foreign contagion in that part of the country. Again, but one or two animals in a herd of twenty or thirty were affected, while with foot-and-mouth disease not one in a herd of that size would escape. In most cases there was little fever, the sores in the mouth were not of the nature of vesicles, and it is doubtful if any affected animals had any lesions about the feet which were the result of the disease. So small a proportion showed signs of lameness that this probably resulted in those animals from accidental causes.

There should be no difficulty in diagnosing at once such a disease as this as distinct from the foot-and-mouth disease of Europe. The foot-and-mouth disease could not originate spontaneously. It must have a point of origin by contagion which would connect the disease with the same malady in some other section of the world; again, foot-and-mouth disease is extremely contagious, being rapidly and unmistakably transmitted from animal to animal and from herd to herd. It attacks every animal in a herd, and not one animal in one hundred or even in a thousand exposed to the contagion escapes the disease, while the vesicles are prominent and unmistakable both in the mouth and about the feet. The increase in temperature and the fever are too marked to be overlooked. A disease with these characteristics has never existed in the interior of the United States. Rumors of such disease have been frequent, but they are started by people who are ignorant of the character of such diseases and who have had their imaginations excited by reading the accounts of these diseases in other countries.

Indeed, the reports are generally made in such a way as to show that the description of the disease is taken from some publication on the subject and not from the disease itself. This is the only possible explanation of the resemblance of the symptoms given in such reports to those observed in the disease suspected, for, when the disease itself is examined, such characters as they mention can not be found.

The report of the Bureau inspector, the main points of which were concurred in by the State veterinarian after a careful investigation, should be sufficient to remove any fears of the existence of this disease in the United States. Indeed the report of the existence of this disease would have attracted little attention had it not been for the great interests at stake and the evident desire of parties in other countries to find a pretext to sustain the restrictions and prohibitions now in force against the introduction of American cattle. These parties have always been ready to give credence to the wildest rumors and to put the worst construction upon any report in regard to disease in this country. The order that all American sheep and swine should be slaughtered on the English docks on account of foot-and-mouth disease, which has been enforced for the last ten years, and the unhesitating acceptance of the recent rumors of the same disease are sufficient evidence of the correctness of this statement. The United States Department of Agriculture now has a large and capable force of veterinary inspectors, whose whole time is devoted to the investigation of diseases, and the official reports of this Department are worthy of the same respect and credence as the government reports of any of the countries of Europe. Usually when a government makes an investigation of a rumored disease its report is believed without question. The numerous attempts which have been made to discredit the conclusion of this Department after the investigation of the disease in Missouri, without giving any adequate reason for not accepting it, show that these parties are influenced in regard to American questions by motives which do not apply to the same subjects when affecting other countries.

SCIENTIFIC INVESTIGATIONS.

The original scientific research of the year has been mostly confined to southern or Texas cattle fever and to the infectious diseases of swine. With both very important results have been obtained from the scientific as well as the practical point of view.

SOUTHERN OR TEXAS FEVER OF CATTLE.

The discovery of a germ in the red corpuscles of the blood in this disease—a germ entirely distinct from bacteria but belonging to the protozoa—was mentioned in the report of last year. This notable discovery was abundantly confirmed by the investigations of the year just past, and an additional point in the problem has been brought to light.

It has long been suspected by cattle owners that the appearance of the disease in northern cattle was in some way connected with the ticks distributed by southern cattle. This hypothesis has, however, been generally discredited by scientific men, and indeed the evidence in favor of it was very slight and intangible. It seemed, however, worthy of investigation, and the result has been to obtain indisputable evidence that the disease is produced by ticks from southern cattle.

Ticks taken from southern animals and placed upon pastures which could have been infected in no other way, so infected these grounds that susceptible cattle placed upon them contracted the disease in the same length of time and were as seriously affected as were other susceptible cattle placed upon pastures in company with southern cattle. Again, young ticks that were hatched from the eggs of large ticks picked from southern cattle were placed upon susceptible animals and produced the disease.

There are, consequently, two factors in the production of southern fever—first, the tick, and secondly, the protozoal microörganism which lives in and destroys the red blood corpuscles of the affected cattle. Where the tick obtains the protozoön is not yet known, but that the microörganism can be transmitted from one generation of ticks to another through the egg is demonstrated. It is important to learn through how many generations of ticks the germ can be transmitted without losing its virulence and whether there is any other means by which it gains access to the system of cattle in addition to being introduced by the punctures made by ticks.

There are evidently ticks which do not harbor this minute parasite, because cattle susceptible to southern fever are frequently badly infested with ticks without showing any marked symptoms of disturbed health. On the other hand there may be means by which the protozoön gains access to the blood of cattle independently of the agency of ticks; but it appears from the investigations just made that in the great majority of cases cattle are infected by means of ticks. That is, the adult ticks drop from southern cattle and lay their eggs upon the pastures. The eggs hatch and the young ticks get upon susceptible cattle and produce the disease.

If this supposition is correct it is of great practical importance. In the first place, susceptible cattle taken to the South for breeding purposes could be protected from the fever by keeping them in such a manner that they would not become infested by ticks. That is, they could be kept in stables not previously occupied by other cattle, bedded with clean straw and fed upon hay or grass cut from fields where no cattle had been for a considerable time. In the second place, it would seem that southern cattle might be rendered innocuous by washing them with some preparation that would destroy the ticks, or by holding them upon uninfected ground a sufficient time for the ticks which are upon them to mature and drop to the ground, but not long enough upon any one pasture for the young ticks to hatch and reinfect them.

The probability of reaching important practical results is such that these investigations should be continued until the subject is thoroughly understood.

SWINE DISEASES.

The investigations of swine diseases have been carried on with the idea of determining (1) the relative prevalence of hog cholera and swine plague, (2) the value of protective inoculation by various processes as a preventive of hog cholera, and (3) to test the practicability of preventing those diseases by the use of the ptomaines or bacterial products developed by growing the germs in proper culture media.

These researches have shown that swine plague is relatively more prevalent than was first anticipated and that it is probably the cause of as much mortality as is hog cholera. They also confirm our conclusion of last year that inoculation is not a practical or reliable method of preventing hog cholera.

The investigations of the bacterial products have been very interesting, at least from a scientific point of view and as regards their application to the prevention of human diseases. This interest is increased at the present time by the announcement of the celebrated German investigator, Professor Koch, that he has discovered a remedy for tuberculosis. This remedy is now believed to be a product of the growth of the bacillus of tuberculosis in appropriate culture material.

It should not be forgotten that the possibility of applying these bacterial products to the prevention and cure of diseases was first made evident by the investigations of the Bureau of Animal Industry, and that if Professor Koch's remedy is of the nature supposed his method consists in the application of a principle discovered here.

Our recent work in this line has been to separate the substance which has this preventive power from the many other chemical principles present in the culture liquids, and to study its nature and properties. This chemical work was placed in the hands of Dr. von Schweinitz with general directions as to the character of the investigations, in the spring of 1890, and since that time the products of the hog-cholera germ have been studied quite thoroughly and their remarkable power in conferring immunity has been confirmed.

Unfortunately these products are very irritating, and in the dose necessary to produce an effect upon the system of the hog they cause an inflammation at the point where injected into the tissues, which is a great objection to their use. They could be given in smaller and more numerous doses, but this increases the expense so much as to make their use impracticable. When administered by way of the stomach their effect is lost.

That this method of preventing disease with other maladies and other species of animals and particularly with mankind is destined to be of much service seems very probable. With this ultimate object in view we have endeavored to produce artificially a drug which would have the same composition and effect as the bacterial products. By such a process we hope to obtain the preventive agent at less expense and without danger of being contaminated with the deadly germs that cause the disease. To a great extent these researches have been successful and we are now able to produce a substance entirely by chemical processes which not only resembles the bacterial product of the hog-cholera germ in composition but which has almost if not quite the same power of conferring immunity from the disease.

By these preliminary studies we have worked out the proper methods of investigation, and it is hoped that by applying them to tuberculosis and other diseases which affect animals of greater value than hogs successful means of prevention may be secured. And if incidentally these methods of prevention can be applied to diseases affecting mankind, their value to the country and to the world will only be increased thereby.

GLANDERS.

The improvement in the District of Columbia in regard to this disease is shown by the number of affected animals discovered in 1890 as compared with those in 1889. The last report of this Bureau gave the number of horses condemned each month up to and including November, 1889. Since then the number condemned monthly has been as follows:

December	0	July	4
January	2	August	1
February	2	September	2
March	0	October	2
April	4	November	0
May	2		
June	4	Total	23

During the twelve preceding months the number condemned was seventy-eight. During the spring of 1890 a very general inspection was made through the city with especial attention to all large stables, and the fact that so few animals were discovered shows that now the District is very nearly free from the disease. It is impossible, of course, to maintain absolute freedom from such a malady, as it is frequently introduced by horses from other parts of the country that are sold in this market.

PUBLICATIONS.

The great need of publications for gratuitous distribution which treat in a systematic and thorough manner of the different subjects connected with the breeding and care of the domestic animals has long been apparent. The field is a large one to cover and can not be properly treated in the works of private firms without making the publications so expensive that they would be beyond the reach of the people who most need them. For this reason the Bureau of Animal Industry has undertaken the preparation of a series of reports on the breeding and management of live stock in health and disease.

These reports are intended for popular use, and while so complete and accurate that they will be useful to the professional man or scientist, their language is to be as plain and free from technicalities and unusual expressions as is consistent with a clear and forcible treatment of the subject. Their purpose is educational, and it is hoped that they will do much to clear away the absurd traditions and practices born of ignorance which still obtain in some parts of the country, and that they will furnish a basis for a progressive and successful management.

Large amounts of money are being expended for improved stock, and unless buyers understand the peculiar characters of the different breeds, the conditions under which they have been formed, the care which is necessary for their existence, and the diseases to which they are subject, they can only meet with indifferent success in breeding them. The best stock is the result of the most intelligent management, care, and selection, and unless this management and selection are continued the stock will deteriorate.

The number of breeders who have succeeded in establishing or improving a breed have been relatively few, and the number who can even maintain all the good qualities of our most improved breeds without continually infusing new blood are not numerous. This shows a lack of knowledge among the great majority of breeders as to the requirements of improved breeds of animals which calls for correction. It is the object of this Bureau to collect this valuable information from the few who do know and distribute it broadcast to the many who ought to know.

The first work of the series treats of the animal parasites of sheep, one of the most important subjects which confronts the sheep breeders. This work has been received with great favor, and the first edition was exhausted within a few months after it was ready for distribution. A second edition was immediately ordered and the applications for copies are still numerous.

The second report of the series is at this writing going through the press, and it will probably be ready for distribution by the 1st of February, 1891. It treats of the diseases and accidents from which horses suffer, and it will be useful to an even larger class than the volume which has preceded it. No labor has been spared either on the text or the illustrations, and we have endeavored to make it compare favorably with the splendid volumes in other and less practical fields of science and research which the various departments of the Government have from time to time issued.

A volume on sheep husbandry and one on trotting and thoroughbred horses will be ready for the press almost as soon as the report just mentioned is out of the way. In addition to these the regular report of the Bureau of Animal Industry for the years 1888 and 1889 is in an advanced stage of preparation and will be sent to the press early in 1891.

CONDITIONS AFFECTING THE PRICE OF HOGS.

The conditions affecting the price of the animals produced upon the farm is one of the most interesting and important studies which can be made for the benefit of the stock grower, and as the chief of the Bureau has recently made an investigation of this subject a brief statement of the facts and conclusions are inserted in this report.

The fluctuations in the price of hogs appear at present to be more easily traced and more subject to principles that can be definitely formulated than the variations in the price of other farm animals, and consequently they have been selected for this preliminary investigation.

The calculations which follow are principally based upon the statistics of the United States Census Bureau, the estimates of the Statistical Division of the Department of Agriculture, the report of the Bureau of Statistics of the Treasury Department, and the annual report of the Cincinnati Price Current. The population for the intermediate years is estimated by the rate of growth for the ten years, taking account each year of the immigration.

The following table shows the population of the United States, the total hog product including lard put on the market by the packing establishments, the quantity which this constitutes per capita of population, the quantity of hog product exported, and the total and per capita quantity remaining for home consumption for each year since 1873:

TABLE 1.

Years.	Population.	Hog products.				
		Total.		Exported—year ending June 30.	Home consumption.	
		Pounds, year ending March 1.	Per capita.		Pounds.	Per capita.
1873	42,125,489	1,654,707,583	39.3	690,063,405	964,644,178	22.9
1874	43,281,338	1,701,314,614	39.3	623,415,255	1,077,899,359	24.9
1875	44,374,463	1,611,038,842	36.3	473,308,273	1,137,730,569	25.6
1876	45,431,938	1,457,743,118	32.1	550,331,129	907,411,989	20.0
1877	46,482,434	1,669,369,043	35.9	764,470,273	904,898,770	19.5
1878	47,550,552	2,045,239,979	43.0	1,007,371,526	1,037,868,453	21.8
1879	48,679,389	2,515,978,153	51.7	1,143,309,938	1,372,668,215	28.2
1880	50,155,783	2,423,535,672	48.3	1,230,702,175	1,192,833,497	23.8
1881	51,473,728	2,643,053,296	51.3	1,233,015,127	1,410,038,169	27.4
1882	52,928,275	2,357,932,478	44.5	798,841,846	1,559,090,632	29.5
1883	54,215,960	2,148,369,223	39.6	627,093,446	1,521,275,777	28.1
1884	55,435,564	2,228,427,478	40.2	715,142,817	1,513,284,661	27.3
1885	56,547,692	2,441,877,868	43.2	755,416,926	1,686,460,942	29.8
1886	57,613,057	2,586,117,826	44.9	800,784,530	1,785,338,296	31.0
1887	58,848,103	2,677,814,968	45.5	827,349,998	1,850,464,970	31.4
1888	60,155,898	2,523,552,000	42.0	732,079,843	1,791,472,157	29.8
1889	61,378,141	2,479,053,000	40.4	782,601,275	1,696,451,725	27.6
1890	62,622,250	3,047,651,000	48.7	1,159,642,885	1,888,008,115	30.1

The quantity of pork products put upon the markets by the packing houses of the East and West is partly estimated, but is so nearly correct that the exact figures could not in any way change the conclusions which are here drawn from the table.

We see by this table the enormous amount of hog product put upon the market in this country, an amount which varies in round numbers from 1,457 million pounds in 1876 to 3,047 million pounds in 1890. No account is taken of the hogs killed and consumed by farmers or sold in villages, towns, and cities, but which are not packed, as there are no definite data from which it can be determined. Although this quantity is large it probably has no great effect upon the price of hogs in the packing centers, since it is the visible supply of hog products, the quantity put into the channels of commerce by the packing establishments, which we would expect to influence prices.

As would be expected there has been a great increase of hog product during the years covered by the table. From 1873 to 1877 the total amount was less than 2,000 million pounds per annum, varying from 1,457 millions in 1876 to 1,701 millions in 1874. From 1878 to 1889 the product was over 2,000 millions each year, varying from 2,045 millions in 1878 to 2,677 millions in 1887, and reaching the enormous aggregate of 3,047 millions in 1890. The quantity which this constitutes per capita of population varies from 32.1 pounds in 1876 to 51.7 pounds in 1879 and is only 48.7 pounds for the great output of 1890.

The quantity of pork products exported reached the highest figures in 1880 and 1881, dropping off in 1882 and subsequently, as a result of the unfavorable restrictions and prohibitions imposed by several foreign governments. Deducting the exports from the total production we find that the quantity left on the domestic market for home consumption has varied from 19.5 pounds in 1877 to 31.4 pounds in 1887 and was 30.1 pounds in 1890.

In order to bring out the effect of demand and supply upon the price the following table has been compiled, which shows in parallel columns the cost of the hogs used for the winter packing in the West, the total hog product per capita, and the domestic supply per capita for the year:

TABLE 2.

Year.	Cost of hogs, winter packing to March 1.	Hog product, per capita.	Domestic supply per capita.	Year.	Cost of hogs, winter packing to March 1.	Hog product per capita.	Domestic supply per capita.
1873	$3.73	39.3	22.9	1882	$6.06	44.5	29.5
1874	4.34	39.3	24.9	1883	6.28	39.6	28.1
1875	6.66	36.3	25.6	1884	5.18	40.2	27.3
1876	7.05	32.1	20.0	1885	4.29	43.2	29.8
1877	5.74	35.9	19.5	1886	3.66	44.9	31.0
1878	3.99	43.0	21.8	1887	4.19	45.5	31.4
1879	2.85	51.7	28.2	1888	5.04	42.0	29.8
1880	4.18	48.3	23.8	1889	4.99	40.4	27.6
1881	4.64	51.3	27.4	1890	3.66	48.7	30.1

This table shows that in a general way the cost of hogs has varied inversely with the total hog product per capita, that is to say, the cost has increased in most cases as the product decreased, and *vice versa*. The variations are not always, however, in this inverse sense, and there is even less correspondence to be found between the fluctuations in cost and the quantity remaining for domestic consumption per capita. It is evident that there is some influence aside from the mere question of supply and demand, which has had an equal or greater effect on the price of hogs. Our investigation indicates that this important factor is the price of corn.

The following table is compiled to show in parallel columns the value on the farms of the corn crop and the cost of hogs for the succeeding winter's packing:

TABLE 3.

Year.	Cost of corn on farms.	Year.	Cost of hogs, winter packing to March 1.
	Cents.		
1872	39.8	1872-'73	$3.73
1873	48.0	1873-'74	4.34
1874	64.7	1874-'75	6.66
1875	42.0	1875-'76	7.05
1876	37.0	1876-'77	5.74
1877	35.8	1877-'78	3.99
1878	31.8	1878-'79	2.85
1879	37.5	1879-'80	4.18
1880	39.6	1880-'81	4.64
1881	63.6	1881-'82	6.06
1882	48.4	1882-'83	6.28
1883	42.0	1883-'84	5.18
1884	35.7	1884-'85	4.29
1885	32.8	1885-'86	3.66
1886	36.6	1886-'87	4.19
1887	44.4	1887-'88	5.04
1888	34.1	1888-'89	4.99
1889	28.3	1889-'90	3.66

The above table shows that the fluctuations in the price of corn and of hogs correspond so closely as to be really surprising. The only discrepancies are in accordance with what appears to be a general rule that there is a tendency, after corn has been high, for the price of hogs to be sustained or even to advance for one year after corn has declined.

These facts are best shown by the accompanying diagrams. The domestic supply of hog product per capita, that is, the total hog product put on the market by the packing houses less the quantity exported, is compared in Diagram A with the price paid by packers in the West for hogs used in the winter's packing. It will be seen that while the direction of the lines representing the fluctuations is generally in an opposite direction, this relation is by no means constant. It is evident that there are other and more important factors which influence the price of hogs.

Diagram B illustrates the fluctuations in the price of corn, the price of hogs, and the total hog product per capita placed upon the markets by the packers. By following the direction of the lines from year to year it is seen that there was a sharp advance in the price of the corn crops of 1873 and 1874, the price of hogs immediately following. The decline in the price of corn in 1875 was not at once followed by a decline in the price of hogs, but, on the contrary, the winter packing ending March 1, 1876, cost more than that of 1875, although made from cheaper corn. The reason for this is seen in the decline in production. In 1879, 1880, and 1881 we find another advance in corn, followed at once by an advance in hogs. Again we find the

DIAGRAM A.

Average price of hogs and home consumption of hog products per capita.

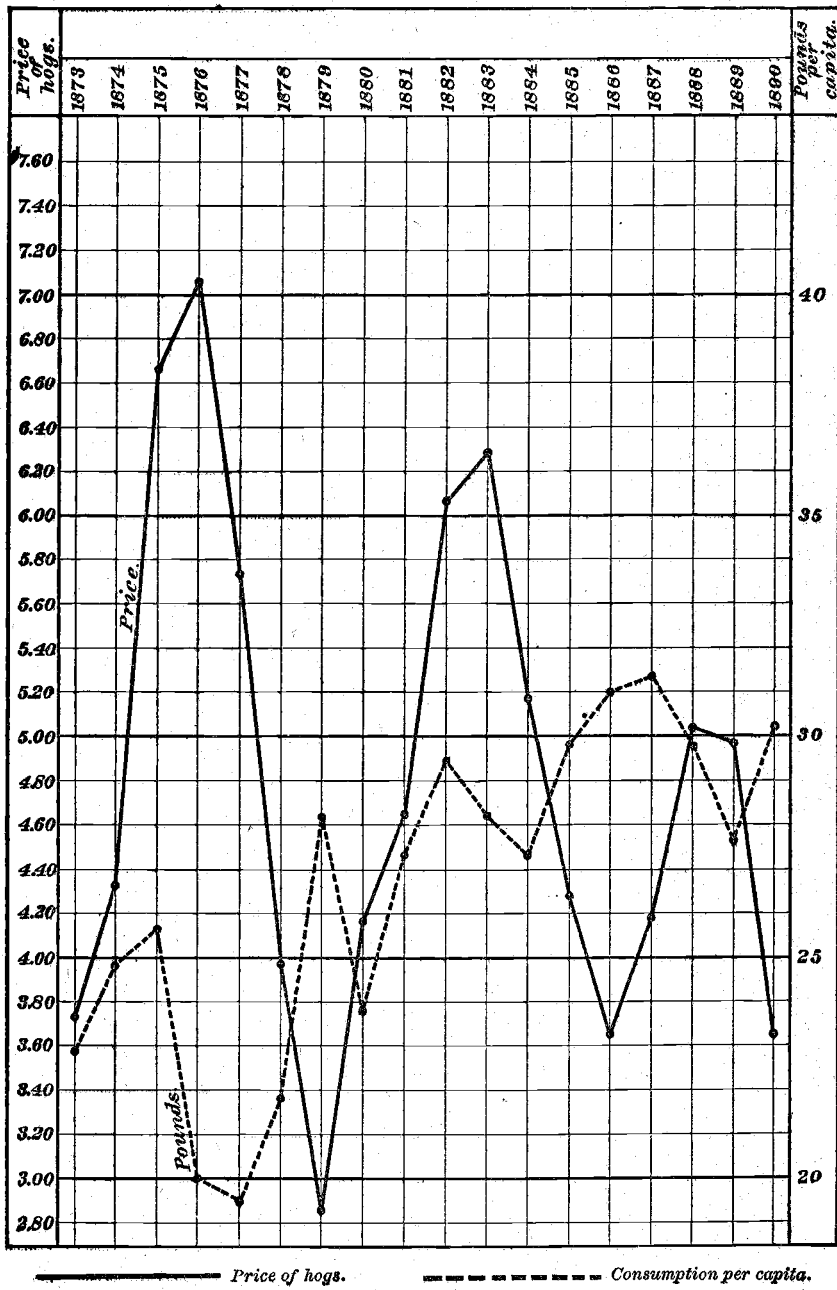
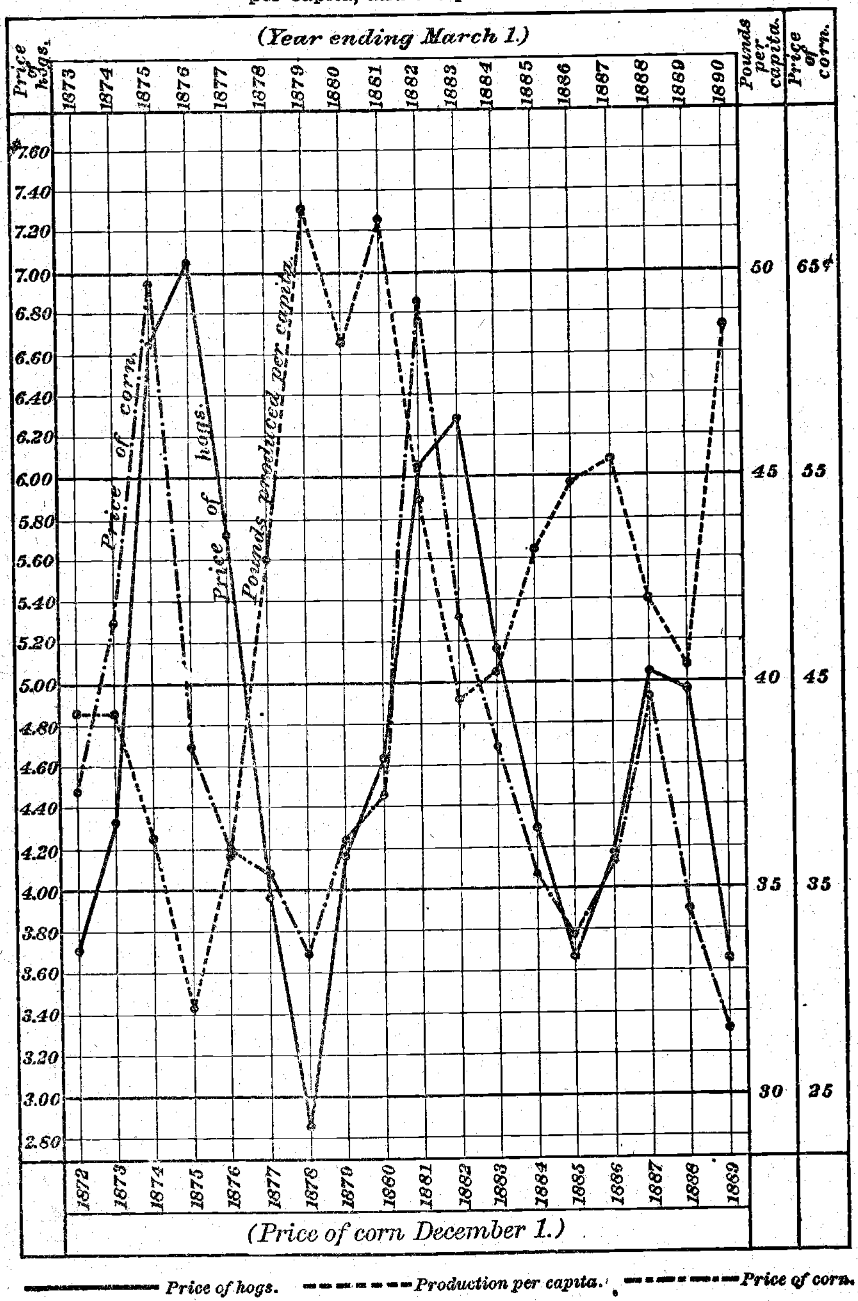


DIAGRAM B.

Average price of hogs, compared with the total production of hog products per capita, and the price of corn.



price of hogs advancing in the winter of 1882–'83, although the 1882 corn crop shows a very considerable decline in price. This advance in the price of hogs corresponds with a decreased production of hog product per capita of population. The second year of decline in the price of corn, that is, 1883, is followed by a marked decline in the price of hogs, and this corresponds with a slight increase in production of pork product. Then we find that, with the continued decline in corn during 1884 and 1885, there was also a decline in hogs. The 1886 corn crop brought more money and the price of hogs at once advanced. The crop of 1887 was still higher in price and the price of hogs again advanced. The 1888 corn crop was lower in price, and here we see the effect of the rule above referred to, for, while the price of hogs did not advance, it was sustained and the drop was very slight, only 5 cents per hundred pounds. In 1889 the price of corn was still lower and the drop in the price of hogs was very marked.

If, now, we turn our attention to the line on the chart showing the quantity of hog product in proportion to the population we find that in 1874 the price of hogs advanced before there was any decrease in production. The second year after the advance in corn the reduction in the quantity of hog product is marked, and the reduction continued one year after there was a fall in the price of corn. In 1878–'79 the production per capita reached the highest point, corresponding with the low-priced corn crop of 1878. In 1880 there was a decrease in hog product corresponding to the advance in corn, and in 1881 we find an exception to the rule—an increase in hog product and at the same time a second increase in price of corn. Then comes a drop in production in 1882 corresponding to the increase in the price of the corn crop of 1881. With the drop in the price of corn in 1882 we find that the hog product instead of increasing continued to decrease. This shows a tendency, exhibited also in 1876, that should be noted, which is that the hog product does not always respond to a fluctuation in the price of corn until the succeeding year. That is, when the hog crop has been decreasing for one or more years it requires some time to change the conditions and increase it, or *vice versa*. We see the operation of this rule again in the increase in the product of 1887 over 1886, although there was an advance in the price of the crop fed. So again the decrease in the price of corn in 1888 over 1887 was not followed by an increase in hog production until the succeeding year.

From these facts we may conclude that during the eighteen years covered by the tables and charts the following general rules appear to bear upon this question:

(1) The price of hogs increased with the price of corn without regard to the amount of hog product placed upon the market.

(2) After an advance in the prices of corn and hogs for a series of years the price of corn dropped one year before the decline came in the price of hogs.

(3) The fluctuation in the quantity of hog product per capita of population which followed an advance or decline in the price of corn after having moved in the opposite direction did not usually occur until a year had intervened. When corn had been high this failure of the hog product to increase with the first decline in corn kept up the price of hogs or even increased it for one year after corn dropped; but when corn had been low the failure of the hog product to decrease in quantity the first year that corn advanced did not prevent the

advance in the price of hogs immediately following the increase in the price of corn.

It would appear that the above conclusions are worth remembering, for if these rules have held good for eighteen years they will likely apply for some time in the future.

Having determined some of the factors which have influenced the price of hogs, and having found that the most important of all was the price of corn, it may be well to briefly consider the causes which fix the latter. The following table shows the price of corn, the total production, and the production per capita of population.

TABLE 4.

Year.	Price of corn.	Production per capita.	Total production.	Year.	Price of corn.	Production per capita.	Total production.
	Cents.	*Bushels.*	*Bushels.*		*Cents.*	*Bushels.*	*Bushels.*
1873	48.0	22.1	932,274,000	1882	48.4	30.6	1,617,025,100
1874	67.7	19.6	850,148,500	1883	42.0	28.6	1,551,066,895
1875	42.0	29.8	1,321,069,000	1884	35.7	32.4	1,795,528,000
1876	37.0	28.2	1,283,827,500	1885	32.8	34.2	1,936,176,000
1877	35.8	28.8	1,342,558,000	1886	36.6	28.9	1,665,441,000
1878	31.8	29.2	1,388,218,750	1887	44.4	24.7	1,456,161,000
1879	37.5	36.0	*1,754,591,676	1888	34.1	33.0	1,987,790,000
1880	39.6	34.2	1,717,434,543	1889	28.3	34.4	2,112,892,000
1881	63.6	23.2	1,194,916,000				

* Census.

Diagram C illustrates these fluctuations graphically. We see that, beginning with 1872, there was a decreased production of corn per capita of population in 1873, and a further decrease in 1874, and that there was a corresponding increase in price. In 1875 there was an increase in production and a decrease in price. In 1876 there was a decrease in production and a further decrease in price. In 1877 there was a slight increase in production and an equally slight decrease in price. In 1878 there was another increase in production and a decrease in price. In 1879 there was a considerable increase in production and also an increase in price. In 1880 there was a slight decrease in production and a slight increase in price. In 1881 there was a great decrease in production and an equally marked increase in price. In 1882 the production increased and the price decreased. In 1883 there was a decrease both in production and price. In 1884 and 1885 the production increased and the price decreased. In 1886 and 1887 the production decreased and the price increased. In 1888 and 1889 the production increased and the price decreased. This shows that as a rule the increase in production corresponds with the decrease in price, and *vice versa*, the only exceptions being found in the years 1876, 1879, and 1883, or three years in the eighteen covered by the diagram.

It is interesting to note concerning the three exceptional years just mentioned that two of them, 1876 and 1883, correspond to the years on Diagram B, where it is shown that the price of hogs advanced in spite of the fact that the price of corn declined. That is to say, the reduction of the stock of hogs not only increased the price of hogs but lowered the price of corn, because there were not so many hogs to feed and the corn which would otherwise have been fed was put upon the market. The remaining exception, 1879, which is a fluctuation in the opposite direction, corresponds to the year on

DIAGRAM C.

Production of Corn per capita, and the average price per bushel on farms, December 1.

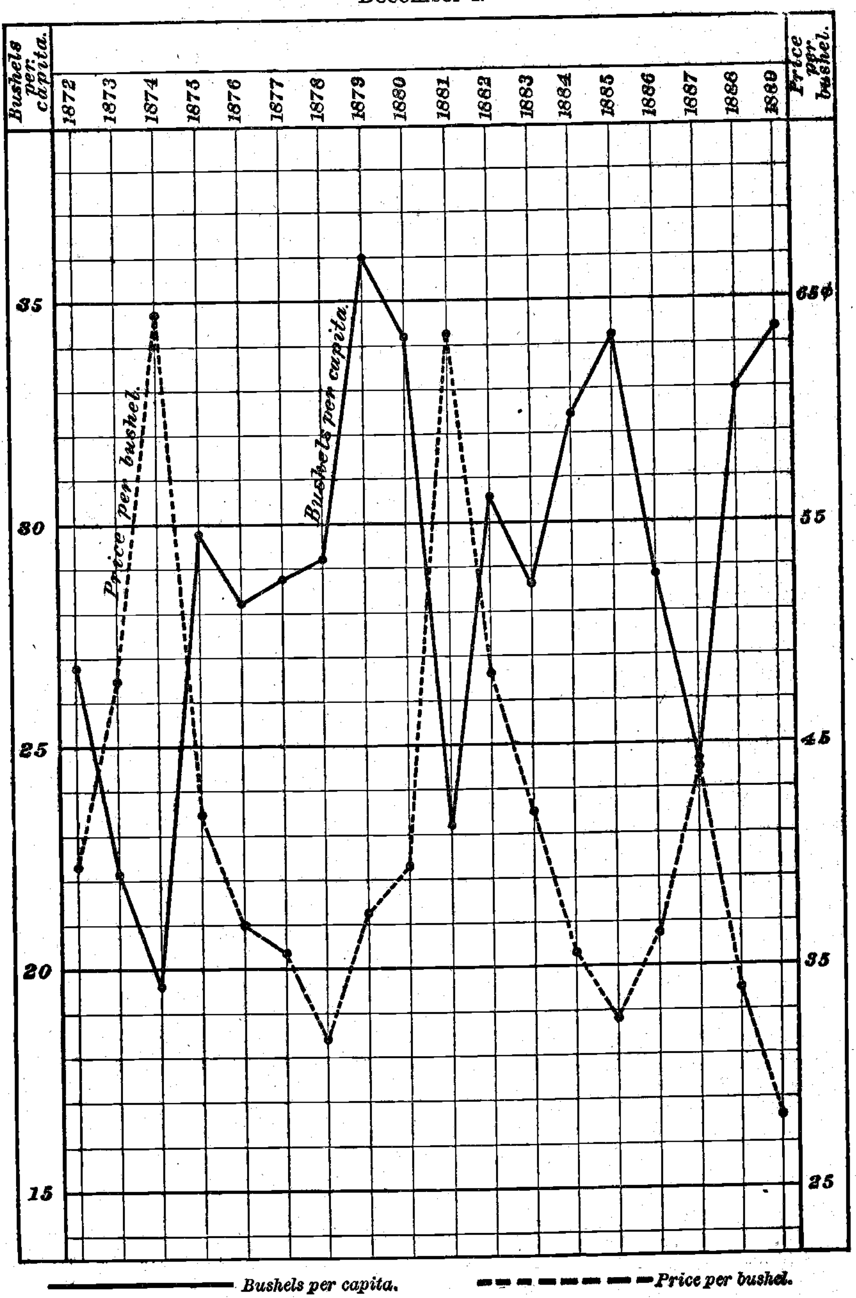


Diagram B when the production, and, consequently, the stock of hogs had reached the highest point. The large stock of hogs then on hand evidently was the means of furnishing a home market for the corn and caused an advance in price when under other conditions there would have been a further decline.

The price of corn is therefore governed primarily by the law of supply and demand, but it may also be influenced by the financial condition of the country, the purchasing power of money, and the relative supply of other cereals, and perhaps by other conditions.

There is one other point deserving of consideration in this connection. It is a very common custom when corn advances in price for farmers to hurry their hogs to market and reduce their breeding stock. A glance at the table demonstrates the existence of this custom, for we see that the hog product was invariably decreased as the price of corn advanced and when the price of corn declined the hog product again increased.

This fact has led the writer to inquire if there was in reality any less return to the feeder for each bushel of corn when the price was high than when it was low. To determine this the three years 1874, 1881, and 1887, were taken, at which the ascending lines were at their highest point, and it was found that the average price of corn for those years was 57.5 cents and the average price of hogs $5.92—that is, the value of a bushel of corn was equivalent to the value of 9.54 pounds of hogs.

Taking now the four years 1872, 1878, 1885, and 1889, when the descending lines reached their lowest point, we find the average price of corn to have been 33.2 cents and the average price of hogs $3.47. In this case a bushel of corn is equal in value to 9.56 pounds of hogs, or practically the ratio is exactly the same as when corn was high.

It appears that the best returns for hogs in comparison with the price of corn were received during the intermediate years between the extremely high or extremely low prices. Taking the eight years 1873, 1876, 1877, 1879, 1880, 1883, 1884, and 1886, we find the average price of corn to have been 39 cents and the average price of hogs $4.59. For these years it will be seen that 8.5 pounds of hogs brought as much as a bushel of corn.

These facts are important as indicating the proper course for the farmer to pursue under the varying conditions which are here considered. Their application is so plain to those that are interested that it is not necessary to go into greater details in this report

UNITED STATES CATTLE QUARANTINE.

The superintendents of the various neat cattle quarantine stations report the names of the importers and the number and breed of each lot of animals imported during the year 1890, as follows:

Station for the port of Baltimore, St. Denis, Maryland.

[Dr. A. M. Farrington, acting veterinary inspector.]

Date of arrival.	Name and post office address of importer.	Port of shipment.	Name of breed.	No. of animals.
1890. Mar. 17	S. C. Kent, West Grove, Pa	Liverpool	Guernsey	62

Station for the port of New York, Garfield, New Jersey.

[Dr. Wm. Herbert Lowe, superintendent.]

Date of arrival.	Name and post office address of importer.	Port of shipment.	Name of breed.	No. of animals.
May 13	H. N. Heffner, Delaware, Ohio	London	Red Polled	14
15	Alfred Sully, New York City	....do	Hereford	6
21	E. M. Barton, Hinsdale, Ill	Antwerp	Swiss	14
Nov. 27	W. W. Law, New York City	London	Jersey	4
	Total			38

Station for the port of Boston, Littleton, Massachusetts.

[Dr. A. H. Rose, superintendent.]

Mar. 21	R. J. Mendenhall, Minneapolis, Minn	Liverpool	Shorthorn	7
May 2	S. P. Clarke, Dover, Ill	....do	Galloway	2
July 3	....do	....do	....do	3
	Total			12

Station for the port of Boston, Littleton, Massachusetts.

[Dr. A. H. Rose, Superintendent.]

SHEEP.

Oct. 28	Jno. Milton, Marshall, Mich.	Liverpool	Shropshire	41

The following shows the whole number of cattle and sheep received at the various stations from January 1, 1889, to January 1, 1890:

Patapsco station	62
Garfield station	38
Littleton, Massachusetts	53
	153

INVESTIGATIONS OF THE INFECTIOUS DISEASES OF ANIMALS.

By Dr. THEOBALD SMITH.

The following brief account of the investigations conducted under my direction into the nature of the infectious diseases of animals has been prepared by Dr. Theobald Smith, who is in charge of this branch of the work of the Bureau of Animal Industry. All minor details, as well as the greater part of the autopsy notes, have been reserved for special reports, and only the most important results are given in this place.

INVESTIGATIONS OF TEXAS CATTLE FEVER.

The investigations into the nature and causes of Texas or southern cattle fever have been busily pushed during the summer of 1890, and some very important advances made which are destined to be of great practical importance.

During the summer of 1888 much time was spent in determining whether or not any specific bacteria are the cause of this disease as they are of a host of human and animal infectious diseases. This was the more necessary inasmuch as former observers have always described bacteria of one kind or another associated with it. But no bacteria could be found in the bodies of animals which had succumbed to Texas fever excepting those which quite invariably multiply in dead bodies after a time and have no significance whatever. At the same time the writer came to the conclusion that the disease was confined to the blood and consisted essentially in a breaking down of the red corpuscles.

During the summer of 1889 arrangements were made by which the disease could be studied near the laboratory in Washington, and, as reported last year, a parasite was found within the red corpuscles whose presence could only mean the breaking up of the corpuscle itself sooner or later. This discovery was adapted to explain satisfactorily the various lesions observed, as well as the great reduction in the number of corpuscles observed in those cases which died after prolonged disease or which ultimately survived. In some of these cases the blood is watery; it has in fact scarcely any color remaining. This condition was expressed mathematically by counting the number of blood corpuscles. Thus in most cases before death the number of corpuscles was but one-sixth of the number normally present in the body. When we contemplate the very important functions of these elements we need not be surprised at the serious effects resulting from loss to the body, within one or two weeks, of five-sixths of its corpuscles.

During the present year the disease was produced at the Experiment Station by the importation of North Carolina and Texas cattle and the investigations continued. The work was sufficiently extensive to occupy most of the time from July to December, while the examination of preparations and other work connected with this subject occupied much of the writer's time last winter and will of necessity require much additional labor this winter.

During the summer about fifty-three native animals, distributed around in various experimental inclosures at the station, received more or less careful attention. The temperature of all was taken every other day by Dr. Kilborne to detect the beginning of the disease. Of these about twenty-four either succumbed to Texas fever or else were killed in a dying condition. These cases were subjected to a careful *post-mortem* examination, and the internal organs underwent a careful microscopic scrutiny at the laboratory. The surviving animals were examined at different intervals of time more especially with reference to the condition of the blood. The blood corpuscles were counted and carefully examined with reference to the presence of the Texas fever parasites in order to determine the presence of any disease and the progress it was making. Those animals that died were also examined more or less frequently during the course of the disease in the same way. It was found moreover that these blood examinations were absolutely necessary in many cases to detect any disease whatever, and they put the field experiments, to be outlined later on, on a positive basis.

The examination of the internal organs, such as the spleen, liver, and kidneys, from those animals that died of Texas fever showed the presence of the blood parasite described last year in every case; in some in such enormous numbers that every other blood corpuscle appeared infected. In the course of the disease the parasites were detected in many of the cases examined. They were also present in the circulating blood one or two days before the animal died.

This parasite, which, as has been stated before, does not belong to the bacteria but to the protozoa, received considerable attention during the summer. It has appeared under several forms, and distinct amœboid movements of the largest forms were seen within the red corpuscles whenever the preparation was maintained above a certain temperature.

The work of the summer has thus confirmed that done during the two previous summers. There can be no doubt of the existence of genuine parasites within the red corpuscles and their destructive activity.

THE RELATION OF TICKS TO TEXAS CATTLE FEVER.

While the investigations into the nature of this disease were going on other equally important work was being carried on at the Experiment Station on the external characters of the disease.

It is well known to those who have come in contact with southern cattle in summer that they are infested with the so-called cattle-tick, a pest belonging to the class *Arachnoidea* and to the family *Ixodidæ*. These ticks are carried north with cattle during the warm season of the year. When fully matured they drop off from the southern animals, lay their eggs on the ground, and perish. The young ticks are hatched within fifteen to thirty days after the eggs are laid and at once get upon the cattle where they become mature within twenty to thirty days to again drop off, lay their eggs, and die. This process goes on continuously until the cold weather comes.

At various times and in different parts of the country it has been suggested that the ticks were the cause of Texas fever in northern cattle. This inference was undoubtedly suggested by the fact that nearly all cattle that die of Texas fever are observed to have these ticks of various sizes attached to the skin. Moreover the disease only makes its appearance after the young ticks have attached themselves to cattle. Though this was purely a *post hoc propter hoc* inference, it was nevertheless true, as the experiments to be recorded will amply prove.

During the summer of 1889 Dr. F. L. Kilborne, in arranging the various inclosures at the Experiment Station for the exposure of native cattle to the infection of Texas fever, conceived the happy idea of testing this popular theory of the relation of ticks to the disease. This he did by placing southern (North Carolina) cattle with native cattle in the same inclosure and picking the ticks from the southern stock as soon as they had grown large enough to be detected on the skin. This prevented any ticks from maturing and infecting the pasture with the eggs and hence prevented any ticks from infesting native cattle subsequently. At the same time, in another inclosure, the ticks were left on the southern cattle. The natives in the latter field died of Texas fever; those in the former did not show any signs of the disease.

Another experiment was made in September in the same manner by preparing three fields, one with southern cattle and ticks, a second with southern cattle from which the ticks were removed, and a third over which only adult ticks had been scattered. The result was equally positive. In the first field no natives died, but careful examination of the blood by the writer showed Texas fever in an unmistakable manner. In the "tick" field one animal died of Texas fever, and the examination of the blood showed that most other natives in the field were sick. In the third field containing southern cattle without ticks no disease could be detected.

These two tests pointed directly to ticks as being in some way the cause of Texas fever. At the same time it was thought best to confirm these results by further experiments during the present year before other agencies could be eliminated. The immediate inference was that the ticks infect the pastures, and that in some unexplained manner the infection finds its way into the body of susceptible cattle. The preliminary conclusions deducible from the work of 1888 and 1889 can be formulated as follows:

(1) Texas fever is a disease not caused by bacteria. Its nature can not be understood by supposing a simple transfer of bacteria from southern cattle to pastures and from pastures to northern cattle.

(2) The cause is very probably a protozoön, with a more complex life history, living for a time within the red corpuscles of infected animals.

(3) Southern cattle without ticks can not infect a pasture.

(4) Ticks alone scattered on a pasture will produce the disease.

The work of 1890 was planned to confirm or refute these preliminary conclusions and to furnish additional information.

The fields were arranged as before. One contained North Carolina cattle with ticks, a second Texas cattle with ticks, a third North Carolina cattle without ticks, a fourth ticks only, and a fifth soil from the pastures of infected North Carolina farms. Other fields were also laid out to test questions which need not engage our attention in this brief survey.

The results confirmed those of last year. The first animal to die was in the "tick" field, containing no southern cattle. No disease appeared in the soil field. Unfortunately, owing to the limited space of ground at our disposal and its barren, rolling character, ticks or eggs were washed during the very heavy rains of the summer from the tick field into the field containing southern cattle without ticks, although a wide lane intervened. The natives in this field thereupon all died of Texas fever. At the autopsy of these cases ticks were found attached to their skin in abundance.

The disease caused by Texas cattle could not be distinguished in character from that which was produced by North Carolina cattle. These results similarly pointed to ticks as the cause. The precise manner in which they caused the disease was by no means clear, however. The theory which seemed for a time most acceptable was that the adult ticks as they dropped off infected the pastures with germs which they had taken in with the blood of southern cattle, and that the germs were introduced into the body of northern cattle with the food. At the same time no parasite could be detected in the blood of southern cattle examined at various times, on which fact I would lay no great stress, however. Of more importance is the peculiarity which is exhibited by this disease in its period of incubation, as it may be provisionally denominated, and which is opposed to this theory. Thus, when native and southern cattle are placed on the same pasture at the same time it will take from forty to sixty days for the disease to appear. After the disease has once shown itself fresh animals placed on the same pasture may die, according to our experience, within thirteen days after the beginning of the exposure. We might say that the virus has "to ripen" on the pasture, which takes nearly two months, depending on meteorological conditions. When once "ripened" this virus does its deadly work within two or three weeks. This explanation, however, would be merely formulating our ignorance concerning the true nature of the infectious principle.

To the writer there seemed but one inference to be drawn from the facts and that is that the presence of young ticks is in some way directly associated with the appearance of the disease. It requires from forty to sixty days for the matured ticks to drop from the southern cattle and the eggs laid by them to develop into young ticks. After that period young ticks are present on the pastures until they are destroyed by the cold, or until the cold interferes with the development of the embryo in the egg. In other words, the period of incubation of the disease is explained without any difficulty by the life history of the tick.

The question was solved, experimentally, in the following manner: Eggs laid by ticks sent from North Carolina were placed on dried leaves in a dish partly filled with moist soil and kept in the laboratory until the young emerged from the egg. The period of incubation depends entirely upon the relative amount of heat, and has varied from fifteen days in midsummer to forty days in November, when the rooms of the laboratory became cold at night (50° to 60° F.). These ticks were placed on four different animals of different ages, kept away from any infected inclosures. Two were placed in stalls, one of them on an adjoining farm, and two were allowed to stay in a patch of woodland with healthy cattle. Of these four two died of Texas fever, as determined by careful *post-mortem* examination. One of them was in the stall away from the Station, the other in the patch of woodland. The other two became very ill; one of them never recovered but had to be killed later on, the other recovered. In all of them the germs were observed in the blood. The disease possessed the same characters as those observed in cattle in the infected pastures during the summer. There was an elevation of temperature from nine to twelve days after the young ticks were placed on the animals, going as high as 107° F. in one animal. Accompanying the fever a gradual reduction in the number of blood corpuscles was observed. In order to show more conclusively the truth of the statements made a few brief notes from one of the experimental cases is appended:

No. 144.—Cow about eight years old, purchased September 16 from a neighboring farm and placed among a number of healthy reserve cattle in a piece of woodland at some distance from any infected field.

September 17.—A considerable number of young ticks, hatched in the laboratory from the eggs laid by ticks sent from North Carolina, placed on this animal.

September 18.—Temperature 101.2° F., 6.3 millions red corpuscles in blood; normal.

September 24.—Another lot of recently hatched ticks placed on the animal.

September 27.—A. M., temperature 104° F.

September 29.—10.45 a. m., temperature 106.2°, pulse 54, respirations 27, 4.93 millions corpuscles in blood. Ticks abundant on body, especially on inside of thighs. Still quite small.

September 30.—P. M., 107°.

October 1.—P. M., 106.3°.

October 2.—P. M., 104°.

October 3.—Found dead this morning. Seen alive at 6 p. m. yesterday. A large number of ticks on animal, just through second molt. None of them large as yet.

Lungs only partly collapsed; trachea and bronchi filled with foam. Ecchymoses under epicardium of both ventricles of heart and under endocardium of left ventricle.

Spleen very large, blackish, soft. Weighs 4 1-16 pounds. (Normal weight about 2 pounds.)

Liver weighs about 12 pounds; enlarged, yellowish on section. Complete injection of the intra-lobular bile capillaries. Extensive fatty degeneration of liver tissue. Occasional groups of hæmatoidin crystals.

Bile dark, scarcely flows. Density due to large quantity of yellowish flakes and mucus.

Kidneys deeply congested; tubules contain much yellowish pigment. Urine in bladder of a deep, port wine color, barely translucent in small test-tube; alkaline; specific gravity, 1015; no sediment; albuminous precipitate very abundant (.6 per cent. according to Esbach). Heavy flocculent precipitate when acetic acid added (hæmoglobin).

In preparations of blood from the heart, of liver, spleen, and kidneys a small number of corpuscles contain parasites, in contracted state, from 1.5 to 2 micromillimeters in diameter. In the blood, spleen, liver, and kidney preparations a moderate number of large bacilli of *post-mortem* growth. (These bacilli are invariably present when the animal dies early in the night and is not examined until next day. They are never found in animals killed in a dying condition. They occur in other diseases under similar conditions.)

These brief notes demonstrate that Texas fever can be produced by placing young ticks on cattle, and that the disease can not be due to any abstraction of blood, for the ticks were still quite small and had scarcely begun to draw blood on a large scale. Moreover the corpuscles perished *in the body* as is shown by the coloring matter in the urine, by the thick bile, and the presence of pigment in the liver and kidneys. No disease appeared among the other cattle in the same inclosure.

While the nature of Texas fever is by no means made clear as yet, we are able to affirm that ticks can produce it. Whether the disease can be transmitted by any other agency must be decided by future investigations. Meanwhile the evidence accumulated thus far seems to favor very strongly the dictum: No ticks, no Texas fever.

SWINE DISEASES.

AN EXPERIMENT TO TEST THE VALUE OF SUBCUTANEOUS INJECTIONS OF HOG CHOLERA BACILLI AS A MEANS OF PREVENTING HOG CHOLERA.

In the report for 1889, page 87, it was stated that an experiment was in progress which we hoped would be a final test as to the practical value of subcutaneous injections of cultures of hog cholera bacilli in making swine insusceptible to the virus of hog cholera. The first tests in this direction were made at the Experiment Station early in 1886, soon after the hog cholera bacillus had been discovered. The tests at that time consisted in making two injections under the skin of minute quantities of culture liquid containing hog cholera bacilli, several weeks apart. This method was modeled after that of Pasteur in anthrax vaccination. No favorable result could de detected at that time. Although there was little hope that such a method would prove efficacious in another trial, still it was thought best to make it inasmuch as the disease to which the inoculated swine had been exposed in 1886 was of more than the usual virulence.

The method of subcutaneous injections of culture liquids containing hog cholera bacilli while on the one hand fraught with the possible danger of scattering disease germs where they do not originally exist is nevertheless the simplest and cheapest method that can be devised for the vaccination of animals; these qualities of simplicity and cheapness are of vital importance in a question which has only a commercial aspect. It was therefore thought best to give this method another and final trial, and in planning such an experiment it was considered necessary to eliminate all those sources of error which might possibly lead to an erroneous interpretation of results. Hence the following inportant conditions were kept in view:

(1) The animals must be young, unexposed hitherto even to a suspicion of disease. (2) There must be a large number of control or check animals of the same age and breed, which are to be subsequently exposed to the disease under precisely the same conditions as the vaccinated animals. (3) The disease to which they are exposed must have been carefully studied, the absence of other infectious diseases, such as swine plague, determined, and the virulence of the hog cholera germs causing it tested on rabbits. The disease must be virulent enough to prove fatal to the control animals to make the test of any value whatever.

That all these conditions are of prime importance is evident from general considerations, and was made evident in a very striking manner by the outcome of the experiment as will be seen further on.

The vaccine used.—In order to obviate the fatal effect of doses of hog cholera cultures injected under the skin which sometimes shows itself quite unexpectedly, especially in young animals, the writer deemed it advisable to reduce the virulence of the cultures by appropriate means, so that larger quantities of the culture liquid might be injected to increase, if possible, the vaccinating effect without endangering the life or stunting the future development of the animal.

In reducing the virulence, or attenuating it, as it is more commonly denominated, the following method was pursued: Tubes of peptone bouillon* inoculated with hog cholera bacilli were placed in a favorable temperature for multiplication (95 to 100°) over night. On the following day the culture liquid, now slightly clouded, was placed in an unfavorable temperature of 110 to 111° F. (43.5 to 44° C.) and kept there for about ten days. Thereupon fresh tubes were inoculated from these and subjected to the same process. From time to time rabbits were inoculated to test any attenuation that might have taken place, and it was noticed that there was a slight modification of the disease in rabbits after a time. After the bacteria had thus been exposed to a high, unfavorable temperature for more than two hundred days and passed through twenty cultures, a small dose of one-tenth cubic centimeter (one five-thousandth of a pint approximately) injected under the skin did not prove fatal to a rabbit, while larger doses were still fatal. Small quantities injected into an ear vein were likewise fatal. The reduction of virulence was therefore not very great, even after this very prolonged exposure to a high temperature. At the same time it was thought advisable to use it as vaccine *a*.

A second vaccine was prepared at the same time. It was exposed for only ninety to one hundred days, and passed through nine cultures in place of twenty, as with vaccine *a*. It was still virulent enough to kill rabbits in small doses, and in fact there was little

* Beef broth containing a little peptone and common salt.

difference between this and the original virus. This we shall call vaccine *b*.

The animals used.—The pigs that were chosen for vaccination numbered forty-eight in all. Of these twenty-seven were from one farm in the District of Columbia where no disease had existed among swine for years. They were all raised in pens. The remaining twenty-one were obtained from a farm in the District which likewise had been free from disease for a long time. They, however, had not been raised in pens, but were allowed to range over a large pasture. At the time of vaccination they were all about three months old. The first lot were the product of an Essex boar and Berkshire sows, pure bred. The second lot were mixed Jersey Reds and Chester Whites, grades. At the date of vaccination they weighed from 50 to 75 pounds each, the weight being slightly in favor of the first lot.*

A large pen had been built for this purpose, divided into compartments, which were separated from one another by tight board partitions. We will denominate for convenience the twenty-seven penfed swine as lot A, the twenty-one pasture-fed pigs as lot B. They were divided as follows:

In compartment 1	7 of lot B.
In compartment 2	7 of lot B.
In compartment 3	7 of lot B.
In compartment 4	empty.
In compartment 5	9 of lot A.
In compartment 6	9 of lot A.
In compartment 7	empty.
In compartment 8	9 of lot A.

The vaccination consisted in injecting a definite quantity of peptone bouillon, in which the attenuated bacilli had grown for about twenty-four hours, into one or both thighs according to the quantity used. The date of the two vaccinations and the quantity injected into each pig is given in the following table:

Compartment.	Lot.	October 18, 1889.	November 5, 1889.	
1	B.	Checks		
2	B.	10 cubic centimeters* vaccine *a*	4 receive 2½ cubic centimeters 3 receive 5 cubic centimeters	Vaccine *b* Do.
3	B.	5 cubic centimeters vaccine *a*	4 receive 10 cubic centimeters 3 receive 2½ cubic centimeters	Vaccine *a* Vaccine *b*
4				
5	A.	10 cubic centimeters vaccine *a*	4 receive 2½ cubic centimeters 4 receive 5 cubic centimeters	Vaccine *b* Do.
6	A.	5 cubic centimeters vaccine *a*	4 receive 10 cubic centimeters 5 receive 2½ cubic centimeters	Vaccine *a* Vaccine *b*
7				
8	A.	Checks		

* 1 cubic centimeter is equivalent to $\frac{1}{125}$ gill or to $\frac{1}{30}$ fluid ounce approximately.

From this table it will be seen that the pigs received two injections each, eighteen days apart. Both lots were treated alike, while the quantity of liquid injected was varied somewhat. It will also be noted that some pigs from both lots received only vaccine *a* both times.

After the first injection and as a result of it one pig in compartment 5, belonging to lot A, died nine days after the injection. The spleen contained hog cholera bacilli. Thus but one out of thirty succumbed to vaccine *a*, and in this case death may have been due to

* The selection of pigs, arrangement of pens, and inoculations were made by Dr. F. L. Kilborne.

the accidental puncturing of a vein under the skin by the needle of the hypodermic syringe, by which means the bacilli may have been injected into the blood. This procedure is quite invariably fatal when large doses are used, as will be seen from the details of the experiment to be reported further on. Fourteen days after the second inoculation a second animal in the same compartment died, evidently as a result of it, since hog cholera bacilli could still be detected in the internal organs. Thus two out of thirty were killed by the inoculation, or $6\frac{2}{3}$ per cent., a proportion rather high for any method destined to have any practical value. But the problem before us now was to see whether any method of subcutaneous inoculation could be relied upon to give sufficient immunity to resist the natural disease. A method sufficiently severe to lead to the death of $6\frac{2}{3}$ per cent. of the vaccinated animals should therefore in the sequel prove specially efficacious for those animals that survived it. This, however, did not prove to be the case.

Of the control animals two from compartment 8 died sixteen and twenty-one days, respectively, after the vaccinated animals had received the second injection of the vaccinal culture. In one there was found diphtheritic inflammation of the middle portion of the small intestines, in the other the mucous membrane of the large intestine was more or less inflamed. In neither case, however, could hog cholera bacilli or any other bacteria be detected in the internal organs. It might be inferred that this compartment had been infected by the vaccinated pigs. It will be seen, however, that the neighboring compartment was left empty and the greatest care was taken not to use utensils indiscriminately. Moreover the evidence of hog cholera, the presence of the bacilli in the body, was not obtainable. Meanwhile the check pigs in compartment 1, adjoining the vaccinated lot in compartment 2, showed no signs of disease.

It should also be noted that all four deaths were from lot A, the pen-fed pigs. Lot B stood the vaccination without any accident, and the checks remained well till the time of exposure to the natural disease. The effect of the injections manifested itself in general by a slight indisposition and a refusal to eat the daily ration for one or two days. The place of injection showed in most cases a subcutaneous tumor from 1 to 2 inches long.

The exposure to diseased pigs.—The two injections or vaccinations, as may be seen from the table, were made October 18 and November 5, 1889. On December 19, about one and one-half months after the last injection, the pigs were exposed to the disease. At this time there were twenty-three of lot A, of which seven were checks or control animals and sixteen vaccinated, and twenty-one of lot B, of which seven were checks and fourteen vaccinated; so that there were in all twenty-eight vaccinated and fourteen control animals to be exposed.

The animals in the different compartments, hitherto kept apart, were allowed to mingle by removing the partitions and thus making one large pen. At the same time eight infected and diseased pigs were placed in the pen with the rest. These had been infected on the station from an outbreak carefully studied, from which swine plague could be excluded with certainty. That the introduced disease was sufficiently virulent is shown by the fact that all eight infected pigs died between December 20 and December 27, at the rate of about one a day, beginning the day following their mingling with the vaccinated and control animals.

The result of the experiment was curious and quite unlooked for. The exposed pigs began to die on the 28th of December and continued to succumb until February, when apparently all the susceptible animals had been weeded out. The status of the experiment February 1 was as follows:

Of the lot of pen-fed pigs only one animal died, and this one of the check animals. It had been small and unthrifty before the exposure, and at the autopsy besides the rather mild hog cholera lesions there was a general anæmic condition manifest. Hence practically all of lot A resisted the disease, control animals included. The infection had been too mild for them.

With the other lot of pigs the case was different. At the beginning of the exposure there were fourteen vaccinated and seven control animals. At this time (February 1) there were left but three vaccinated and one control animal. The disease had made no discrimination between the treated and the not treated and had killed seventeen out of twenty-one. Of the whole lot remaining all were thriving excepting two or three, which were stunted in growth.

The inference to be drawn from these results is that the subcutaneous inoculations had little or no effect on the course of the disease. For lot A the disease was too mild, for lot B it was fatal in spite of the vaccination. This is practically the conclusion arrived at in 1886 when the experiments gave no better results than those just quoted. It may be possible that, by increasing the quantity of the culture liquid and the number of inoculations, a point may be reached at which immunity is produced. But such modification besides endangering the life of the animal would be too tedious and expensive to be of practical value.

There are some other not unimportant inferences to be drawn from this experiment. They bear upon the methods employed in testing the truth or falsity of subcutaneous vaccination and the evidence that can be adduced in its favor.

Had we chosen the pen-fed pigs to be vaccinated and the pasture-fed pigs as control animals we might have reached the erroneous conclusion that our vaccination was a complete success. Or had the circumstances been just the opposite—had the pasture-fed pigs been used for vaccination, the pen-fed for checks—we would have seemed justified in concluding that vaccination or preventive inoculation is not only a failure but predisposes swine to the natural disease. Neither of these inferences is correct, however, as the experiment proves. We should therefore be extremely cautious to accept any conclusions in regard to matters of such importance without the results of carefully conducted experiments before us. Experiments conducted in the field have at best but a partial value, since the disease may be introduced into a given herd or not depending on circumstances over which no proper control can be exercised, or else if the disease appears the animals are of different ages and of different degrees of health or else not exposed to the same dangers, etc.

Thus this experiment as well as those of former years afford sufficient evidence for the conclusion that the subcutaneous injection of culture liquid containing hog cholera bacilli is not capable of protecting swine from hog cholera.

In order to determine the effect of the vaccination and exposure upon the surviving pigs their weight was roughly estimated February 1. Of lot A the six control pigs had an average weight of 105 pounds each, the fifteen vaccinated ones about 93 pounds. The individual weights varied from 60 to 160 pounds, the heaviest being a control animal. Of lot B the three surviving vaccinated animals weighed on an average 84 pounds each, and the surviving check or control animal 105 pounds. The vaccination had thus the effect of slightly reducing the body weight in comparison with the control animals.

A few additional experiments were made with this lot of pigs which may be very briefly summarized:

March 18, 1890.—One cubic centimeter of a peptone-bouillon culture of the hog cholera bacillus was injected into one of the crural veins of two control and four vaccinated pigs, all from lot A. Of these six animals one control died six days later. The others recovered. This showed that some immunity had been gained by the vaccination.

April 18.—Six other pigs from lot A, two control and two vaccinated animals were fed each with nearly a quart of viscera from hog cholera cases. All survived.

April 29.—Another and final test was made by taking the five pigs of lot A, which had survived the intravenous injection of March 18, together with four others of the same lot and two of lot B, not thus treated March 18, and injecting into the crural vein another dose of bouillon culture of hog cholera bacilli. Three of those which received the injection of 1 cubic centimeter March 18 now received the large dose of 5 cubic centimeters. All the rest received 2½ cubic centimeters.

Of these eleven animals thus inoculated three died within two, four, and forty-two days, respectively, after the inoculation. These three belonged to the lot of six which had not previously received the intravenous injection. The other three survived. Expressed in another form, of those which had received the intravenous injection March 18 100 per cent. survived; of those which had not received it 50 per cent. survived. Of the three which died, the two which died in two and four days after the injection belonged to the original check animals, the one which died forty-two days after was a vaccinated animal.

These last tests lead to the inference that injections of hog cholera bacilli into the veins in small quantity protects the animal against injections of large doses ordinarily fatal.

The history of the surviving vaccinated animals up to November 1, 1890, may be given very briefly. They were kept in the same pens in which they had been exposed to the disease. Three died subsequently, two being in very good condition at the time of death. In one (June 22) there was a rupture of the œsophagus at its insertion into the stomach, permitting the contents of the stomach to enter the chest cavity. The second (September 3) was not examined. The third died from enlargement and softening of the bones of the head, impeding respiration. The remaining animals weighed from 140 to 280 pounds apiece. Those that received the injections into the veins were the poorest in weight.

AN EXPERIMENT TO TEST THE VALUE OF INJECTIONS OF HOG CHOLERA BACILLI INTO THE VEINS AS A MEANS OF PRODUCING IMMUNITY.

The preceding test had shown that two injections of hog cholera bacilli under the skin had no appreciable effect in protecting swine from the disease itself. Subsequent experiments with the same lot of animals proved that when small doses of hog cholera bacilli are injected directly into a vein the animal so treated is able after a time to resist fatal doses administered in the same manner.

The plan laid out for this experiment was to inject into a vein of the leg a very small quantity of culture liquid containing hog cholera bacilli to begin with; then after a certain period of time, depending on the effect produced by the first inoculation, to inject a larger dose in the same manner, and perhaps a third dose still larger, using control animals to gauge the effect of the various doses on fresh pigs; finally, to expose these inoculated animals to the natural disease.

The actual experiment carried out may be briefly summarized: Twenty-five pigs were selected, and at the time of the first injection they were about seven months old, in good condition, and weighing from 75 to 90 pounds each. The culture employed was derived from an outbreak studied in 1889 and somewhat attenuated by age.

On August 23 thirteen pigs of this lot received the first injection. Five received one-eighth of a cubic centimeter of a peptone-bouillon culture, five one-quarter of a cubic centimeter, and three one-half of a cubic centimeter each. In every case the small dose was diluted with some sterile liquid, such as beef broth to bring it up to 1 cubic centimeter. On the following day all pigs were sick and in proportion to the dose received. This was shown by a refusal to eat, and lasted but one or two days.

On September 4, twelve days after the first injection, only one pig had lost weight. They were all inoculated in the same way with 1 cubic centimeter each, and in addition four fresh pigs with the same dose. After one or more days of slight illness following the inoculation they all recovered, excepting the four fresh pigs. These grew thin and weak, and two died September 29.

On October 17 a final injection of 5 cubic centimeters was given to all surviving pigs and three fresh ones. The result of the inoculations is given in a more condensed form in the following table:

Table giving the results of intravenous inoculations of culture liquid containing hog cholera bacilli.

Pig. No.	August 23.	September 4.	October 17.	Remarks.
347	⅛ cubic centimeter.	1 cubic centimeter.	5 cubic centimeters.	November 8, condition good.
348	....do	....do	....do	November 8, stunted.
349	....do	....do	....do	November 8, condition good, swelling and ulceration over left tarsus.
350	....do	....do	....do	November 8, condition fairly good.
351	....do	....do	....do	November 8, condition very good.
359	¼ cubic centimeter.	....do	....do	November 8, condition fair, crippled by swelling on feet.
364	....do	....do	....do	November 8, condition good.
365	....do	....do	....do	November 8, condition very good.
366	....do	....do	....do	Dead October 21.
367	....do	....do	....do	November 18, stunted.
256	½ cubic centimeter.	....do	....do	November 18, condition good.
357	....do	....do	....do	Do.
358	....do	....do	....do	November 18, condition fair, swelling and sores on all feet.
352		....do	....do	Dead October 20.
353		....do		Dead September 29.
354		....do	5 cubic centimeters	November 18, condition good; enlargement of left fore and hind feet.
355		....do		Dead September 29.
361			5 cubic centimeters.	Dead October 21.
362			....do	Dead October 23.
363			....do	Dead October 20.

From this table we learn that the three last control animals died three, four, and six days, respectively, after the inoculation. This indicates a decided immunity on the part of those which received the two previous injections, since but one of these thirteen succumbed to the last inoculation on October 21, or in other words, 100 per cent. of the last control animals and but 7 per cent. of the previously inoculated animals died as a result of the last injection (which has thus far always proved fatal to pigs).

When we come to the four control animals of the second inoculation (Nos. 352 to 355 inclusive) which received 1 cubic centimeter to begin with, we find that two of these died as a result of the inoculation, the third died as a result of the last inoculation, and the fourth survived.

Although this method thus showed that pigs can be made more or less insusceptible to fatal doses injected into the veins, it is not as yet proven that it will eventually prevent the treated animals from acquiring the disease in the ordinary way. We have thus far been unable to expose these animals, since no outbreak has been found during the fall within reach to furnish the starting point at the Experiment Station.

Another point deserves consideration, and this is the effect of this method of inoculation. If we examine the remarks appended to the twelve cases which were inoculated three times, we learn that only seven are in good condition, two are stunted and small, and three are affected with enlargement and ulceration of the feet (from the carpal and tarsal joints down) though otherwise in good condition. These injuries are most likely the result of the inoculations, which one it is impossible to state, and may be directly due to the injected bacilli lodged in the bones perhaps and causing their destruction. How much damage will be done thereby can not be surmised at this time.

SWINE PLAGUE.

The standpoint of pathologists and students of infectious diseases both in man and animals at the present time is that two diseases must be regarded as identical or dissimilar according as the causes which produce them are the same or different. Two maladies in many respects the same are yet different from one another if the bacteria which produce them are different. Not only is this standpoint theoretically correct but sound also from a practical point of view, for the simple reason that only an exhaustive study of the causes of disease can eventually help us in suppressing them. While pathology has done but little in the treatment of infectious diseases of man and animals, most authorities being opposed to any treatment as useless and dangerous, it has already done much in formulating rules for the prevention of such diseases by tracing the insidious ways by which diseases are carried from place to place and introduced into herds of animals, by studying the nature of the virus, its vitality under various conditions, and the agents which are capable of destroying it.

All these important facts result from the study of the disease-germ in the laboratory, in the diseased animals, and in nature. Hence it follows that the disease-germ is the most important factor to be studied before other problems can be solved and before any sound information concerning the disease itself is obtainable. It also follows from these considerations that it is of essential importance to recognize the specific disease-germs wherever they may be found. This study of bacteria or bacteriology lies therefore at the basis of all investigations of infectious diseases and upon it subsidiary investigations relating to vaccination, inoculation, and treatment must rest.

Two infectious diseases of swine have been recognized in the investigations of the past five or six years, denominated, respectively, hog cholera and swine plague. The specific bacteria which cause them, and which can be made to reproduce them by inoculation, are readily distinguished by any novice in bacteriological studies. Their differences are sufficiently pronounced to demand careful separate investigations, although the diseases themselves may be easily confounded and may occur side by side.

It has been maintained in some quarters that this position of the Bureau of Animal Industry in insisting upon the existence of two distinct infectious swine diseases is wrong and that there is but one disease in the country demanding attention. This latter position may be due either to inability to distinguish between the germs causing these diseases, to inability to find them in diseased animals by not applying appropriate methods, or else to the nonexistence of one of these diseases in that part of the country where the investigations were made.

No amount of time and labor has been spared in the study of these two diseases, especially swine plague, in order that a thorough knowledge of its nature might be obtained. During midsummer of this year we had the good fortune to find an outbreak of swine plague on the coast of New Jersey, several miles from Pleasantville and Atlantic City. The owner of the herd in which the disease had broken out, Mr. Joseph Young, gave us all the assistance in his power and freely sacrificed his animals for the purpose of investigation.

The history of the outbreak may be stated very briefly as follows: In May of the present year the owner purchased two lots of pigs from a dealer, numbering ninety-seven in all. At the time of the purchase more or less coughing was noticed among some unthrifty animals in the lots. On the farm they were kept on dry, sandy soil, and fed with hotel slops from Atlantic City. The coughing did not entirely disappear, and on July 1 they began to die. Up to July 19 thirty-four had perished. July 20 four died, July 21 seven died, and on July 22 eight died. These few facts indicate a very virulent and rapidly fatal disease. It was without doubt brought with the pigs themselves, as there had been very few pigs and no disease upon the farm for years, nor was any disease reported among swine in the vicinity though fed and kept in the same way.

The symptoms noticed by the owner were coughing, loss of appetite, and emaciation. Vomiting was a common occurrence. The sick animals were in the habit of straying and hiding themselves in out-of-the-way places and under bushes. Some died within three to five days after the first symptoms of disease; others lived a few days longer. Some died suddenly without manifesting any signs of disease.

From this herd about seventeen animals were examined after death. Ten of these were examined on the farm between July 21 and 23 inclusive and cultures made from the internal organs of six. This part of the work could not be done very thoroughly, owing to the primitive facilities and the innumerable insect pests on the farm. The results of this work indicating that we had an outbreak of swine plague instead of hog cholera to deal with as we had anticipated, it was deemed advisable to make a more thorough investigation of this disease. Dr. Kilborne was therefore directed to return alone to this farm July 28, and send to the Experiment Station at Washington some sick animals where the disease could be more carefully investigated in connection with the laboratory. On the farm two more autopsies were made on dead pigs and five diseased ones sent by express to the Experiment Station. Of these latter one died on the 1st, three on the 3d, and one on the 5th of August. Subsequent information from the owner showed that only seven out of the entire herd had survived the infection, *i. e.*, about 8 per cent.

It would be out of place in this brief report to go into detail concerning the appearance presented on *post-mortem* examination of the affected animals. In general both lungs and intestines were diseased and the impression made upon the writer at first was that of an outbreak of hog cholera. The disease resembled very closely that studied in Iowa in 1888, and the belief at that time on making the *post-mortem* examination in several herds was that the disease was hog cholera in some herds and swine plague in others. As in the Iowa disease, so in this New Jersey outbreak, the impression that the disease was hog cholera was entirely dispelled by the bacteriological work, as will be shown further on.

As regards the lungs, these were consolidated more or less in ten out of the seventeen cases. The hepatization was in most cases accompanied by pleurisy of varying degrees of severity and more rarely by pericarditis. The spleen and lymphatic glands were engorged with blood in the majority of cases. The mucous membrane of the stomach was usually deeply congested and in a few cases portions of the membrane had undergone mortification or necrosis.

In the large intestine there was disease in almost every case. This disease was manifested by a general reddening or by discoloration and pigmentation of the mucous membrane, by more or less extensive diphtheritic inflammation, causing superficial necrosis or mortification and by isolated ulcerations. In nearly all cases ulcers were present. It is not surprising that hog cholera and swine plague should be regarded as one disease when the lesions they produce are so much alike to the casual observer.

In order to determine the true nature of the disease it became necessary to learn whether hog cholera or swine plague bacteria were present or whether perhaps some third unknown germ could be regarded as cause of the disease. Cultures were, therefore, made from the organs of six animals on the farm and from five animals in the laboratory. The result of this laborious work was that no hog cholera bacilli were found in any of the cultures made from these eleven animals. They manifestly had nothing to do with the disease. In four out of the eleven cases swine plague bacteria were found distributed through the organs of the body. In the remaining cases most of the cultures from the organs remained sterile. A few contained other bacteria of a miscellaneous character, most of them known from former investigations.

The disease-producing power of the swine plague bacteria from this outbreak is well illustrated by the two following experiments made subsequently:

Inoculation of healthy pigs.—Two pigs three months old and weighing 40 pounds received into a vein of the leg 1 and 5 cubic centimeters, respectively, of a peptone-bouillon culture of the swine plague bacteria derived from this outbreak. The animal which had received 5 cubic centimeters was dead within sixteen hours. There was more or less redness of the skin, œdema of the lungs, commencing peritonitis, hemorrhagic condition of the kidneys, and congestion of the mucous membrane of the stomach. The pig which had received but 1 cubic centimeter died in four days. There was found at the autopsy extensive double pleuritis, pericarditis, and consolidation of a small portion of the left lung. The kidneys contained numerous abscesses. At the same time a third pig was inoculated by injecting 5 cubic centimeters of the culture liquid into the right lung. This animal died within twenty-four hours with pleuritis, beginning hepatization of the lungs, peritonitis, and pericarditis. These results are indicated to show how virulent the swine plague germ of this outbreak was and that the destructive activity of this germ is fully equal to that of the hog cholera bacillus.

In order to test the effect of feeding substances containing this germ the organs of six rabbits which had been inoculated with it were fed to two pigs. They showed no signs of disease. A subcutaneous injection of 5 cubic centimeters of culture liquid was likewise without effect. The negative result following these methods of introducing the swine plague germ into the body simply confirms former experiments of a similar character with swine plague germs from other outbreaks.

Exposure of healthy pigs to sick animals from this outbreak.—The five pigs sent to the Experiment Station were placed in a wooden pen with two healthy pigs. One of these died eleven days after with a large number of necrotic masses in the lungs, exudative inflammation of the pleura and pericardium, intense hyperæmia of the stomach, and portion of the large intestine. Swine plague germs were detected in lungs and intestines. The other pig exposed at the same time became very unthrifty and was killed several months later. No disease could be detected, but the weight of the animal at the time it was killed was but 25 in place of 70 or 80 pounds. Three other healthy pigs were placed into this pen, one of them while two of the diseased pigs were still alive, the remaining two when all of the original lot had died. These three exposed pigs also survived, but they became unthrifty and after several months they were all over 50 pounds behind in weight. The explanation of this condition is by no means obvious, although it would appear that the infection disappeared in great part from the pen with the death of the diseased animals and that more direct contact with such diseased animals is necessary to produce a fatal result in swine plague than in hog cholera.

Little need be said in this connection of the swine plague germ itself. It did not differ from the same germ obtained from various sources since 1886, and described in detail in the reports of the Bureau of Animal Industry issued since that date, excepting perhaps in its greater virulence. A very minute quantity of growth from cultures placed beneath the skin of rabbits proves fatal in less than sixteen hours. Its fatal effect on guinea pigs and mice is no less pronounced. These small animals are thus of great service to the pathologist in exactly gauging the virulence of the same germs from different localities.

The investigation of this outbreak of swine disease has once again demonstrated the existence of a highly infectious, extremely fatal disease, which can not be included under hog cholera, and which without difficulty may be ranked with hog cholera in economic importance to the farmers of the country.

Its mode of introduction into a herd is probably mainly through sick animals, which are suffering from the disease in a chronic form and are the remnants of other outbreaks sold by unscrupulous persons or those who are not aware of the dangers and losses to which they may subject owners of swine into whose herds these remnants are taken.

The disease still awaits a complete explanation of its various characters, however, more especially as to any other channels by which it may be transmitted from herd to herd, from animal to animal, and its capacity for thus transmitting itself, which capacity was very feeble in the disease after it had been brought to the Station. Meanwhile the same rules of prevention* and for the application of disinfectants apply to both swine plague and hog cholera, although there are points of difference which need not be dwelt upon in this connection.

TWO OUTBREAKS OF HOG CHOLERA.

Two other outbreaks of swine disease may be briefly mentioned, inasmuch as there was no difficulty in making the diagnosis of hog cholera.

A limited outbreak was reported as having occurred in the District of Columbia, a few miles from Washington City, during September. There were eight in the herd, all of which died with the exception of one, which was brought to the Experiment Station for examination. After lingering several weeks it also died. The most important lesions found were superficial necrosis of the ileum and about a dozen large ulcers in the large intestine. *The lungs were normal and in the spleen hog cholera bacilli were detected,* which produced by inoculation the characteristic disease in rabbits.

The disease was traceable to the Washington market, where the animals were purchased. This is not the first time that outbreaks in the vicinity of Washington have been traced to this source.

Another outbreak was investigated by Dr. E. C. Schroeder at Quantico, Virginia, during October, whose report may be briefly summed up as follows:

On October 28 Dr. Schroeder made *post-mortem* examinations of two pigs which had been dragged from the farms where they belonged to the common to be disposed of by the buzzards. One had been dead one or more days, the other was still warm, having died very probably only a few hours before. In the first animal were noted enlarged spleen, reddening of mucous membrane of the stomach, numerous ulcers in the large intestine. In the lungs were a few small collapsed areas, otherwise they were healthy.

In the second animal the lesions were practically the same. There was no consolidation of lung tissue as in the preceding case. From the spleen of this animal cultures were made and these contained only hog cholera bacilli, which produced in rabbits the peculiar and characteristic inoculation disease of the hog cholera germ.

Dr. Schroeder furthermore was informed that hundreds of pigs had perished of hog cholera this season. The manner of disposing

*See Report of the Bureau of Animal Industry for 1887–'88, page 148; Bulletin on hog cholera, page 123; report of the Secretary of Agriculture for 1888, page 156.

of the carcasses mentioned above, as well as the custom there prevalent of allowing swine to roam at large over the country does not make this extension of the disease appear at all surprising.

INVESTIGATION OF E. A. V. SCHWEINITZ, PH. D.

The following is a brief account by Dr. E. A. v. Schweinitz of the chemical investigations conducted under the direction of the chief of the Bureau of Animal Industry into the nature and effects of the chemical products developed during the growth of the microbes of hog cholera and swine plague:

In January, 1890, the writer was appointed to take charge of the chemical work of the Bureau of Animal Industry and investigate the chemical side of the diseases of animals, especially hog cholera and swine plague. It was necessary first of all to secure laboratory room suited to this class of investigation. On account of the crowded condition of the offices of the Department, space was procured by partitioning off rooms in the Museum building. This laboratory was supplied with water, gas, and steam, the necessary working desks, apparatus and chemicals, and by April 1 it was in proper condition to begin the investigations.

HOG CHOLERA.

The first problem undertaken was the study of the culture liquids of the hog cholera germ. Investigations of recent years have shown that when different disease germs are allowed to multiply in artificial nourishing media, as beef broth, they form substances which have the general composition of alkaloids and proteids, and give a number of the chemical reactions characteristic of these two classes of bodies. The alkaloids formed by germs are called, as a class, ptomaines, and the proteids, albumoses. Some of these substances, that have been isolated, are very poisonous in small doses; others only slightly so, or not at all. The fatal effects of a number of diseases which are known to be produced by specific germs are held to be due to the fact that the multiplication of the germ in the animal organism, just as when allowed to grow upon artificial media, forms large quantities of these poisonous alkaloids and proteids, which in their turn produce death.

This suggests the inquiry: If this be true can not these poisons be isolated by chemical methods and their exact nature and properties determined? Further, is it not possible by giving small doses of these poisons at a time to so accustom the animal organism to their effect that a subsequent large dose of the same poison, even when produced in the body by the active multiplication of the germ, would not result fatally? That this object may be accomplished by treating animals with sterilized artificial culture media, in which the germ had been allowed to grow for some time, was demonstrated by the work of this Bureau upon pigeons in 1887.

The problems for solution were:

(1) To isolate the chemical compounds, alkaloidal and albuminoidal, which the hog cholera germ forms.

(2) Determine whether one or more of these compounds exist in the artificial culture liquids.

(3) Which are the important ones?

(4) Will the isolated compounds produce immunity in animals from the disease of hog cholera?

(5) What is their exact chemical constitution?
(6) Are there known compounds of the same or similar composition, or one that can replace them?
(7) Can these compounds be made artificially?
(8) Can chemical inoculation be made practical, and if so, what is the minimum amount of substance and time required?

The results of the experiments permit of positive answers being given to all of these questions except the last so far as the disease of hog cholera is concerned, and only some details remain to be worked out.

After a number of experiments we found that acid beef infusion containing one half per cent. of peptone is the most satisfactory medium in which to grow the bacillus of hog cholera. Erlenmeyer flasks of 500 cubic centimeter capacity were used to contain the liquids, the mouths of the flasks being closed with a cotton plug, and after inoculation allowed to stand in the incubator at 37° C. for two to three weeks. The liquids had by this time become alkaline in reaction and careful examination showed that there was no contamination with foreign germs. In isolating the chemical products from these solutions the methods by which Brieger has obtained such excellent results were with slight modifications followed.

The culture liquid, after being neutralized with dilute hydrochloric acid, was evaporated on the water bath. The residue was then extracted with 96 per cent. alcohol and the filtered solution treated with mercuric chloride. A heavy crystalline precipitate was formed which increased upon standing. After filtration this precipitate was treated with water, decomposed with sulphuretted hydrogen, and the mercury sulphide removed by filtration. From the filtrate, after removal of the excess of sulphuretted hydrogen and concentration, I was able to isolate cadaverine and methylamine. The filtrate from the mercuric chloride precipitate was freed from excess of mercury by sulphuretted hydrogen, and the mercury sulphide filtered off. The residue, after concentration of this filtrate, was extracted with absolute alcohol, the solution thus obtained showing the presence of a salt of an alkaloidal character. The reactions were as follows:

With phosphomolybdic acid—light yellow precipitate;
With bismuth potassium iodide—red needles;
With phosphotungstic acid—a white precipitate;
With potassium iodide and iodine—brown red precipitate;
With platinum chloride—yellow crystalline precipitate;
With gold chloride—yellow red crystalline precipitate.

Subsequently the use of mercuric chloride was omitted, and repeated extraction of the residue with alcohol alone substituted.

The double salt obtained with platinum chloride was submitted, after crystallization from 96 per cent. alcohol, to preliminary analysis, giving results which correspond to the formula, $C_{14}H_{34}N_2PtCl_6$. The free base I have not yet succeeded in obtaining in a pure form. The hydrochloride of this base is soluble in absolute alcohol as well as water, and can be obtained as needle-like crystals.

By treating the original culture liquids of the hog cholera germ with a large excess of absolute alcohol, a white flocculent precipitate was obtained, a portion of which was soluble in water and could again be precipitated by alcohol. By repeated treatment of this sort with water and alcohol a small quantity of an albuminoid body containing carbon, hydrogen, nitrogen, oxygen, and sulphur, was finally obtained. This substance, which we will call albumose, was dried over sulphuric acid in vacuo, giving white translucent crystalline plates. After drying it was still soluble in water, though dissolving with more difficulty. The water solution gave with platinum chloride an almost soluble precipitate, appearing under the microscope as needle-like crystals. The composition of this platinum salt shows it to be a substance allied in composition to peptone. As to the exact nature of this latter substance, whether it is a true proteid or belongs to the class of ferments, remains to be determined by subsequent study and investigation.

Brieger and Fraenkel (*Ber. Klin. Woch.*, 1890, No. 11), who have extracted a similar substance from culture liquids of the diphtheria, tetanus, and cholera germs, and Baginsky and Stadthagen (*Ber. Klin. Woch.*, 1890, No. 13), who obtained an allied body from cultures of the cholera-infantum germ, hold that the substances are proteids. Roux and Yersin (*Annales de l'Institut*, Pasteur, 1890, p. 385), on the contrary, hold that the substances obtained by the precipitation with alcohol are ferments. Hankin (*British Medical Journal*, July 12, 1890, p. 65), who has also isolated a substance from cultures of anthrax possessing albuminoid properties, holds the same view as Brieger and Fraenkel, that the body in question belongs to the class of proteids.

In so far as our work upon the hog-cholera culture liquids goes, we are inclined to the opinion that we have to deal with albumoses, which can be heated in presence of acids to 70° without decomposition. I am preparing now a considerable quantity of this albumose and hope to be able in a short time to have something more definite as to its exact nature. To be sure that the substance one is dealing with is absolutely pure is very difficult when it is a body of this nature, and only extended experiments can be regarded as conclusive.

As to the nature of the new ptomaine which has been isolated, we will not go into a discussion of its exact chemical composition until it is more definitely determined.

In order, however, to distinguish the active principles formed by the hog-cholera germ, I have named the ptomaines as a class sucholotoxins, and the new base sucholotoxin (from the Greek Σῦς, a hog, Χολέρα, cholera, from Χολή, bile, and Τοξικόν, poison). To the proteid body I have given the name sucholoalbumin. These names will be used in referring to these bodies in the future.

Some experiments were made later, but may be inserted here, in regard to substituting some other material for peptonized beef infusion in furnishing nourishing media for the artificial cultivation of the germ. Potato broth, pea broth, and plain beef infusion have been used. In all of these the hog-cholera germ grows very vigorously, forming the ptomaines and albumoses, but not in so large a quantity as in the peptonized beef infusion.

Now, in regard to the toxic effect of the sucholotoxin and sucholoalbumin, active poisons for guinea pigs, in small doses, they are not. In large doses, corresponding to from 6 to 15 cubic centimeters of the culture liquid, death is produced in guinea pigs in from six to twenty-four hours. A small subcutaneous injection causes the animal to appear stupid and uncomfortable for a short time, fifteen minutes, produces a slight rise in temperature, necrosis of tissue, and ulceration at the point of injection.

It may be added here that in making these and all the following experiments special precautions were taken to prove that the material used was entirely free from germs. Cultures were always made from the substances used for injection.

The autopsy of a case resulting from poisoning with the ptomaines may be inserted here: Liver, pale and fatty; subcutaneous tissue over abdomen necrosed, and infiltrated muscle soft and friable. Other organs apparently normal.

The next point to be decided was: Can immunity be produced from hog cholera by previously treating the animals with these substances, isolated from the culture liquids? The results are recorded in the following experiments, which are very conclusive. For the laboratory experiments guinea pigs were used as being convenient to handle and susceptible to hog cholera. They have proved very satisfactory.

The first of our experiments that we will record were made with sucholotoxin.

Experiment I.—Two guinea pigs, each weighing about three-fourths of a pound, were treated with a solution of about 0.05 gram of sucholotoxin hydrochloride each. The solution was introduced under the skin of the inner side of the left thigh. Immediately after the operation the animals appeared uncomfortable, but were not made ill. For a few days there was a rise in temperature and also a slight swelling at the point of inoculation, which, however, disappeared in about five days, and the animals were then well.

Two more guinea pigs were now selected as checks, approximately of the same size and weight as those which had been treated, and the four animals were then inoculated with 0.1 cubic centimeter of hog cholera virus each (0.1 cubic centimeter beef infusion peptone culture one day old, plus 0.2 of sterile, normal salt solution). This is the dose which previous experiments made in the Bureau had shown to be the proper quantity to kill a guinea pig in from eight to ten days. The inoculations with the virus were also made subcutaneously in the thigh. The checks died in eight and nine days.

Of the animals which had been first treated with the substance mentioned, and afterwards inoculated, one died two days after the last check. The other guinea pig of this set was quite ill for ten days, with a large swelling at the point of inoculation. This finally opened and healed, and the animal was quite well within three weeks after the inoculation, and has continued so to date—five months.

Experiment II.—The next series of experiments were made with sucholoalbumin from beef infusion peptone culture media.

Two guinea pigs were again selected and treated with about 0.008 gram each of sucholoalbumin. There was a slight rise of temperature in the animals and the formation of a small, hard lump at the point of injection. This disappeared by the eighth day and the animals were quite well. Two more guinea pigs were now taken as checks, and all four animals were inoculated with 0.10 cubic centimeter of hog cholera culture. The checks died within seven days. The *post-mortem* appearances were practically the same as those noted in the first series. The two guinea pigs which had been treated with the sucholoalbumin died *ten* days after the checks. This indicates considerable resistance to the disease. Several other experiments were made by treating guinea pigs with the albumin in varying quantities, all showing resistance, and subsequently immunity.

Experiment III.—Three guinea pigs were treated with sucholoalbumin, 0.1 gram being given to each, subcutaneously in the thigh. The albumin for two of the animals was derived from cultures containing blood serum, the albumose given to the third was from ordinary beef infusion peptone culture. Ugly ulcers formed at the point of inoculation, which healed, however, in from ten to fourteen days, and the animals, with the exception of a slight rise of temperature, were well.

Two checks were again selected and the five animals were inoculated with 0.10 cubic centimeter hog cholera virus. The checks died, respectively, in eight and ten days from hog cholera. The animals which had received the preventive treatment were slightly ill for a few days with swelling at the point of inoculation, which finally opened and then healed nicely, and within a week the guinea pigs were well.

Three weeks after the inoculation one of these animals was chloroformed and examined *post-mortem*. Not the slightest scar could be discovered, all the organs appeared perfectly normal, and no germs were found.

Experiment IV.—Four guinea pigs were treated, two with a mixture of sucholotoxins, two with sucholotoxin and albumin. The injections were made as before, subcutaneously in the thighs, and at intervals extending over a period of four weeks. The sore caused by each injection was allowed to heal before the next one was made. After the animals had recovered from the last treatment two checks were selected, and the six were each inoculated with one tenth cubic centimeter hog cholera virus. The checks died, one in eight and the other in ten days, the *post-mortem* examination showing characteristic hog cholera lesions. The animals having the preventive treatment were ill about four days, those that received only the sucholotoxins being more dull than the others. There was also slight swelling at the point of inoculation with the germ, which subsided in ten days, after which the animals were perfectly well, and have remained so four months.

Experiment V.—Six guinea pigs were inoculated for this experiment, two with solution of the sucholotoxin and four with a solution of the mixed sucholotoxins. The sucholotoxin solution produced only slight local lesions, while the mixed toxins caused ulceration at the point of injection which did not heal for two weeks. The animals having by this time recovered, the test experiment with hog cholera virus was tried. Four of the animals mentioned above were taken—two from each set—and also two checks, and the six were inoculated. The checks died in eight and nine days, the autopsies showing the characteristic conditions of death from hog cholera. Those that had the preventive treatment were ill and dull for from four to six days after the inoculation. At the point of inoculation there was also some swelling and infiltration, very slight, however, compared with the similar swelling on the checks. In the treated animals the swelling sloughed and healed, and within ten days after the inoculation they were perfectly well. To test the resistance of the animals that had been treated by this method to ordinary exposure the following experiments were conducted.

Experiment VI.—Two guinea pigs that had received the preventive treatment, two blanks—*i. e.*, animals that had received no treatment—and two check animals that were inoculated with hog cholera virus were placed in one large cage. The checks became ill and died in eight or nine days from hog cholera. During this time the cage was cleaned only three times, so as to give full and free opportunity for contagion. One week after the checks had died one of the blanks became ill, and died within ten days. The autopsy showed hog cholera lesions. The second blank became ill a few days after the first blank succumbed, and died within thirty days. The animals which had the preventive treatment are now and have been quite well, though continually exposed for five weeks to every opportunity for contagion.

These experiments have answered conclusively the first five propositions named in the beginning of this report, and brings us to the sixth. Can these substances be replaced by one of allied composition and character that we already know and can prepare synthetically in the laboratory? The experiments also give an affirmative answer to this problem. If the ptomaines when introduced into the system produce certain changes, or induce certain powers of resistance on the part of the animal to subsequent doses of the poison, then it is possible that not only this one particular alkaloid but several, belonging to the same class and of approximately the same chemical composition, should produce similar effects when introduced into the system, as the true ptomaine extracted from the culture liquids, and subsequently immunity should result, when the animal should be exposed to the virus of hog cholera. I thought of a substance which could be prepared without difficulty, and which I will refer to as pure chemical. Some of it was prepared and the solution used for injection. The injections and treatment were conducted in the same manner as already recorded for the other guinea pigs, three animals being used for this experiment.

Experiment VII.—There was a slight rise in temperature of the animals and swelling and soreness at the point of injection. After this had healed these animals and two checks were inoculated with one tenth cubic centimeter of hog cholera culture. The checks died in eight and nine days. The animals which had been previously treated became ill, two dying five and six days after the checks. The third entirely recovered.

Experiment VIII.—One guinea pig was treated with a solution of the chemical in the same way as the previous experiment, except that a somewhat larger dose was given. Two pigs were again taken for checks, and the three inoculated with 0.1 cubic centimeter hog cholera culture. The checks died in six and seven days, respectively, of hog cholera; the treated animal recovered entirely. In the treated animal there was a slight swelling at point of inoculation with the germ, but this gradually decreased, finally opened, sloughed, and healed within a few days after the death of the checks.

Experiment IX.—Four guinea pigs were treated with a solution of the chemical substance. This modification of the injections was adopted, *i. e.*, very small quantities were used at a time and the dose repeated every day. The local irritation was in this way much diminished and what soreness was produced healed more rapidly. Two checks were taken and the six animals inoculated with 0.1 cubic centimeter of hog cholera culture. The checks died of hog cholera in eight days, one vaccinated pig in thirteen days, the others recovered.

Experiments were also made in producing immunity with the ptomaines obtained from the potato, pea, and simple beef broth cultures, which resulted successfully.

Two of the guinea pigs which had recovered from experiment IV, and two that had recovered from experiment V, were now reinoculated with double the dose of hog cholera virus used in the first test.

Checks were taken and given one half dose in quantity of the virus. These died in eight and nine days. The other pigs were a little stupid for a day or so, but at no time ill, and have since remained perfectly well.

One pig from experiment V, and one from experiment III, were chloroformed four or five weeks after their recovery, and an autopsy made. All the organs appeared perfectly normal, not even a scar being left at the point of injection, and the immunity produced was therefore perfect.

Our experiments had now proved that the chemical principles produced by the germ could be isolated; that their injection into guinea pigs rendered the animals secure against an attack of hog cholera, and that we have at hand a compound fairly easily obtained which will give the same results in securing immunity.

EXPERIMENTS UPON HOGS.

The next question was: Will these same materials produce immunity in hogs, and can the production of immunity by this method be made practical? The experiments were carried on at the Animal Experiment Station of the Bureau. The injections were made by Dr. Kilborne, who recorded the notes upon the condition of the animals. Necessarily the hogs were not as easy to handle as the guinea pigs, and the first experiment, which is the only one complete at this time, is not conclusive; but considering the time which must elapse before a question of this sort can be positively decided we regard the ultimate practical solution of the problem only as a question of detail, which a few more experiments will enable us to decide.

In order to test the value of this ptomaine, which had proved so satisfactory for guinea pigs, and also of the synthetically prepared chemical compound upon hogs, the following experiment was conducted:

Nine pigs, black Essex grade, aged three months, were selected, four of them being placed in one pen and five in another.

Pig No. 374, aged three months, weight 60 pounds, treated on July 26 with solution of the ptomaine, 18 cubic centimeters of solution were used, the injection being made subcutaneously at three points. On July 30 there was a large swelling at seat of injection. By August 8 this had sufficiently healed to permit of injecting more of the solution of the ptomaine. The dose was repeated on August 16. August 20 there was swelling (lumps the size of a hen's egg), at the points of injection. These sores had healed by sloughing, and on September 9 the animal was inoculated in the femoral vein with 2 cubic centimeters of beef infusion peptone hog cholera culture, one day old.

Pig No. 375, aged three months (weight 60 pounds), was treated in the same way as pig No. 374, with solution of the ptomaines, and showed the same soreness and symptoms. On September 9 inoculated with 2 cubic centimeters of hog cholera beef infusion peptone culture one day old.

Pig No. 376, aged three months (weight 50 pounds), treated with ptomaines as other two and inoculated September 9 with 2 cubic centimeters beef infusion peptone hog cholera culture.

Pig No. 377, aged three months (weight 50 pounds), treated on same dates as the above with a solution of the synthetical compound and inoculated September 9 with 2 cubic centimeters beef infusion peptone hog cholera culture one day old.

Pig No. 378, aged three months (weight 45 pounds), treated in same way as pig No. 377, and inoculated September 9 with 2 cubic centimeters beef infusion peptone hog cholera culture.

Pig No. 379, aged three months (weight 60 pounds);
Pig No. 380, aged three months (weight 69 pounds);
Pig No. 381, aged three months (weight 50 pounds);
Pig No. 382, aged three months (weight 50 pounds), were all inoculated in the vein on September 9 with 2 cubic centimeters beef infusion peptone hog cholera culture one day old. These served as checks to Nos. 374 to 378, inclusive.

The results of this experiment were that of four checks three died, two in four and five days after the inoculation with the germ, the third in seventeen days, and the fourth check recovered.

Of the three pigs treated with the ptomaine one recovered, two died in five and six days after the inoculation.

Of the two pigs treated with the synthetical compound one died in thirty-nine days after the inoculation and fourteen days after the last check; the other one recovered entirely. Though this experiment is not conclusive, it certainly indicates that the pigs which had been treated offered considerable resistance to the disease, and that the synthetical compound is more effective than the ptomaine obtained from the culture liquids.

Had a somewhat larger quantity of the ptomaines been used for treatment, and the injections been made in smaller quantities, extending over a longer period of time, it is probable that all the treated animals would have recovered. At any rate we are sufficiently encouraged to continue the experiments. I may take occasion here to mention the valuable assistance rendered me by Dr. V. A. Moore in connection with the bacteriological work, autopsies, etc., and by Dr. Theobald Smith in allowing the use of the facilities of the bacteriological laboratory in his charge, and also the uniform kindly encouragement of Dr. Salmon, Chief of the Bureau.

SWINE PLAGUE.

While awaiting the results of further experiments upon hog cholera it was thought well to begin a study of the swine plague cultures, with the object of obtaining from them albuminoid and alkaloid poisons. The swine plague germ grows but slightly in the ordinary beef infusion culture. Dr. Moore, however, found that if instead of making a simple beef infusion a beef broth was prepared by boiling the meat the growth of the swine plague germ in this liquid was much more abundant. Alkaline media of this description were therefore used, 1,000 cubic centimeters in Erlenmeyer flasks being inoculated and kept in the incubator for two days at a temperature of 37° C. The growth of the germ was by this time very perceptible. The contents of the flasks proved to be uncontaminated. When opened a disagreeable, pungent odor was noticed.

After filtration about eight times its volume of absolute alcohol was added to the solution, and a considerable amount of a white flocculent precipitate was obtained. This, after settling, was filtered off, redissolved with water and again precipitated with absolute alcohol. The precipitate was thoroughly washed with absolute alcohol and dried over sulphuric acid in vacuo. A white translucent mass was thus obtained, with difficulty soluble in water and having properties of an albuminoid or proteid body. The filtrate from the albumose was neutralized with hydrocholoric acid evaporated to dryness, and the residue extracted with absolute alcohol. This alcohol extract gave alkaloidal reactions with mercuric chloride, phosphomolybdic acid, platinum chloride, etc., showing the presence of a ptomaine. The double platinum salt of this body I have prepared, but have not at this writing been able to make a satisfactory analysis of it. I have demonstrated, however, the existence in the culture liquids of the swine plague germ of a ptomaine and albumose. The name suplagatoxin may be given to the ptomaine (from the Greek *ευζ*, a hog, *πληγή*, plague, and *τοξικόν*, poison), and suplagoalbumin to the albumose. This would be distinctive from the *hog cholera* ptomaines. While purifying a larger quantity of these substances in order to make a closer study of them chemically, I thought it advisable to use the material at hand for making some experiments in the production of immunity in guinea pigs from swine plague by preventive treatment. Previous to this Dr. Moore had made a number of inoculations of guinea pigs with swine plague, which showed that one one-thousandth of a cubic centimeter of beef infusion peptone culture of swine plague one day old, was sufficient to kill a guinea pig in from twenty-four to forty-eight hours. Further, in order to see if the treatment which proved satisfactory for producing immunity against hog cholera might have any effect in retarding the disease of swine plague, two guinea pigs that had been submitted to the preventive treatment for hog cholera, but never exposed by inoculation, were inoculated with one one-thousandth of a cubic centimeter of beef infusion swine plague culture one day old. Both animals succumbed in forty-eight hours to the disease of swine plague. Two guinea pigs that had been subjected to the preventive treatment, then inoculated with hog cholera and recovered and were perfectly well, were inoculated with one one-thousandth of a cubic centimeter each of beef infusion peptone swine plague culture one day old. Both died, as was expected, in forty-eight hours. These experiments serve further to demonstrate, if proof is necessary, that the diseases of hog cholera and swine plague are distinct, and that an animal that has had the hog cholera and recovered is still susceptible as ever to the swine plague.

Experiment XII.—Two guinea pigs were selected, and on three successive days .0030 gram of swine plague albumose was injected subcutaneously in the thigh. About .0010 gram of substance was given at each injection. There was a slight swelling at the point of injection, which disappeared in four or five days and the animal appeared well. Two checks were now taken and the four inoculated with one one-thousandth of a cubic centimeter swine plague culture. The checks died, one in forty-eight hours and the other in thirty-six hours. The treated pigs appeared a little stupid for a day or two and then recovered entirely.

Experiment XIII.—Two guinea pigs were treated with a solution of the ptomaine extracted from the culture liquids. The injections were made subcutaneously in the inner side of thigh, the quantity of ptomaine used corresponding to about 15 cubic centimeters of the culture medium. There was a slight swelling and soreness at the point of injection, but otherwise the pigs appeared well. These, together with two checks, were inoculated with one one-thousandth of a cubic centimeter of swine plague culture. The checks died of swine plague. One of the treated animals died in thirty-six hours. The autopsy, however, showed but few marked characteristics of swine plague. At the point of inoculation there was a slight infiltration. Blood vessels in heart much injected; liver slightly reddened. Bladder distended with urine. Otherwise the organs were normal. Coverglass from spleen and liver showed *no swine plague germs*, but cultures from the liver showed that the swine plague germ was present. The other treated pig died five days after the checks, or eight days after the inoculation.

The ptomaine, therefore, produced resistance and a large dose would probably give immunity.

These few experiments, following the more extended ones upon hog cholera, prove conclusively that both these diseases can be prevented in guinea pigs by chemical inoculation. The experiments upon swine plague will be extended and a careful study made of the ptomaine and albumose produced by this germ, and their effect upon hogs.

Hankin holds that albumose is the one and principal factor in the production of immunity, and that the reason more results have not been secured in this direction is because the proper material has never been used. We think, however, that the albumose is only an intermediate product of the germs and the final and most fatal effect of the disease results from the ptomaines. At any rate the experiments upon hog cholera lead to the conclusion that while a mixture of the albumose and ptomaine seems to produce greater immunity than either substance alone, nevertheless when used separately they are of about equal value.

MISCELLANEOUS.

In addition to the study in connection with the disease just recorded the writer has given some little attention to the presence of tyrotoxicon in milk. In May a sample of milk from Maryland came into his hands which was supposed to have caused the sickness of a number of children. The symptoms as given indicated a possible tyrotoxicon poisoning. The milk was examined for the poison, but the latter could not be detected. Some months after this some cheese, which had produced sickness in this city, and two lots which had caused illness in Ohio, were received. In all three cases the questionable tyrotoxicon was blamed for the sickness. I could not, however, establish the presence of tyrotoxicon in any instance by the methods prescribed by Vaughan. This led me to repeat one of Vaughan's experiments, which should have given me considerable quantities of tyrotoxicon. Half a gallon of fresh normal milk was placed in a loosely stoppered glass jar and allowed to stand at the temperature of the room for three months during the summer. At the end of this time it was examined for tyrotoxicon, but the test failed to establish its presence. From this milk as well as from the samples of cheese Dr. Moore isolated several different germs, but other more important work has prevented a closer study of these and their products.

Our own experiments, supported by the negative results of a number of other chemists, force us to conclude that the toxic principles of poisonous cheese and milk have not been yet sufficiently studied, and that there is here a very important field for further investigations.

A number of other unimportant examinations and analyses have been made, but the facts established in regard to hog cholera and swine plague are the important results of our six months' work.

Tabulated experiments in producing immunity from hog cholera in guinea pigs.

No. of experiment.	Material used for treatment.	Hog cholera virus used for each animal.	No. of animals used.	No. of checks.	No. of days between inoculation with virus and death of checks.	Result in treated animal.
		Cc.				
I	Sucholotoxin	0.10	2	2	8 and 9	One died in 11 days; one recovered.
II	Sucholoalbumin	0.10	2	2	7	Died in 17 days; great resistance.
III	....do	0.10	3	2	8 and 10	Recovered; immunity.
IV	1. Sucholotoxins	0.10	2	....	....	Do.
	2. Sucholotoxin and albumin.	0.10	2	2	8 and 10	Do.
V	1. Sucholotoxin	0.10	2	....	....	
	2. Sucholotoxins	0.10	2	2	8 and 9	Do.
VI	Sucholotoxins	0.10	2	2 and 2 blanks.	8 and 9	Blanks died in 18 and 30 days; others not affected; immunity
VII	Pure chemical	0.10	3	2	8 and 9	Two died in 13 and 14 days; third recovered; immunity.
VIII	....do	0.10	2	2	6 and 7	Recovered; immunity.
IX	....do	0.10	4	2	8	One died in 13 days; others recovered; immunity.

EXPERIMENTS UPON HOGS (ESSEX GRADE).

X	Sucholotoxins	2	3	....	4 and 5	Two died in 5 days.
XI	Pure chemical	2	2	4	and 17 days; one recovered.	One in 36 days; two recovered; resistance.

EXPERIMENTS IN PRODUCING IMMUNITY FROM SWINE PLAGUE IN GUINEA PIGS.

XII	Suplagatoxin	$\frac{1}{1000}$	2	2	2 and 3	Recovered; immunity.
XIII	Suplagoalbumin	$\frac{1}{1000}$	2	2	2 and 3	One in 3 days, the other in 8 days.

REPORT OF THE CHEMIST.

WASHINGTON, D. C., *December* 22, 1890.

SIR: I have the honor to submit herewith a brief report of the work of my Division during the past year.

I am, respectfully,

H. W. WILEY,
Chemist.

Hon. J. M. RUSK,
Secretary.

STUDIES ON THE SEPARATION OF SUGAR FROM SORGHUM JUICES.

For many years attempts have been made by the division to secure a more perfect separation of the sugar from the non-sugars in sorghum juices. Extensive practical experiments were made in this direction at Fort Scott in 1886, in the practical application of the process of carbonatation.

This process consists in the addition to the mill or diffusion juices of large quantities of lime, from 1.5 per cent to 3 per cent of the weight of the juice, according to the amount of impurities present. The lime is then precipitated by blowing through the liquid a current of carbonic acid derived from a limekiln or coke furnace, or even from the chimneys of the boiler furnaces. The result of this process was entirely successful in respect of the yield of sugar, but on account of the blackening of the molasses, which was at that time a valuable by-product, it met with no favor from sorghum sugar manufacturers, but on the contrary was condemned by them as being unsuitable for the purpose.

Subsequently extensive laboratory experiments were made looking to the precipitation of the crystallizable sugar in the juices as sucrates of lime. The process employed in the Steffen method of separating sugar from beet-root molasses was the one tried for this purpose. While these experiments were successful in separating the crystallizable sugars in the form of a precipitate, they were not wholly so in securing a separation from the non-sugars, the greater part of which were also thrown down as lime compounds or carried down mechanically with the precipitated sugar. This process was, therefore, abandoned as not being practical.

The destruction of the reducing sugars or glucoses present by boiling with excess of quicklime was next tried. This process was entirely successful in so far as destroying the glucoses was concerned, but it had no effect whatever upon the other carbohydrates, of an amorphous nature, present in the juices. Inasmuch as the glucoses exert the least unfavorable influence of the non-sugars present in the juices the process was at once seen to be inapplicable from a practical point of view. The experience of the Department, and of manufacturers of sugar, has shown that the reducing sugars known generally under the term of glucoses, exercise a much less influence in preventing the crystallization of the sugars than was formerly supposed. In fact, it is supposed that could all other disturbing influences be removed, the glucose might be unobjectionable in securing an almost complete crystallization of the sucrose present in the juices. It would furnish a mother liquor in which the crystallizable sugar would be highly insoluble and from which it would easily separate. Having abandoned, therefore, the methods of separation above noted, there remained to be studied some process which would separate as nearly as possible the gummy amorphous bodies from the juices without precipitating the sugar. The property of alcohol to produce precipitation in sorghum juice was made use of in the further study of this problem. On account, however, of the large amount of alcohol, which would be required to treat the juices in their natural state, or as they come from the diffusion battery, it was decided to apply the process at a later period of manufacture.

In order to carry out this idea the juices of sorghum were treated precisely in the manner in which they are ordinarily in a sugar factory. The natural acidity of the juices was carefully neutralized with lime and the temperature raised to the boiling point. The scums which were formed were carefully removed and the juice boiled in an open dish, until all greenish scums and coagulated matters were separated.

The inversion of sugar which takes place during the boiling, which lasts only a few minutes, was not noteworthy. The juices were next concentrated in vacuo until they reached a density of 45° to 50° Brix. After cooling, the sirup thus formed was mixed with an equal volume of 95 per cent alcohol, which was sufficient to produce a complete precipitation of the gummy amorphous matters. These matters were separated by passing through a filter press, forming a hard, firm cake, easily separated from the filter cloth. The filtered sirup was limpid and of an exceptionally pleasant flavor. Evaporating in vacuo after removal of the alcohol, it readily crystallized during evaporation, forming a massecuite of good grain and absolutely free from gum and capable of being treated most easily in a centrifugal.

From very poor sorghum juices from immature cane, having a purity of only 60, a most excellent article of massecuite and sugar was made by the above process.

In regard to the quantity of matters separated by alcohol, some determinations were made with the following results:

Percentage of gum secured by alcohol—	
Experiment 1	2.08
Experiment 2	1.88
Mean	1.98

The juices from which these separations were made contained about 16 per cent of solid matters; thus the percentage of matters secured by alcohol on the whole amount of solid matters present was 12.5

It is seen from the above data that from each 100 pounds of sorghum juice about 2 pounds of gum can be separated.

The difficulties which have been encountered in manufacturing sugar from sorghum juices have been chiefly due to the presence of these gums. Their removal, therefore, if it can be accomplished on a manufacturing basis, would at once place sorghum in a high rank as a sugar-producing plant.

The alcohol which is used in precipitation can be almost wholly recovered by subsequent distillation. Our experiments show that the total loss need not exceed 5 or, at most 10 per cent, of the quantity of alcohol used. One of the most encouraging and at the same time least expected results of the work has been the demonstration of the fact that the gum separated in the manner above described is completely fermentable, yielding almost one half its weight in alcohol. It thus appears that from the gums themselves a sufficient amount of alcohol may possibly be derived to supply the whole waste of alcohol which would take place in the process of manufacture. Any additional quantities of alcohol which might be needed could be easily obtained from the molasses after the extraction of all the crystallizable sugar. In other words, the process which has been demonstrated as thoroughly practical in the laboratory, so far as can be foreseen for the operation of an actual trial on a manufacturing scale, is capable of being conducted with economy, and a proper stock of alcohol once being provided the wastage therein in the process of manufacture could be wholly, or in great part at least, supplied by the refuse matter which otherwise would be a manufacturing waste.

Experiments were also made to determine the quantity of alcohol necessary to precipitate the total gum matters and also the strength of the alcohol required with the following results:

SORGHUM SIRUP, OF 44° BRIX AT 60° F.

On adding 15 cubic centimeters of 80 per cent alcohol, to 25 cubic centimeters of juice, the main part of the amorphous matters was precipitated.

Series of experiments.

[Comparison showing quantities of alcohol of 70, 80, and 90 per cent and of methyl alcohol (crude) necessary to precipitate 25 cubic centimeters of sirup, of 44° Brix at 60° F.]

	70 per cent.	80 per cent.	90 per cent.	Methyl alcohol.
	cc	*cc*	*cc*	*cc*
Chief precipitation of amorphous bodies	20	15	10	12
Total precipitation of those bodies	35	25	20	20

The portion of the amorphous bodies which is soluble in water becomes, in part, redissolved before filtration when precipitated with 70, and rather less so with 80 per cent alcohol.

The separation of the amorphous bodies can be attained on the manufacturing scale with 80 per cent alcohol by the application of 1 volume of alcohol to 1 volume of sirup of 44° Brix.

In order to illustrate the practical application of the method on a manufacturing scale in the manufacture of sorghum sugar the following theoretical data are given:

A normal sorghum juice may contain at 18° Brix 12 per cent of sugar; a normal sorghum sirup may contain at 44° Brix 29.33 per cent of sugar, which is equal to 29,330 pounds of sugar in 10,000 gallons of sirup. Of this, 29,330 pounds (from 7,280 to 13,000 pounds), or about an average of 10,000, has been obtained by the methods of manufacture in use.

By the use of alcohol for the removal of the amorphous bodies which prevent the crystallization of the sugar, the *minimum* per cent of sugar, which, after this process would be obtained, may be put at 80 per cent (87 per cent is usually computed from pure juices), or 23,464 pounds.

10,000 pounds, at 4 cents		$400
23,464 pounds, at 4 cents	$938	
Cost of alcohol lost in the work	84	
		854
Value of product, usual method	400	
Value of product, alcohol method	854	
A gain of		454

In this estimate the material from which the alcohol is made is not regarded as of any value, since it otherwise would be wasted. If the molasses be used as a source of alcohol, then the item for the cost thereof must be increased.

On account of the ease with which a heavy sirup can be preserved it has also been thought possible that during the manufacturing season the whole apparatus of the factory could be directed to making sirup alone which could be preserved and worked into sugar subsequently.

Inasmuch as it is highly important, in working a sorghum crop, to have it taken off in as short a time as possible, any scheme which will tend to simplify the operation during the harvesting season is worthy of consideration.

It is true that the storage of a whole crop of sirup would require considerable room and the cost of tanks or cellars in which it is to be held would be an item which could not be neglected. However, it must not be forgotten that by the storage system the machinery of the factory could be operated during a much longer period. For instance, it is well known that the harvesting operations and the manufacture of sugar must be chiefly conducted during the months of September and October. The manufacture of sirup into sugar, however, could be continued through the winter months, or if they were found too cold, the work could be safely left until the beginning of spring, when the factory could be again set in operation.

The whole of the apparatus for manufacturing the alcohol and for treating the sirup therewith could, therefore, be built on a much smaller scale than if it were necessary to treat the sirup as soon as it was manufactured during the months of September and October. With the sirup already made and stored in cisterns a very small force would be sufficient to convert the whole of it into sugar and at a very small expense. It would thus be possible for one factory to take care of a much larger crop of cane than it could possibly do were the whole of the manufacturing operations to be conducted at once.

The sirup as made and as it passes into cisterns could be subjected to the influence of sulphurous acid or some other anti-ferment which would be sufficient to preserve it perfectly from fermentation, even if there were danger of such a decomposition without any antiseptic treatment.

The storage capacity of a factory which would work 20,000 tons of sorghum cane will be seen from a perusal of the following data: Assuming of 20,000 tons of chips and 10 per cent marc we have, 11,782,030 pounds sirup at 55° Brix=volume of 149,988 cubic feet, requiring a cistern 20 by 86.5 by 86.5 feet. At 75° Brix=8,640,380 pounds=volume of 100,213 cubic feet, requiring a cistern 20 by 75 by 75 feet.

In the event of boiling from 55° to 75° Brix, the water evaporated will be, on 20,000 tons of cane chips, 3,141,650 pounds, or 377,150 gallons. Basing calculations on Yaryan's figures, the coal consumption (at 8½ pounds water per pound coal) in again evaporating from 55° to 75° Brix will be 369,600 pounds, using live steam altogether, as would be necessary in the contemplated division of the season. Hence the loss of coal occasioned by boiling to 75° Brix as a means of preserving and subsequent dilution would be 133,261 + 369,600 = 502,861÷2,240=225 tons, plus incidental losses, radiation, time, etc.

Placing the value of coal at $4 per ton, which is rather a high average, it is seen that the total additional expense, so far as fuel is concerned, involved in manufacturing the sugar after the harvesting of the crop, would be only about $900 a year, a very insignificant item when compared with the value of the time gained.

In order that this method of production of sugar may become possible, it will be necessary for the revenue laws to be changed so as to allow the preparation of the alcohol used in the process to be carried on without tax. This could be easily done without any danger of defrauding the revenue. The alcohol could be made under bond, given by the sugar manufacturer, that it should be used only for the purpose of separating the gummy matters from the sorghum juice, and should in no case enter commerce for any purpose whatever. In making this alcohol the manufacturer should be allowed to erect such apparatus as may be necessary, and this apparatus could be under the direct inspection of revenue officers in order that they might be able to see that the conditions of the bond were faithfully carried out.

It is earnestly recommended that the revenue laws be so amended as to allow a trial of this process by the sorghum-sugar makers of the country. If this can not be done without a further illustration, the law, at least, should be so adjusted as to permit the Department to make an experiment on a small scale with this method in connection with the work which it is now doing in the experimental station for the improvement of sorghum cane and the manufacture of sugar therefrom.

It is important also that the Department be empowered, by a special grant, to carry out these experiments in a practical way. From the best estimates which are now at my disposal I should say that a grant of $25,000 would be entirely sufficient to subject this process to an experimental trial. The magnitude of the interest involved is so great that it is hoped that no objection will be made to this experiment.

Not only is the increase in the output of sugar from sorghum cane to be taken into consideration, but also the improvement in the quality of the product. The sugar will be of a finer grade and much more easily separated from the molasses. The molasses instead of being, as it is now, a waste product scarcely marketable, and in many cases only fit for cattle food, will be suitable for table use and especially for mixing, in case compound sirups are desired. The flavor of both the sugar and the molasses produced is of the finest quality and of such a nature as to render it difficult to believe that it could have been made from sorghum, which, under ordinary circumstances, affords a molasses which is totally unpalatable.

This process having been outlined above in such a way as to indicate its true character, it is hoped it may be given to the sugar manufacturers of the country without interference from any patents which may be attempted to secure its provisions for private benefit. As our patent laws now stand any process which has not been in use for two years may be covered by letters patent, but in this case it must be distinctly proved that the inventor is, as he claims in his application, the true discoverer of the process. This process having been discovered and operated by the Chemical Division of this Department, is unpatentable, except by the Department, for the common use of the people.

THE COMPOSITION OF THE BODIES PRECIPITATED BY ALCOHOL FROM SORGHUM SIRUPS.

The existence of starch and allied bodies in sorghum juices has long been a matter of demonstration. It was deemed desirable, however, in connection with the practical work of separating from sorghum juices the mucilaginous and dismorphous bodies present to inquire more particularly into their nature. As has already been indicated, the chief melassigenic or molasses-forming properties of the non-sugars present in sorghum juices must be attributed to the gums, mucilaginous bodies, and difficultly crystallizable carbohydrates present therein. The percentage of alkaline salts in the ash of the sorghum is so small compared with that of the ash in beets as to reduce the molasses-forming properties of the salts of the ash to the lowest possible degree. Quantitative determination of the amount of bodies precipitated by alcohol from the normal expressed juice of sorghum cane shows that about 2 per cent of the total weight of the juice of the cane belong to this class of bodies. The precipitation was made in juices in which a portion of the albuminous matter, together with the chlorophyll present, had been removed by coagulation with heat and careful skimming. This quantity of precipitate may therefore be regarded as that which would be retained in the sorghum juices during the process of manufacture, and finally appear in the massecuites and molasses.

An account of the details of the work which has been done on these bodies would be of interest only to professional chemists and it is therefore omitted. It was found that they were composed chiefly of mucilages and gums, together with certain nitrogenous bodies and difficultly crystallizable carbohydrates, related to the starch series, and including some starch.

A full description of this work will be found in Bulletin No. 29. The work outlined above was done in co-operation with Mr. Walter Maxwell.

CHEMICAL CONTROL OF SORGHUM SUGAR FACTORIES.

The Department made no direct experiments during the season of 1890 in the manufacture of sorghum sugar. The work done was confined solely to chemical supervision of the processes of manufacture. To secure as wide an experience as possible in this direction chemists were detailed from the Department for the factories at Fort Scott, Topeka, Conway Springs, Attica, and Medicine Lodge, Kansas. A summary of the chemical work done, together with such data as were accessible, will be found following:

ATTICA.

Work at this station was started on the 19th of September and and continued, at intervals, until October 25. On this latter date one of the lower doors of the diffusion battery cell was broken and it was not thought worth while to repair the battery for the remaining portion of the crop. A very small quantity of cane remained unworked. The many difficulties encountered in the working of this house would render it unjust to make the results a test of the possibilities of manufacture of sorghum sugar.

The cane crop was much shortened by a severe drought, which set in about a month after the planting and continued unbroken for sixty days. The yield of cane per acre was reduced from 12 to 15 tons of last year to 5 and even 3 tons per acre. Chinch-bugs were also quite numerous and did considerable damage. Hot winds, the most dreaded enemy of the farmer in that region, were prevalent during the continuation of the drought. Not only was the crop shortened by the continued dry weather, but also the supply of water for the factory was inadequate, the small stream upon which dependence was placed having been completely dried up. Under these conditions the factory was not operated continuously, but only during the day.

The necessity of better cultivation of the cane fields was fully manifested in a number of instances. The fields which received poor cultivation were almost devoid of crops, while those which received the best cultivation yielded a fair crop in spite of the hot and dry weather. It was not until October 12 that there were sufficient rains to insure an ample supply of water for operating the factory, but at that time it was not possible to get enough cane to operate the factory.

The seed which had been received from the Department of Agriculture produced, in all cases, the best cane grown in the locality, averaging 4 and 5 tons per acre above all other varieties. The loss of a large quantity of sugar in the battery was owing to the heaters which leaked very badly. Another serious loss occurred between the clarifiers and double effects. This was due to the inability of the double effects to evaporate the juice extracted so that some of the thin juice was left sometimes as long as 12 hours before being concentrated and, of course, fermentation took place.

Special attention was given to studying the characteristics of the cane showing that certain physical properties are associated with high percentages of sugar. By studying these properties carefully, it is possible for every farmer to go into his field and be able to determine certainly whether his cane is ripe or not. The most striking of these properties is found in the last joint of the cane bearing the seed head. By stripping the cane of its covering a yellow coloration will be observed extending more or less along the length of the joint as the cane nears maturity. By the extent of this coloration one is able to select the very best or the very poorest canes in the field almost as accurately as though tested by a polariscope. It is found that the cane which has the highest sucrose, lowest glucose and highest purity has this coloration extending one-half the length of the joint. Should it be found to extend the full length, it shows that the cane has already commenced to deteriorate. On the other hand should no coloration be visible, it shows that the cane is not yet mature. These observations have extended over one season of rather remarkable characteristics and hence they may not prove equally applicable to a crop grown in a season with the ordinary amount of rainfall.

The analyses of the sorghum at Attica were commenced on the 9th of September and continued until the 24th of October. During this period one hundred and fifteen average samples, as taken from the field, were analyzed with the following mean results:

In the juice.

Per cent sucrose	14.26
Per cent reducing sugars or glucose	1.53
Purity coefficient	71.91
Maximum per cent sucrose	17.95
Minimum per cent sucrose	5.85
Maximum per cent reducing sugars or glucose	3.43
Minimum per cent reducing sugars or glucose	.55
Maximum purity of juice	90.80
Minimum purity of juice	35.83

Between the dates of October 6 and 9 the purities of the juices were remarkably high, averaging about 85, and the percentages of sucrose therein were almost 16, showing that at that season the cane was in the best condition for manufacture. The analyses, however, for the whole season show a cane well suited for the manufacture of sugar, and which should yield, if all the sugar could be obtained, except the quantity which would naturally stay in the molasses, quite 200 pounds to the ton of clean cane.

Many of the farmers found the growing of cane profitable, while in other cases quite a number failed to make any profit or cultivated the cane at a loss. The figures representing one farmer's account with the company will illustrate what may be secured in a poor season in the growing of sorghum cane.

Total weight of cane grown	pounds	357,735
Total weight of seed grown	do	74,915
Amount received for the cane		$357.74
Amount received for the seed		$35.18
Total receipts for the crop		$392.92

Against this sum the following expenses are to be charged:

Cost of planting	$37.50
Cost of cultivating	50.00
Cost of harvesting and delivering to mill	175.00
Total cost, as charged	262.50

Leaving a net profit of $130.42. The number of acres cultivated in this crop was 30, and on the numbers given above the profit per acre would be $4.35. It will be noticed in the above that no charge has been made for the rent of the land, which is, of course, a legitimate expense which must come out of the calculated profit per acre. The value of the land upon which this cane was grown is not known to me, but, judging from the average value of land in that locality, it may safely be put at $20 to $25 per acre; hence a deduction of $2 per acre should be made for rent of land, leaving a profit per acre of only $2.35 instead of $4.35.

The analyses of the samples of chips taken from the shredders as they pass to enter the battery, which samples give a fair estimate of the quality of the chips entering the diffusers, show, as is usual in all cases, a less saccharine strength than average samples of field cane. The reason of this difference is twofold. In the first place the samples of the first chips must of necessity give a better representation of the crop than any possible selection of single stalks or number of stalks of cane can give. In the second place, in spite of the best clarifying apparatus, particles of the blades and sheaths enter the shredder with the pieces of cane, and the juices of these are expressed afterward and mingle with the juices of the cane. Forty samples of these chips were analyzed during the season with the following mean results:

In the juice.

Sucrose....per cent..	12.56
Glucose....do....	1.99
Purity....	63.20

Thirty-two samples of the diffusion juices, representing the mean composition of the juices during the season, were subjected to analysis with the following mean results:

Sucrose....per cent..	7.99
Glucose....do....	1.20
Purity....	66.48

Thirty-two samples of the exhausted chips, representing the mean composition of the whole mass of exhausted chips during the season, were analyzed, the analyses showing that they contained 0.60 per cent of sucrose.

Twenty analyses of the filtered and clarified juices, representing the mean composition of the clarified juices of the whole season, showed the following average constitution:

Sucrose....per cent..	8.11
Glucose....do ...	1.01
Purity....	67.46

Seventeen analyses of the sirups before entering the strike pan, representing the average composition of the whole sirup worked during the season, gave the following mean results:

Sucrose....per cent..	32.91
Glucose....do....	7.12
Purity....	63.11

Eight analyses of the massecuites, representing the average composition of the whole mass produced during the season, gave the following mean results:

Sucrose....per cent..	54.89
Glucose....do....	12.32
Purity....	62.35

Five analyses of the second massecuites, boiled from the first molasses after the separation of the first mass of crystals, showed the following mean composition:

Sucrose....per cent..	47.52
Glucose....do....	12.77
Purity....	55.65

The total amount of field cane purchased during the season was 1,305.3 tons. After cleaning, the total weight of cane which entered the diffusion battery was 900.2 tons.

The theoretical percentage of sugar in the clean cane, as calculated from the juice of the chips, was 238.6 pounds.

The quantity of sugar obtained in a merchantable form can not be accurately known until the official report of the State Inspector is known. The quantity, however, in proportion to the total amount present was extremely small and probably did not exceed 75 or 80 pounds per ton.

The enormous losses, therefore, in manufacturing sorgum sugar which have always been noticed in practice are illustrated in a very emphatic manner by the results of the season's work at Attica. Such losses are due to the natural wastage during the process of manufacture, and are, of course, raised to an unusual degree where lack of skill exists in the manipulation of the factory. The chief losses, however, as heretofore, have been due to the character of the juice itself, presenting in its constitution peculiar difficulties in the separation of the crystallizable sugar present.

OPERATIONS OF THE TOPEKA FACTORY.

The Topeka Sugar Factory, which was destroyed by fire last year, was rebuilt during the present season and operated for the manufacture of sugar.

Difficulties of various kinds, but in no wise inherent to the process of manufacture, caused delays in the operations of the factory and rendered its work expensive. The supply of steam was not sufficient for the full working extent of the rest of the machinery, and the multiple effect pans were provided with very low domes, which rendered successful boiling difficult. Moreover, the fuel employed was of particularly bad quality. The pumping arrangements were found inadequate to provide an abundant supply of water.

The crop of cane was somewhat later in maturing than usual, due to the autumnal rains following a very dry summer. The crop ripened in a very irregular way, thus causing to be delivered to the factory canes in various stages of maturity. The amber cane reached its maximum maturity about the middle of September, and the orange cane about the middle of October.

The battery work was extremely irregular, the percentages of dilution ranging from 8 to 14, and the percentages of extraction of sugar from 80 to 95 per cent. The percentages of sucrose in the exhausted chips vary from 0.05 per cent to 2 per cent; the number of diffusion cells worked daily varied from twenty-three to one hundred and four, and the loss of time daily by stoppages was from two to fourteen hours. Under such irregular conditions of work, due generally to the causes already mentioned, it is not strange that attempts at the successful manufacture of sugar were fruitless.

Cane contracted for by the company was........acres..	1,200
Cane delivered to the mill was...................do...	1,000
Cane delivered..................................tons..	6,412
Yield of cane per acre..............................do...	6.41
Total amount of sugar made..................pounds..	278,687
Yield of sugar, per ton of field cane..............do...	43.57

By the term "field cane" is meant the cane with its blades and tops. The average amount of clean chips afforded by such cane is 75 per cent. of the total weight. The amount of clean cane, therefore, entering the battery under this estimate was 4,809 tons. The yield of sugar, per ton of clean cane chips, was therefore nearly 58 pounds.

The sampling of the chips entering the battery was made in the usual way so as to secure a fair average of the cane worked. The analyses of these samples were commenced on the 10th of September and were continued until the close of the house on the 8th of November.

Forty-seven samples of fresh chips were analyzed with the following mean results:

In the juice.

Total solids	per cent..	15.97
Sucrose	do....	10.15
Glucose	do....	2.14
Purity		63.56

A mere glance at these figures will show that the cane was in a very poor condition for sugar making purposes. This was due to the causes already stated, namely, the autumnal rains which prevented the cane from properly maturing, and the fact that the fields were planted with mixed seeds so that some of the cane was mature at a much earlier period, and doubtless the principal cause was imperfect cultivation. The poor character of the chips for sugar making purposes is illustrated in a striking way by comparing the analyses of them with the analyses of chips from cane in other parts of the State. Considering the character of the material worked, the yield per ton must be considered as quite satisfactory.

Twenty-seven analyses of the exhausted chips were made, showing a mean percentage of sugar therein of 1.77. This result shows very poor battery work. A mean percentage of sugar in the exhausted chips of more than 0.5 per cent shows some grave defect in the method of working. This defect is usually due to imperfect chips; the shredders become dull, allowing large pieces of cane to go through unshredded, the internal portions of which are protected from the diffusion process. With chips properly prepared and the temperature of the battery properly regulated there is no difficulty whatever in securing extraction which will leave 0.5 per cent or less of sugar in the bagasse.

Fifty analyses of average samples of the diffusion juice were made with the following mean results:

Total solids	per cent..	12.99
Sucrose	do....	8.54
Glucose	do....	1.67
Purity		67.39

Forty-eight analyses of the clarified juices were made with the following mean results:

Total solids	per cent..	13.23
Sucrose	do....	8.91
Glucose	do....	1.57
Purity		68.49

Twenty-five analyses of the sirups entering the vacuum pan were made with the following mean results:

Total solids	per cent..	38.58
Sucrose	do....	25.24
Glucose	do....	3.94
Purity		64.69

For convenience of reference the work of the factory was divided into three periods, namely: First period from September 10 to 20; second period from September 20 to October 15; third period from

October 15 to October 30, not including the last two days of the run in November. The mean data for the three periods are as follows:

Fresh chip juice.

	First period.	Second period.	Third period.
Total solids........per cent..	16.58	16.09	16.67
Sucrose..............do.....	10.02	10.38	11.18
Glucose..............do.....	2.68	1.81	1.84
Solids not sugar......do.....	3.94	3.90	3.65
Glucose ratio................	26.15	17.44	16.45
Purity coefficient...........	60.43	64.51	67.67

The means for the whole season, excluding the November run, are:

Total solids..............................per cent..	16.32
Sucrose..do....	10.54
Glucose..do....	1.92
Solids not sugar.................................do....	3.86
Glucose ratio..	18.22
Purity coefficient.....................................	64.56

The constant improvement of the material entering the battery from the beginning to the end of the season is strikingly illustrated by the above figures. We find the same fact true of sorghum that is illustrated in sugar cane, that the longer the season for manufacturing can be delayed the richer the material in sugar will become. With an average of 10.5 per cent sugar in the juice and 9.45 per cent sugar in the cane, the total amount of sucrose in a ton of clean chips is 189 pounds and the amount obtained in a merchantable form of the raw sugar, as indicated above, is 58 pounds, which would amount to about 55 pounds of pure sugar.

The results illustrate the striking loss of sucrose in the juice in sorghum sugar manufacture heretofore carried on, viz., a loss of 134 pounds of sucrose for each ton of clean chips worked. This loss, as has already been pointed out repeatedly, is due to the pernicious effects of the reducing sugars and organic matters not sugars present in the juice, such organic matters, as shown by our work during the present year, having amounted to 3.86 per cent. It is perfectly safe to say that the total loss of sugar in the molasses was almost exclusively due to the presence of these gummy matters in the juice. It is evident at once that the financial success of sorghum sugar manufacture must follow some method of work which would elminate these sources of loss.

CONWAY SPRINGS.

The large factory at Conway Springs having been abandoned after two seasons of unsuccessful operation, the only work which was done at that place consisted in an attempt to make sugar in a small way by milling and open evaporation.

The results, easily predicted, only serve as another illustration of the futility of attempting sorghum sugar manufacture without any of the appliances or conditions necessary to success.

The promoters of the enterprise, however, desiring to have some chemical work done, a chemist was employed for the season. Chemical work was commenced on the 25th of September, and practically concluded on the 25th of October. During this time the mill was in operation only at irregular intervals, and there was found a total lack of proper preparation. The whole process, in fact, was characterized by unscientific methods.

The cane showed a great deterioration from the quality produced in the preceding years, but the cause of this inferiority is not clearly evident.

Forty-two analyses of samples of cane from the field showed in the juice the following percentages:

Total solids	per cent..	18.1
Sucrose	do....	10.4
Glucose	do....	4.4
Purity		57.5

Twenty-four samples of juices taken from the mill during the period it was in operation showed the following numbers:

Total solids	per cent..	16.5
Sucrose	do....	9.5
Glucose	do....	4.5
Purity	do....	57.6

The utter unfitness of these canes for sugar making purposes is at once evident. As a natural result of the poor quality of the raw material and inadequate methods of manufacture pursued, no sugar at all was produced, and even the molasses made was of a very inferior quality.

RESULTS AT FORT SCOTT.

The general operations of the Parkinson Sugar Company, and the results obtained, are set forth in the following report of the manager, Prof. J. C. Hart:

The spring of 1890 was all that could be desired by the sorghum growers. The winter had been mild, with just enough rain to make the ground work well, and the larger part of our cane ground was plowed before the first of March. The first planting was done March 28, and this cane did remarkably well, ripening the first week in August. The weather continued favorable until July, when it became very hot and no rain fell for several weeks. Cane was forced to head prematurely, especially on high ground and thin soil. In September there were heavy rains, and canes that had ripened early threw out from one to four new heads, which grew much taller than the original stalk and occasioned loss of sugar. The September rains brought on the late cane, so that the tonnage was good, though the quality was not what it would have heen had the season been uniform. Work was begun in the sugar house August 19 and continued till November 1, a total of sixty-nine working days.

Acres of cane	1,100
Tons of cane	7,575
Tons for sugar	7,100
Pounds sugar	356,000
Gallons sirup and molasses	117,000

The chemist's report has not yet been made and I can not give the quality of the cane as compared with last season, though the density will average somewhat higher this year, and purity of diffusion juice about the same as last; that is, 62. Diffusion juice to September 15, from Amber, only shows a density of 11.35; September 15 to October 1, part Amber and part Orange, 13; and for October, all Orange, the density was 14.2. The amount drawn in October was 50 litres less than in September, but allowing for that the yield from Orange was better than from Amber. I received from the Department several selected seed heads which were grown at Sterling in 1889. I give the analyses of a few varieties as compared with last season:

Amber, 235; average seven analyses, 1889, sucrose, 13.51; Amber, 235; average twelve analyses, 1890, sucrose, 13.1; Brix, 17.3.

Maximum density August 16, 1890, 18.5; maximum purity August 14, 1890, 80.6; maximum sucrose August 25, 1890, 14.1.

Stalks small, but the variety is valuable for its high sucrose and early maturity. Seed heads of all tested stalks saved, together with several bunches not tested.

Cross of Amber and Link's Hybrid, 161; average nine analyses, 1889, sucrose, 15. Cross of Amber and Link's Hybrid, 161; average nine analyses, 1890, Brix, 17.7; sucrose, 12.8. First ripe canes, September 5; 17.7 Brix; 12.9 sucrose. Maximum sucrose, 13.9 October 7. A good variety, but rather slender and falls easily.

Cross of Amber and Orange, 293; average five analyses, sucrose 17.38. Cross of Amber and Orange, 293; average seventeen analyses, Brix 18.71; sucrose 14.21.

First test, September 5, Brix 18.6, sucrose 15, was ready for working ten days earlier and is valuable as an early cane, as it is stockey, stands up well, and holds its purity much better than Amber. On October 14 it showed Brix 21.44, sucrose 15.6, and October 24 Brix 18.9, sucrose 12.3.

India and Orange, 320; average ten analyses, 1889, 15.97 sucrose; average six analyses, October 1890, Brix 18.62, sucrose 14.43. This is a heavy cane and will be valuable.

Folger's Early, 205; 1889, Brix 19; no sucrose given. Twelve analyses, 1890; Brix 18.6, sucrose 13.78. First analysis, August 25; was ripe a week earlier and is very valuable as an early variety, being tall and strong.

Black African, Undendebule, 254, and Honduras gave good results, but need further trial to determine their value for this locality.

Beet seed was obtained from the Oxnard Beet Sugar Company and several plots were planted as soon as the seed arrived, which was May 20.

A very poor stand was obtained owing to heavy rains immediately following the planting. Web worms destroyed a large part of the crop. Twelve analyses in October gave Brix 16.05, sucrose 13. Beets taken from the field December 12 tested 17.76 Brix, 15.67 sucrose.

OPERATIONS AT MEDICINE LODGE.

Manufacturing operations at Medicine Lodge commenced on the 18th of August and continued until the end of October. The machinery in use last year had been thoroughly overhauled and placed in excellent working order. No delays, of any consequence, were experienced in working the apparatus, and, for the first time in the history of the manufacture of sorghum sugar, the losses due to delays were reduced to a minimum.

The crop of sorghum cane was grown in a season of great drought, which prevented the corn crop from maturing. The evil effects of the drought were felt also on the cane, but in spite of it a crop of considerable magnitude was produced. On the 25th of August the long period of drought and hot winds was broken by copious rains and from that time until the end of the manufacturing season frequent rains fell. The cane in the fields readily ripened after the rains and many fields which were considered worthless redeemed themselves and produced considerable quantities of merchantable cane. The high red loam of the uplands produced a better crop than the low bottom lands, both in quantity and quality. In addition to this, the first frost affected only the bottom lands and the cane on the uplands had fully three weeks longer season on this account than the cane on the lowlands.

Interesting observations were made on the effect of the drought upon the different varieties of cane. The Early Orange and Link's Hybrid gave about the same tonnage under similar conditions and also had about the same content of sugar. If there was any advantage it was in favor of the Link's Hybrid. The varieties Undendebule and Honey Dew gave disappointing results; the tonnage was light, sucrose and purity low, and the cane rapidly deteriorated after a light frost. A new variety of cane, which may be called, provisionally, Medicine Lodge Orange, made a splendid showing. The seed head of this variety is small, compact, and does not spread or open on reaching maturity. The stalk is perfectly formed and resembles very nearly that of the Early Orange, from which it can be distinguished only by its earlier ripening. It contains a high percentage of sucrose, low glucose, and endures a dry season remarkably well. It ripens in from 90 to 100 days from the time of planting. It is also hardy and does not deteriorate rapidly after frosts.

The Black African was one of the best varieties tested during the season. This variety not only has high sucrose and purity, and low glucose, but is a large cane and endures drought well. Its tonnage was nearly double that of the other varieties and it maintained its high percentage of sucrose longer than any other variety tried.

As a result of the agricultural experience of the season, it seems best to plant only the early maturing varieties on the lowlands while the late maturing varieties should be planted on the uplands.

The results of the mean analyses of the cane chips entering the battery for the season show the following numbers:

In the juice.

Total solids	per cent	18.20
Sucrose	do	12.62
Glucose	do	2.24
Purity		69.86

The exhausted chips contained 0.81 per cent sucrose; the mean polarization of the first sugars made was 91.8 and of the second sugars made 91.2. The mean percentage of sugar in the cane extracted for the whole season was 93.6. The mean percentage of marc or fiber in the cane was 12.2.

In regard to the analyses of the Link's Hybrid variety, the means of four hundred and thirteen analyses show the following numbers:

In the juice.

Total solids	per cent	19.72
Sucrose	do	13.59
Glucose	do	1.85
Purity		70.00

Four hundred and sixty-two analyses of the Early Orange during the season show the following data:

In the juice.

Total solids	per cent	20.20
Sucrose	do	13.20
Glucose	do	1.96
Purity		65.24

Eighty-seven analyses of the Medicine Lodge Orange gave the following data:

In the juice.

Total solids	per cent	20.18
Sucrose	do	15.60
Glucose	do	1.87
Purity		78.82

Thirteen analyses of the Undendebule gave the following data:

In the juice.

Total solids	per cent	18.80
Sucrose	do	12.45
Purity		65.98

Thirteen analyses of Honey Dew showed for the season the following results:

In the juice.

Total solids....per cent..	17.42
Sucrose....do....	11.43
Glucose....do....	2.98
Purity....	64.19

Following are the mean analyses of the Black African for the month of November:

In the juice.

Total solids....per cent..	19.88
Sucrose....do....	13.90
Glucose....do....	2.04
Purity....	71.98

Samples of cane were taken from 1,973 loads brought to the factory and examined with the following mean results:

In the juice.

Totol solids....per cent..	19.31
Sucrose....do....	13.30
Purity....	69.14

Nine hundred and forty-one miscellaneous analyses of the cane from farmers in different parts of the county were made with the following mean results:

In the juice.

Total solids....per cent..	19.83
Sucrose....do....	15.12
Glucose....do....	2.21
Purity....	71.01

The summary of the season's work will give a fair idea of what was accomplished:

Working days....	35
Clean cane worked....tons..	3,957
First sugar obtained, per ton of clean cane..pounds...	101.1
Second sugar obtained, per ton of clean cane...do....	22.5
Total yield, per ton of clean cane....do....	123.6
Sugar obtained, based on total amount in cane, per ct.	51.4
Molasses made, per ton of clean cane....galls..	13.8
Total weight of sugar made....pounds..	489,357

DIFFICULTY OF MAKING SORGHUM SUGAR IN SMALL QUANTITIES.

It is to be regretted that certain hallucinations seem to constantly follow the development of the sorghum sugar industry. This Department has pointed out repeatedly the insurmountable difficulties attending the production of sorghum sugar in a small way and with crude apparatus and unscientific methods. The record of the past season at the various points where the Department was represented by its chemists tends to confirm the views in this regard so often expressed heretofore. Thus the development of this industry has had to contend not only with natural difficulties but with the discouragement attending numerous failures, although such failures were altogether due to causes which would have resulted as disastrously in connection with any other industry. In some cases, as in the experiment at Conway Springs for instance, the promoters testified to the honesty of their convictions by investing their own private funds without any public aid. While such an investment is certain to be followed by financial loss, what is far worse from a public point of view, it will prejudice the community against the whole business, and prevent people from viewing in the proper light processes which really give promise of success.

It is evidently the duty of the Department to caution farmers, and to reiterate what has been so often stated, that with our present knowledge, and with the present degree of development of the sorghum cane, it is an utter impossibility to produce sugar profitably in a small way and without an ample and suitable equipment. That a good article of table sirup can be made with moderate facilities, and profitably, has long been known, and I conceive it to be the duty of the Department to encourage such work as that, and to discourage in every possible way attempts to make sugar under conditions and with apparatus suitable only for the manufacture of sirup. It is unfortunate that in spite of the unsatisfactory results a glowing report has been published of the season's work at Conway Springs, and still more unfortunate to find it published in an influential sugar journal without any comment whatever, thus lending to it an air of authority which it is feared may prove to some extent injurious.

If the alcohol method of treating sirups should prove to be a success, it might then be profitable in some localities to make a thick sirup in some small way for delivery to a central factory. Such a method might be advisable in cases where cane would otherwise have to be hauled a long distance to the central factory. These possibilities, however, are still in the future, and do not call for discussion at the present time.

CULTURE EXPERIMENTS AT STERLING.

The experimental work of the Department at Sterling was continued during the year 1890 on the same general lines of work as those followed in previous years. The whole year was unexceptionally dry. Planting was commenced on the 1st of May and finished on the 23d. Before the last of the planting was completed the ground had become so dry that the seed of the last plots planted remained for a long time in the ground without germinating. Not only did this cause a late maturity of the canes whose germination had been deferred, but also produced an uneven ripening of all the plots thus affected. Some of the seed which germinated as soon as planted produced canes ripening long before those from the delayed germination. Planting was done by hand and the seed covered by a hoe.

The land varied widely in quality, from fairly fertile spots to barren sandy knolls. Much of it had not been in cultivation for several years, and part of it had been in sorghum for many years. In addition to these disadvantages of soil and season, a severe frost on the 13th of September killed all the cane in the greater part of the experimental plots. This frost was almost a month earlier than the average of the locality. After the frost the working force of the station was brought down two-thirds and the total amount of work done was probably only about one-third what it would have been had the frost been delayed for another month. In many of the plots, however, the analyses were kept up for some time after the frost, selecting for this purpose stalks here and there which still showed green leaves. In some cases the canes which had been frostbitten rapidly deteriorated, and in no case did they improve, but in some instances they remained quite stationary in quality for a considerable length of time. It was noticed in many cases that the canes retained their sugar content in quite a constant manner for five weeks after the frost had destroyed nearly all the leaves. The comparison of varieties under such circumstances must be more or less unreliable, and hence the analytical work of the station is not as indicative in its results as it was during previous years. The experimental plots occupied in all about 165 acres. The different plots were sowed in plots 25 feet wide, leaving about 25 feet between them to avoid mixing. This is probably not a sufficient distance, but on account of the large number of plots with which it was desired to experiment, it was not possible to plant them farther apart without extending to undue proportions the total area under cultivation.

One hundred and twenty-seven plots were planted with seeds from foreign countries, received through the Department of State in response to a request from the Department of Agriculture. Two hundred plots were planted with seed selected at the station last year by the analyses of single canes. Twenty-six plots were planted from seeds which were received from Dr. Peter Collier, director of the Experiment Station at Geneva, New York. Four hundred and fifty-five plots were planted with seeds from canes which showed evidences of being crosses of Link's Hybrid and Early Amber. Each of these plots was planted with seed from a single head and were grown in the hope of finding among them canes showing new and desirable qualities. Some of these plots gave remarkably fine canes of new types having from 14 to 16 per cent of sugar, while others were inferior in every respect to each of the parent forms. In all, twenty of these plots seemed sufficiently good to justify preservation and the seed was saved from them for future growth.

All the one hundred and fifty-three plots planted with foreign seed, including two varieties, unnamed, from Australia, produced fine canes of good quality.

Of the various crosses first selected in 1888, planted in 1889 and again in 1890, several having proved unusually good during the three years of trial, will be retained for further experiment. Most of these new varieties are now well established and uniform in their characteristics, but there are some which still show a persistent tendency to reversion. Special data which were obtained with the Colman cane and with numbers 160, 161, and 289, are of such a character as to fully justify the whole of the labor which has been expended by the Department at the station in the development of new varieties from crosses. These four varieties possess qualities for sugar making superior to all other known varieties of sorghum, and these characteristics have been secured by careful attention to scientific principles of selection and propagation which have been practiced at Sterling from the first. There is still opportunity for a large amount of judicious work in selecting from varying seedling canes, having juices of greater purity, for there are wide differences in this respect, and it will require several years more to develope among them characteristics sufficiently uniform to justify their selection as sugar-producing plants.

Many varieties which had given good results in previous years were planted in a large number of plots in different soils and at various times in order to determine their average value. The stand of cane was almost perfect except where destroyed by drift sand. The seeds selected at the station have often shown a vitality of 98 per cent at the time of planting. With such seed and due care in sowing it would seem possible, so far as the experimental work has shown, to have a good stand of cane without either thinning or replanting. Neither was done this year. No fertilizers were used and no suckers nor offshoots removed. With the exception of small plots, which were hoed twice, the cultivation was such as any careful farmer would give his crop. In such hot and dry seasons as this was there seems no doubt that deep and close cultivation after the canes are large injures them. On the other hand, frequent and shallow cultivation, even after the canes are well grown, favor their development on principles of soil physics which are well understood.

The yield of cane per acre was not nearly so large this year as in the season of 1889, but was better than in 1888. In general all the varieties which have been subjected to careful selection showed a larger percentage of available sugar in the juice than any other of the previous years. Another point mentioned is that the character of the juices in the sorghum appears to vary less with the season than does the yield of cane. As an instance of this characteristic, developed by the experiments, we may cite the variety of cane known as 161. In 1889 seventeen analyses of this variety were made, extending from September 4 to October 26. The average percentages given were as follows:

Sucrose	per cent..	13.24
Reducing sugar	do....	.45
Solids not sugar	do....	3.56
Purity	do....	76.75

In 1890 twelve analyses of the same variety were made, extending from August 12 to October 21, showing the following mean percentages:

Sucrose	per cent..	14.81
Glucose	do....	.69
Solids not sugar	do....	3.77
Purity	do....	76.85

One of the most marked effects of selection, as practiced at Sterling, has been manifested in the earlier maturing of the cane. Some of the different varieties grown during the past year ripened two or three weeks earlier than was the case with the progeny of similar but unselected seed. Judging from the work already done sorghum cane may be developed in any particular direction by continuous selection of the qualities desired. If, for instance, a high sugar content be desirable, by continued selection for high sugar only, this property of the cane may be made persistent, and the same is true of low glucose or low non-sugars.

The work of the station during the year comprised 2,500 analyses of average samples of sorghum, in large quantities, taken from the plots, and about 9,000 polarizations of the juices of single selected canes. Twelve thousand selected seed heads from the best varieties were wrapped separately and descriptive tags attached to them for the purpose of continuing the work, not only at the station, but by distributing these seed heads to those interested in such researches. By planting a single seed head and saving all the seed produced therefrom a very large field of cane can be produced from each of these 12,000 heads in 1892. In other words, from these 12,000 selections it would be possible to produce seed enough to plant all the sorghum cane which will be required by all the factories in the United States in 1892. These 12,000 heads have been divided into four classes.

Those coming from canes which give a juice of from 80 to 85 per cent purity, irrespective of sugar content, were placed in the first class; those having a purity of 75 to 80 in the second, and those from 70 to 75 in the third class, and the whole of the remainder in the fourth class.

The seed selections were taken from the following varieties: Early Amber, Undendebule (Nos. 1 and 2), Colman cane (cross of Orange and Amber), Folger's Early, Planters' Friend, Early Orange, Link's Hybrid, No. 160, No. 161, No. 110, No. 112, No. 208, No. 244, No. 289, and No. 350.

The method of making selections may not be devoid of general interest. The method pursued at Sterling was as follows:

Many thousands of canes of the particular kinds selected are run separately through hand mills and the juice from each one put in a tin can. These juices are then roughly tested by a hydrometer, giving reading, representing the percentage of total solids contained in them. If this reading is below a certain fixed standard the seed head from this cane is at once rejected, the standard of the juice being kept high enough to insure a rejection of the majority of the canes. If the first reading is satisfactory, the can and the seed head of the cane furnishing the juice therein receives a number. For instance, in the variety No. 112, 765 canes were found which came up to the required standard. These were again assorted by subjecting them to analysis and 185 samples were found to contain over 15 per cent of sugar. These seed heads were then saved and all the others from the variety rejected. From those which were saved another selection was made on the purity of the juice and 121 were found to have purities ranging from 75 to 80. These seed heads were preserved and all the others rejected. Thus of the many thousands of the canes of No. 112 submitted for examination only 121 seed heads were saved to distribute for planting next spring. With the force at the command of the station it was possible to test 3,000 canes per day. Of course it is not expected that canes showing a high percentage of sugar, say 18 per cent in the juice, will give seed which will on planting give a cane uniformly possessing this high quality. Were this true it would be possible to permanently secure and perpetuate each accidental variation showing a high percentage. Nevertheless, it is true that seed selected in this way has a tendency to produce a larger number of high-testing canes than before, and thus by continued selection it is possible to develop finally a permanent type showing a decided increase in sugar-producing power.

It must also be taken into consideration that in cases of seed selection the development of the particular varieties of cane should be largely influenced by the environment, that is, by the soil and climate; hence it is illogical to suppose that seed which has been selected in this way and permanently established at Sterling will do equally as well in a soil and climate radically different. It is the object of the Department in this work not to select and establish varieties which will do equally well in all parts of the United States, but to illustrate the methods of establishing varieties in one particular locality, so that the particular variety of cane which is suitable to any one locality may be speedily and scientifically established by selection in other places. In many cases the seeds which have been sent from Sterling, and which continue to give there the best results, have produced canes of much inferior quality in Louisiana and Mississippi, as will be seen by data given from those localities in another place. After three years of study of all the heads of sorghum which could be obtained, amounting in all to nearly one thousand, it does not seem premature to give a list of those varieties which may be called the best. It must be understood, however, that this list is for a soil and climate similar to those in Western and Central Kansas, and this list can not be regarded as being absolutely correct for other and widely different localities.

From the results already obtained Early Amber will be suitable for earliest planting and manufacture or for very late planting when such is unavoidable. Earlier maturing varieties than Amber have been studied but none of them can as yet be recommended. Folger's Early has improved by selection, and No. 160 and No. 161 ripen soon after Amber and are much superior to it in many respects. Undendebule, Colman, and the well-known Link's Hybrid complete the list. To these may also be added Orange cane and its different varieties, which have proved so successful for manufacture but which did not deport themselves as well under selection as the heads mentioned. With the exception of Early Amber, all of these can be recommended in respect to high sugar content,good purity, and persistency of type. Folger's Early has a relatively high glucose content, but the purity is about the same as that of the others. Link's Hybrid is somewhat later in maturing and has a tall slender stalk which is liable to be blown down. This latter defect it shares with Nos. 160 and 161.

It is hoped that in the course of a year or two No. 161 can be hastened enough in maturing to take the place of Amber. The belief is entertained that these varieties, excepting Amber, are not superior to those commonly grown for sugar making, but selection on the lines already explained will probably result in considerable further improvement.

Hitherto the work of selection has been carried on mainly in the direction of high sugar and low glucose percentages, and in this respect its success has been most gratifying. In the future it seems evident that more particular attention must be paid to the purity of the juice, unless indeed Congress should see fit to permit the introduction of the process, for making sorghum sugar, by removing the gummy matters, which is proposed in another part of this report. Unless this can be done the greatest hope of the success of the sorghum-sugar industry lies in the direction of securing a juice of high purity and especially one low in the organic matters not sugar. It would be better, therefore, in this respect, to base at least one line of selection in this direction so as to eliminate as far as possible the gummy matters in the cane. The average purity of the juices of the sorghum which have been manufactured so far is not much, if any, above 65, while with sugar cane it is about 80 and with the sugar beet even higher. Of the varieties already selected and established the Colman and No. 161 give the best results in regard to purity, the number expressing the purity varying between 75 and 80. The importance of having a pure juice will be at once realized when it is known that the amount of sugar which is secured from a given weight of cane does not depend solely upon the contents of sugar in the juice but upon the amount of this sugar which the gummy and other uncrystallizable bodies in the juice will allow to crystallize. This was well illustrated in the work of the Department at Fort Scott, Kansas, in 1886. From sorghum cane the juice of which averaged 7.7 per cent and less than 60 purity only 21.5 pounds of commercial sugar per ton of clean cane were made, while from sugar cane sent from Louisiana containing 10.45 per cent of sugar and having a purity of 73, and worked by precisely the same processes and under the same control, 144 pounds of sugar were made per ton.

It appears true of sorghum juices that the non-sugars, consisting of the glucose and solids not sugar taken together, may be in all about 4 to 5½ per cent of the juice. It has been shown by the three years' selection at Sterling that the glucose percentage can be reduced to a point at which it may be practically neglected, viz., to about one half of 1 per cent. The selection for the purpose of reducing the organic bodies not sugar has not been carried far enough to determine whether or not similar success can be expected. At the present, however, it appears that there is a kind of reciprocity existing between the glucose and solids not sugar so that as one is increased the other is diminished the sum thus remaining about a constant quantity. As a rule the varieties which have a low glucose content have a high content of organic solids not sugar, and the reverse is true. If this should be the correct view it would make the problem of selection a more difficult one and the wiser plan would be to pursue it in the direction of reducing the organic solids not sugar and increasing the glucose, provided the manufacture of sugar is to be carried on as it now is; while if the alcohol process for the separation of the organic solids in sugar should come into use then the wiser plan would be to pursue the selection with reference to diminishing the glucose to the least possible degree. The separation of the organic bodies not sugar, by alcohol, would leave a juice of remarkable purity and capable of yielding the maximum percentage of crystallizable sugar. It is highly probable, however, that all the non-sugars may finally be much reduced in amount by continued selection.

The results of the station work show that Early Amber, Folger's Early, and the various varieties of Orange have comparatively high glucose, and, as a rule, low percentages of solids not sugar. This accounts for the fact that in practice the Orange, although having a high percentage of glucose, has given uniformly good results. On the other hand, Undendebule, Colman cane, No. 161, Sorghum Bicolor, and Link's Hybrid show generally low percentages of glucose and high percentages of organic solids not sugar.

In general, therefore, it may be said that the lines of selection as indicated above will depend upon the method of manufacture to be pursued. If the method remains as it is, then without any question the direction of the lines of selection should be toward securing a juice of greater purity even should the sucrose content itself suffer. It is far better for the manufacturer to have a sorghum juice containing 12 to 13 per cent of sugar in the juice and a purity of 85 than to have one from 16 to 18 per cent sugar in the juice with a purity of 65.

I have already said that the cause of a poor yield of sugar in sorghum of high polarization is due to the presence of some form of carbohydrate or other organic body exercising a higher melassigenic power than invert sugar or any form of levulose or dextrose, and the results of the research carried on in the laboratory during the past eighteen months have disclosed to us the exact nature of this body and also revealed the method of separating it as indicated in another portion of this report.

Mr. John Dymond and Dr. W. C. Stubbs estimate that a fair average of Louisiana sugar cane, in the juice, would be as follows:

Solids	per cent.	15.00
Sucrose	do	12.00
Glucose	do	1.50
Purity		80.00

It would be of interest to compare these numbers with the averages of the sorghum worked in the four sugar houses at Attica, Medicine Lodge, Conway Springs, and Meade during the season of 1889, and also to compare it with the general average of the Colman cane during the present season:

	Louisiana sugar cane.	Factory sorghum.	Colman cane.
Total solids ....per cent..	15.00	17.46	19.48
Sucrose ....do....	12.00	11.08	14.88
Glucose ....do....	1.50	2.37	.84
Solids not sugar ....do....	1.50	4.01	3.76
Purity ....do....	80.00	63.45	76.37

It is easy to see from the above figures that the Louisiana cane yields a much larger percentage of sugar than sorghum. At the same time a glance will show that the removal of 3.76 per cent of the solids not sugar in the Colman cane would at once place it in the first rank of sugar-producing plants as compared with the others given above.

In the selections made at Sterling particular attention has always been given to the constitution of the sugar content. A variety which retains such a long time a high percentage of sugar in the field is of course preferable to one which rapidly loses its sugar content after having become fully ripe. The former allows more latitude for harvesting the crop, and also permits those canes which from various causes mature later than others, time to attain their maximum content before they are harvested, so that when they are finally worked they are in good condition. There are considerable differences in this respect among the different varieties. Some, as for instance the White African, and even the Early Amber, begin to retrograde soon after maturity; others are much more constant. Of all the varieties tried No. 161 has proved the most durable. One plot of this variety has held up its sugar content for seventy days, the longest period ever known, and, in spite of exceptionally adverse climatic conditions. Colman cane, which ripens somewhat later, is second in this respect. It seems probable that both these varieties will continue to disclose this good quality and will keep their sugar until second growth is far advanced. With this latter point is closely connected another, viz., the preservation of sugar content in the canes after they have been harvested. It is probable that the two are correlated and that the kind which keeps better in the field than others will also hold up its sugar content better after harvesting. It is very difficult for factories to so arrange cutting, hauling, and manufacture to insure the selection of all the canes suitable after harvesting. The losses, therefore, in this respect are very great at every factory and the glucose ratio differs widely between field and diffusion battery.

If varieties of cane could be produced which might be cut and left for a week or so before working without serious damage it would be a great step forward in the sorghum sugar industry. Work in selection on this line was planned, but owing to the press of other work and early frost it was abandoned during the present season.

In general, it appears that all the varieties of sorghum which have been tested may be divided into several classes. First, those varieties which have only a fair percentage of sugar and low glucose, as for instance Sorghum Bicolor, which for three years has had an average in its working period of 12.50 per cent of sugar and less than 1 per cent of glucose. Second. Varieties which have a less percentage of sugar and comparatively high glucose with a low percentage of solids not sugar. This variety is illustrated by the Early Orange, which for three years has shown during its working period about 14 per cent of sugar and 2 per cent of glucose. Third. Varieties which have high sugar content and low glucose. This variety is illustrated by Undendebule No. 1, which has shown for three years during its working period 15.50 per cent of sucrose and 0.70 of glucose. No. 161 has also shown good results in this direction, having for two years an average of 15 per cent sugar and about 0.50 per cent glucose. Fourth. Varieties with a moderate percentage of both glucose and sucrose. This class is illustrated by No. 250, an African variety which has given for two years an average of 12.50 per cent sucrose and 1.25 per cent glucose.

In respect of the detailed studies of the different varieties grown at Sterling, reference will be made to the bulletin of the Department, No. 29, which will contain all the data collected from the Sterling station during the present year.

EXPERIMENTS WITH SORGHUM NEAR COLLEGE PARK, MARYLAND.

The experiments made in 1889 near College Park were rendered entirely nugatory by the exceptionally wet season, which prevented planting the cane at the proper time, interfered with its cultivation, and retarded its maturity. Hoping to obtain better results it was decided to continue the work, on a small scale, during the present season. Four acres of land were leased from Mr. D. M. Nesbit, and this land was divided into eight equal portions. The land was in the form of a parallelogram, the length lying east and west and was twice as long as it was wide. An attempt was made to secure land of a perfectly uniform nature, but even in so small a portion as 4 acres this was found to be impossible. The western part of the land was a gravelly loam, while about 1½ acres of its eastern portion was much more sandy and less fertile than the western part.

The eight subdivisions were planted north and south and were numbered by the letters of the alphabet beginning on the west side with plot A and continuing to the east end to plot H, each plot containing half an acre. In an eastern and western direction the plots were divided into five equal portions and the numerals from 1 to 40 were applied to the small plots made by the crossing of the eight north and south divisions with the five east and west divisions, each plot containing one-tenth of an acre.

The method of plotting the field and the number of each plot are shown in the diagram.

On plots 1, 6, 11, 16, 21, 26, 31, 36, 3, 8, 13, 18, 23, 28, 33, 38, Link's Hybrid was planted; on plots 2, 7, 12, 17, 22, Early Amber; on plots

4, 9, 14, 19, 24, 29, 34, and 39, Undendebule; on plots 27, 32, 37, Red Liberian; on plots 5, 10, 15, and 20, Early Orange; on plots 25, 30, 35, and 40, Improved Orange and two rows of Early Orange to finish out the plot of which there was not enough Improved Orange seed to complete.

The principal object of the experiment was to determine the influence of different kinds of artificial fertilizers on the composition of the cane. The fertilizers employed and the method of distributing are indicated in the following scheme:

N

	A	B	C	D	
	1	6	11	16	
	2	7	12	17	
W	3	8	13	18	E
	4	9	14	19	
	5	10	15	20	

S

Link's Hybrid:
Plots 1, 6, 11, 16, 21, 26, 31, 36.
3, 8, 13, 18, 23, 28, 33, 38.

Early Amber:
Plots 2, 7, 12, 17, 22.

Undendebule:
Plots 4, 9, 14, 19, 24, 29, 34, 39.

N

	E	F	G	H	
	21	26	31	36	
	22	27	32	37	
W	23	28	33	38	E
	24	29	34	39	
	25	30	35	40	

S

Red Liberian:
Plots 27, 32, 37.

Early Orange:
Plots 5, 10, 15, 20.

Improved Orange:
Plots 25, 30, 35, 40.

Scheme for distributing fertilizers.

1............Cottonseed meal.
2............Superphosphate.
3............Kainite.
4............Nitrate of soda.
5............(1, 2, and 3) equal portions of each.
6............(2, 3, and 4) equal portions of each.

On A........No. 5.
On B........No. 2.
On C........Nothing.
On D........No. 3.
On E........No. 4.
On F........Nothing.
On G........No. 6.
On H........No. 1.

Basis of application.

[Pounds per acre.]

No. 1....... 600.
No. 2....... 600.
No. 3....... 600.
No. 4....... 400.
No. 5....... 600.
No. 6....... 600.

In regard to taking samples for analysis the following plan was pursued:

Beginning, for instance, with the Early Amber, which was the first to ripen, samples of the cane were taken by cutting about one hundred canes of Early Amber from each of the different lettered plots on which it was planted, viz A, B, C, D, and E. These canes were thrown together, well mixed, and divided into four parts, and one part sent to the laboratory for analysis. In this way samples were taken from each of the plots under the influence of each kind of fertilizer on the same day. On September 11 five samples of Early Amber were sent to the laboratory for analysis, including one sample from each of the lettered plots on which the Amber was grown. On the 19th, 24th, and 30th of September, and the 3d and 10th of October, samples were taken in the same way from each of the plots of Amber. The other varieties were treated in the same way when they approached maturity, the object being to secure a study of the characteristics of the cane at about that period at which it would be used for manufacturing purposes if grown on a large scale.

The character of the cane was rather disappointing, with the exception of the Early Amber, indicating a crop which would have been unprofitable for manufacturing purposes.

With the exception of the Early Amber the growth of cane was luxuriant on all the plots except those at the extreme eastern end in the poor ground. The Early Amber, as is usual with this variety, was very small as compared with the other varieties, and yet the yield per acre was fair. The mean analyses of the Early Amber variety for the different plots are as follows:

	A	B	C	D	E
Total solids .... per cent..	17.5	17.7	17.1	16.7	16.0
Sucrose .... do....	13.4	13.1	12.9	12.1	11.4
Glucose .... do....	1.3	1.7	1.8	2.2	2.5
Purity	76.5	73.9	75.0	72.5	71.0

The analyses of the Early Orange were commenced on the 20th of September; subsequent sets of samples were examined on the 1st, 4th, 13th, 18th, and 30th of October. The mean results were as follows:

	A	B	C	D	E	F	G	H
Total solids.per cent..	14.5	15.3	15.0	14.5	15.5	15.3	15.2	16.1
Sucrose .... do....	7.7	8.9	8.4	8.1	9.9	9.7	9.7	10.6
Glucose .... do....	4.8	4.6	4.5	4.8	4.1	4.2	4.1	4.0
Purity	53.1	57.3	56.1	55.0	64.1	63.0	63.7	64.5

The analyses of Link's Hybrid were commenced on the 22d of September and continued on the 25th and 29th of September and the 6th, 11th, and 29th of October. The mean results obtained were as follows:

	A	B	C	D	E	F	G	H
Total solids.per cent..	14.6	14.9	14.4	14.3	15.8	15.1	14.7	15.9
Sucrose ....do....	10.2	9.5	8.9	9.8	11.8	10.1	10.7	11.3
Glucose ....do....	2.2	3.1	3.9	2.7	1.8	2.8	2.3	2.2
Purity	69.9	64.5	61.4	68.3	74.8	66.5	72.8	71.5

The analyses of Undendebule were commenced on the 26th of September and continued on the 2d, 17th, and 25th of October. The mean results obtained follow:

	A	B	C	D	E	F	G	H
Total solids.per cent..	13.5	14.2	14.6	15.0	15.9	15.6	16.3	16.1
Sucrose ....do....	9.3	8.9	9.1	11.3	11.2	10.2	11.4	10.9
Glucose ....do....	2,4	3.3	3.3	2.1	2.2	2.8	2.6	2.4
Purity	68,4	62.3	62.4	75.3	74.0	65.1	69.6	67.6

The analyses of Improved Orange were commenced on the 16th of October and continued on the 21st and 27th. Following are the means obtained:

	E	F	G	H
Total solids ....per cent..	15.8	15.3	15.4	15.6
Sucrose ....do....	11.3	10.9	10.7	10.7
Glucose ....do....	3.8	4.2	4.0	4.0
Purity	71.1	71,3	70.0	68.5

Analyses of Red Liberian were commenced on the 15th of October and continued on the 20th and 28th. Following are the mean results obtained:

	F.	G.	H.
Total solids ....per cent..	14.4	14.5	15.2
Sucrose ....do....	3.9	4.5	5.2
Glucose..do....	6.6	6.5	6.2
Purity	25.8	30.4	33.9

In order to obtain a comparison in richness of sugar of the results on all the different plots with the different kinds of fertilizers, the following tabular arrangement has been constructed. Taking the mean results of each variety they have been arranged in the following order:

First, in the order of highest sucrose; the plot giving, for instance, the highest sucrose being placed first and those containing the next subsequent percentages in order below. For instance, in the case of Early Amber, it was found that the highest sucrose was in plot A and there is a regular decrease from plot A, so that this was arranged in alphabetical order, A, B, and so on. In the next group are contained the plots with the lowest glucose beginning with the lowest and continuing to the highest. In the next group are collected the mean purities, beginning with the highest purity and continuing to the lowest purity in order.

Classification of plots in respect of sucrose, glucose, and purity.

Variety.	Highest sucrose.								Lowest glucose.								Highest purity.							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Early Amber	A	B	C	D	E	...	...	...	A	B	C	D	E	...	...	...	A	C	B	D	E	...	...	...
Early Orange	H	E	F	G	B	C	D	A	H	G	E	F	C	B	D	A	H	E	G	F	B	C	D	A
Link's Hybrid	E	H	G	A	F	D	B	C	E	A	H	G	D	F	B	C	E	G	H	A	D	F	B	C
Undendebule	G	D	E	H	F	A	C	B	D	E	A	H	G	F	B	C	D	E	G	A	H	F	C	B
Improved Orange	E	F	G	H	...	...	...	...	E	F	G	H	...	...	...	...	F	E	G	H	...	...	...	...
Red Liberian	H	G	F	...	...	...	...	...	H	G	F	...	...	...	...	...	H	G	F	...	...	...	...	...

An analysis of this table shows that the plots have the following relations:

Plots.	Rank.								Total.
	1	2	3	4	5	6	7	8	
A	3	1	1	3	0	1	0	3	12
B	0	2	1	0	2	1	4	2	12
C	0	1	2	0	1	2	2	4	12
D	2	1	0	3	2	1	3	0	12
E	5	4	2	0	1	0	0	0	12
F	1	2	4	2	2	4	0	0	15
G	1	5	6	2	1	0	0	0	15
H	6	1	2	4	1	0	0	0	14

Per cent.:

A for first place	25.0
B for first place	00.0
C for first place	00.0
D for first place	16.7
E for first place	42.7
F for first place	8.3
G for first place	8.3
H for first place	50.0

Multiplying each rank of each plot by the number of times it occurs and dividing by 8 will give the mean position of each plot in the series.

A = 6.25 E = 3.00
B = 8.37 F = 7.38
C = 8.63 G = 5.30
D = 6.63 H = 4.38

In reviewing these results the following facts are noticed: With Early Amber the highest sucrose was produced by fertilizer 5, followed in order by 2, 0, 3, and 4. The lowest glucose appears in same order.

The highest purity was found with No. 5, followed by 0, 2, 3, and 4.

With Early Orange the highest sucrose was produced with No. 4, followed in order by 2, 0, 3, and 5.

The lowest glucose was found with No. 4, followed by Nos. 0, 2, 3, and 5.

The highest purity was found with No. 4, followed in order by Nos. 2, 0, 3, and 5.

The above comparison, however, is not strictly just on account of the fact that all varieties were not planted on all the plots. It will be better, therefore, to compare only those plots and varieties which present a complete comparison. These plots are A, B, C, D, and E, and the varieties Early Amber, Early Orange, Link's Hybrid, and Undendebule.

Classification of Plots A, B, C, D, and E, with varieties Early Amber. Early Orange, Link's Hybrid, and Undendebule.

Variety.	Highest sucrose.					Lowest glucose.					Highest purity.				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Early Amber	A	B	C	D	E	A	B	C	D	E	A	C	B	D	E
Early Orange	E	B	C	D	A	E	C	B	D	A	E	B	C	D	A
Link's Hybrid	E	A	D	B	C	E	A	B	D	C	E	A	D	B	C
Undendebule	D	E	A	C	B	D	E	A	B	C	D	E	A	C	B

With Link's Hybrid the highest sucrose was found with No. 4, followed in order by Nos. 5, 3, 2, and 0.

The lowest glucose was found with No. 4, followed in order by Nos. 5, 2, 3, and 0.

The highest purity was found with No. 4, followed in order by Nos. 5, 3, 2, and 0.

With Undendebule the highest sucrose was found with No. 3, followed in order by Nos. 4, 5, 0, and 2.

The lowest glucose was found with No. 3, followed in order by Nos. 4, 5, 2, and 0.

The highest purity was found with No. 3, followed in order by Nos. 4, 5, 0, and 2.

A general comparison of the numbers is given in the following table:

Plot.	Rank.					Total.
	1	2	3	4	5	
A	3	3	3	0	3	12
B	0	4	3	3	2	12
C	0	2	4	2	4	12
D	3	0	2	7	0	12
E	6	3	0	0	3	12

Multiplying the times each plot occurs in the series by the number of the rank and dividing by 5 we obtain the mean position of each plot.

1 E=5.4	4 B=7.8
2 A=6.6	5 C=8.8
3 D=7.4	

Hence it appears that in general results nitrate of soda (fertilizer applied to plot E) has produced the most favorable effects. Followed by this is a mixture of equal parts of cottonseed meal, superphosphate, and kainite. Next in order comes kainite alone. In the next rank we find superphosphate alone, while the plot C, which received no fertilizer at all, showed the poorest results.

These data are more valuable in indicating the methods of studying the effects of intensive culture on sorghum than for the definite knowledge obtained. It is evident at once that only several years of continual investigation would make a solution of the problem possible.

The agricultural data are briefly given in the following resumé:

Plots A, B, C, and part of D were rather light soil, containing a large percentage of sand and having perfect natural drainage; the remainder of the plots was more clayey and compact. The light soil favored the growth of sorghum so that it matured on an average one month earlier than that in the other plots. It is worthy of note that the sorghum showed far greater sensitiveness to difference in soils than a field of maize grown next to it on the same kind of ground. The following statement gives the number of stalks per acre, and the gross weight per acre, including the blades and seed heads, and the net weight per acre including only the clean cane for each variety on the different plots. These weights were all taken on the same day, viz., the 15th of October, and the weight per acre is based upon a carefully measured portion of each plot the whole of which was harvested and weighed in the manner indicated:

Plots.	Link's Hybrid.			Early Amber.			Undendebule.		
	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.
		Pounds.	*Pounds.*		*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*
A	22,000	23,500	17,500	20,000	15,000	12,000	23,000	32,000	27,500
B	27,000	29,500	21,500	21,000	10,000	7,500	18,000	27,500	21,500
C	15,000	23,000	17,000	18,000	7,500	6,000	27,000	29,000	21,000
D	21,000	36,000	26,500	18,000	12,500	9,000	23,000	20,000	14,000
E	24,000	37,000	27,000	18,000	6,000	4,500	21,000	22,500	16,500
F	25,000	32,500	24,500	....	....	....	21,000	24,000	16,500
G	21,000	25,500	19,000	....	....	....	17,000	21,500	15,000
H	23,000	28,500	19,500	....	....	....	20,000	22,000	15,000

Plots.	Early Orange.			Improved Orange.			Red Liberian.		
	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.
		Pounds.	*Pounds.*		*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*
A	18,000	33,000	25,500	....	....	....	....	....	....
B	21,000	27,500	22,200	....	....	....	....	....	....
C	20,000	22,000	17,000	....	....	....	....	....	....
D	18,000	27,500	21,000	....	....	....	....	....	....
E	....	....	....	17,000	13,500	10,000	....	....	....
F	....	....	....	18,000	14,500	10,500	21,000	30,000	23,000
G	....	....	....	18,000	17,000	11,500	22,000	24,500	19,500
H	....	....	....	17,000	18,000	13,000	14,000	22,500	16,500

EXPERIMENTS AT THE MISSISSIPPI AGRICULTURAL EXPERIMENT STATION, STARKVILLE, MISSISSIPPI.

Quite a number of the seed heads selected at the Sterling station in 1889 were sent to the director of the Mississippi Agricultural Experiment Station, Prof. S. M. Tracy, with the request that he coöperate with the Department in testing the value of the different varieties sent in the soil and climate of Mississippi. The cultivation of the samples was undertaken solely at the expense of the Mississippi station, and in the analyses the Department of Agriculture furnished only the hand mill which was used in expressing the juice from the canes. The analyses were made by Mr. L. G. Patterson, the chemist of the experiment station. A review of the analytical data obtained strongly illustrates the statement which has already been made that the production of a superior variety of cane by selection in one locality will not always insure the development of similar canes from seeds which are planted at a great distance from the original station, where the conditions of soil and climate are quite unlike those under which the standard variety of cane has been developed.

In a variety of Red Liberian No. 137, coming from a cane whose juice showed a content of total solids equal to 19 per cent, analyses were made at the Starkville station beginning September 1 and running to September 10, in which the content of sucrose in the juice of the cane varied from nothing to 4.9 per cent, while the glucose varied from 5 to 7.45 per cent. The mean numbers were sucrose 3.0 per cent; glucose 6.07 per cent. It seems hardly possible that a selected seed head could deteriorate so rapidly in being removed to a different locality. Analyses were continued with this variety planted from a seed head from plot No. 138 of the 1889 Sterling number, showing 18° Brix; No. 125 with a sucrose content of 15.04 per cent; No. 135, showing 18° Brix and No. 125 bis with 14.81 per cent of sucrose. These experiments were continued from September 1 to October 2, but in no case was the result comparable with the character of the parent cane. The percentage of glucose was almost uniformly higher than that of sucrose, and the result of the experiments with this series of selected seed heads was a record of most remarkable deteriorations. In several cases the polariscope failed to reveal any sucrose whatever present in the juices of the cane.

The mean percentages obtained in the juice were as follows:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
138........	12.2	4.8	4.6
125........	12.2	4.2	4.7
135........	11.8	4.3	4.8
125 bis....	14.1	6.0	4.8

Experiments were also made with selected seed heads from the Undendebule variety of cane selected at Sterling last year and of the following descriptions; Plot No. 297 of 18° Brix; No. 31 of 21° Brix; No. 31 of 20° Brix; No. 254 of 15.53 per cent sucrose. These analyses were commenced on the 2d of October and continued until the 4th of October. In many cases good results were obtained, but in no case was the parent cane excelled. With stalks produced from seed head plot No. 254, analyzed on the 3d of October, the sample was found to contain 15.2 per cent of sucrose and 0.54 per cent of glucose, and showing 20° Brix. Many of the other analyses showed fairly good percentages, but the mean of all of them would indicate a general deterioration in the most marked degree from the parent canes. Seed head from plot 31, 21° Brix, is a partial exception.

The mean results follow:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
297	12.0	6.4	1.7
31	18.3	13.1	1.4
31 bis	12.1	6.7	2.0
254	15.6	10.5	1.3

Analyses of the variety Rio Blanco were made on October 4. The samples were taken from canes grown from seed-head from plot 107, of 21° Brix, and from seed head plot 107, of 20° Brix. The results here also showed the most remarkable deterioration. In no case did the Brix of the samples grown equal that of the parent cane.

The means were as follows:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
107	13.3	7.8	3.8
107 bis	15.2	9.2	3.5

Experiments were also made with the India and Orange varieties from Sterling, plot 289 of 1889, showing 21° Brix, and from selected seed head 14.175 of India and Orange, showing a sucrose content of 16.42 per cent, the experiments having been made on the 4th and 6th of October. In these cases, also, there was a marked deterioration. In the case of the canes developed from seed head No. 14,175, the highest percentage of sucrose reached was 13, with a glucose content of 1.73 per cent and 18° Brix. This was on the 6th of October. The lowest sucrose content was 4.2 per cent. The average is far below the percentage of sucrose in the original cane, which as before stated was 16.42. Means

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
289	14.7	9.6	2.9
14,175	15.9	10.1	2.8

Experiments made with a variety of Honduras, grown from seed head 12,677, with a sucrose content of 16.72 per cent, showed the same reversion, only in a much more marked degree.

Experiments with Sorghum Bicolor, seed head No. 13,799, with a sucrose content of 13.25 per cent, also failed to develop as rich a cane as the parent, the highest percentage of sucrose found being 12.2, with a percentage of glucose of 0.83.

Mean results.

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
13,799	14.3	8.4	1.1

Experiments were made on the 11th of October with Link's Hybrid variety, from plot 194, seed head 11,586, with a sucrose content of 16.01 per cent. The results also were very poor, the highest sucrose content obtained being 10.3 per cent.

Mean results.

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
194	14.7	7.6	4.3

Red Liberian, examined on the 11th of October, from seed-head No. 13,631, showing a sucrose content of 13.52 per cent, gave somewhat better results than the same variety examined earlier in the season, the highest sucrose found being 11 per cent. From the same variety, seed head 13,655, showing 13.97 per cent sucrose, the results were poorer, the highest sucrose content found being 9.1 per cent.

The means were:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
13,631.....	14.4	8.5	1.9
13,655.....	13.7	6.2	4.5

From a cross of Amber and Orange, seed head 13,927 having a sugar content of 16.85 per cent, much better results were obtained. The examination was made on the 17th of October. The percentages of sucrose obtained in the samples examined on that day were as follows: 15.1, 13.6, 14.2, 11.9, 13.5, 13.5, 11.9, 14.1, 13.7, and 12.9.

The percentages of glucose in all except three instances fell below 1, while the purities were very high. This sample appears to have given the best and most uniform results of any examined during the season.

The mean data are:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
13,927.....	17.6	12.5	0.75

On the 18th of October analyses were made of Link's Hybrid again from seed head 11,491, showing a sucrose content of 16.69 per cent, the results being also favorable. The percentages of sucrose were 13.8, 15, 12.6, 13.4, and 14.3, the glucose averaging about 1 per cent, and the purity being high. Analyses of the same plot, continued on the 20th of October, showed results equally good. The means for the two days are:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
11,491.....	18.4	13.6	1.2

Samples of Link's Hybrid, from seed head 13,897 with a sucrose content of 15.66 per cent, analyzed on the 20th of October, gave less favorable results, the highest sucrose conteut found being 14.5 per cent, and the lowest 8.8 per cent. Samples from another plot, grown from seed head 11,558, showing a sucrose content of 16.21 per cent, gave still less favorable results, and the same is true of another plot grown from seed heads Nos. 13,379 and 11,585. The means are:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
13,897.....	17.0	11.6	1.5
11,558.....	15.0	9.6	1.8
13,379.....	15.1	9.5	2.4

Red Liberian examined later in the season, namely, on October 29, still showed the same extremely poor characteristics as were manifested in the earlier part of the season, with the exception of canes grown from seed head from plot 127, showing 19°.5 Brix. The means from this plot were:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
127........	19.5	14.6	1.2

The analyses were completed on the 31st of October by the examination of a sample of a cross of Amber and Orange from seed head No. 12,142 with a sucrose content of 17.99 per cent. In the three samples examined the sucrose was 15.0, 12.5, and 13.8 per cent, and the glucose 1.01, 2.17, and 1.72 per cent, and the Brix 19°.5, 18°.0, and 18°.0. Means:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
12,142.....	18.5	13.8	2.0

The full discussion of the details of these analyses will be reserved for Bulletin No. 29. In general, however, it may be said that the Red Liberian, which has done fairly well in Kansas, was a total failure in Mississippi with the exception of one plot. The same is true but in a less degree of the Undendebule, although some analyses of this last variety were quite favorable, but the average of them all will show a much lower percentage of sucrose than in Kansas. Rio Blanco, which is a kind of Orange cane, also did very poorly in Mississippi, and the same is true of the cross of India and Orange. The Honduras in Mississippi as elsewhere has shown itself to be a worthless cane for sugar purposes. Sorghum Bicolor also did poorly in Mississippi. The best results obtained were from the cross of Amber and Orange, the one plot of Red Liberian, and Undendebule from plot 254, seed head 13,336, of which the mean analyses showed:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
254........	18.7	14.8	0.57

This brief review of the data obtained at the Mississippi station tends to show that if sorghum sugar culture is to become a success in that locality it will be quite necessary that a line of experiments in seed selection should be carried on similar to those which have produced such excellent results in Kansas. There is every reason to believe that by the pursuit of the same policy all the standard varieties of cane might be developed which would be as suitable to the soil and climate of Mississippi as those which have been developed in Kansas are to the meteorological conditions of that locality. Still, it must not be forgotten that the general tendency of the researches of the Department has been to show that sorghum does better in a semi-arid locality, and that therefore we ought not to expect as high a development in sugar-producing qualities in Mississippi as can be obtained in more arid regions.

EXPERIMENTS WITH SUGAR BEETS.

From Mr. Henry T. Oxnard, the Department purchased 3 tons of sugar beet seed, of which the greater portion was the variety known as the Kleinwanzlebner, grown by Dippe Brothers, of Quedlinburg. In addition to this, however, smaller quantities of the White Improved Vilmorin were purchased, together with the varieties of beets grown by Lemaire and Florimond and Bulteau Desprez. These different varieties were put in 1 pound packages and sent to over one thousand different persons, mostly to those who had made special inquiry for them. Accompanying these packages were directions for preparing the soil and planting and cultivating the beets. Later directions were sent for harvesting and sampling the beets and for sending samples to the Department for analysis. Nearly one thousand different samples of beets were received by the Department, of which the analyses were made and the results communicated to the farmers sending them. In addition to this work a large number of the beet plots was personally inspected by agents of the Department, and particular inquiry was directed to a large number of farmers in regard to the methods of cultivation which they had pursued. Only in a few instances were the directions of the Department followed out to the letter. In most cases the planting and cultivation of the beet seed were conducted according to such methods as the agriculturist might hit upon at the time.

From the information gathered, it was found that the chief variation from the instructions was in the preparation of the soil. In very few cases was a subsoil plow used and most of the beets which were sent to the Department were evidently grown in soil of insufficient depth. In some cases where the exact directions for cultivation were carried out the character of the beets received showed by contrast with the others the absolute necessity of employing the best methods of agriculture for their production. It was not thought best the first year to make any effort to obtain from the farmers the exact yield of their beets per acre. The difficulty of securing such information is almost insurmountable. In the first place the amount of land under cultivation is usually guessed at and in very few cases are exact measurements made. The results, therefore, at best are only estimates unless the absolute control of measurements and weights can be secured. It was thought best, therefore, to depend for estimates of yield upon the actual quality of the beets produced, since it is well known that about 40,000 beets of fair quality can be produced upon an acre. It is therefore fair to presume that the yield per acre would be, within ordinary limits, the weight of the average beet sent for analysis multiplied by 40,000. When, however, it is necessary to speak of beets weighing from 2 pounds upward the rule no longer holds good, as it would be evidently impracticable to grow 40,000 beets of such a size upon an acre. It is fair, however, to estimate the yield upon beets weighing about 1 pound at 40,000 per acre or 20 tons. It is not meant by this that a yield of 20 tons can be obtained by farmers at the beginning, for this is not the case; it is only exceptionally that such a yield can be secured. When, however, the exact methods of beet culture are thoroughly understood and the method of fertilizing and preparing the soil studied, it will not be difficult, with favorable climatic conditions, to secure a yield of beets equal to 20 tons per acre.

For the information of those who might desire hereafter to enter upon the cultivation of the beet, the following brief summary of the methods of preparation of the soil, fertilization and cultivation is given:

The soil which is to be planted in beets, if fertilized with stall manure, should have a dressing of well rotted manure applied in the autumn and plowed under. The plow should be placed at a depth of 8 or 9 inches and should be followed with a subsoiler, which should loosen the ground to the depth of 6 or 7 inches more, without throwing the subsoil on top. The layer of stall manure would thus be placed at a point about half way from the surface to the total depth to which the soil is loosened. If the stall manure be well rotted when applied the soil will be in excellent condition by spring for the reception of the beets. The farmer can not be too strongly cautioned against the application of the stall manure in the spring, nor against its application in the autumn unless in the well rotted condition mentioned above. There are many soils, in fact, in which the application of the stall manure is not at all necessary, namely, those soils which are rich in organic matter and those which have not been exhausted by long years of cultivation.

In regard to artificial fertilizers, the standards for the sugar beet, of course, are those containing phosphoric acid, potash, and nitrogen. The amount of nitrogen applied in artificial fertilizers, however, should be the minimum necessary for the production of a good vegetation. Any additional amount of nitrogen in excess of this quantity tends to produce a larger beet at the expense of its sugar content, and is to this extent injurious.

Phosphoric acid is usually employed in the form of superphosphates which are easily soluble by the growing crop.

Potash salts of organic origin have proved themselves to be the best; those which come from the beet-sugar factory itself being, of course, best suited for the nourishment of the succeeding crop. The potash and phosphoric acid in wood ashes also act with excellent effect. Inorganic potash salts produce a good effect when the soil is deficient therein. Of these inorganic salts kainite and high-grade sulphate are generally employed.

The artificial fertilizers may be applied in the spring if they are thoroughly plowed under by stirring the surface of the soil with an appropriate cultivator. The potash salts, however, should rather be applied in the autumn, inasmuch as it is important that they should be buried as deeply as possible in the soil.

For a full discussion of the principles of fertilization reference must be made to Bulletin No. 27 of the Chemical Division.

Planting.—The beet seed should be planted in rows about 18 inches apart. In very fertile soils the rows are sometimes placed only 16 inches apart. These rows should be made as straight as possible, and the beets are best planted in a small way by a hand drill and on a large scale by a horse drill. When a horse drill is used two or more rows can be planted at once. The rows when the contour of the soil permits are better made north and south than east and west, although this is a matter of no very great importance. It is highly important, however, that they should be perfectly straight, so that the beets will not be injured during cultivation. In some localities it is customary to keep the beet seeds in a moist and warm condition for about forty-eight hours before planting them; they are thus quite ready to germinate when placed in the soil. This is a perfectly safe process if, at the time the beets are planted, the soil is moist and warm enough to continue the germinating process, but if, on the other hand, the soil should be too cold or too dry, then this previous maceration of the seed might prove injurious to its vitality.

The surface of the soil in which the beets are planted should be, immediately previous to the planting, thoroughly stirred and loosened to the depth of 2 or 3 inches, and all clods should be broken and the surface left comparatively smooth. Much of the cultivation of the beets may be secured before their planting by having the soil in perfect tilth. The thorough plowing and harrowing of the surface just before planting destroys all the weeds which may have germinated, and thus leaves the beets a fair chance with the weeds in the race for life.

It is highly important that the beet seed should be planted very thick, much thicker, in fact, than would be required if they should all germinate. The policy, however, of planting the beet seed just where the beets are expected to grow, and in no greater quantities, would prove most disastrous, since at the best many of the seeds do not germinate, and thus there would be left long distances where no beets would grow. The very best growers of beets use about 15 pounds of seed per acre, although if the seeds were all good probably 3 or 4 pounds might be amply sufficient to obtain a good stand. The advice, therefore, is given to farmers to plant about 10 to 15 pounds per acre, since a little additional expense for seed will be more than compensated for in the uniform stand obtained. The beets should be covered to a uniform depth of about 1 inch. If they are planted much deeper than this it may be difficult for the tender plantlet to reach the surface; if at a less depth dry weather supervening may prevent their germination.

When the beets are fully above ground the spaces between the rows may be thoroughly stirred by the horse hoe, furnished with shields, described in Bulletin No. 27. These shields prevent the young plant from being covered, while the hoe thoroughly stirs the soil between the rows and kills all sprouting weeds. As soon as the beets begin to show three or four leaves the process of thinning should take place. This may be done altogether by the hand and hoe, or partly by a horse hoe. A very common method, when the stand is very thick, is to cross the rows with a slender horse hoe, which will take out about 6 inches of each row and leave about 4 inches untouched. The most healthy beet remaining in the 4-inch piece is left, while all the others are carefully taken out by the hand or hand hoe. This will leave one beet for every 10 inches, which is quite thin enough. In fact, an effort should be made to have a beet every 9 inches in the row in rich soils, while in very poor soils the distance may be left at 10 to 12 inches. In very rich soils it may be brought down as low as 8 inches. This thinning process is the most laborious and expensive of all the processes in beet culture, but is absolutely necessary to secure a good crop.

The surface cultivation can be carried on almost exclusively by horse power, and the ground should be thoroughly stirred between the rows and to a considerable depth at least once a week until the foliage of the beet begins to cover pretty thoroughly the spaces between the rows. If the cultivation of the beet begins about the 20th of May it should continue at least until the 1st of July, and in some instances for a longer time. The more attention which is paid to cultivation the larger will be the yield, other things being equal.

It is highly important that beet growers should realize the immense amount of labor which is necessary to produce a good beet crop. Farmers who are accustomed to growing maize and wheat are apt to think that beets can be grown over large areas much the same way, while, in point of fact, it requires as much labor to grow 10 acres of beets as it would 100 acres of maize. Mistakes are thus often made by beginners in attempting to grow more beets than they can attend to, with resulting failure. All farmers not accustomed to grow beets should begin with small quantities, and when the art has once been learned they will be able to estimate the area which they can successfully cultivate.

STATUS OF THE MANUFACTURING INDUSTRY OF BEET SUGAR IN THE UNITED STATES.

The readers of the agricultural reports are well aware, from what has already been published, of the fact that a beet-sugar factory has been in operation in Alvarado, California, for more than ten years. This factory has proved quite successful and the culture and manufacture of the sugar beet is now an established industry in that locality. For three years another large factory has been in operation at Watsonville, California, and from reports, which are accessible to the Department, this has also proved to be successful. Last year a large sugar factory was built at Grand Island, and as far as manufacturing operations are concerned was completely successful. This factory contains the latest and best forms of machinery suitable to the production of beet sugar and was built and operated upon the most approved plans of sugar technical engineering.

The beets which were brought in for manufacture were uniformly of a high character, as will be seen from a discussion of the analytical data relating thereto further on. The data of manufacture, however, are not accessible to the Department, the factory being purely a private corporation and not feeling disposed to furnish the Department with an itemized account of expenditures and receipts. From the best information accessible to us, however, it appears that about 5,000 tons of beets were received for manufacture and that the amount of sugar made per ton of these beets was probably 240 pounds. If the company should apply for the bounty given by the State of Nebraska, which is 1 cent a pound, it would be possible to give the exact amount from the report of the bounty paid. The Department, however, is not in possession of any facts in regard to this matter and hence only an estimate of the yield can be given.

By the courtesy of the managers of the company the Department was permitted to station a chemist at Grand Island, who had charge of the sampling of the beets as they came to the factory in wagons or carloads. Nearly three thousand analyses of samples were made and the full tabulated reports of these analyses will be found in a bulletin (No. 29) which will soon be issued on this subject, and a brief discussion of them will be found elsewhere in this report.

The proprietors of the factory were so encouraged by the season's work that they have decided to erect another large factory at Norfolk, Nebraska, and work on this factory is now going on.

Manufacturing experiments, on a small scale, with sugar beets, were also carried on during the season just past at Medicine Lodge, Kansas. About 80 acres of beets in all were harvested for the factory, and a summary of the work done will be given in another place and the details published in the bulletin above mentioned.

In general, the following remarks may be made concerning the last season's work in the beet-sugar industry, from a commercial point of view, in Nebraska and Kansas.

The summer in both localities was exceptionally dry. For this reason and on account of lack of knowledge among the farmers in regard to the proper methods of raising beets the average crop was very short. In Nebraska the exact tonnage can not be known, but probably it would not average more than 2 or 3 tons of beets per acre; in Kansas the average seems to have been somewhat higher. In many cases farmers obtained 10 and even 15 tons of beets per acre, showing that even in adverse conditions of season a reasonably large crop may be harvested when all other conditions necessary to the proper growth of the crop are attended to.

As might well be expected from the small yield, the farmers in general were dissatisfied with the season's work. It is not reasonable to expect satisfaction from a crop of so low an average when the labor of growing it is so great; but while the farmers are dissatisfied it must be confessed that a great deal of this dissatisfaction must be attributed to their own lack of knowledge of the subject or to their disinclination to put upon the beet fields the proper amount of labor and culture at the proper time. Instead of being therefore deterred from continuing the production of sugar beets, it would seem wiser on the part of the farmers to study carefully the methods of agriculture pursued by those who made a success of beet culture, and to imitate those methods during the coming season. The fact should not be forgotten, however, that even with the poor results obtained the beet crop was uniformly better than the average of other crops in the same locality.

It would be useless to hold out to the farmer the hope of financial reward from a beet crop which would average only 3 tons per acre; but if from this acre he could produce 10 to 15 tons of beets then his venture would prove financially successful. In order that the manufacture of beet sugar should become an established commercial success, the factories and the farmers must work in harmony. The method pursued in France and in Germany would probably be best suited to bring about this result. In those countries the beet growers themselves are usually shareholders in the factories, and thus participate in the profits. It is probable that the average dividend of German and French beet-sugar factories would not fall much below 20 per cent net on the capital invested. The farmer, therefore, who has even a small interest in such a factory secures a handsome profit on his invested capital. At the same time he has a vote in the board of directors and is personally interested in the success of the factory. In many factories of Europe the stock is thus held by the beet-growers. If, on the other hand, the whole of the factory be owned by the capitalists, then there is a cause for continual conflict between the interests of the farmer and the interests of the manufacturer, although this conflict is perhaps more in theory than practice. Even if the factory be owned exclusively by the capitalists, it is to their interest to work in harmony with the farmers, in order that they may secure a crop of sufficient magnitude to render the operation of their factory profitable.

It perhaps, however, would be unavoidable at the beginning of the industry that a feeling of animosity should exist between the beet-grower and the manufacturer. After a few years the prices to be paid for beets, and other arrangements with the farmers will doubtless be adjusted on a scale of equity and satisfaction to all concerned. In case farmers have no money to put into beet-sugar factories they might take shares of stock and pay for them with beets during the first and second years; in this way they would secure a financial interest in the company, own their shares of stock, and pay for them from the proceeds of the field without investing in ready cash. By adopting some such plan as this it might be possible to get every beet-grower within reach of the factory to become interested as a stockholder.

ANALYTICAL DATA COLLECTED FROM VARIOUS LOCALITIES WHERE BEETS WERE GROWN FROM SEED FURNISHED BY THE DEPARTMENT.

The samples of beets which were sent to the Department in response to the request already noted were immediately analyzed and the results of the analyses communicated to the growers of the beets. These data have been tabulated by States and by counties in States, and will be printed in detail in Bulletin No. 29 of the Chemical Division. Returns were received from a great many States, but principally from Nebraska and Minnesota. A brief summary of the results obtained follows:

Two samples were sent from Missouri, from Bates County. These were of poor quality, containing only 8.4 per cent of sugar, with a purity of 66.8. The beets, however, were of good size, averaging 600 grams (100 grams are equivalent to 3.53 ounces). Two samples of beets were received from Texas, Scurry County. These beets were of better quality than those from Missouri, containing 10 per cent of sugar, with a purity of 69.3. They were, however, very much too large for first-class sugar beets, averaging 1072 grams in weight. One sample of beets was received from Idaho, from Ada County. This sample contained 8 per cent of sugar, with a purity of 68.3, while the beets were extremely small, averaging only 100 grams. Six samples were received from Massachusetts, five from Hampshire County, containing 11.2 per cent sugar, with a purity of 82.8, the average weight of the beets being 468 grams, and one from Suffolk County, containing 16 per cent of sugar, with a purity of 82.8, and weighing 350 grams. Four samples of beets were received from California, Los Angeles County. These contained an average of 14.7 per cent sugar, with a purity of 84.6 and a mean weight of 382 grams.

In order to secure brevity the data obtained for the other States and the localities where the beets were grown have been compiled in the following tables:

State and county.	No. of samples.	Per cent of sugar in the beet.	Purity coefficient.	Average weight in grams.
Connecticut:				
Litchfield	2	9.7	76.1	400
Maryland:				
Prince George's	81	12.3	79.7	416
Oregon:				
Jackson	2	15.1	73.4	560
Washington:				
Lewis	1	15.2	84.2	450
Virginia:				
Augusta	19	11.4	76.3	415
Loudoun	2	5.4	53.7	480
Pennsylvania:				
Dauphin	2	8.4	76.7	1,209
Lancaster	7	7.5	72.8	566
Philadelphia	1	10.04	75.2	1,225
Wyoming:				
Carbon	2	12.3	78.8	1,213
Crook	1	16.3	.....	260
Laramie	2	17.3	84.8	508
Illinois:				
Kendall	1	6.5	64.8	832
Pike	1	10.2	71.8	1,368
Platt	1	6.1	61.0	685
Will	4	11.9	75.8	830
New York:				
Genesee	3	12.2	79.4	1,732
Oneida	2	11.1	78.8	423
Warren	2	13.8	84.5	643
Yates	3	11.4	71.7	470
Wisconsin:				
Calumet	3	11.9	81.9	705
Kewaunee	2	13.5	79.6	632
Ozaukee	2	12.7	81.5	505
Vernon	3	13.8	81.6	493
Ohio:				
Butler	1	9.2	76.4	1,017
Erie	1	8.8	71.5	305
Hamilton	1	12.4	80.9	458
Sandusky	3	12.3	76.9	935
Trumbull	7	9.6	77.9	808
Van Wert	2	6.2	67.3	370
Colorado:				
Garfield	1	13.00	74.1	405
Larimer	7	14.00	83.2	644
Mesa	1	14.40	86.4	453
Phillips	3	12.90	71.9	638
Prowers	5	9.80	68.8	519
Pueblo	6	12.80	79.2	578
San Miguel	2	9.90	65.8	820
Yuma	2	9.90	69.5	573
South Dakota:				
Brookings	7	14.4	84.9	472
Brown	1	16.3	80.4	295
Davison	2	12.6	72.3	806
Grant	1	11.0	73.0	856
Hyde	4	13.0	78.8	619
Kingsbury	2	10.5	71.1	553
Meade	2	14.1	74.2	765
McCook	2	10.6	76.4	365
North Dakota:				
Burleigh	1	10.4	70.3	453
Cass	5	13.0	75.5	736
Dickey	2	11.0	70.4	1,060
Morton	1	13.8	73.9	508
Nelson	1	13.6	74.1	675
Ransom	4	10.3	71.3	794
Sargent	2	20.8	.....	218
Stutsman	1	12.5	77.6	570
Traill	7	14.7	76.7	701
Kansas:				
Barber	3	14.7	80.0	363
Bourbon	3	9.3	73.3	1,403
Butler	1	9.7	70.5	685
Kansas—Continued.				
Clay	4	9.3	67.6	611
Douglas	2	8.4	65.1	1,175
Hamilton	2	12.6	76.8	750
Johnson	2	12.4	68.4	295
Lyon	2	4.4	50.6	2,423
Saline	2	7.9	63.2	889
Stafford	1	11.5	75.2	548
Iowa:				
Audubon	1	10.7	74.9	535
Black Hawk	6	12.8	78.2	578
Carroll	6	12.8	78.2	578
Cherokee	2	10.4	68.2	474
Fayette	2	11.3	75.7	750
Harrison	2	10.8	73.1	1,013
Page	1	11.1	72.6	668
Polk	2	8.0	56.0	355
Sioux	3	11.6	72.7	786
Webster	4	14.4	84.8	560
Woodbury	2	9.7	67.0	628
Michigan:				
Clinton	2	11.5	77.2	763
Eaton	2	9.1	.....	187
Gratiot	4	12.3	75.7	1,018
Huron	1	11.1	74.7	1,282
Ingham	1	12.5	76.6	1,515
Ionia	2	15.2	82.9	415
Lenawee	2	8.0	60.5	2,193
Macomb	2	15.4	87.5	693
Muskegon	11	12.2	80.9	699
Saginaw	2	12.9	82.0	773
St. Clair	1	10.0	71.5	1,660
Indiana:				
Benton	19	12.0	80.0	697
Cass	6	12.4	71.9	625
Clinton	1	18.1	78.9	430
Decatur	1	5.3	58.9	1,840
Grant	5	8.6	70.3	701
Greene	2	13.4	77.9	303
Hamilton	2	10.2	69.7	506
Hancock	2	6.9	51.8	718
Henry	1	10.6	82.6	780
Howard	1	13.2	70.5	600
Marion	6	9.8	65.6	548
Montgomery	2	7.7	64.4	953
Newton	2	10.0	71.7	543
Pike	1	10.5	75.7	432
Tippecanoe	2	8.3	64.6	603
White	3	8.2	63.3	543
Minnesota:				
Anoka	10	12.6	76.7	637
Becker	3	12.2	73.7	1,410
Blue Earth	8	10.5	74.1	684
Brown	2	8.5	68.1	1,158
Carver	4	11.0	71.1	951
Chisago	5	12.9	79.9	923
Clay	2	13.0	75.2	765
Cottonwood	2	12.3	67.7	898
Dakota	2	14.6	81.1	367
Faribault	2	9.8	64.6	873
Fillmore	2	11.4	74.6	826
Goodhue	6	10.9	71.1	685
Hennepin	6	12.4	77.8	1,216
Houston	1	13.0	80.6	510
Isanti	3	10.0	70.5	1,623
Le Seuer	2	10.8	73.2	508
Lincoln	2	12.3	73.2	1,343
Lyon	2	14.9	78.2	490
Marshall	1	8.5	66.9	740
Martin	7	11.2	73.5	889
McLeod	2	10.9	73.7	943
Meeker	2	11.0	75.0	525
Murray	5	15.2	84.4	415

State and county.	No. of samples.	Per cent of sugar in the beet.	Purity coefficient.	Average weight in grams.	State and county.	No. of samples.	Per cent of sugar in the beet.	Purity coefficient.	Average weight in grams.
Minnesota—Continued.					Nebraska—Continued.				
Nicollet	1	13.0	75.6	612	Hall	2	16.1	88.8	423
Nobles	2	13.1	76.4	1,268	Hamilton	2	13.8	.....	235
Pipe Stone	2	11.0	71.0	1,154	Harlan	4	10.7	68.8	328
Ramsey	12	10.6	81.0	830	Hayes	3	14.2	74.5	913
Rock	1	13.5	79.3	870	Hitchcock	4	14.0	73.0	464
Steele	2	9.3	67.6	1,043	Holt	17	13.5	73.9	777
Traverse	2	17.0	76.3	708	Howard	1	11.9	79.6	810
Wabasha	1	9.8	71.0	280	Jefferson	7	11.8	72.4	434
Washington	3	10.6	76.4	1,103	Kearney	3	20.2	76.1	224
Wilkin	1	14.6	80.6	447	Kimball	1	10.8	70.4	227
Wright	1	10.0	71.4	910	Knox	5	10.7	71.4	868
Nebraska:					Lincoln	9	12.5	75.0	613
Antelope	29	12.5	74.7	419	Loup	2	9.6	66.0	692
Banner	3	11.4	70.4	612	Madison	5	11.6	74.7	523
Blaine	2	12.6	76.3	580	McPherson	2	12.4	76.2	238
Boone	36	10.1	69.2	550	Nuckolls	4	8.5	67.4	347
Box Butte	6	12.2	71.6	666	Pawnee	4	12.7	80.5	693
Brown	1	10.1	69.7	350	Perkins	7	12.4	74.9	857
Butler	2	12.7	68.9	245	Phelps	5	12.4	76.2	305
Chase	8	11.7	70.6	796	Pierce	1	10.9	75.2	565
Cherry	2	8.9	60.5	530	Platte	4	10.0	68.3	369
Colfax	7	11.8	71.3	661	Polk	3	10.9	68.4	533
Cuming	2	10.4	69.8	692	Red Willow	2	8.1	61.2	940
Custer	4	7.0	58.2	550	Richardson	5	9.8	65.4	733
Dawes	3	12.7	73.3	258	Rock	1	14.4	88.1	400
Dawson	2	10.5	73.3	670	Saline	2	7.8	60.1	425
Deuel	1	18.8	....	248	Saunders	4	13.1	75.8	559
Dodge	2	14.8	82.3	600	Scott's Bluff	1	22.7	83.3	333
Dundy	1	10.0	67.7	1,565	Seward	2	11.2	72.3	450
Fillmore	5	11.6	68.7	677	Sheridan	9	11.2	69.8	503
Frontier	7	12.3	74.4	531	Thayer	13	14.6	77.8	682
Furnas	5	12.7	76.0	454	Valley	2	10.6	69.7	503
Gage	6	9.4	68.6	721	Wayne	2	9.0	70.8	413
Garfield	6	15.4	74.8	533	York	9	12.9	72.4	443

In the above summary of the beets sent from Nebraska are not included those which were examined at the Grand Island Sugar Factory under the direction of the Chemical Division, but only those which were sent directly to the Department at Washington for examination. In addition to these two sets of analyses large numbers of samples were examined in the laboratory of the Agricultural Experiment Stations at Lincoln and Madison, Wisconsin.

In a critical study of the summary given above there are many points of interest, a few of which only can be given here, while the others will be given at greater extent in Bulletin No. 29. In judging of the character of a beet for sugar-making purposes three factors must be taken into consideration. First of all, the beet must be large enough to make its growth profitable to the farmer. Experience has shown that a beet which weighs about 500 grams, that is, a little over 1 pound, is best suited to secure the interests of both the farmer and the manufacturer. Therefore, in all cases attempts should be made to grow beets as uniformly as possible of that weight. Having once established the average weight of the beet, the next point to be considered is its content in sugar. In the data given the percentage of sugar is reckoned on the weight of the beet itself and not upon the extracted juice. Sugar beets contain on an average about 5 per cent of marc and 95 per cent of juice. Therefore if the analysis is made upon extracted juice, the number obtained must be multiplied by 0.95 to give the percentage of sugar in the beet.

The question may arise as to how poor a beet can be in sugar and still be profitable for sugar making. This of course is a question which has to be determined by a comparison with many economic problems, the study of which can not be introduced at the present time. In general, however, it may be said that the limit of profit in manufacture will be reached when the percentage of sugar in the beet drops to 12, although it is possible under certain conditions for factories to work economically and profitably on beets having a lower percentage of sugar than that indicated.

With the present degree of perfection in the production of rich sugar-beet seed, and with the knowledge of the scientific principles of agriculture which should guide the beet grower, it is possible, I think, to show that beets can be produced, under favorable soil and climatic conditions, which will contain on an average 14 per cent of sugar. The farmer, therefore, should not be satisfied if his results fall below this standard.

It will be easy to see by comparing the averages given in the above table how many of the beet growers have succeeded in growing plants which will average 500 grams in weight and contain 14 per cent of sugar.

In addition to these two factors, however, a third must be taken into consideration, namely, the purity of the juice. By the purity of the juice, or, as it is expressed in the table, the coefficient of purity, is meant the percentage of pure crystallizable sugar in the solid bodies present in the juice. For instance, if in 100 parts of solids there are 80 parts of pure crystallizable sugar, the coefficient of purity of that juice is said to be 80. The number 80 may be taken as a fair average which should be attained in this country. In the older beet-growing countries a much higher degree of purity can be obtained than this. The degree of purity of the juice is influenced chiefly by the amount of salts represented by the ash obtained on the ignition of the sample. In soils highly impregnated with mineral substances, such as are often found in our western States, the percentage of ash will be found very high, and there will be a corresponding depression of the purity coefficient. In lands, however, which have been long cultivated and scientifically treated from an agricultural point of view, the percentage of ash in the beet will be diminished and the purity coefficient correspondingly raised. The ash of the beet consists largely of phosphoric acid and potash, and these two substances are essential to the proper growth of the beet. It is therefore not expected that the ash of the beet shall be reduced below a certain content, otherwise the growth and maturity of the plant will be retarded. It will not be possible in the space which is at our disposal here to discuss each of the series of data obtained by these analyses, but the above remarks are made for the purpose of enabling anyone who is interested in any particular series or analysis to discuss it intelligently and determine from the numbers given the value of the beets produced for sugar-making purposes. At the present time, for the purpose of fixing a standard of comparison, I would say that the typical sugar beet for sugar-making purposes should weigh 500 grams, contain 14 per cent of sugar, and have a purity of at least 80. With such raw material at his disposal in sufficient quantity, the manufacturer can not fail of success, provided he be supplied with the latest and most improved forms of machinery.

It may also be of interest in connection with the data above given to discuss some of the particular qualities of the beet separately. In general the mistake is made by those not acquainted with the principles of the growth of the sugar beet and manufacture of beet sugar of judging of the possibilities of success by the percentage of sucrose in the beet alone. The danger of relying solely upon this constituent of the beet is at once manifest from the considerations above mentioned. Nevertheless as it is often done, I have collected into tabular form from the analyses given above all of the results showing from 15 to 18 per cent of sugar in the juice. In another table have been collected all the analyses in which more than 18 per cent of sugar was found. In the case of Minnesota 3 samples of beets were found in which the percentage of sugar was more than 18; in the State of Indiana, 1 sample; in Iowa, 1; in North Dakota, 4; in Maryland, 5; in Colorado, 1; in Wyoming, 1; in Nebraska, 13. Of beets showing a percentage of sugar from 15 to 18 in the juice, the following numbers of samples were found: In Illinois, 3; in Minnesota, 15; in Nebraska, 36; in Maryland, 8; in Iowa, 4; in Wyoming, 2; in Colorado, 9; in North Dakota, 4; in Massachusetts, 1; in Wisconsin, 2; in California, 2; in South Dakota, 6; in Michigan, 4; in Kansas, 3; in Washington, 1; in Oregon, 2; in Virginia, 2.

The production of beets containing from 15 to 18 per cent of sugar is not unusual, and such beets may be regarded as strictly normal in constitution, but possessing a particularly high content of sugar. When, however, the content of sugar in the beet exceeds 18 per cent it must be regarded at the present time as something abnormal and due to peculiar conditions affecting the particular locality, or even the particular plant itself. Such beets are usually extremely small in size, and the richness of their sugar content has been acquired at the expense of normal growth. In other cases the effect of a particularly dry season preceding the time of harvest or other very peculiar conditions may affect the sugar content. In many other cases, from the wilted condition in which the beets have been received, it must be admitted that a portion of the water which they contained has dried out between the time of harvest and the time of analysis, thus increasing the apparent percentage of sugar in the beet. It will doubtless be possible hereafter, when the beet has been more fully developed by careful selection, to produce beets normally which contain more than 18 per cent of sugar, but to expect at the present time the production of such beets on a large scale would be unreasonable, and such an expectation would not be realized. Even when we consider the other class, namely, those containing in their juice from 15 to 18 per cent, we must confess that it would be unwise to look for a production of beets on a large scale containing so large a percentage of sugar. In many of the cases of beets of this class the high-sugar content must be ascribed primarily to some of the conditions mentioned for the class above 18.

When, however, the tables are further studied and the remarkably low percentages of sugar are noticed which were sometimes found, it must be confessed that in these cases the abnormally low content of the sugar is also due to the abnormal growth of the beet. In some cases these beets are of great size, weighing 2,000 grams or over, and to this extraordinary growth must be attributed to a certain extent the low content of sugar. In general, it has been found that when beets exceed 500 grams in weight it is difficult to maintain their sugar content at a high standard. When, therefore, the beets become greatly overgrown it is always accompanied with a falling off in content of sugar. In the cases, however, of the small beets, which have shown a low content of sugar, the result must have been due to defective conditions of soil and climate, or to defective methods of planting and cultivation, or to premature harvesting.

When we consider the varying qualities of beets which have been grown from the same seed, we are at once struck with the immense importance of the factor of soil and climate and cultivation in the production of the sugar beet. The fact that the seed of the Klein Wanzlebner variety of beet in the hands of different farmers will show a variation of from 6 to nearly 20 per cent of sugar, it must be confessed that we have in soil and climatic conditions, and in methods of cultivation, a more potent means of influencing the sugar content of the beet than is found in the germ of the seed itself. It can only be expected that a sugar-beet seed which is high bred will be able to reproduce its kind when it has become fully acclimated and has received in its new condition the same scientific treatment and selection which it had in its original home. The great hope, therefore, of uniform production of sugar beets high in sugar-producing power in the United States must be found in the establishment of culture stations, where different varieties of beets can become fully acclimated, and where they can receive the same careful scientific culture and selection which have brought them up to their present state of excellence in Europe.

CHARACTER OF BEETS DELIVERED TO THE GRAND ISLAND FACTORY.

Through the courtesy of Mr. H. T. Oxnard the Department was allowed to establish a laboratory at the sugar factory at Grand Island for the purpose of obtaining information in regard to the character of the beets entering into manufacture. In all about three thousand samples of beets were examined, a sample having been taken from every wagonload and every carload of beets delivered to the factory. These samples were taken in such a way as to give as nearly as possible the average character of all the beets worked. A large number of beets was taken from each sample, and after they had been properly cleaned and dried their average weight was taken. The beets were then rasped, the juice expressed, and an analysis made on the expressed juice. The total solid matter was determined by a specific-gravity spindle, and the percentage of sucrose in the juice was estimated by the polariscope. The purity coefficient was determined by dividing the percentage of sucrose in the juice as indicated by the polariscope by the percentage of total solids as indicated by the spindle.

Average weight of beets.—The average weight of all the beets examined was 200 grams. This small size of the beet was doubtless due to the extremely dry season. The drought throughout the region covered by the sugar-beet fields was the most severe perhaps that has ever been known in the State of Nebraska. Ordinary crops such as corn were almost total failures, and it is a matter of encouragement to note that in such a season the beets, although not making an average yield, yet did fairly well. On the whole, however, it must be confessed that the results from an agricultural point of view were disappointing; but this disappointment must be chiefly attributed to the exceptionally severe drought already mentioned.

It is also doubtless true that in the practice of the new system of agriculture which is required for the proper production of sugar beets many failures were made, and perhaps very few of the farmers practiced that form of agriculture which was best suited to the soil and the season. In a soil which is apt to be dry as in Nebraska too much attention can not be paid to the importance of loosening the ground to a good depth. Deep plowing followed by deep subsoiling, together with such harrowing and other treatment of the surface as will produce a perfect tilth, are absolutely essential to the production of a profitable crop.

The remarkably high percentage of sucrose shown in the juice is an evidence of the fact that the soil and climate of Nebraska are favorable to the production of a beet rich in crystallizable sugar. It must, however, not be forgotten that the extremely high percentage of sucrose in the juice is probably a reciprocal of the small size of the beet due to the dry season. Had the season been favorable to the production of a beet of average size, with a tonnage of from 15 to 20 per acre, the percentage of sucrose in the beets would doubtless have been less. This is well illustrated in the data obtained in the Department from the analysis of sugar beets sent from Nebraska. It is evident from the character of the samples which were received by the Department that the farmers have selected the larger beets to be sent on for analysis. It is seen by comparison of the respective sizes of the beets received for analysis by the Department with those received for manufacture at Grand Island that the beets sent on for analysis were about three times the size of those manufactured into sugar. It will also be noticed that in the beets received for analysis by the Department the percentage of sucrose is low as compared with those which entered into manufacture at Grand Island. It would therefore hardly be just to claim that beets as rich as those manufactured at Grand Island during the past season can be grown in quantities of from 15 to 20 tons per acre. It is not a matter of surprise that many of the farmers who grew beets are discouraged at the results of the first year's work. The planting and cultivation of the sugar beet as is well known are matters which require great labor and expense, and when, therefore, an unfavorable season cuts the crop very short, it is but natural that the farmer should be discontented. It is, however, difficult to see how he could have done better with any other crop, and the fact that in many instances even with the present dry season the farmers of Nebraska were able to grow 10 or even 15 tons per acre, shows that with proper cultivation and proper attention in other ways to the growing crop the evils which attend a severe drought can be greatly mitigated if not altogether avoided. It is not the purpose of the Department to encourage farmers to engage in an industry which does not give promise of success; but it will be a matter of regret to every one who desires to see the success of the sugar industry if the discontent which naturally attends a very unfavorable season should be sufficient to deter farmers from continuing the cultivation of a crop which under ordinary conditions promises so fair a yield as sugar beets. It would be wiser on the part of the farmers to continue the cultivation of the sugar beet until it has been demonstrated at least that even with favorable years it is not profitable. In that case it would be perfectly justifiable in the farmers, of course, to cease the cultivation of a crop which afforded no prospect of financial success.

EXPERIMENTS WITH SUGAR BEETS AT MEDICINE LODGE.

In addition to the analyses and control of the sorghum sugar work extensive examinations were made of the beets growing in the locality of Medicine Lodge.

The season was a peculiar one for beets. At the commencement of the rains, on the 28th of August, the beets were scarcely at all developed and were regarded as a total failure. After the rains commenced the beets grew rapidly and continued to grow vigorously through the months of September and October. About the middle of November the harvesting of the beets was commenced and continued until December. At that time the beets had reached a fair size and developed a high content of sugar. Two hundred and sixty-one wagonloads were brought to the factory and large samples were taken from each of these loads and subjected to analysis. The means of two hundred and sixty-one analyses follow:

In the juice.

Total solids	per cent..	18.52
Sucrose	do....	15.12
Purity		81.04

Four hundred and eleven miscellaneous analyses of the beets from different plots in the vicinity of Medicine Lodge were made with the following mean results:

In the juice.

Total solids	per cent.	17.80
Sucrose	do....	13.20
Purity		75.60

The fresh chips entering the battery had a mean sucrose content, in the juice, of 13.90 per cent, much less, as will be noted, than that represented by the analyses from the different loads.

The diffusion juices show a content of 10.45 per cent sucrose and a purity of 81.2.

The working of the beets with the sorghum-sugar machinery was extremely slow, and either from this cause or from the method of liming, which was very heavy without any subsequent use of carbonic acid, the clarification and boiling of the juices became a matter of great difficulty, and they suffered in this process rapid deterioration; for instance, the purity of the clarified juice was only 78.8 and of the sirup 78.3, while the mean purity of the massecuites showed the enormous depression represented by the difference between 78.8 and 59.4. The actual cause of this remarkable deterioration in boiling is not well understood, and the juices boiled with the greatest difficulty, it being almost impossible to prevent them from foaming in the pan. The semisirups also, after standing for a time, deposited a large quantity of mucus or viscous material, and this would lead to the supposition that a pernicious fermentation of a viscous or mannitic nature was the cause of the great loss of sugar during the boiling operations.

It is evident at once that the attempt to make beet sugar without appropriate apparatus must be regarded as futile. Beets of the quality of those delivered at the Medicine Lodge factory, if they had been properly and promptly manufactured, would have yielded almost 250 pounds of sugar to the ton; instead of this the yield was extremely small, the separation from the massecuite very difficult, and the whole manufacturing process disappointing.

In regard to the probability of producing beets in the locality of Medicine Lodge, I am still of the opinion, expressed in Bulletin No. 27, that it is a locality too far south to expect the successful culture of the sugar beet. In using the term "too far south" it is not meant in an absolute sense, but too far south from the zone of the probable beet industry as indicated in the map given in Bulletin No. 27. The actual growing season at Medicine Lodge it will be noticed was not during the summer, but in the autumn after the rains fell and the weather had become cool. Had the early part of the season been wet enough to secure a growth of the beets it is hardly probable that they would have shown the high content of sugar which they did. The splendid results obtained at Medicine Lodge in the working of sorghum cane would seem to indicate the course which the sugar industry should follow in that locality. Everything indicates that the culture of sorghum sugar will prove a success while there is little to encourage the further development of the beet-sugar industry in that locality.

PRODUCTION OF SEED.*

There is, perhaps, no other agricultural crop which has illustrated in so marked a manner the importance of seed selection as the sugar beet. By the careful selection of those variations in the original beet which seemed most favorable to the production of sugar, and the careful selection of beets in the production of seed during the succeeding year, and by judicious and scientific fertilizing for the purpose of increasing the sugar content, there has been a great evolution in the sugar-producing power of the beet which has placed it at the head of the sugar-producing plants of the world.

The influence of the quality of the seed, according to Vilmorin, is absolutely predominant from the point of view of the results obtained in the culture of the sugar beet. The numerous experiments of scientific investigators have shown that remark to be true. In France the firm of Vilmorin-Andrieux & Co. has paid special attention to the improvement of the standard varieties of the sugar beet by the method above mentioned. They have endeavored to produce different varieties of beets of which each one would have all the possible advantages in the different economical and culture experiments to which manufacturers and farmers will submit them.

It is true, without doubt, that the same variety of beet could not be the most advantageous in every case, and that, according to the results to be obtained, it might be an advantage in one place to cultivate a variety extremely rich and in another place one, which, while still rich in sugar, would also produce a heavy yield in pounds. To these different needs different varieties of beets respond. In one case the pure white variety, in another the white variety with green neck or the rose variety with rose neck, or the Vilmorin Improved, a variety which is suitable everywhere and particularly in those countries where the duty on beet sugar is laid directly on the beet. Since the introduction of the new law in France, in 1884, levying the tax upon the actual weight of beet produced, the White Improved Vilmorin beet has recommended itself by its exceptional richness, its great purity, and the ease with which it can be preserved. But in order to meet all the conditions necessary to the greatest success

* Bulletin No. 27, Division of Chemistry, pp. 41-46.

it is essential to find out by experiment that variety of beet, which, in any given locality, fulfills most of the conditions required to produce a high yield of sugar with a minimum cost and one which will be equally profitable to the farmer and manufacturer.

At the present time, it is necessary in this country to go abroad for beet seed of the highest character. Up to the present time the sugar-beet seed which has been grown in this country has been produced without especial reference to the conditions necessary to maintain the beet at a high standard and to improve it as is done in foreign countries. In other words, the sugar-beet seed which one will obtain from American dealers, if it should be that which is grown at home, does not come with the pedigree of the beet, in regard to content of sugar and purity of juice, nor with that assurance of care in cultivation which the professional producers of beet seed in foreign countries bestow upon their work. There is no reason, however, to suppose that it is impracticable to produce beet seed in this country of as high a grade and of as pure a quality as that which can be obtained in other countries. The method of doing this will be briefly indicated.

In growing the beets the greatest care should be taken to secure all the conditions necessary to produce a beet of maximum richness in sugar, coupled with a yield per acre of fair proportions. This can be done by attending to the directions for culture to be given, combined with judicious application of those fertilizers which will tend to increase the sugar content of the beet without unduly increasing its size. The fertilizers which are most suitable for this purpose are carbonate of lime, when it is not present in sufficient quantities in the soil, a small quantity of magnesia, and larger quantities of phosphoric acid with varying proportions of potash and nitrogen, according to the character of the soil in which the beets are grown. No certain rule can be given for the application of fertilizers until the conditions of the season and the character of the soil in each particular locality have been carefully studied experimentally. For this reason, it is certain that in this country, as in others, the business of producing beet seed will be one entirely distinct from that of raising beets for manufacture or from the manufacturing thereof. It is this business which will require not only the highest scientific agriculture but the most careful agronomic skill.

SELECTION OF "MOTHERS."

The beets which are to be used for producing the seed should be selected on account of the possession of those properties which are most suitable to secure the highest results in the production of sugar. In the first place, all beets of irregular or unwieldly shape should be rejected; those selected should be of uniformly even texture, smooth outline, and symmetrical shape.

The sugar content of these beets should be determined by the analysis of others grown in the same plot and of the same seed, and thus obtain the average content of sugar for the whole lot. Only that class of beets showing the highest content of sugar combined with the qualities given above, and the greatest purity of juice, should be preserved. In many cases the beets themselves, which are to be used for propagation of seed, are subjected to analysis by the removal of a cylindrical section by an instrument provided for that purpose and the analysis of this section. In this way the actual sugar content of the beet which produces the seed can be obtained. It is said that good results have also been secured by replacing the portion of the beet removed by sugar at the time of planting, which will afford an additional food product for the earlier growth of the beet in its second year.

Another method of selecting the beets, which has been widely employed, is that of determining their density. A solution of some substance is made in water, such as salt or sugar, of such density as to permit beets of inferior quality to float on the surface and those of superior quality to sink. These heavier beets, other things being equal, contain larger quantities of sugar and are more suitable for the production of seed. The beets, of course, which are to be used for the production of seed must be very carefully harvested so as not to be bruised, leaving the roots as much as possible uninjured, and they must be carefully preserved in silos over the winter until the time for transplanting in the spring. The transplanting and the successful cultivation of the beets need no detailed description.

The character of the beet is also sometimes determined by removing a small portion, as indicated above, for polarization, expressing the juice and determining its specific gravity by weighing in the juice a silver button of known weight.

The absolute necessity of securing a few beets of the highest sugar coefficient and purity for the purpose of producing a crop of seed in third, fourth, or fifth year, according to the number selected, has in the last few years been recognized to a degree unknown before. At first it was the custom to select the beets, by some of the methods mentioned above, in large numbers sufficient to grow in the second year seed for the market. A much more rational method, however, and one which secures higher results, consists in a more careful selection of the mother beets for the purpose, not of producing seed for the market in the second year, but only for the purpose of securing an additional crop of beets in the third year which in the fourth year will produce seed for the market. The methods employed by different seedsmen vary somewhat, but the principle in all cases is the same. The general method may be indicated by that pursued by Dippe in Quedlinburg:*

First year.—Seed planting for mother beets, from seed which came from the highest polarizing beets of different varieties, which have, of course, been kept separate. The planting is in rows 18 inches apart, and the plants are cut away in the rows so as to stand 10 or 12 inches apart. At the time of harvesting the beets are selected out according to form, growth, and leaf formation, as these best approximate the characteristics of the parent variety.

Second year.—In March and April these selected beets are examined in the laboratory † in the following manner:

At a certain point which it is presumed will give an average of the entire beet, a cylindrical piece is cut out, subjected to strong pressure in a juice press, which will give, for example, from 17 grams of beet 10 grams of juice, of which 5 cubic centimeters are diluted with lead acetate and water to 25 cubic centimeters, filtered and polarized. For the different varieties minimum limits are established, and the beets are arranged in three classes according to their polarization:

First, beets which go below the limit and are thrown out; second,

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* Stammer, pp. 200, *et seq.*, Lehrbuch der Zucker Fabrication.

† This is not done until spring in order that only well-preserved beets may be chosen.

beets which are above the limit, and fairly good for seed purposes, and, third, beets which show an extra high figure.

These extra good beets are now examined still further, two more cylinders taken out, and the sugar estimated by the extraction method. From this result and the estimation of the sugar in the juice the (apparent) content of juice is calculated. Those beets which do not reach a standard, established for each variety (between 92 and 94), are thrown out, while those that attain it are the chosen "mother beets" of the crop, which are to perpetuate the variety, and which furnish the seed for each new succession, as mentioned in the first paragraph.

In the second year are planted all the beets saved, the extra and medium as well; the former furnish seed for extra mother beets, which are used as indicated for the normal-sized mother beets which furnish seed for a new succession, while the latter are to produce a generation of dwarfs, the seed from both being saved.

Third year.—The seed from the medium and extra mother beets is planted, and the latter produce the mother beets for future breeding purposes, as indicated, but the plants from the former seed, which was planted a little later than would be the case for beets ordinarily, and in soil fertilized with ammoniacal superphosphate and also some guano, in rows 12 inches apart, are cut out to about every 3 to 5 inches. The small beets are very carefully preserved under a thick covering of earth. In the spring of the

Fourth year.—They are uncovered and planted at about 26 to 24 inches apart. The seed from these when harvested in the fall is ready for the market, so that it has taken five years to attain this end.

In the establishment of Branne, in Biendorf, the procedure is similar, but the beets are selected by their specific gravity in the field. A woman sits at a table and cuts from each beet a very small piece and throws it into a solution of salt of known density (for example, with the Klein Wanzleben, 16° Brix). If the piece of beet floats, the corresponding beet is thrown away, but if it sinks the beet is reserved for further investigation in the laboratory. The beets chosen in this way are submitted to further selection by the examination of the juice from a cylinder.

In a somewhat different way, but still by means of the examination of individual beets, is the culture of the Klein Wanzleben variety carried on by Rabbethge, in Klein Wanzleben, whose object is not so much to furnish establishments with all the seed they require for planting, but rather with seed for the production of mother beets, and their own seed from these. The fact that Klein Wanzleben has never yet harvested more than 3 tons of seed in a season indicates the character of the work, which is much to be commended.

The seeds are always taken from mother beets of considerable weight, never from small or dwarf beets, and the aim is not so much to produce individual beets of exceptionally high sugar content, but large beets as well; that is, beets which give the highest yield of sugar from a given amount of land. These roots, which are chosen from a field of the best (Elite) beets, and which possess most distinctly the characteristics of the variety, are weighed and their juice polarized, and this operation is continued until 20,000 beets are chosen which fulfill the requirements as to weight and sugar content.

These 20,000 best mother beets are sufficient to furnish the planting of a hectare (2½ acres), and from them are obtained 40 to 60 hundred weight of the best (Elite) seed, and this gives the following year 60 to 100 hectares of the best (Elite) beets, or 5,000,000 to 7,000,000 plants. From these are finally chosen the 1,500,000 seed-bearers which furnish the planting of 100 hectares and the seed for sale and for the perpetuation of the breed.

An entirely different method of selection is what is known as "family" breeding. Hundreds of specially selected beets, excellent in every way, are planted out separately. The seed of each is gathered and planted separately. If among the beets thus obtained any are found that excel the mother beet in every respect, and this improvement endures through several generations, these are incorporated with the other mother beets and used for breeding. As examples of weight and polarization of the selected beets the following figures for the highest and lowest weights are given, representing the best mother beets of the years 1883 and 1884 ·

Weight.	Sucrose in juice.	Weight.	Sucrose in juice.
Grams.	*Per cent.*	*Grams.*	*Per cent.*
1,550	11.24	600	15.11
1,450	13.68	600	16.28
1,250	14.29	600	16.28
1,500	15.87	400	16.13
1,450	14.60	550	15.62
1,700	11.76	400	16.83
1,860	14.86	550	16.88
2,100	14.35	400	16.63
1,900	14.60	600	15.63
600	16.13		

Among 200 beets were found only 11 with a weight of less than 500 grams; 12 with a weight of 500 to 600 grams; 29 with a weight of 600 to 700 grams; 21 with a weight of 700 to 800 grams; and finally 127, or 63 per cent, with a weight of over 800 and up to as high as 2,100 grams.

The beets between 700 and 1,000 grams are of nearly identical sugar content, a peculiarity of the Klein Wanzleben variety.

The established normal weight varies, according to the season, between 600 and 900 grams; in the year 1883 it was 897 grams, corresponding to the average of the beets from a field.

A still different method is followed by v. Proskowetz (Kwassiz). The beets from which selections are to be made are placed in a solution of salt showing 17.5° Brix, and those which float are used as fodder; those which sink are analyzed for sugar content by the alcohol extraction method, for which purpose a small quantity, half the normal weight, is cut out with a rasp and polarized in a 400-millimeter tube. Beets which give at least 19 per cent of sucrose form the first class; those showing 18 to 18.9, inclusive, the second, and those from 16 to 18 the third. Beets under 16 per cent are used for fodder.

METEOROLOGICAL CONDITIONS.*

In addition to suitable soil, fertilizing, and cultivation the sugar beet requires certain meteorological conditions for the highest production of sugar. Temperature and rainfall exercise the most

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pronounced influence, not only on the yield of beets but also on their saccharine qualities.

A mean summer temperature of 70° Fahr. for ninety days is sufficient to push the beet well on to maturity, while a much higher degree than this tends to diminish its saccharine strength.

The experience of beet growers in California indicates that in certain latitudes the beet can flourish with a much less rainfall than has hitherto been deemed a minimum for its proper growth; but this is not conclusive evidence that in all localities so small a supply of moisture would be sufficient. In regions of dry and hot winds, or where the subsoil is less porous, or aerial evaporation much more vigorous, less favorable results would be obtained. Dr. McMurtrie traced his area of beet-sugar limits with an isotherm of 70° Fahr. for the summer months, and a minimum rainfall of 2 inches per month for the same period. By the kindness of the Signal Office I have obtained a record of mean temperatures and precipitation for each month in the year for a period of ten years of those portions of the country in which the culture of the sugar beet is most likely to succeed. Also from the same source a tracing of the mean isotherm of 70° Fahr. for ten years for the three months of June, July, and August. Beginning at the city of New York this isotherm runs nearly due north to Albany, and then curves westward and slightly southwest, touching the edge of Lake Erie near Sandusky. It runs thence in a northwesterly direction to Lansing, Michigan, and thence southwest to Michigan City, Indiana. Thence it continues in a northwest direction through Madison, Wisconsin, to a point a few miles south of Eau Claire, whence it continues almost due west to South Dakota. Entering Dakota the line makes a sharp curve to the north, and near the one hundred and first meridian turns almost due south until it reaches the 33° of latitude in New Mexico, near the Mexican border. Its further tracing across the Rocky Mountains is not necessary here. Extending for 100 miles on either side of this line the map shows a belt extending from the Atlantic to the Pacific, within whose limits the most favorable conditions for growing beets, as far as temperature alone is concerned, will be found.

The mistake must not be made of supposing that all the region included within the boundaries of this zone is suitable for beet culture. Rivers, hills, and mountains occupy a large portion of it, and much of the rest would be excluded for various reasons. In the western portion perhaps all but a small part of it would be excluded by mountains and drought. Beginning at a point midway between the one hundredth and one hundred and first meridan, beets could be grown only in exceptional places without irrigation. On the Pacific coast only that portion of the zone lying near the ocean will be found suitable for beet culture.

On the other hand, there are many localities lying outside the indicated belt, both north and south, where doubtless the sugar beet will be found to thrive. The zone, therefore, must be taken to indicate only in a general way those localities at or near which we should expect success to attend the growth of sugar beets in the most favorable conditions other than temperature alone.

In respect of the rainfall it is necessary to call attention to the fact that a wet September and October are more likely to injure a crop of sugar beets than a moderately dry July or August. A wet autumn succeeding a dry summer is almost certain to materially injure the saccharine qualities of the beet before it can be properly harvested. In this regard it will be seen from the tables of precipitation that the two Dakotas are more favorably situated than Oregon and Washington.

The rainfall in Oregon and Washington for September and October is 2.17, 3.25, and 2.24, and 4 inches, respectively, while in the two Dakotas it is only 1.11, 1.27, and 1.54 and 1.26 inches. The importance of this slight rainfall in securing a safe harvest without danger of second growth is easily recognized.

During the winter months the temperature that is best for beets is one of uniformity and sufficiently low to prevent sprouting or heating in the silo. Sudden and extreme variations are alike injurious—on the one hand causing danger from freezing and on the other from sprouting. On the coast of California the winters are so mild that the beets require very little protection, in fact more from the heat than the cold, while in Nebraska and the Dakotas the temperature often falls so low as to endanger the beets even in well-walled silos.

All these problems in meteorology deserve the most careful consideration from those proposing to engage in the sugar-beet industry, and it is hoped that the subjoined tables may help to elucidate them.

Table showing the average precipitation, for each month of the year, at the stations specified. (Deduced from observations during the period January, 1880, *to December,* 1889.)

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Maine:												
Cornish	4.24	4.47	3.24	2.65	3.36	2.94	4.54	3.19	3.76	3.88	4.43	3.93
Eastport	4.64	4.49	4.68	3.14	4.82	3.72	4.49	2.82	3.16	4.89	4.22	5.26
Gardiner	5.02	5.20	4.27	3.31	3.53	3.09	3.47	2.48	3.62	3.80	3.86	4.64
Orono	4.52	4.64	4.06	2.76	3.60	3.29	3.70	3.83	3.38	3.76	4.44	4.45
Portland	4.22	4.72	3.23	2.90	3.42	3.04	3.96	3.23	3.51	4.02	4.21	4.44
	4.53	4.70	3.90	3.15	3.75	3.22	4.03	3.01	3.49	3.87	4.23	4.54
New Hampshire:												
Antrim	*4.61	*4.27	*3.72	2.80	3.95	3.37	4.53	3.43	4.32	4.00	4.30	4.11
Concord	3.83	3.55	2.79	2.14	2.88	3.03	3.67	2.98	3.74	3.16	3.12	3.41
Hanover	†2.84	†2.55	†1.84	†1.30	†2.70	‡2.90	‡3.38	†2.87	†2.49	†2.48	†3.27	†2.47
Weir's Bridge	3.84	3.73	2.89	2.32	3.14	3.18	4.01	3.17	3.94	3.40	3.68	3.90
	3.78	3.52	2.81	2.14	3.17	3.12	3.90	3.11	3.62	3.26	3.59	3.47
Vermont:												
Burlington	1.68	1.48	1.78	1.67	2.86	2.98	2.82	3.08	3.64	3.12	2.88	1.85
Lunenburgh	2.99	2.49	2.83	1.15	3.14	3.35	3.60	3.25	3.41	3.76	3.10	2.88
Strafford	3.64	3.16	3.14	1.90	3.06	2.95	4.52	3.61	3.70	3.02	3.92	3.28
Woodstock	*3.00	*2.77	*2.68	§1.66	§3.16	§2.24	*3.98	*3.00	‖3.41	*2.68	*2.09	*3.27
	2.83	2.48	2.48	1.60	3.06	2.88	3.73	3.24	3.54	3.14	3.00	2.80
Massachusetts:												
Amherst	4.23	3.72	3.62	2.53	3.59	3.45	4.69	4.08	4.50	3.40	3.77	3.67
Boston	4.81	3.99	3.64	2.78	3.86	2.81	3.51	3.58	3.30	3.62	3.38	3.97
Fitchburg	4.61	3.56	2.66	2.56	3.14	2.79	4.05	3.85	3.74	3.24	3.31	3.31
Lawrence	*5.44	*4.28	*3.91	*2.75	§3.30	§2.84	§4.18	§4.87	§3.59	§3.77	§4.69	§3.58
New Bedford	4.78	4.76	3.99	3.45	3.61	3.07	4.00	4.08	3.45	3.56	3.97	3.98
Springfield	†4.44	†4.36	†3.23	†2.65	†3.48	†3.80	†4.97	†4.09	†3.52	†3.62	†3.72	†3.84
Williamstown	†3.34	†3.25	3.10	†2.60	3.02	2.98	†4.61	†3.72	3.05	2.62	3.24	†3.40
Worcester	‡4.56	‡4.42	‡3.49	‡2.67	†4.13	‡3.63	‡3.38	‡3.33	†3.84	†3.85	†3.96	†4.06
	4.53	4.04	3.46	2.74	3.52	3.17	4.17	3.95	3.62	3.46	3.76	3.63
Rhode Island:												
Narragansett Pier	*5.84	*4.95	*4.28	‡3.27	‡2.88	‡2.69	†3.89	‡3.99	‡3.40	‡4.46	‡4.32	‡3.78
Providence	†6.19	†6.30	†4.33	†3.22	†3.67	†2.99	‡4.07	†4.06	†3.29	†4.10	†4.11	†4.59
	6.02	5.62	4.30	3.24	3.28	2.84	3.98	4.02	3.34	4.28	4.22	4.18

* For seven years. † For nine years. ‡ For eight years. § For six years. ‖ For five years.

Table showing the average precipitation, for each month of the year, at the stations specified, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Connecticut:	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Hartford	5.10	4.39	3.49	2.53	3.37	2.61	5.02	4.01	3.49	3.97	3.88	4.19
Middletown	3.52	4.95	4.27	2.70	3.17	3.30	5.02	3.59	4.17	4.25	4.02	4.38
New Haven	4.44	4.56	4.30	2.64	3.84	3.14	5.37	4.67	4.04	3.97	3.48	3.97
New London	5.25	5.41	4.46	3.36	3.94	3.47	4.04	4.55	3.77	4.72	4.40	3.77
	4.58	4.83	4.13	2.41	3.58	3.13	4.86	4.20	3.87	4.23	3.94	4.08
Northern New York:												
Albany	2.95	2.56	2.72	2.24	3.13	3.58	3.08	3.67	3.28	3.18	3.46	2.94
Oswego	3.18	2.93	2.49	1.99	3.02	3.61	2.60	2.41	2.66	2.92	3.47	3.66
Rochester	2.61	2.35	2.35	2.16	3.61	3.37	2.30	3.10	2.10	2.63	2.53	2.44
	2.91	2.61	2.52	2.13	3.25	3.52	2.86	3.06	2.68	2.91	3.15	3.01
Northwestern Pennsylvania:												
Erie	3.38	3.79	2.58	2.76	3.46	4.29	2.73	3.29	3.71	4.06	4.46	3.47
Franklin	3.90	3.38	2.52	2.41	3.50	6.12	4.04	3.54	3.27	2.89	2.94	¶ 3.25
	3.64	3.58	2.55	2.58	3.48	5.20	3.38	3.42	3.49	3.48	3.70	3.36
Northern Ohio:												
Cleveland	2.44	3.37	2.34	2.20	2.52	4.03	3.47	2.53	3.38	2.56	3.07	2.54
Sandusky	2.14	3.18	2.38	2.34	3.64	4.29	3.08	3.87	2.59	2.51	2.72	2.54
Toledo	2.14	2.55	1.95	1.98	3.78	3.67	3.29	2.44	2.54	2.92	2.74	2.30
Wauseon	2.40	3.17	2.47	2.43	4.58	3.90	3.51	2.65	2.12	3.14	3.26	2.55
	2.28	3.07	2.28	2.24	3.63	3.97	3.34	2.75	2.66	2.78	2.95	2.48
Northern Indiana:												
Logansport	2.14	4.24	2.59	3.04	5.29	5.15	3.71	2.76	3.08	3.03	3.55	3.44
Michigan:												
Adrian	2.25	*3.48	*2.47	2.60	4.44	4.90	3.81	3.24	3.38	3.79	3.44	2.70
Alpena	3.08	2.61	2.27	2.23	3.81	4.21	3.07	3.24	3.57	3.71	3.16	2.90
Escanaba	2.04	1.68	1.59	2.06	3.17	3.84	2.74	3.64	4.16	3.51	2.26	2.44
Grand Haven	2.78	3.21	2.38	2.45	3.21	4.04	3.57	3.23	3.50	3.75	2.75	3.14
Kalamazoo	2.46	2.96	1.87	2.24	4.36	4.96	2.93	2.52	3.06	2.84	2.39	2.93
Lansing	1.96	2.68	2.55	2.24	3.92	4.43	3.17	2.90	3.14	3.21	2.66	1.80
Marquette	3.28	*1.88	1.74	2.68	2.71	3.24	2.74	3.27	4.27	3.06	2.72	2.96
Port Huron	2.34	2.97	2.40	2.00	3.43	3.60	2.62	2.44	2.16	2.76	2.63	2.26
	2.52	2.68	2.16	2.31	3.68	4.15	3.08	3.06	3.40	3.33	2.75	2.64
Northern Illinois:												
Chicago	2.22	3.03	2.19	3.08	3.83	3.53	3.86	3.42	2.88	3.65	2.82	2.42
Riley	2.28	2.66	2.37	2.61	3.25	3.64	3.18	3.44	3.16	3.14	2.00	2.05
Sycamore	†2.12	†2.40	†2.10	†3.70	*4.06	*4.78	*4.68	*3.47	*3.23	*4.21	*2.56	*2.59
	2.21	2.70	2.22	3.13	3.71	3.98	3.91	3.44	3.09	3.67	2.46	2.35
Iowa:												
Cresco	1.47	1.11	1.64	2.27	3.73	*4.53	*5.19	*3.52	*4.26	2.29	1.28	1.50
Davenport	1.55	1.91	2.14	2.38	4.42	4.47	3.85	3.64	3.41	3.75	1.88	1.92
Des Moines	1.31	1.29	1.40	2.94	5.30	5.88	4.02	3.74	3.95	3.66	1.77	1.54
Dubuque	1.83	1.84	2.23	2.73	4.12	4.74	4.66	3.39	4.47	3.22	1.75	2.11
Logan	†1.86	1.26	1.42	3.05	4.49	5.82	5.22	3.93	3.00	2.94	*1.44	†1.32
	1.60	1.48	1.77	2.67	4.41	5.09	4.59	3.64	3.82	3.17	1.62	1.68
Wisconsin:												
Embarrass	2.96	2.65	2.27	2.92	4.45	5.71	5.15	5.58	5.05	4.17	2.94	3.14
La Crosse	1.31	0.99	1.45	2.10	2.80	3.57	5.00	3.85	4.71	2.15	1.32	1.32
Madison	2.08	2.30	2.54	2.92	3.56	4.64	5.36	3.76	3.71	3.28	1.76	2.55
Milwaukee	1.96	2.36	2.16	2.18	2.78	3.95	3.80	2.68	2.71	2.24	1.60	2.22
	2.08	2.08	2.10	2.53	3.40	4.47	4.83	3.97	4.04	2.98	1.90	2.31
Minnesota:												
Duluth	1.26	.34	1.35	2.44	3.50	4.52	3.32	4.14	3.90	3.14	1.76	1.33
Moorhead	*0.82	*0.86	*0.76	*2.18	*2.75	*3.84	*4.87	*2.70	*2.40	*2.25	*0.93	*0.83
St. Paul	1.21	1.00	1.21	2.69	2.58	3.55	3.53	2.99	3.24	1.64	1.22	1.33
	1.10	1.07	1.11	2.44	2.98	3.97	3.74	3.28	3.18	2.31	1.30	1.16
North Dakota:												
Bismarck	0.52	0.61	0.67	1.86	2.11	2.98	2.68	1.98	0.88	1.04	0.52	0.75
Fort Buford	0.66	0.43	0.42	1.11	1.51	3.07	1.96	1.55	0.84	0.80	0.35	0.56
Fort Totten	0.48	0.59	0.38	1.21	2.11	3.84	2.62	2.66	0.80	1.49	1.02	0.75
St. Vincent, Minn	*0.48	*0.50	*0.53	*1.26	*2.00	*3.01	*2.70	*2.28	1.93	1.76	0.56	0.71
	0.54	0.53	0.50	1.37	1.93	3.22	2.49	2.12	1.11	1.27	0.61	0.69

* For nine years. †For eight years. * For six years.

Table showing the average precipitation, for each month of the year, at the stations specified, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
South Dakota:	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Deadwood, Rapid City ..	1.25	1.34	1.78	3.98	4.19	3.66	2.70	2.31	0.86	1.06	1.24	1.12
Fort Sisseton, Wadsworth	0.39	*0.37	*0.87	*1.78	*2.33	*3.50	*3.16	*3.88	*1.30	*1.81	†0.56	*0.52
Fort Sully..............	0.51	0.43	0.53	1.84	2.10	3.16	2.67	2.23	0.82	0.52	0.36	0.49
Yankton	0.59	0.77	1.05	3.35	4.83	3.14	3.16	3.30	3.17	1.66	0.84	0.87
	0.68	0.73	1.06	2.74	3.36	3.36	2.92	2.80	1.54	1.26	0.75	0.75
Nebraska:												
De Sota	1.00	0.86	1.55	2.29	3.64	4.71	3.86	3.55	2.56	2.45	0.89	1.10
Genoa..................	0.93	0.67	1.03	2.85	3.96	4.21	4.57	2.86	3.29	1.68	0.66	0.86
North Platte	0.34	0.88	0.70	2.03	3.30	3.58	2.76	2.72	1.57	1.37	0.37	0.55
Omaha..................	0.82	0.91	1.33	2.93	4.64	5.76	5.26	3.55	3.06	2.97	0.92	0.94
	0.77	0.70	1.15	2.52	3.88	4.56	4.11	3.17	2.62	2.12	0.71	0.86
California:												
Benicia Barracks	2.87	*2.06	*2.75	2.62	0.70	0.30	Trace	Trace	0.25	†1.33	*2.10	4.60
Fort Bidwell	3.51	2.46	2.03	*2.31	†1.11	†1.13	*0.32	*0.09	*0.27	*1.66	1.90	*3.47
Fort Gaston.............	9.99	6.45	4.30	5.69	2.60	0.96	0.10	*0.04	*0.88	*3.55	4.76	10.68
Los Angeles.............	2.39	3.38	3.35	1.92	0.41	0.16	0.04	0.06	0.07	1.07	1.67	4.29
Red Bluff	3.05	2.04	2.80	2.54	1.00	0.65	0.01	0.00	0.63	1.83	3.33	5.44
Sacramento..............	3.15	2.28	3.17	3.01	0.77	0.25	0.00	0.00	0.03	1.29	2.52	4.96
San Diego...............	1.91	2.38	2.05	1.19	0.50	0.09	0.01	0.05	0.02	0.63	0.76	2.40
	3.82	3.01	2.92	2.75	1.01	0.51	0.07	0.03	0.31	1.62	2.43	5.12
Oregon:												
Albany..................	7.92	5.70	3.67	3.51	2.27	1.71	0.60	0.40	1.78	3.76	3.98	8.76
Eola	7.16	4.73	3.27	2.73	1.84	1.39	5.48	5.22	1.84	3.40	3.59	7.06
Fort Klamath............	3.62	2.44	*1.42	1.52	1.35	‡1.49	5.70	1.14	4.73	†1.68	*1.99	*4.19
Portland	7.28	4.97	3.72	3.66	2.48	1.71	0.61	0.56	1.93	4.31	5.01	9.56
Roseburgh...............	6.06	3.92	2.30	2.87	1.55	1.48	0.51	0.15	*0.58	3.01	3.18	6.78
	6.41	4.35	2.88	2.86	1.90	1.56	2.58	1.49	2.17	3.25	3.55	7.27
Washington:												
Blakeley	6.25	4.32	4.02	2.81	2.05	1.48	0.83	0.80	2.15	3.73	4.22	7.86
Fort Canby	8.08	7.15	5.94	4.63	3.06	2.37	1.26	0.87	3.35	6.26	6.96	9.84
Olympia	8.68	5.78	4.14	3.83	2.50	1.70	0.71	0.56	2.54	4.31	4.97	9.09
Port Townsend	2.71	1.46	1.33	1.73	1.43	1.28	0.98	0.74	0.90	2.54	2.17	3.08
	6.43	4.68	3.86	3.25	2.26	1.71	0.94	0.74	2.24	4.06	4.58	7.47

* For nine years. † For eight years. ‡ For seven years.

Table showing the mean temperature in degrees Fahr. for each month of the year at the stations specified. (Deduced from observations during the period, January, 1880, *to December*, 1889, *inclusive.)*

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Maine:	°	°	°	°	°	°	°	°	°	°	°	°
Cornish	18.1	20.4	27.6	41.4	55.3	65.3	68.6	66.5	58.5	45.7	34.7	24.4
Eastport	20.4	21.9	28.1	38.4	47.3	55.8	60.5	60.4	55.8	46.3	37.4	26.5
Gardiner................	17.9	20.6	26.7	41.0	53.5	*62.0	67.2	65.0	58.3	46.5	36.8	25.6
Orono...................	15.4	18.8	27.0	40.0	52.0	62.5	67.0	65.0	57.3	45.1	35.2	23.6
Portland................	23.0	25.1	32.0	44.8	54.3	63.9	68.4	72.7	59.9	48.8	39.4	29.2
	19.0	21.4	28.3	41.1	52.5	61.9	66.3	65.9	58.0	46.5	36.7	25.9
New Hampshire:												
Concord	21.5	24.5	30.8	45.3	57.2	65.3	69.4	67.1	60.3	49.0	38.7	28.2
Hanover	*17.5	18.8	26.6	40.6	56.5	64.1	69.3	65.6	58.2	45.6	33.8	22.4
	19.5	21.6	28.7	43.0	56.8	64.7	69.4	66.4	59.2	47.3	36.2	25.3
Vermont:												
Burlington..............	18.7	20.6	27.5	42.8	58.6	66.6	71.0	69.2	61.6	47.6	37.1	25.6
Lunenburgh	14.5	16.8	24.0	38.8	55.4	63.3	67.3	65.1	57.9	44.2	33.2	21.5
Strafford...	15.1	17.6	25.1	41.3	57.1	63.9	69.5	67.5	59.3	46.3	34.8	22.4
Woodstock...............	12.8	18.1	25.3	40.4	55.7	64.7	68.8	65.3	58.2	45.1	32.6	21.3
	15.3	18.3	25.5	40.8	56.7	64.6	69.2	66.8	59.2	45.8	34.4	22.7

* For nine years.

Table showing the mean temperature in degrees Fahr. for each month of the year at the stations specified, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Massachusetts‖:	°	°	°	°	°	°	°	°	°	°	°	°
Amherst	23.3	25.0	32.1	46.2	57.9	66.6	70.7	68.0	61.4	49.0	39.5	29.6
Boston	26.7	28.1	33.3	44.6	55.7	65.9	70.3	68.5	62.2	50.8	41.8	32.2
Fitchburg	21.9	23.6	29.0	42.8	56.4	65.8	69.7	66.8	60.2	47.3	37.1	27.6
Lawrence	*22.7	*22.7	*31.0	*45.2	*58.8	*67.2	*72.0	*67.2	*59.8	*48.0	†38.4	‡27.6
New Bedford	27.5	28.4	33.1	43.9	54.1	64.1	69.2	67.3	60.1	51.0	42.6	31.8
Springfield	24.0	25.9	32.5	46.8	60.5	68.8	72.8	68.9	63.3	50.4	40.0	§30.0
Williamstown	20.2	22.6	28.2	42.7	56.8	64.6	68.2	64.6	58.7	47.0	37.1	26.6
Worcester	23.4	23.9	30.0	‖42.8	‖55.2	§65.1	§70.0	66.8	§60.7	§48.0	38.7	28.6
	23.7	25.0	31.2	44.4	57.0	66.0	70.4	67.3	60.8	48.9	39.4	29.2
Rhode Island:												
Providence	*25.3	*28.5	*32.2	*45.4	*56.5	*67.6	‡73.1	*69.8	*62.1	*51.2	*41.9	*31.1
Connecticut:												
Hartford	‡22.4	‡24.0	‡30.3	‡46.7	‡59.4	‡67.2	‡72.2	‡68.2	†60.7	*48.6	*39.8	*29.2
Middletown	†24.3	†23.9	†31.4	†46.4	†58.7	†65.9	†70.5	†67.2	‡55.5	†48.4	‡40.4	‡31.0
New Haven	26.5	28.1	33.5	45.7	57.3	66.3	71.0	69.0	63.3	51.7	41.6	32.0
New London	28.9	30.0	35.0	46.0	56.6	65.6	70.5	69.1	63.7	53.0	43.4	34.0
	25.5	26.5	32.6	46.2	58.0	66.2	71.0	68.4	60.8	50.4	41.3	31.6
Northern New York:												
Albany	23.4	25.6	32.1	47.1	60.7	69.0	73.1	70.7	63.8	51.1	40.7	30.0
Oswego	23.3	24.3	28.8	41.5	54.5	62.6	68.4	67.1	61.3	49.0	39.1	29.4
Rochester	23.1	24.0	28.8	42.7	56.6	§62.5	§69.5	§67.4	§62.2	48.7	38.2	29.1
	23.3	24.6	29.9	43.8	57.3	64.7	70.3	68.4	62.4	49.6	39.3	29.5
Northwestern Pennsylvania:												
Erie	26.1	27.2	31.3	43.8	57.2	65.8	70.6	68.7	63.2	51.8	40.9	32.5
Franklin	21.8	23.9	29.1	43.7	56.0	60.2	65.5	62.5	56.8	45.3	34.2	26.2
	24.0	25.5	30.2	43.8	56.6	63.0	68.0	65.6	60.0	48.6	37.6	29.4
Northern Ohio:												
Cleveland	25.3	27.8	32.5	45.1	58.8	66.7	71.1	69.0	63.8	52.1	40.1	31.4
Sandusky	25.8	28.4	33.6	45.4	§59.5	§67.0	§72.9	70.7	64.9	52.5	40.5	31.8
Toledo	25.2	27.9	34.2	46.8	59.8	68.5	73.2	70.2	64.1	52.1	40.3	31.3
Wauseon	24.4	24.9	31.8	46.0	58.5	67.2	71.9	68.9	62.9	49.8	36.9	27.7
	24.4	27.2	33.0	45.6	59.2	67.4	72.3	69.7	63.9	51.6	39.4	30.6
Northern Indiana:												
Logansport	§24.0	‖29.9	‖36.7	§52.9	§64.7	§71.2	§76.2	§73.9	‖67.2	*55.3	§40.0	§30.7
Michigan:												
Adrian	20.3	§25.9	§31.0	45.2	58.4	67.2	71.6	68.4	61.7	49.1	36.6	28.2
Alpena	16.9	16.7	22.9	36.4	49.0	49.0	64.7	63.0	56.7	44.7	33.2	25.0
Escanaba	13.6	20.2	21.2	32.6	45.1	54.4	59.5	57.1	51.2	40.4	28.2	20.1
Grand Haven	23.3	24.2	30.0	43.4	54.7	63.2	68.2	66.3	59.2	49.2	38.0	30.0
Kalamazoo	20.6	23.7	30.3	46.2	57.6	67.1	72.3	69.1	62.4	50.4	36.5	28.1
Lansing	21.1	23.4	30.5	45.8	58.6	68.3	72.7	69.8	62.7	44.8	32.9	22.8
Marquette	14.5	§15.5	21.8	36.6	49.1	57.6	64.2	62.3	56.1	44.5	31.9	23.8
Port Huron	19.2	21.7	28.1	41.5	53.1	63.3	68.3	67.0	60.6	48.8	35.7	26.9
	18.7	21.7	27.0	41.0	52.4	62.5	67.7	65.4	58.8	46.5	34.2	25.6
Northern Illinois:												
Chicago	22.4	26.3	34.1	46.0	56.4	65.4	71.4	70.6	64.2	52.5	39.2	30.2
Rileyville	14.6	19.5	29.1	45.6	56.1	65.7	70.3	67.9	60.2	47.9	33.8	23.1
Sycamore	‖15.3	‖21.0	‡30.4	*46.0	§54.5	§66.8	§71.2	§68.6	§59.9	§48.7	§35.5	§26.2
	17.4	22.3	31.2	45.9	55.7	66.0	71.0	69.0	61.4	49.7	36.0	26.5
Iowa:												
Cresco	7.4	13.6	26.7	44.4	56.2	§66.2	§70.4	§68.1	§58.6	45.8	29.0	18.3
Davenport	19.4	24.9	35.0	50.1	61.2	69.7	74.8	72.2	64.4	52.2	38.2	28.3
Des Moines	16.6	23.1	34.7	50.2	60.9	69.8	74.5	72.1	63.5	51.7	36.6	26.5
Dubuque	16.1	21.7	32.7	48.6	60.1	68.5	73.6	70.9	63.6	50.4	35.7	25.6
Logan	16.5	22.4	35.2	51.7	63.2	71.6	75.9	74.0	65.9	52.4	36.1	26.1
	15.2	21.1	32.9	49.0	60.3	69.2	74.6	71.5	63.2	50.5	35.1	25.0
Wisconsin:												
Embarrass	11.2	15.5	26.4	44.2	59.1	68.0	71.0	68.2	60.9	48.5	32.4	21.2
La Crosse	13.4	19.1	30.5	47.3	59.8	68.5	72.7	69.8	61.4	49.5	34.3	23.8
Milwaukee	17.9	21.9	30.3	42.4	53.3	61.7	68.4	67.4	60.7	49.7	36.0	26.4
	14.2	18.8	29.1	44.6	57.4	66.1	70.7	68.5	61.0	49.2	34.2	23.8

*For seven years. †For five years. ‡For six years. §For nine years. ‖For eight years.

Table showing the mean temperature in degrees Fahr. for each month of the year at the stations specified, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
Minnesota:												
Duluth	7.9	12.4	23.2	37.5	48.1	57.8	65.2	68.6	55.2	44.4	29.5	17.8
Moorhead	2.9	2.9	20.0	40.2	53.6	64.5	67.6	65.1	55.3	39.0	24.9	11.1
St. Paul	9.1	14.9	27.9	45.3	57.8	66.9	71.3	68.6	60.0	47.2	31.0	19.4
	4.7	10.1	23.7	41.0	53.2	62.9	68.0	65.8	56.8	43.5	28.5	16.1
North Dakota:												
Bismarck	3.2	9.2	23.0	41.4	54.9	65.0	69.1	67.0	56.3	43.7	26.6	13.8
Fort Buford	2.6	9.3	24.0	41.7	53.9	64.2	68.0	66.1	54.8	42.6	25.8	10.8
St. Vincent, Minn	*7.5	*0.6	*15.3	*36.6	*51.7	*62.3	*65.0	*62.5	52.6	40.0	21.2	6.2
Fort Totten	*4.5	3.8	17.1	37.7	53.8	64.0	67.3	65.7	55.0	41.3	22.5	8.2
	1.6	5.7	19.8	39.4	53.8	63.9	67.4	65.3	54.7	41.9	24.0	9.8
South Dakota:												
Fort Sisseton	0.4	6.0	21.0	*40.9	*55.2	*65.0	*69.0	*65.1	*56.8	*43.0	*25.4	*11.2
Fort Sully	8.8	15.5	29.6	47.5	58.9	68.9	73.9	72.1	61.9	48.2	30.7	19.1
Deadwood	19.4	22.9	31.3	41.3	50.4	61.1	66.0	65.4	55.2	44.5	32.4	26.0
Yankton	12.6	18.2	30.6	47.0	59.3	69.2	73.5	71.3	61.8	49.6	33.0	22.4
	10.3	15.6	28.1	44.2	56.0	66.0	70.6	68.5	58.9	46.8	30.4	19.7
Nebraska:												
De Soto	14.5	21.5	34.0	50.7	61.5	70.5	74.9	72.6	63.5	51.1	34.4	24.4
Geneva	13.5	20.4	32.3	48.6	60.4	70.0	74.6	72.3	62.8	49.8	33.0	23.4
North Platte	18.6	25.1	35.1	48.5	58.1	68.3	73.2	71.1	62.0	49.6	34.5	27.0
Omaha	16.6	23.4	35.1	51.1	62.2	71.4	76.2	74.4	64.3	52.0	37.0	26.7
	15.8	22.6	34.1	49.7	60.6	70.0	74.7	72.6	63.3	50.6	34.7	25.1
California:												
Benicia Barracks	46.6	*49.6	*54.2	56.9	61.4	65.6	65.8	68.4	*66.6	61.7	54.2	50.3
Fort Bidwell	31.4	33.8	41.4	47.9	*55.9	*63.5	71.0	70.7	62.6	51.2	40.4	35.8
Fort Gaston	41.0	43.7	49.8	†53.8	59.8	65.0	71.8	69.3	63.7	54.5	46.0	44.2
Los Angeles	53.6	54.4	56.2	59.0	62.2	65.9	69.4	70.6	68.7	63.1	58.7	55.5
Red Bluff	45.5	49.1	55.2	59.8	67.5	75.2	82.1	80.5	*74.7	62.7	*52.7	47.5
Sacramento	45.5	49.4	54.7	58.2	63.4	68.2	71.9	71.8	69.6	61.0	52.4	47.5
San Diego	53.5	54.7	56.1	58.8	61.5	64.4	67.2	69.1	67.2	62.6	53.3	56.3
	45.3	47.8	52.5	56.3	61.7	66.8	71.3	71.5	67.6	59.5	51.1	48.2
Oregon:												
Albany	38.6	40.9	47.5	51.8	57.9	61.0	66.3	65.4	62.1	*49.0	43.2	41.8
Eola	37.6	39.8	46.8	50.1	55.8	60.3	60.7	64.4	59.1	51.6	43.7	41.5
Fort Klamath	†26.4	†26.8	‡34.7	†40.0	†49.7	‡56.9	†61.6	†62.1	†51.7	§41.5	†33.2	†30.4
Portland	37.0	40.0	47.6	51.8	58.0	62.1	66.4	65.3	60.6	53.0	44.8	41.6
Roseburgh	40.4	41.6	47.5	51.6	57.1	61.4	66.5	65.0	61.4	52.2	44.5	43.2
	36.0	37.8	44.8	49.1	55.7	60.3	64.3	64.4	59.0	49.5	41.9	39.7
Washington:												
Blakeley	38.5	40.3	46.1	50.8	56.0	61.2	63.3	62.7	57.6	51.0	45.1	41.8
Fort Canby	41.0	41.7	46.0	49.0	53.2	56 5	59.0	59.5	57.8	53.0	47.1	44.1
Olympia	37.6	39.0	44.5	48.7	54.5	59.2	62.3	61.9	56.2	50.1	43.8	40.6
Fort Townsend	*38.7	*39.3	†46.2	51.3	55.0	60.0	62.0	61.2	†56.4	*53.4	*44.0	*40.9
	39.0	40.1	45.7	50.0	54.7	59.2	61.6	61.3	57.0	51.9	45.0	41.8

* For nine years. † For eight years. ‡ For six years. § For seven years.

Dr. McMurtrie, in special report No. 28, has made a careful study of the climatic conditions in the United States favorable to the production of the sugar beet. Maps are given showing the southern limit of a mean temperature of 70° Fahr. for the three summer months, coupled with a minimum mean rainfall of 2 inches per month for the same period. The tables of temperature and rainfall from which these lines were computed are also given in detail. The observations made on the data collated are as follows:

"We see from this that the sections of the United States most favorable to beet-root culture are confined to the North, including New England, New York, a narrow band south of the lakes, Michigan, parts of Wisconsin, Minnesota, and Dakota. Here the line of the southern limit passes into the British possessions and enters the United States again in Washington Territory, and crossing Western Oregon, passes to the coast to the extreme north of California. In most of this band we find a favorable temperature, and the average rainfall is sufficient in quantity, but we are unable to make any observations concerning the number of rainy days. In California, as the tables will show, the temperature is sufficiently moderate, but, from examination of the figures for the stations for which the rainfall has been recorded, we find it to be remarkably deficient. Here, in order to make the culture a success, it would appear that the intervention of irrigation during the summer months would be an absolute necessity.

"We also note a few counties in the southwestern portion of Pennsylvania, and one county in Ohio, without the general band, where suitable meteorological conditions seem to exist. These counties are surrounded by the red line in the more detailed map that has been prepared, showing the county lines near to or over which the line of the limit of favorable meteorological conditions passes. This map is intended for more ready reference for those who may contemplate establishing the culture in the sections in the near neighborhood of the line.

"Now, I do not mean to assert that the band of country I have thus plotted on the map is exclusively that in which the introduction of beet-root culture may be attempted with prospects of success, but it is certain that within this band the chances of success are greater than they are without it, and it also appears that all the unsuccessful attempts that have heretofore been made to establish the industry have been at points without it. It is therefore advisable that farmers or manufacturers who may design entering upon the prosecution of this industry should study with greatest care these influences which operate with so much benefit or injury upon the profit of the crop. It is evident from what precedes that the beet requires a cool or at least a moderate season for suitable progress in development, that it may not reach maturity in advance of the time for working it into sugar, and under the influence of the rains and elevated temperature of the autumn months enter into a second growth, thereby destroying the valuable constituents which render it so desirable as a sugar-producing crop.

"In this connection it has been suggested that in sections of protracted warm seasons, where the root will develop and attain full maturity in August and during the summer drought, the crop could be taken up before the appearance of the autumn rains, and by slicing and drying the roots preserve them until the arrival of the proper season. This mode of procedure has in fact been recommended to the agriculturists of the south of France, and has, it has been stated, been the subject of experiment in Algeria. The method has the objection of being a rather precarious one on account of the chances of the crop being caught after a long-continued drought by late heavy summer showers that would prove almost as injurious as the autumn rains.*

"After the directions given by Briem and others it is scarcely necessary to recapitulate here the meteorological conditions which appear

*The experiment of drying beets for preservation in Maine, in the fall of 1878, proved quite disastrous financially for those who engaged in the enterprise.

to be required by this culture, yet the conclusions arrived at from our study of the subject, in addition, may not appear superfluous. The conditions, then, are in general, comparatively dry and warm spring months during the time for preparation of the soil, planting, and cultivating the crop; moderate temperature, abundant and frequent rains during the summer months, the time for ultimate development of the crop and its valuable constituents; cool, dry fall, the time for ripening, harvesting, and storing the crop. If these conditions prevail, the results will be good; otherwise they will be but medium or even bad."

The amount of rainfall necessary to the proper growth of sugar beets depends largely on the character of the soil, the mean temperature, and the degree of saturation with aqueous vapor of the prevailing winds. In the coast valleys of California, where the proximity of the sea preserves a low temperature through the summer, and where the porous soil permits the tap root of the beet to descend after moisture and moisture to ascend to the root, excellent beets are grown with little rain. The conditions would be entirely reversed in inland localities with high summer heats, stiff clayey soils, and arid winds.

In general, the amount of rainfall during the summer months in the Northern, Central, and Eastern United States is sufficient to secure a good growth, and therefore it may be said that proper soil and attention being provided, beet culture might be undertaken in such localities with little fear of disaster from drought, save in a few exceptional seasons.

In fact, with thorough under drainage and deep subsoil plowing, it would be possible to secure a good crop of beets in the regions indicated quite independently of the variation in the amount of rainfall.

The chief question, therefore, to be considered, is one of temperature and sunshine rather than of rainfall. In the present state of our knowledge it would not be safe to establish beet factories very far south of the mean isotherm of 70° Fahr. for the three summer months, without a more thorough study of the character of the beets produced than has heretofore been made. The possibility of finding localities south of this line, where sugar beets may be grown with profit, is not denied, but the necessity of further investigation is urgent. There are many places situated only a short distance south of this line where the soil, water supply, cheap fuel, and other local considerations supply peculiarly favorable conditions for beet culture, and in such places the industry would doubtless flourish, although the beet might not be quite as rich in sugar as when grown in a more northern locality. In all cases the length of the growing season should be sufficient for the complete maturity of the beet, and the freezing temperatures of winter should come sufficiently late to allow the beets to be safely harvested and covered.

REPORT OF THE CHIEF OF THE DIVISION OF FORESTRY.

SIR: I have the honor to submit my fifth annual report upon the work of the Forestry Division.

With a new fiscal year increased appropriations have marked a new era for this Division, placing at its disposal for the first time funds sufficient to provide for following up in good earnest some special investigations. These funds became available, however, only a few months previous to the writing of this report, and since the arrangements for work were delayed for various reasons proposed methods and promises of results must as yet be discussed rather than the results themselves.

In the line of giving information in answer to requests by letter, the work of the Division has steadily grown. It is to be regretted that the information furnished on many topics is imperfect indeed, no means for acquiring it having hitherto been afforded, especially in the case of requests for statistics regarding timber supplies. The character of much of the correspondence of the Division is indicated by the following classified list of subjects of recent letters:

Statistics.—The loss of useful forest material by fire; present and future supply of white oak; lumber importations and duties; increase or decrease of forest area; soil, timber, and rivers of the Sioux Reservation; manufacture of short-leaved pine in Virginia and North Carolina; amount of long-leaved pine in Georgia and Florida; timber area in the United States and possibilities of exhaustion; area of standing hemlock in the United States and Canada; hard-wood products, markets, etc.; lumber industry of Florida; authors of works on forestry.

Technology.—Oaks suitable for cross ties and tan bark; method of preserving fence material; after treatment of wood when cut; effects of water seasoning upon holly; methods of preserving posts; quality of southern oak; comparative tests of northern and southern oaks; best material for railroad ballast and durability of various timbers in the roadbed.

Forest influences and forest policy.—Plan for seedling distribution; State purchase of land for forest purposes; State forestry legislation; advisability of a department for care of public grounds; repeal of timber-culture law; working of timber-culture law; precipitation before and after deforestation; maintenance of forest cover on mountain slopes; influence of forests and eucalyptus on malaria; protection of timber from fire by law; exemption of forest lands from taxation; artificial rainfall.

Forest planting.—(By regions.) Trees most likely to succeed in Texas; tree planting in Dakota; trees suitable for forest growth in Louisiana; experimental and mixed planting in Michigan; forest growth advisable for Colorado; forest trees for Dakota; growing forest trees from seed in arid regions; advisable mixture of trees for Texas; trees adapted to Arizona; trees suitable for the arid regions; trees for roadside planting; trees for grove planting in California; trees advised for Illinois; trees for street planting; suggestions on deciduous tree growth without irrigation; timber trees desirable for Minnesota; sea-coast planting; instructions for interplanting coniferous seedlings in Minnesota; pecan planting in Georgia; black walnut forest culture; English walnut and pecan culture in New Jersey; treatment of acacia seed in Arizona; treatment of juniper seed in Kansas; trees for shade and ornament in Florida; treatment in pole planting; availability of the ailanthus for Kansas; forest planting in Oregon; conifer seeding in Michigan; timber culture without irrigation in Arapahoe County, Colorado; bamboo planting in Texas and California; climatic conditions for eucalyptus and cottonwood in Central Arizona; black walnut cultivation in Oregon; suitable forest trees for Arizona; reclamation of sand dunes. (By species.) Pinus cembra, its introduction in Maine; osier cultivation; suggestions on growing black walnut; directions for growing seedling conifers; growing cottonwood from seed; maple raising; black walnut planting; black walnut timber, range and cultivation; osier culture in New York and Michigan; acacia seed, its distribution, and value of acacia for tan bark; profitableness of wattles in California; germinating power of catalpa seed in Texas; bamboos, method of propagation; favorable sites for black walnut growing.

Forest management.—Treatment of naturally grown thicket of hard woods; best "works" on trees, their cultivation, etc.; pruning of trees; sumac as material for forest undergrowth; subsoil irrigation; time of transplanting; protection of trees against rabbits; advice on thinning white pine.

Forest botany, etc.—Proper time for gathering and planting seeds of white pine; sprouting of pitch pine; sprouts from conifer stumps; ring growth of trees; quality of wood in different parts of tree; long-leaved pine distinguished from other varieties; discoloration of timber due to fungus growth; locust trees, advice for preventing growth of; varieties of white cedar; hickories indigenous to the United States.

As I have pointed out repeatedly, the character of information expected from this Division is of a twofold nature, namely: technical, in so far as relates to forest management and the production of wood material, and statistical, in so far as the knowledge of the condition of our forest resources may induce application of forestry principles.

Information of the latter kind is needed to influence private activity in the rational utilization of forest supplies, in recuperation of natural forest areas, and in the planting of waste land; more especially, however, to justify the interest and the action of the Government in forestry.

There are three reasons implied why the Government has been induced to establish this Division, and to appropriate funds for forestry work. The first is that, owing to the heavy drains to which our virgin forest supplies are subjected without any provision for recuperation or reforestation, the future of wood supplies may be endangered. The second is that the methods at present followed in utilizing the natural forest areas are destructive, not only of the future forest resources, but also of the cultural and water conditions of the denuded and adjacent territory. A third reason is the desirability from economic considerations (for climatic ameliorations) of encouraging tree growth on the large treeless areas of the United States in the West and on the many places in the East and South which have been made so by irrational treatment on the part of man.

While in regard to the soundness of the third reason there can hardly be any doubt, there has never been a thorough investigation as to the validity of the former two, the work for the Tenth Census being the nearest approach to it.

To establish beyond controversy the fact that our timber supplies as at present utilized are being consumed at a rate more rapid than they are growing would, if at all possible, require a close examination of forest areas, standing merchantable timber, methods of lumbering, the annual drain by cutting, fire, pasturage, and decay, and also capacity for annual reproduction, that we might compare outgo and income.

The hopelessness of accomplishing such a task, especially with the slender means and inadequate organization of this Division, and the doubt whether the expenditure of money and energy in that direction would be fully justified by results, have deterred the Division from entering that field of statistical inquiry. Two years ago it was proposed to settle the controversy as to available supplies of white pine at least. To accomplish this satisfactorily I estimated that not less than $15,000 would be required. Since then, although nobody can predict the time when this staple will be practically exhausted, indications of its rapid decline have become so unmistakable that an attempt to prove the fact would be needless waste of energy. The time of actual exhaustion of any timber, or of supplies of any particular kind, can never be foretold, for the simple reason that changes in the use of material, substitutes, and various other causes introduce uncertain factors into the calculation.

Several years ago I submitted that, with a resource which, like our forest resource, is determinable by area only, and which can and should be kept in perpetuity by natural reproduction, the rational manner of estimating its condition with reference to the furnishing of supplies is to compare our annual requirements with the possible annual reproduction upon the ascertained area. The area some time ago had been ascertained to be less than 500,000,000 acres of woodlands, capable of yielding at best at the rate of 25 cubic feet of wood per year per acre, or one-half only of what is estimated to be the present consumption annually. In addition to these estimates, which are believed to present the case as nearly correctly as can be done with our knowledge, we have reports from various manufacturers noting the decline of supplies of particular kinds, so that we may conclude that Government interest on the ground of the first reason cited is by no means premature.

It is to be regretted that the opportunity which the machinery provided by the Eleventh Census offered for ascertaining more definitely the present extent and condition of the resource has not been used to its full extent, and that we shall be compelled to remain in comparative ignorance and to reason on surmises or partial knowledge with regard to one of our most valuable controllable resources.

That it should not have been deemed desirable (or only partially so) in the present census to ascertain the condition of a resource which yields raw material of a value not less than one quarter of the value of all raw materials manufactured will be a surprise to those interested in the forests of the United States.

We should strive to know from decade to decade what changes in the forest areas and their conditions have taken place, just as we ascertain and compare the areas and crops of the agricultural resource. Such knowledge is called for more and more, for commercial purposes, as the area of virgin timber land available shrinks or falls into the few hands which control the lumber supply of the nation.

The call upon the Division to supply information as to where certain kinds of timber may be found in abundance, and as to location of large bodies of merchantable timber, can only be answered in a very general way, hardly satisfactory to the inquirer.

The second reason for Government interest in the forestry question, namely, the effect of unwise denudation upon soil, water flow, and climatic conditions, has been made a continued study by the Division; and while it has not been possible to institute direct experiments or systematic observations which would lead us to a plain demonstration of forest destruction and deterioration of soil or climate or water flow as cause and effect, the results of experiments and experiences in other countries have been published in former reports, and material is constantly gathered of similar experiences in our own country. The question of forest influences on climate has been carefully studied by Prof. M. W. Harrington, of Ann Arbor, and the results of his investigations into the literature of the subject will be published as soon as opportunity is given.

I may state here that he has mainly occupied himself with a critical scrutiny of the systematic observations in forest meteorology carried on through many years in Europe. The results have been platted in graphic form for ready reference, and the publication will form a desirable basis for further inquiry or experiment, presenting a résumé of what has been definitely accomplished in solving the problem up to date.

My last report contained an analysis of the factors that need consideration in discussing the influence of forest on water supplies, a question which is growing in importance, especially in connection with the irrigation problems of the West.

Granting, then, the existence of sufficient reasons for the interest which the Government has so far taken in the forestry problem, the question every year presents itself anew as to how this interest should manifest itself; for, while it may be easy to recognize the disease, the remedies are not always found at once, and various trials must gradually lead to the selection of those most efficacious.

There are three methods open by which the Government can promote a change in present conditions: First, by placing its own timber holdings under rational treatment; secondly, by direct aid to those who would apply forestry principles in caring for the natural woodlands or in creating new forest areas; and thirdly, by the indirect aid imparted by supplying information.

The total absence of forest management on the timber lands belonging to the United States, nay, the almost total absence of any kind of reasonable management of the same while a forestry division exists in any Department of the Government, is such an incongruity that the influence of the latter must be considerably enfeebled by the reflection that the Government does not act upon its precepts.

The need of a change in this particular—the need of an effective forest administration for the remaining timber lands in the hands of the United States Government—has been pointed out every year in the reports of the Secretaries of the Interior, as well as in those from this Department.

It is the story of the Sibylline books repeated. Every year a part of the domain is wasted by fire, and while thus the value is depreciated without profit to any one, the chance of administering the remainder profitably is diminished. Five years ago I outlined the organization and probable cost of such an administration, and a bill was prepared and laid before Congress which, were it to become law, would enable the population of the Western States, where the Government domain is situated, to obtain their wood supplies in a legitimate manner, while now they are compelled to obtain them by illegal methods. Nor would the mountain sides, as at present, be denuded by fire and ax, not only rendering them waste places but endangering life and property below by giving rise to avalanches and soil-washing torrents, besides rendering the flow of water uncertain.

That the country at large, and especially the region in question, would be benefited by such a forest administration more directly than by any other means, this Division not excepted, must be clear to any unbiased student of the question.

The direct aid which the Government has held out in the interest of forest culture has consisted in permitting the acquisition of Government lands in the treeless regions free of expense, by planting one sixteenth of the areas to trees, and in charging this Division with the distribution of economic tree seeds and plants.

Both these methods, as practiced, have proved of little avail. As I have shown repeatedly in former reports, to make the distribution of plant material effective it would have to be done on a larger scale than the appropriations for the Division have ever warranted. Hence the distribution had to be confined to small trial packages, which may occasionally assist in spreading an interest in tree growth, but can hardly stimulate forest planting. Other difficulties in this method of Government aid have also been pointed out before. It has also been shown in my last and former reports that the timber-culture entries have in the majority of cases not produced the results for which they were intended. The reasons are various, but mainly, I believe, the frequent failures on the part of bona fide settlers to obtain the required stand of trees, necessitating their abandonment or changing the form of entry. These failures were due to unfavorable climatic conditions and to ignorance of methods and of plant material suited to the localities. This ignorance has been partially overcome by trial, with failure or success, and it may be questioned whether or not in future this method of Government aid could be made more effective by modifying the law, divesting it of its objectionable features, and providing for its proper execution. The repeal of the law failed to be accomplished during the last session of Congress, and I would submit that a revision at this stage of development might be preferable to a repeal.

The third method proposed, by which the Government could be effective in advancing forestry reform, is by disseminating information on the subject. This purpose is subserved by this Division. The kind of information needed, and the methods by which it may be obtained, I have outlined in my last and former reports. I may here only repeat that there is much desirable information which it is impracticable for the Division, as at present constituted and endowed, to obtain, such as the statistics of forest areas, etc., and again other classes of information which can be obtained only by experience, the results of experiment carried on through many years, which, therefore, though not now available, can be made so in time.

The method of imparting the information has been mainly by letter in answer to specific inquiry. The more general information, or such as may be considered complete within certain limits, is embodied in circulars or bulletins. In addition the chief of the Division has supplied addresses, papers, and informal talks to many associations and meetings during the year.

Two circulars, the one giving instructions for the growing of seedlings, and another for the treatment of seedlings in the nursery, were issued during the year. The most important publication during the year has been the final report of Mr. Tratman, promised in my last annual report as Bulletin 4, on the Substitution of Metal for Wood in Railroad Ties, prefaced with a brief discussion by myself on practicable economies in the use of wood for railway purposes. The practicability and ultimate economy, safety, and superiority of metal ties over wooden is proved by reports from all parts of the world, the reports giving the experiences with nearly 25,000 miles of metal track in actual operation. The need of economy in this use of forest supplies will appear from the figures presented in the bulletin, which show that estimates based on actual returns from almost 60 per cent of the railroad mileage make the amount of wood used for the purpose of railroad building, in round figures, 500,000,000 cubic feet; over four fifths of which is consumed in railroad ties made from the thriftiest and most valuable timber, namely, oak, chestnut, and pine, with but a small percentage (16 per cent) of cedar, hemlock, cypress, redwood, and other woods. To supply this demand alone continually requires at least 10 per cent of our present forest area. That, even if the use of wood for this purpose be continued, certain economies are desirable and practicable, may also be learned from this report.

From year to year the publication of monographs on the life history of our important conifers has been promised, but always delayed for various reasons. It is hoped that their publication can be accomplished during the coming winter, the illustrations, want of which occasioned the last delay, having been completed. The publication is also expected, without much delay, of a check list of the arborescent flora of the United States. This will form the first of a series of forest botanical papers. The need of such a check list, especially one giving the common names, with their geographical distribution, appeared from the fact that nurserymen, lumbermen, lumber dealers, architects, and others using wood have often been misled by the indiscriminate use of the same names for widely different timbers. It is, for instance, a fact that the users of southern pine in the North are, as a rule, quite uncertain how to order and how to distinguish the three kinds that reach the market, since the same name is applied to each of the different kinds in various regions. Since, lately, the botanists have undertaken to revise the scientific nomenclature also, making the work of the last census, which was used as authority, as well as the botanical text-books, obsolete, it appeared desirable to make and publish the necessary revision in order to establish a basis for intelligent communication. With the aid of botanists throughout the country, who have kindly contributed their notes, it is hoped to unravel the confusion of common names, while the scientific names, that should henceforth stand as authoritative by the law of priority in naming, may be ascertained by reference to the literature of the subject.

This work of revision has proved more laborious and perplexing than was at first anticipated, since even prior revisers were found not to have been successful in all cases, and hence a careful study of authorities became necessary. This work has been diligently pursued by Mr. George B. Sudworth, the botanist of the Division, of whose zeal and efficiency I wish here to express my special recognition. Under his activity the forest botanical herbarium has grown to embody a desirable study material of several thousand specimens. The seed collection for the purpose of identifying the seed of different species now comprises 360 numbers, and a special study collection in alcohol of the buds of our forest trees (some 1,200 specimens of 100 species) has been made and studied with the view of arriving at characters for the ready recognition of our woody plants when without flowers or leaves.

The forest technological investigations referred to in former reports have, by the increase of appropriations, become possible on a scale which was hitherto unattainable. This work, which I desire to discuss further on more in detail, as planned at present, may be considered the most valuable and promising in which the Division has been engaged since its creation, so far as technical scientific work is concerned. It consists mainly of a thorough examination of our prominent timbers in regard to their technical and physical properties in order to ascertain, if possible, how far these properties depend upon the conditions under which the trees are grown, how far physical properties influence mechanical properties, and also whether a simple method of determining by gross examination of structure the quality of timber can not be devised. The first work in this direction was undertaken to settle a controversy between carriage manufacturers as to the superior value of southern or northern grown oak. The results of the tests and investigations will appear further on. Many similar questions arise constantly, but we have so far only surmises, and no definite basis by which to settle them. The magnitude of the undertaking, the necessity of organized coöperation of various workers to supply each his part in the inquiry, makes this evidently an enterprise worthy of Government direction, and in fact is only practicable under such direction.

WOOD PULP INDUSTRY.

Various forestry interests have been canvassed by the agents who are assigned to this Division, as yet with incomplete results. The one to which I wish to direct special attention, as referring to the most important development in the use of forest products, relates to the manufacture of wood pulp.

It can be said, without fear of contradiction, that in no field of industrial activity has a more rapid development taken place within the last few years than in that of the use of wood for pulp manufacture. The importance of this comparatively new industry for the present, and still more for the future, can hardly be overestimated. Its expansion during the next few decades may bring revolutionary changes in our wood consumption, due to the new material, cellulose, fiber or wood pulp.

Though rapid in its growth, the industry has by no means reached its full development. Not only is there room for improvements in the processes at present employed, but there are all the time new applications found for the material. While it was in the first place designed to be used in the manufacture of paper only, by various methods of indurating it, its adaptation has become widespread; pails, water pipes, barrels, kitchen utensils, washtubs, bath tubs, washboards, doors, caskets, carriage bodies, floor coverings, furniture and building ornaments, and various other materials are made of it, and while the use of timber has been superseded in shipbuilding, the latest torpedo ram of the Austrian navy received a protective armor of cellulose, and our own new vessels are to be similarly provided. While this armor is to render the effect of shots less disastrous by stopping up leaks, on the other hand bullets for rifle use are made from paper pulp. Of food products, sugar (glucose) and alcohol can be derived from it, and materials resembling leather, cloth, and silk have been successfully manufactured from it. An entire hotel has been lately built in Hamburg, Germany, of material of which pulp forms the basis, and it also forms the basis of a superior lime mortar, fire and water proof, for covering and finishing walls.

According to the manner in which the raw material for the industry shall be secured it may prove either a new enemy to the forest or it may prove a saving element, rendering rational and profitable forest management in the United States possible and leading toward it. As I have shown elsewhere, such management in our natural woods depends largely upon the opportunity of marketing wood of small dimensions and inferior material, and this, by an economic development of the pulp manufacture, may be to some extent secured. Self-interest should lead the manufacturers to a study of the problem of forest management for continuous supplies, and mill men should combine with them to have the refuse, slabs, etc., worked up into useful material.

Ten years ago there were in Europe about five hundred wood-pulp establishments, making in round figures 15,000 tons of ground pulp, valued at over $5,000,000. With the development of the chemical processes since then it is hardly possible to tell from day to day how fast the production increases. To arrive at an idea how far this industry has developed in this country a canvass has been made among the pulp mills, the results of which have been tabulated below.*

In connection with this, considering the probable importance of the subject to forestry interests, it may be desirable to explain briefly the various processes, their advantages and disadvantages, their significance in connection with our forest resources, and to add suggestions which may be helpful in the development of the industry.

In the following brief statements I have followed, in part, the excellent résumé of the present state of the chemico-technical use of wood by the referee at the Vienna International Agricultural and Forestry Congress, where, if a more liberal policy had permitted a representation from this Department, probably much of additional value in this and other lines might have been learned. For the chemical reactions the recently published Dictionary of Applied Chemistry, by T. E. Thorpe (1890), has also been consulted.

It may first be stated that cellulose is the preponderating constituent of all vegetable tissues; in fact, elaboration of cellulose is synonymous with growth. In addition to the cellulose there are present in the wood nitrogenous substances, resins, gums, and (mineral) ash, which are to be removed, more or less, in order to produce the fiber or pulp. To do this economically and in such a manner that the fiber may remain long, pure, and white and the mass preserve its "felting" qualities as much as possible, is the aim of the various processes.

About half of the wood substance consists of cellulose, the soft woods coutaining, however, more than the hard woods; one reason why the former are preferred in the commercial production of pulp.†

*The first suggestion to use fiber for paper manufacture was made by a German, Jac. Christ. Schaeffer, in 1772; the first patent of commercial importance for chemical production was obtained by Watts & Burgess in 1853, and a small mill erected in London about 1855; the first large pulp mill was established in Manayunk, near Philadelphia, in 1865; in 1868 in England, in 1871 in Sweden, and soon afterward in Germany, where the modern processes have been mostly developed.

†The following percentages of cellulose in air-dried wood were determined by chemical analysis:

Poplar	62.8	Basswood	53
Fir	57	Chestnut	52.6
Willow	56.7	Locust	48.4
Birch	55.5	Beech	45.5
Pine	53.3	Oak	39.5 (45.9)

There may be now distinguished three classes of wood pulp, according to the manner of its manufacture, namely, mechanical, pseudo-chemical, and truly chemical pulp.

The preliminary preparation of the wood is the same for the different processes. It includes the cutting and splitting to suitable size for handling, the removing of the bark on the "barker" (a planing mill with two blades, or other contrivance); the removing of knots by the "knotter," an augur, and the removing of the pith by the pith cleaner, when necessary. For the chemical processes a further preparatory operation consists in the "chipping," which is done by knives placed on the face of cylinders, 5 feet in diameter, making 150 revolutions, having a bite of one eighth inch; the "chips" are further reduced mechanically by crushing rolls, after any knots and discolored pieces have been picked out from the moving apron which carries the chips from the chipper to the rolls.

(1) The *mechanical or ground pulp* is produced by grinding the wood, after proper preparation, on rapidly rotating stones under constant flow of water (Voelter process). For this process round wood is used of 4 to 8 inches diameter, cut into lengths of 10 to 20 inches, according to the face of the grindstones against which the wood is pressed lengthwise with the fiber.

Emery wheel cutters, using 40-horse power, will produce 50 pounds per hour of dry pulp, while natural stones, producing 25 per cent more pulp, require more than double the power. The ground mass, looking like thin gruel, is pumped into tanks, screened into vats, and then run off in thick sheets on the "wet machines" on which it is dried, folded, and pressed, containing still at this stage 60 per cent of water.

(2) *Brown wood pulp* is mainly a mechanical pulp, except that the wood is steamed before grinding, under a pressure of 2 to 6 atmospheres. This steaming, with a heat at 300° Fahr., produces a chemical reaction, the soluble nonvolatile ingredients of the wood forming powerfully acid bodies, which aid in the separation of the fiber; their corrosive action makes it necessary to use for the digesters vessels lined with copper or lead. After the wood is steamed, it is ground between millstones or in a rag engine (system Rasch & Kirchner). To avoid the acid reaction, and the necessity of noncorroding vessel linings, the addition of neutral sulphites has been proposed, when the organic acids combining with the base, are neutralized, a sulphite residue remaining. A sodium sulphite solution (5 per cent $Na_2 SO_3$) with a high temperature, 356° Fahr., is used, the action of which, besides neutralizing the acids, seems mainly to consist in keeping the path open for continued action of the heat and water. It is claimed that this latter process has disadvantages in point of economy.

(3) *Chemical wood pulp*, or cellulose proper (in this country called chemical fiber), is produced by treating finely divided wood or wood shavings with various chemicals, which dissolve or render soluble the incrusting substances, leaving the fiber as long, elastic, and pure as the raw material will furnish it, while the above mechanical processes naturally shorten and deteriorate the fiber mechanically.

The chemical processes can be again classified into alkaline and acid processes, according to the kind of chemicals used. Of the many methods proposed only four or five have been developed with industrial success.

All these processes have in common the mechanical preparation of the wood, as described before, preceding the boiling with chemicals under pressure (which requires hermetically closed digesters, with anticorrosive linings) and subsequent washing out of the residual solution, screening, draining, and drying on "wet machines," and most of them, to produce the desirable white color, require a special bleaching process. The partial manufacture of the solvents and the recovery of the spent liquor of solution, or else its treatment for other useful materials, forms also part of the processes. Since the chemicals are apt to attack the fiber itself, a careful adjustment of their proportions is essential, otherwise the loss of

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While these are laboratory results of European chemists, the following percentages, given by Charles M. Cresson, relate probably to pulping results:

Hemlock	45	Spruce	32
Walnut (very dry)	42	Cherry	32
Birch	40	Chestnut	30
Poplar (seasoned)	37	Hickory	22.6
Poplar (unseasoned)	30	Maple (unseasoned)	21.2
Yellow pine	36.5	Ash and oak (unseasoned)	20.6
White pine	33.25		

The general practice brings out still smaller results.

yield may increase unduly. The drying, after the processes of purification, is also an important part, since it is to be considered not a mere desiccation, but a chemical reaction, which, if not properly conducted, results in hardening and agglutination of the fiber.

Of alkaline processes there are two prominent:

(*a*) *Soda pulp* is produced when caustic soda lye under pressure and steam heat of 300° to 360° is used to remove the incrusting substances, carbonate of soda or solway salt and caustic lime being used to obtain the caustic soda, which can be easily and cheaply recovered by evaporation and calcination, the dissolved organic matter supplying the fuel for the latter part of the process of recovery. About 75 to 80 per cent is thus recovered as "black ash." The tank wastage, consisting of lime, silicates, and impurities, is apt to become a nuisance, if allowed to flow off into rivers, etc. The strength of solution, proportion of it to the material, temperature and duration of the digestion, vary considerably with different woods. The chemical changes are very complex and as the chemical action extends to the cellulose itself, the yield is thereby reduced.

(*b*) *Sulphate pulp* results from digesting the wood at a temperature of 300° to 360° in an alkaline mixture in which sulphates preponderate. This process, which is successfully worked in Europe, but seems unknown in this country, contains several points of economic importance. The liquor is made by treating sodium sulphate (glauber salts, 90 pounds of sulphate to 100 pounds of dry pulp) with caustic lime, when a certain proportion of the former is transformed into caustic soda. The liquor, after the boiling, is evaporated, calcined, and treated with lime, by which it is recovered as sulphide and hydrate (caustic soda) in nearly equal proportions, together with some sulphate; and with the addition of some sulphate (about 20 per cent) to compensate for the unavoidable loss, the cycle of operation is kept up.

The pulp from this process is of very high quality, similar if not superior to soda pulp, the only objection being that in consequence of the presence of some organic sulphur compounds it is somewhat malodorous, which, however, it might be possible to overcome. With cheap materials to begin with and easy recovery of the liquor, this should prove a very economic process. It is really almost the same as the one described as soda pulp, only that instead of buying the more expensive caustic soda, this is obtained in the process itself from cheaper and more easily transported materials. A recent patent by G. Hesse proposes boiling the wood with bisulphate of soda, then grinding the wood and using the spent liquor for the manufacture of sugar and alcohol.

The acid processes are more numerous and have come lately more to the front. Passing by the Bachet-Machard process, which, using dilute hydrocholoric acid, was employed in Switzerland for making coarse packing paper, and the Tilghman-Pictet process, employing sulphurous acid in lead-lined vessels, we come to the so-called (*c*) *sulphite pulp*, which is obtained when removing the incrusting substances by boiling the wood with acid sulphurous salts like the acid sulphite of lime ($Ca(HSO_3)_2$), or bisulphite of lime and magnesia ($\left(\begin{smallmatrix}ca\\mg\end{smallmatrix}\right)(HSO_3)_4$). The various processes of this class (developed by Tilghman, Mitscherlich, Ekman, Francke, Graham, Macdougall, Flodquist, Kellner, and others) are identical in principle and differ only in technical detail. The boiling liquors vary in regard to acid strength (3 to 5 per cent) and proportion of base, temperature, and duration of digestion (300° to 350° and thirty to eight hours). Various woods require, of course, variation in strength of liquor, etc. All require special apparatus protected against the corrosive action of acids by a lead or other (special brick) lining. There are also digesters in use made of a bronze metal which resists the corrosion.

Under a recent patent (F. Salomon) a serviceable lining is obtained by heating the vessel filled with sulphite liquor or gypsum solution, which, when boiling, will deposit a durable crust. This crust, which forms itself during the process anyhow, used to be considered a nuisance, as it resisted removal, until it was discovered that its presence answered as a protective lining. It is claimed to be safer than the combined brick and lead lining for the reason that the latter is hidden from possible inspection, and any leaks occurring unforeseen give rise to explosions. The same patentee proposes several other methods of lining.

The source of the acid liquor is either sulphur or pyrites, burnt in suitable ovens, the fumes being led into towers ("acid towers"), where a constant, well-distributed supply of water flows over and through columns of basic material (calcined magnesia or lime) or a milky mixture of the latter agitated in special apparatus, the reaction in both cases resulting in bisulphite of lime, which collects at the bottom of the tower; from here it is led to the digesters (1,400 to 1,800 cubic feet capacity), in which the wood chips have been steamed before for five or six hours to soften them. The digesters, either stationary or rotary, are now filled up, nearly, with the bisulphite and the temperature raised to 225° and after a certain stage to 265°, at which it is kept until near the close of the process, when it drops again to 220°, the boiling lasting for thirty to fifty hours. The liquor is then drawn off, the acid washed out of the pulp in vats under constant agitation, sifted, drained, and dried.

While the lime needed in the process is found almost anywhere—magnesite, which is found in California, and the dolomites, which are found more generally, and react more readily—the sulphurous constituents are not as easily obtainable. The supply of sulphur for the United States comes mainly from Sicily, although sulphur mines are opened in Utah near Salt Lake and in Humboldt County, Nevada (Rabbit Hole Mountain). Pyrite ores, which form the principal native source of sulphurous acid, are mined at Capleton, Connecticut; Elizabeth Mine, Vermont; Rowe, Massachusetts; Mineral City (formerly Tolersville), Virginia; and several localities in Georgia; also in Nova Scotia and on the north shore of Lake Superior (Sudbury), and in the Western States.

It is suggested that the sulphurous products from the roasting of copper ores and of zinc blende ores might be utilized, the latter being found largely in Southwest Missouri (Joplin) and Southeastern Kansas (Galena), Southern Wisconsin and Illinois (La Salle). It is also suggested that the gas works lime might be worked over for the sulphur it contains.

The residue from the process, sulphate of lime with resin gums, etc., combined, is of no value.

The outlay for mill and machinery in this process is said to range from $5,000 to $15,000 for each ton of daily product, and the cost of manufacture $30 per ton.

(*d*) *Electro pulp* is a product of most recent processes (developed by C. Kellner), in which the wood is digested in a solution of common salt at 250° to 260°, constantly electrolyzed.

Two digesters in communication are employed and the liquid is kept in continuous circulation from the electrolyzing vessel over the wood in the digesters and back to the electrolyzer, the latter a separate vessel in communication by means of pipes with both digesters.

The electric action splits up the salt into caustic soda and chlor-oxygen compounds; these latter, of well-known bleaching power, make the usual subsequent bleaching unnecessary and the process is said to furnish at once a "snow white" fiber. Under this class of processes belong also those pulping processes which employ chlorine gas as a disintegrator rather than a bleaching agent. The effect of the chlorine gas or its active oxygen compounds is to oxydize the incrusting substances so that they become soluble in very dilute alkali liquors without the need of higher temperatures.

The bleaching is done, as a rule, by the use of hyposulphite or bleaching powder, which is mixed with the pulp in varying quantities.

Lately an electro-chemical bleaching process (E. hermite) seems to have been brought to perfection, in which a weak (5 per cent) solution of magnesium chloride is electrolyzed. The chlorine developed acts as a bleacher and then combines again with the base, so that the same liquor can be used over and over again, the cost of the motive power for the electric machine being the only expense. The elaborate plant is objected to. (See Journal of Society of Chemical Industry, London, 1890, containing one paper in vindication (Cross & Bevan), and another against the process (Hurter.) A further improvement of this process consists in adding a small proportion of quicklime to the salt solution, whereby it is claimed the electro-motive force may be reduced and other advantages gained.

To estimate the commercial value of these various processes three points, it seems, ought to be considered: (1) The resulting product as to quality and yield; (2) the cheapness and convenience of the necessary plant and chemicals; (3) the application to various woods.

Ample water power and clear water, supply of suitable woods with large proportion of cellulose, long felting fiber, and requiring least expense in freeing it from incrustations, are the conditions, in addition to those which favor any other commercial enterprises, to be looked for in locating plants. I would especially point out in the interest of forest management and forest supplies that an adaptation of the plant to the simultaneous use of the various woods offered, combining those of long and short fiber, will have to be the study of the future.

The material obtained by the different processes differs in quality and quantity and answers different purposes.

The *ground pulp* is naturally of short fiber, and while without addition of a long, elastic, and felting fiber, only short (brittle) paper can be made from it, for a filling material of better classes of pulp in the manufacture of ordinary cheap paper and cardboard it answers very well, giving body and capacity. Common newspaper consists of 80 per cent of ground pulp.

The yield should be 1 pound per horse power per hour of dry stuff and about 19 pounds per cubic foot of wood where spruce and fir are used. The larger yield reported—namely, 2,000 pounds to the cord—refers either to a very well measured cord or else to material not thoroughly air-dried. The plant is naturally cheap and with pure water and sufficient fall of the same is easily put up and run economically. The wood need not be as clean as for the chemical processes, inferior material being satisfactory, although branch knots must be removed as they discolor the pulp, and rotten wood can not be used. The better class of firewood answers very well. All woods can be used for this process, but the harder woods require more power, and hence are less economically worked, so that now mostly conifers are ground; also aspen, poplar, cottonwood, basswood, birch, buckeye, and gum.

The *brown pulp*, which seems not to be made in this country, yields a much longer and better felting fiber, since by the steaming process a part of the incrustation is dissolved and the fibers are loosened, and hence not so much lacerated in the grinding. Since, however, the dissolved compounds impart a dark color to the pulp, it can be used only for brown papers. It makes, however, an excellent, tough packing paper and strong pasteboard. Attempts to remove the brown color by boiling in dilute oxalic acid have so far been only partially successful. A process by which the wood is boiled in hydrosulphuric alkalis with subsequent washing in hot water seems to be more successful in yielding a whiter material capable of treatment with bleaching powder. The salts can be recovered and used again, while the brown liquor of solved materials may be worked advantageously for wood alcohol, so that this process promises much economy. The yield of pulp under favorable conditions is said to be as high as 70 per cent in weight of the wood, which is the highest claimed for any process.

The chemical processes furnish the best material, but since the chemicals under higher temperatures attack and dissolve part of the cellulose itself, the yield is considerably less than from the mechanical and partly chemical processes. While the electric process is as yet in its infancy, there can hardly be any doubt that it will be rapidly developed and eventually supersede all other processes, since it involves no other expenditure than that for motive power and promises to yield a superior product.

The *soda pulp* is similar to that from cotton rags, of greater softness and opacity than the acid pulps, but the yield is rather low on account of the strong action of the chemicals on the cellulose; thus, while the bisulphate may yield 45 to 50 per cent from white pine, the soda process would yield only 33 per cent, or 800 to 1,000 pounds per cord. The present low cost of soda and the easy and cheap method of recovery from the spent liquor by evaporation and calcination, in which latter operation the fuel is supplied by the dissolved organic matter, are factors of economy which may offset the lower yield.

The *sulphate pulp* yields a paper similar in quality to that from soda pulp, perhaps somewhat better, approaching linen paper. The objectionable smell and the economic features of this process have been pointed out before. The absence of tank wastage is particularly noticeable. It is also claimed that it bleaches far better and with half as much bleaching material as other processes in the market. It is probably classed with either soda or sulphite pulps.

The *sulphite pulp* is harder and more transparent than the pulp obtained by alkaline treatment. It may be used without further bleaching for tinted and low white paper, but to produce a fully white material like soda pulp 15 to 30 per cent its own weight of bleaching powder is required. The yield should be 40 to 50 per cent, but from the reports it would appear that the practice in this country brings hardly more than the soda process. With the residual liquor an entire loss, and no special features of superiority, it is questionable whether this process, although at present on a boom and enormously extended, will ultimately maintain its high position Especially when it is considered with reference to wood supplies, it can not be expected to supersede the alkaline processes.

ADAPTATION OF WOODS.

The soda and sulphate processes can utilize much more resinous and knotty woods or parts of trees because the resins combine with the alkalis to form soaps soluble in water and hence easily washed out, while the acid processes, like the sulphite, dissolve the resins only partially, and are, therefore, preferably used for young growth and sapwood, leaving the older heartwood intact, although it is claimed that the knots in spruce and balsam fir soften as readily as the rest of the wood; but the heart of the Norway pine and probably of the more resinous pines of the South would not yield to this treatment.

The fibers of conifers resemble those of cotton, are of considerable length, flat, tape-like, and flexible, which characteristics impart to them superior felting quality.

The deciduous woods are most readily acted upon by the solving liquids, and some of them, poplar, aspen, tulip, and basswood, especially excel by their white color; they would, therefore, form a most desirable raw material if their shorter fiber were not objectionable. The cells being in the average only about one tenth of an inch in length, tubular and pointed, they do not make a good felting pulp, although they are quite flexible, and hence even the chemical pulp of these woods, with few exceptions, is used only as filler. A further study of our native hard woods, with reference to their fiber, is, however, still desirable before classing them all as second for pulp material.

The poplars, which have the longest fibers of those so far used, have the advantage of a persistent white color, while basswood, next in value, takes a reddish tint, birch a pink, and maple a purple hue, which makes it objectionable; larch is said to color very badly. Spruce, balsam fir, hemlock, jack pine, cedar in the North, loblolly pine, and cypress in the South are at present staples. The spruce especially furnishes at present the bulk of pulp manufactured in this country, a frequent practice being to add some poplar or aspen pulp for the purpose of whitening the spruce pulp.

It is said that trees twenty-five to thirty years old are best for grinding, that evenly grown wood is the most desirable, and that trees from marshy ground are not acceptable. The wood must be freshly cut, as too much exposure to the air hardens the fiber by drying. By keeping the wood in the water until ready to use it, not only is it kept softer, but some of the resinous substances are leached out.

If prices give a correct estimate of values, the chemical pulp is about two and two thirds times superior to mechanical pulp. For the sake of comparison the following quotations are here given:

	At London.	At New York.	Domestic.	Tariff.
Ground pulp (pine), dry, per ton	$24.00	$30.00	....	....
Ground pulp (aspen), dry, per ton	40.00	35.00	$26.00- 28.00	$2.50
Brown pulp, dry, per ton	30.00	....	....	....
Soda unbleached	$50.00-60.00	$54.00-61.00	....	6.00
Soda bleached	67.50	70.00-78.00	70.00- 75.00	7.00
Sulphite unbleached	50.00-75.00	54.00-71.00	75.00- 80.00	6.00
Sulphite bleached	82.00-88.00	85.00-95.00	90.00-100.00	7.00
Wood flour	....	27.00	30.00	....

Making the average yield per cord 1,700 pounds for ground, 1,000 for sulphite, and 800 for soda pulp. By the different processes the value of a cord of wood may be brought to $24.50 or $30, respectively.

From the compilations of the Paper Trade Journal (Howard Lockwood, New York), the growth of the industry for the last nine years can be learned:

Growth of daily capacity of running wood pulp manufacture.

	Chemical fiber.	Ground wood pulp.
	Pounds.	*Pounds.*
1881	250,500	484,300
1883	466,000	633,450
1884	576,000	795,550
1885	587,000	885,830
1886	537,000	960,600
1887	602,000	1,085,900
1888	617,000	1,536,500
1889	866,500	2,607,600
1890	1,376,500	2,900,700

This would show that the business has increased nearly 500 per cent in the last eight years and nearly 200 per cent in the last four years.

In 1888 the stumpage consumed for pulp was valued at $2,235,000. The product, 225,000 tons ground and 112,500 chemical pulp, was valued together at $12,375,000, the capital employed being estimated at $20,000,000. The figures given below would indicate a present consumption in round numbers of 1,000,000 cords of wood per annum. When it is considered that about 1,000,000,000 pounds of book and news paper are consumed annually in this country, two thirds of which might be made of wood fiber, there is still a considerable margin for this use alone to be supplied by wood pulp.

In reply to the question what the Department might do for the pulp makers' interests, the need of stopping the firing of the woods is most prominently mentioned. The planting of trees, bounty for such planting, or distribution of plant material, are also suggested. Railroad facilities, tariff protection, and reports giving reliable information are asked for by others.

Statistics of the wood pulp industry of the United States, 1890

(*a*) NUMBER OF MILLS IN OPERATION AND THEIR CAPACITY.

States.	Mechanical (ground) pulp.			Chemical (soda) fiber.			Chemical (sulphite) fiber.			Mechanical and chemical combined.		Total.	
	Number of mills.	Capacity, daily. Range in 1,000 pounds.	Capacity, daily. Total.	Number of mills.	Capacity, daily. Range in 1,000 pounds.	Capacity, daily. Total.	Number of mills.	Capacity, daily. Range in 1,000 pounds.	Capacity, daily. Total.	Number of mills.	Capacity, daily.	Number.	Capacity.
Maine	15	2.5–70	407,500	4	20–52	149,000	5	16–30	106,000	...	....	24	662,500
New Hampshire	15	4–30	220,500	2	60	60,000	1	10	10,000	...	....	18	290,500
Vermont	17	2–80	273,500	...	......	....	1	8	8,000	...	....	18	281,500
Massachusetts	3	4–10	21,000	1	11	11,000	3	8–20	43,000	1	40,000	8	115,000
Connecticut	...	......	....	...	......	....	1	......	11.000	...	....	1	11,000
New York	67	1.5–80	855,800	4	8–55	117,000	3	16–30	76,000	1	6,500	75	1,055,300
Pennsylvania	3	6–20	42,000	7	6–80	233,000	1	......	25,000	...	....	11	300,000
Delaware	...	......	....	1	44	44,000	...	......	....	...	....	1	44,000
Maryland	1	25	25,000	1	27	27,000	1	......	20,000	...	....	3	72,000
Virginia	2	12–18	30,000	...	......	....	...	......	....	...	....	2	30,000
West Virginia	3	30–30	84,000	...	......	....	1	......	50,000	...	....	4	134,000
North Carolina	3	......	7,000	...	......	....	...	......	....	...	....	3	7,000
South Carolina	1	......	2,500	...	......	....	...	......	....	...	....	1	2,500
Georgia	5	.6–4	11,850	...	......	....	...	......	....	...	....	5	11,850
Kentucky	1	......	22,000	...	......	....	...	......	....	...	....	1	22,000
Ohio	2	8–10	30,000	1	......	7,500	2	......	30,000	...	....	5	67,500
Indiana	11	1.5–40	129,500	1	......	30,000	...	......	....	...	....	12	159,500
Michigan	8	3–24	67,000	1	......	8,500	4	4–30	72,000	...	....	13	147,500
Wisconsin	21	6–30	310,000	...	......	....	5	......	74,000	...	....	26	384,000
Minnesota	2	2–20	22,000	...	......	....	...	......	....	...	....	2	22,000
Oregon	2	8–40	48,000	...	......	....	1	......	20,000	...	....	3	68,000
California	1	......	40,000	...	......	....	...	......	....	...	....	1	40,000
Total	183	......	2,649,150	23	......	687,000	29	......	545,000	2	46,500	237	3,927,650

NOTE.—In addition to the above 237 mills, which number represents nearly all at present in operation, there are reported 14 idle and 2 abandoned. From Canada 33 pulp mills are reported, 24 of which have a daily capacity of 276,800 pounds.

(*b*) SUPPLIES AND PRODUCT.

States.	Number of mills.	Kinds of wood used.	Range of yield, per cord, in hundreds of pounds.			Number of mills reporting supplies.					Remarks.
			Mechanical.	Soda.	Sulphite.	Good.	Fair.	Limited.	Declining.	Poor.	
Maine	12	Spruce only or chiefly	16–20	......	11–13.5	20	1	..	..	..	
	7	Spruce and poplar	15–20	10	....	..	..	..	..	..	
	1	Spruce, poplar, and pine	......	......	....	..	..	..	..	..	
	1	Poplar	......	10.3	....	..	..	..	..	..	
New Hampshire.	13	Spruce only or chiefly	18–24.5	......	10	11	2	2	..	..	1 get supplies mostly from Canada.
	2	Spruce and poplar	......	10	....	..	..	..	..	..	2 get supplies partly from Canada.
Vermont	11	Spruce only or chiefly	18–20	......	....	11	..	4	1	1	1 gets supplies mostly from Canada.
	5	Spruce and poplar	20–23	......	....	..	..	..	..	..	
	1	Poplar and pine	20	......	....	..	..	..	..	..	
Massachusetts.	4	Spruce only or chiefly	15–22	......	10	5	..	..	..	3	2 supplies from Northern Vermont and New Hampshire.
	4	Spruce and poplar	17–18	......	....	..	..	..	..	..	

Statistics of the wood pulp industry of the United States, 1890—Continued.

(*b*) SUPPLIES AND PRODUCT—Continued.

States.	Number of mills.	Kinds of wood used.	Range of yield, per cord, in hundreds of pounds.			Number of mills reporting supplies.					Remarks.
			Mechanical.	Soda.	Sulphite.	Good.	Fair.	Limited.	Declining.	Poor.	
Connecticut	1	Spruce								1	Supplies from New Brunswick and Nova Scotia.
New York	52	Spruce only or chiefly	15–22		13	34	7	8	2	2	1 supplies mostly from Canada.
	4	Spruce and poplar	16–20								15 supplies from Canada or distant points.
	1	Spruce and hemlock			11						
	1	Spruce, hemlock, bass			10						
	2	Spruce, poplar, and pine									
	2	Poplar	14	9							
	1	Poplar, bass, pine, and spruce.		10							
	1	Spruce and pine									
Pennsylvania	2	Spruce only or chiefly	19–20			1		1			
	1	Spruce and poplar			10					1	Supply from West Virginia and Nova Scotia.
	2	Poplar		10						2	Supply from Maryland and Virginia.
	2	Poplar, bass, pine		9–10			2				
	2	Poplar, bass, pine, maple		7–12			2				
	1	Hemlock, pine, beech, bass.		10		1					
	1	White pine	16			1					
Maryland	2	Spruce only or chiefly	18		10	1	1				Spruce from West Virginia and Canada.
	1	Poplar		10		1					
Delaware	1	...do						1			
Virginia	2	...do	20			2					
West Virginia	4	Spruce only or chiefly	17		10.5	2	2				
North Carolina	2	Pine	10				2				
South Carolina	1	Cypress and gum					1				
Georgia	3	Pine	20–27			3					
	1	Cypress and gum				1					
	1										
Kentucky	1	Spruce, buckeye, and maple.	18				1				
Ohio	2	Spruce only or chiefly	17			2					
	1	Cottonwood and bass		9	10		1				
Indiana	3	Aspen	16			1		1		1	
	1	Spruce and poplar	16				1				
	2	Poplar, spruce, pine	12					1		2	
	1	Aspen, poplar, cottonwood.	10							1	
	1	Cottonwood	20					1			
	1	Basswood		9		1					
Michigan	4	Spruce only or chiefly	16		8–10	1	2			1	1 supply all from Canada.
	3	Poplar	16–20	15		2		1			
	4	Poplar, pine, tamarac, spruce, and balsam.				4					
	1	Aspen, pine, poplar, spruce, and bass.	14						1		
Wisconsin	4	Spruce only or chiefly	16–18		9–10	1	2		1		
	15	Spruce and poplar	13–15		9–10	5	5	2	1	2	
	4	Spruce, poplar, pine	10–12			1		1	2		
Minnesota	1	Spruce only or chiefly	15					1			
Oregon	1	Cottonwood				1					
California	1	Tamarac and fir	17			1					

TIMBER TESTS.

While the use of wood pulp and other substitutes may displace in many ways the use of wood in its natural state, there will always be desirable qualities inherent in the latter that make its use indispensable. Hence the desirability of knowing the qualities of our timbers and, if possible, of knowing the conditions under which the wood crop will develop the desirable qualities.

Much work and useful work is done in the world by the rule of thumb. All such work is not reliable and certainly not economical. With the need of greater economy in production, the need of more accurate measuring arises, and with that the need of more specific knowledge of the materials to be measured.

Wood is one of the materials which has been measured by the rule of thumb longer than others. Iron and other metals used in the arts have their properties much more accurately determined than wood material. Especially in the United States, when we speak of quality of our timbers, it can only be in general terms; we lack definite data.

One difficulty in determining reliably the qualities of our timbers lies in the fact that living things are rarely precisely alike. Every tree differs from every other tree, and the material taken from the one has a different value from that taken from the other of the same species. Yet every tree has some characteristics in common with all those grown under similar conditions. But even these common properties differ in degree in different individuals. Individual variation tends to obscure relationship.

The factors which determine the quality of timbers are found directly in the structure of the wood, and it is possible from a mere ocular examination to judge to some extent what qualities may be expected from a given piece of timber, although even in this direction our knowledge is very incomplete, and but few definite relations between structure and quality, or between physical and mechanical properties, are established. We know that the width of the annual rings, their even growth, the closeness of grain, the length, number, thickness, and distribution of the various cell elements, the weight, and many other physical appearances and properties of the wood influence its quality, yet the exact relation of these is but little studied. Conjectures more or less plausible, suppositions, and a few practical experiences preponderate over positive knowledge and results of experiments. Again we know, in a general way, that structure and composition of the wood must depend upon the conditions of soil, climate, and surroundings under which the tree is grown, but there are only few definite relations established. We are largely ignorant as to the nature of our wood crop, and still more so as to the conditions necessary to produce desirable qualities, and since forestry is not so much concerned in producing trees as in producing quality in trees, to acquire or at least enlarge this knowledge must be one of the first and most desirable undertakings in which this Division can engage.

Accordingly a comprehensive plan has been put into operation to study systematically our more important timber trees.

It will at once be understood that as long as the qualities are to be referred to the conditions under which the tree is grown the collection of the study material must be made with the greatest care, and the material must be accompanied with an exhaustive description of these conditions. Since, further, so much individual variation seems to exist in trees grown under seemingly the same conditions, a large number must be studied in order to arrive at reliable average values. For the present it has been decided to study the pines, especially the white pine and the three southern lumber pines.

In selecting localities for collecting specimens, a distinction is made between station and site.

By station is understood a section of country (or any places within that section) which is characterized in a general way by similar climatic conditions and geological formation. Station, then, refers mainly to the general geographical situation. Site refers to the local conditions and surroundings within the station, such as difference of elevation, of exposure, of physical properties and depth of the soil, nature of subsoil, and forest conditions, such as mixed or pure growth, open or close stand, etc.

The selection of characteristic sites in each station requires considerable judgment.

On each site five full grown trees are to be taken, four of which are to be representative average trees; the fifth or "check" tree, however, should be the best developed tree that can be found on the site. Some additional test trees will be taken from the open and also a few younger trees. The trees are cut into varying lengths, and from each log a disk of 6-inch height is secured after having marked the north and south sides and noted the position of the log in the tree.

The disks are sent for examination of the physical and physiological features to the Michigan University, while the logs, and later on special parts of the disks are to be sent to the test laboratory of the Washington University of St. Louis. Here, for the first time, a systematic series of beam tests will be made and compared with the tests on the usual small laboratory test pieces. Such tests with full length beams in comparison with tests on small specimens promise important practical results, for a few tests have lately developed the fact that large timbers have but little more than one half the strength they were credited with by standard authorities, who relied upon the tests on small specimens.

From the "check" tree mentioned before only clear timber is to be chosen, in order to ascertain the possibilities of the species and also to establish, if possible, a relation between such clear timber and that used in general practice, where elements of weakness are introduced by knots and other blemishes.

An authority on engineering matters writes regarding this work:

> Inasmuch as what passes current among engineers and architects as information on the strength of timber is really misinformation, and that no rational designing in timber can be done until something more reliable is furnished in this direction, the necessity for making a competent and trustworthy series of such tests is apparent. This is a work which the Government should undertake if it is to be impartial and general.

A careful record of all that pertains to the history and conditions of the growth from which the test pieces come, and of their minute physical examination, will distinguish these tests from any hitherto undertaken on American timbers.

The disk pieces will be studied to ascertain the form and dimensions of the trunk, the rate and mode of its growth, the density of the wood, the amount of water in the fresh wood, the shrinkage consequent upon drying, the structure of the wood in greatest detail, the strength, resistance, and working qualities of the wood, and lastly, its chemical constituents, fuel value, and composition of the ash.

For this part of the work, which is the most laborious and difficult, Mr. Filibert Roth, of Ann Arbor, is engaged, having prepared himself for it by several years of preliminary study in that line. The testing will be done by Prof. J. B. Johnson, of St. Louis, whose facilities, central location, and interest in the work promise desirable progress. The collection of the southern pine specimens, which will occupy the greater attention of the work this year, is done by Dr. Charles Mohr, which assures a judicious selection of material and competent description of conditions of growth.

Thanks are due to the Louisville and Nashville Railroad Company and to the Chicago, Milwaukee and St. Paul Railroad and to the Chicago, Burlington and Quincy Railroad Companies, who in a generous manner have offered free transportation for test logs.

It is estimated that for the first series fifty trees will be studied, involving about two thousand tests and a large amount of laboratory determinations.

Incidentally with this line of work, at the request of the Committee on Timber Supply of the National Carriage Builders' Association, some tests of northern and southern grown oak for carriage stock were undertaken, the results of which are here reported.

Unfortunately it was not possible to secure the test material, or to carry out the tests as thoroughly as should have been done, in time for the desired report to the Carriage Builders' Convention. The following tests and examinations, therefore, are not to be considered as samples of what will be done, but only as indications of the kind of questions to be settled by this inquiry. It will be found that the descriptive part is not what it should be, and the number of tests is too small to allow generalization, yet some interesting results are nevertheless anticipated from these preliminary tests.

In the descriptive part the schedule, which is to be filled out for the more elaborate tests, is given in full in order to establish uniformity in description. A series of descriptive words appear in the schedule (as given for sample *a*), so that the collector needs only to underscore the suitable one.

(*a*) *Description of station, site, and trees from which test material was taken.*

I. Station:	A (Connecticut).	A.	B (Arkansas).
1. Average longitude....	73.		91.
2. Average latitude	41.30.		36.
3. Average altitude......	200 (?)		
4. General configuration.	Plain, hills, plateau, mountainous, general trend of valleys or hills.		
5. Climatic features.....	....		
II. Site:	*a*.	*b*.	
1. Aspect..............	Level, ravine, cove, bench, slope (angle of).		Specimens selected from stock in the yard of Woody, Holmes & Co., carriage stock manufacturers. History unknown. Supposed to represent fair average of first-class timbers that can be supplied in large quantities.
2. Exposure..........			
3. Elevation above average station altitude.			
4. Soil conditions........	Upland....................	Lowland....	
(*a*) Geological formations.			
(*b*) Mineral compositions.	Clay, limestone, loam, marl, sandy loam, loamy sand, sand.		
(*c*) Surface cover	Bare, grassy, mossy; leaf cover abundant, scanty, lacking.		
(*d*) Vegetable mold, depth.			

(a) Description of station, site, and trees from which test material was taken—Continued.

II. Site—Continued.			
4. Soil conditions—Continued.			
(*e*) Grain, consistency, and admixtures.	Very fine, fine, medium, coarse, porous, light, loose, moderately loose, compact, binding, stones or rocks (size of).		
(*f*) Moisture conditions.	Wet. moist, fresh, dry, arid, *well drained*, liable to overflow, swampy, near stream or spring or other kind of water supply.	Wet	
(*g*) Color			
(*h*) Depth to subsoil	Shallow, 6 inches to 1 foot; 1 foot to 4 feet, deep; over 4 feet, very deep; shifting.		
(*i*) Nature of subsoil.			
5. Forest conditions:			
(*a*) Growth	Mixed, pure, dense, moderately dense. open.		
(*b*) Associated species			
(*c*) Proportion of these.			
(*d*) Average height			
(*e*) Undergrowth			
6. Conditions in the open.			
(*a*) Nature of surroundings.	Field, pasture, lawn, clearing (how long cleared).		
(*b*) Nature of soil cover.	Weeds, brush, sod		
III. Description of trees:			
1. Species	White oak	White oak	White oak.
2. Number	I.	II.	
3. Special position (if not covered sufficiently by general description).			
4. Origin of tree	Natural seeding, sprout from stump, artificial planting, unknown.	Sprout	
5. Diameter (breast high).			
6. Height of stump			
7. Length of felled tree.			
8. Total height			
9. Height to first limb			
10. Age (annual rings on stump).			
11. Time when cut, and after treatment			

(b) Description of test material and results of physical examination.

Notation as to station, site, and tree	A. a. I.	A. b. II.	B.
Number of test piece	1.	3.	
Exposure in tree	North.	Southwest.	
Height in tree	"Butt cut."	"Butt cut."	
Position in tree (with reference to periphery)	Not known.	Not known.	
Size of test material:			
Length	4	4	
Breadth	1¾ inch.	1¾ inch.	
Depth (measured across rings)	1¾ inch.	1¾ inch.	
Number of rings			
Width of rings (average)	2.7 millimeters.	1.5 millimeters.	
Summer wood as a whole	80 per cent.	54 per cent.	
Firm bast tissue	60 per cent.	37.5 per cent.	
Space lost by large vessels	14.7 per cent.	24.9 per cent.	
Moisture conditions when tested	Nearly seasoned.	Half seasoned.	
Density	.84	.77	

(c) Results of tests made in Washington University Laboratory, St. Louis, Missouri, by Prof. J. B. Johnson.

Test piece.		Bending and crossbreaking. Size of test piece 1⅝ by 1⅝ by 24.						Compression.				Shearing.	
		Stiffness.		Ultimate strength.		Resistance to shock.		Endwise.		Transverse.		Longitudinal.	
Where procured.	No.	Range No.	*Modulus of elasticity, pounds per square inch.	Range No.	Modulus $\frac{3.W.L.}{2.b.h^2}$ pounds per square inch.	Range No.	Modulus inch-pounds per cubic inch.	Range No.	Modulus pounds per square inch. Size 1⅝ by 5 inches.	Range No.	Modulus pounds per square inch.	Range No.	Modulus pounds per square inch.
A. a. I	1	9	990,000	3	13,760	4	59	6	6,160	1	3,400	3	1,375
	2	5	1,280,000	1	18,500	1	92	7	5,480	3	3,100	1	1,560
Average.	....	3	1,135,000	1	16,130	1	76	3	5,820	1	3,250	1	1,468
A. b. II	3	6	1,120,000	8	12,300	6	47	11	4,740	7	2,500	6	....
	4	10	920,000	5	12,700	5	55	9	4,980	4	2,800	7	1,225
Average.	....	4	1,020,000	3	12,500	3	51	5	4,860	2	2,650	3	1,225
	5	11	850,000	9	11,400	2	83	8	5,230	5	2,700	4	1,375
	6	7	1,140,000	7	12,300	7	45	10	4,820	8	2,500	2	1,540
Average.	....	5	995,000	5	11,850	2	64	4	5,025	3	2,600	2	1,458
B.........		Size: 1⅝ by 1⅝ by 18 inches.						Size: 1⅝ cube.					
	7	3	1,570,000	6	12,380	9	27	4	6,800	11	2,000	10	860
	8	8	1,100,000	2	14,690	3	82	1	7,800	2	3,200	5	1,260
	9	4	1,385,000	11	11,240	11	19	5	6,800	9	2,300	11	825
Average.	....	2	1,351,667	2	12,770	4	43	2	7,133	4	2,500	5	982
	10	1	1,653,000	4	13,030	8	30	3	6,900	6	2,600	8	1,050
	11	2	1,581,000	10	11,590	10	22	2	7,700	10	2,100	9	940
Average.	...	1	1,617,000	4	12,310	5	26	1	7,300	5	2,350	4	995

* Young's modulus of elasticity: $E = \frac{W.L.^3}{4\,D.b.h.^3}$ where W. = total load at center in pounds. L. = length in inches. D. = deflection in inches. b. = breadth in inches. h. = height in inches.

As stated before, these tests can hardly settle definitely any question. Samples 1 and 2 being selected stock, second growth, can not be used for comparison with samples of B, except to show that for stiffness the unselected southern stock is superior to the best northern growth, as also in resistance to endwise compression. The samples 3, 4, 5, and 6 are probably more nearly comparable to samples of B, and here we find the southern oak very much superior, not only in stiffness and columnar strength, but also in ultimate crossbreaking strength, while for resistance to shock at least one sample of southern oak is superior to three samples of forest-grown northern, and even to one of the best northern second growth. This piece (No. 8) exhibits, altogether, qualities which render the verdict tenable that southern oak is not necessarily inferior to northern oak in any of its qualities.

Beyond this it would not be safe to use these figures for generalizations. From Mr. Roth's examination of the two northern oak samples we learn that the time taken to lay on the same amount of wood which the open-grown upland oak made in one year was, in the forest-grown lowland oak, 21.5 months, showing the former superior from the forest economical point of view as it is also from the wood consumers' standpoint.

Comparing these two sticks with reference to density they would stand as 5 to 4, while comparing the relative amounts of firm bast and spring wood the ratio would be 8 to 5; and Mr. Roth argues that the former ratio would probably give more nearly a comparison for strength and stiffness, while the latter should be considered as the proper ratio regarding the value of the two sticks for wagon spokes. In reality the tests for stiffness, if the modulus of elasticity is considered to indicate stiffness, proved the ratio to be nearer 6 to 7, the first stick showing least stiffness. The tests for cross-breaking strength establish a ratio of 6 to 5, while the ratio of resistance to endwise compression corresponds to the density ratio.

Resilience (resistance to shock), which Professor Johnson takes as the nearest expression of the quality called toughness, showed the ratio of 6 to 5. From these single tests we do not, therefore, derive an unmistakable relation of physical and mechanical properties.

FORESTRY INTEREST IN THE STATES.

While it may not be possible to point to any particular development as a sign of progress in the forestry movement, the indications that greater interest is felt throughout the country in the endeavors of the friends of forestry reform have become more frequent with every year. One of the most promising signs is the frequent discussion of forestry matters, not only in the general press, but especially in the papers devoted to the interests of the lumber business. These papers, as well as lumbermen at large, begin to recognize that the time is nearing when methods of obtaining the supplies for the lumber business must be modified so as to secure, instead of preventing, natural reforestation of the better kinds. How the present methods of lumbering reduce the chances of desirable natural reforestation will appear further on.

There are now holders of large timber areas who would be willing to follow a rational policy in regard to their lumbering operations if they knew how to do it. Since conditions vary so greatly, it would be impossible to give information in this respect capable of general application. On the other hand the presentation of what is involved in forest management, in a definite, concrete case, may aid in forming some idea of the manner in which other conditions may be satisfied.

I am fortunately able to furnish such reference to a definite case of proposed forest management, which, in my estimation, marks a new era in the forestry movement. I refer to the purchase by the Adirondack League Club of a large area of virgin timber lands (some 93,000 acres) in the southwestern part of the Adirondacks, with the stated purpose of placing it under forest management. As a proof of the bona fide intention of the club, I may say that the direction of the forest policy of the club was confided to the present writer. I deem this move such an important one, and the opportunity of teaching forestry principles in their application to a definite object so welcome, that I ask leave to reproduce here such parts of my report to the executive committee of the club as may be of general interest and helpful in inducing other proprietors of woodlands to apply as far as practicable similar principles.

To the Executive Committee of the Adirondack League Club, New York:

* * * * * * *

The club is to be congratulated on two things; first, on the laudable intention of practically applying, for the first time in the United States, forestry principles to the management of its woodlands, and secondly, on the excellent opportunity for such application offered in its valuable property, combining as it does the three essential conditions which may render profitable forest management in the United States at the present time possible, namely, a sufficiently large and compactly situated area, a large amount of available and valuable material uninjured by fire or otherwise, and proximity to large centers of consumption, to which it can be made accessible.

THE PROPERTY.

You have been fortunate in securing in a tolerably compact body one of the best-wooded, absolutely virgin timber tracts of the Adirondack region, situated in the southwestern outskirts of the mountain region proper, within easy reach of Albany and New York, the largest lumber markets of the East, with waters—the head-waters of Black River and of the Mohawk (West Canada Creek)—capable of floating the soft woods, and with a topography which admits of easy grades for roads and railroads, and presents no serious difficulties of any kind for carrying on lumber operations and forest management.

As far as examined the property represents a hill country, well watered, with gentle slopes and no elevations more than 500 or 600 feet above the mean altitude of about 2,000 feet above sea level. The soil is a sand of moderate depth, overlying the native rock, richly impregnated with the products of humification from the fallen foliage of centuries and then covered with "duff," resulting from the imperfect humification of the spruce needles. It is a soil, which, when exposed and put into cultivation, soon shrinks and deteriorates, having no durability for agricultural use, but which if kept carefully under forest cover, forms a most excellent basis for tree growth and forest management.

The forest consists principally of birch* and maples† of magnificent proportions with the admixture of beech and black spruce.‡ There occur on the tract also, although rarely in large numbers, except in a few localities, white pine, balsam fir, tamarack, hemlock (the latter sometimes of large size and in predominant quantity), and hard woods, single trees of black cherry, elm, and in low places, black ash. None of these or of the few other species found need to be at present considered in the forest management, which will have to concern itself primarily with the birch, maple, and spruce. The ratio in which these kinds occur may be roughly estimated as averaging 40 per cent for the birch, 30 per cent for the maple (hard maple predominating) and beech, and 25 per cent for spruce, leaving, say, 5 per cent for the other timbers.

* * * * * * *

The beech, although numerically equal to the maples, shows an inferior development and small diameter, and is for that reason hardly to be counted among the principal growth. It may, in fact, become rather troublesome in the forest management, owing to its superior capacity for reproduction under the prevailing light conditions, thus excluding the more desirable kinds.

The quantities of merchantable timber per acre, it would, of course, be impossible to state from such a superficial inspection as was afforded the writer. But from what could be seen in a four days' tramp through the woods, I should be inclined to consider an average yield of 6,000 feet of spruce (above 12 inches) and enough of birch and maple to make altogether 15,000 to 20,000 feet of merchantable timber per acre a fair estimate. This refers, of course, only to the fully matured timber. There is also a large amount of "down timber," fallen trees, of which the sapwood only is defective, and which will increase the yield considerably.

As is the rule in a virgin forest, trees of all sizes and ages occur side by side. It is, however, noticeable that really young growth occurs very rarely, owing to the fact that the old growth has very dense and shady crowns, shutting out the light

*Two species: *Betula lenta*, the black or cherry birch, and *B. lutea*, the gray or yellow birch.

†*Acer saccharum*, the hard or sugar maple, and the two soft maples *A. saccharinum* and *rubrum*.

‡*Picea mariana*, formerly called *nigra*.

so essential to a proper development of the young plant. The apparently young growth of spruce especially, which is found here and there through the woods, is in fact nothing more, in most cases, than stunted growth of considerable age, which has been capable of persisting and vegetating under adverse light conditions.

To get at an approximate valuation of the property as a wood producer the following calculation might be ventured: Allowing of the total area say, in round figures, 70,000 acres as fully productive, and taking 15,000 feet of merchantable timber standing per acre, I estimate the stock available, at present figures, as 1,050,000 M feet, board measure, worth on the stump, at present minimum price, a round million dollars. Allowing a rotation of one hundred years as desirable in which to cut over and reproduce this area—a shorter rotation would probably be quite practicable—the annual cut in the old stock would yield 10,500 M feet. To this must be added an accretion of 350 feet per year to the acre, an exceedingly conservative estimate, representing over the entire area 24,500 M feet of annual growth, so that the property would be capable of yielding annually for the next one hundred years, and practically forever, at least 35,000 M feet of lumber, which, figured at the present minimum price on the stump, means an annual income of $35,000.

* * * * * * *

It should, of course, be understood that an annual cut exceeding the above figure is by no means objectionable, as long as old stock is on hand and due regard is given to reproduction. An annual cut of the same amount in material, or in value only, from year to year, presupposes that it is desirable to have a regular dividend of nearly even amount instead of irregular ones. If need be, and if the conditions of the market make it appear more profitable, there can be no objection to increasing the cut, reducing it proportionately afterward.

THE CONTRACT.

The club acquired its property with an undesirable liability upon it, which is bound more or less to handicap its endeavors in the introduction of forest management. I refer to the contract under which a certain lumber firm obtained the right to cut during the next fifteen years all the spruce above 12 inches in diameter on any part of the property without any restrictions. While as a matter of financial expediency this contract may have been desirable, it was, I understand, an unavoidable condition in the purchase. As a matter of forest policy, the club can not flatter itself on having inaugurated any advance upon methods already existing. Aside from the facts that this contract confers a most valuable privilege at an exceedingly low figure, and takes out of the hands of the club the unrestricted control of the property, from a technical point of view it can not be considered good forestry. Lumbermen in various parts of the country have before this abstained from taking all the cream at once, mainly because it did not pay, and having left certain sizes of certain timbers uncut, have found and cut a "second crop" after a number of years, the smaller sizes having grown to fair dimensions.

Friends of forest preservation in their recommendations, and the commissioners of Crown lands in Canada in practice, have made the size down to which timber might be cut a condition of forest conservancy. It can not be denied that by restricting the cut to special timbers and sizes presumably absolute clearing is avoided, and the absolute exhaustion of the particular kinds of timber on the area prevented or at least delayed, and in so far as these two contingencies are attained there is a benefit in this restricted utilization. But these contingencies are matters of chance rather than of certainty, and the main object of forest management, namely, reproduction of the valuable timbers, is to a large extent, if not entirely, overlooked and frustrated. For, as I shall presently show, by culling out, as is done under your contract, the best of the spruce, this species is at once placed at a disadvantage as against those left on the ground. It is questionable whether any openings made in this culling process would seed themselves to spruce rather than to the prolific birch and maples, and even if a young growth of spruce should sprout up, would it find suitable light conditions to maintain itself? I repeat again that most of the spruce growth remaining after cutting would be not young growth but stunted trees which had been vegetating in the shade of the older timber.

A restriction in the number of trees per acre which might be cut or which might be left would have more show of rational conservancy, but even so the demands of a proper forest management would not be satisfied.

If it is considered desirable, as it decidedly should be, to foster and reproduce the spruce growth, it will be necessary to cut and utilize a part of the hard woods simultaneously—possibly before the spruce is cut—and the time and manner of cutting either will determine the manner of reproduction. The cutting must be done with a view to favor reproduction, and not in the haphazard way in which the lumberman does it. Here comes in the science of forestry.

A LESSON IN FORESTRY.

* * * * * * *

That foresty is a business carried on for profit seems still to be a matter unknown to many who talk and write on the subject. As agriculture is practiced for the purpose of producing food crops, so forestry is concerned in the production of valuable wood crops, both attempting to create values from the soil. Other conditions like the preservation of climatic, soil, or favorable water conditions, which are claimed for the forest cover, may influence and *modify the manner* in which the primary object of forestry, namely, production of wood crops and profits, is attained, but they do not necessarily exclude this primary object. In fact, the demands of forest preservation on the mountains, and the methods of forest management for profit in such localities, are more or less harmonious; thus the absolute clearing of the forest on steep hillsides which is apt to lead to desiccation and washing of the soil is equally detrimental to a profitable forest management necessitating as it does replanting under difficulties.

Forest preservation does not, as seems to be imagined by many, exclude proper forest utilization, but on the contrary may well go hand in hand. Forestry in a wooded country means utilization of the wood crop in such a manner that it will reproduce itself in the same, if not in a superior composition of kinds, as the original growth. Reproduction, then, is the aim of the forest manager, and the difference between the exploitations by the lumberman and by the forester consists simply in this, that the forester cuts his trees with a view of securing desirable reproduction, while the lumberman cuts them without this view, or at least without the knowledge as to how this reproduction can be secured and directed at will.

The efficient forest manager requires no other tool than the ax or saw; he has missed his highest aim when it becomes necessary to use the planting tools, unless, indeed, he meant to introduce new species, which were not at all or not in sufficient number to be found in the original growth, or unless clearing and subsequent replanting appears the more profitable and more successful method of reproduction. In hilly and mountainous country this latter method is for various reasons not desirable, hence management for natural reproduction by proper use of the ax should here form the rule.

How is this reproduction secured? To understand this it is necessary to realize that as in the animal world so in the vegetable there is a constant struggle for existence and supremacy going on among the different species as well as among the individuals of the same species. All struggle for the occupancy of the soil. The weapons with which this struggle is carried on are various, offensive and defensive. This species seeks to gain foothold by prolific annual seed production, aided perhaps by the lightness of the seed, which is wafted by the winds for miles in all directions; the ubiquitousness of the aspen wherever an open space affords light, is accounted for by this capacity.

Another species by its dense foliage shades the ground so that no rival can find favorable conditions of existence underneath; such are firs and spruces. Others again maintain themselves by developing a vigorous root system, which enables them to endure the shade of the superior growth, vegetating poorly, but biding their time until other agencies have decimated the enemy, ready then to occupy the field. The oak is an example of this kind. The alternation in forest growth, so often looked upon as a mystery, is thus accounted for. Man by fire or ax, nature by tempests and insect pests removing the superior growth, the species which persisted under the shade of the former and escaped or resisted the destructive agencies will occupy the ground.

Especially the different requirements in regard to light conditions and the relative rate of height growth, by which the species may or may not escape suppression by its neighbors, influence the temporary local distribution of plants and are of greatest interest to the forest manager. Light is one of the essential factors of tree growth and almost the only one which man can regulate. Forest management, then, could almost be defined as management of light conditions. The leaves exercise their functions under the influence of light and feed the tree by assimilating the carbon of the air. Such thinly foliaged trees as the aspen and some of the birches and others can only exist under a full complement of sunlight; they are, therefore, endowed with a rapid rate of height growth to enable them to grow quickly out of the danger of being overshadowed by their neighbors. Other species, like the firs, and in less degree the spruces, with a dense foliage and a large number of leaves, can be satisfied with less light and are as a rule slower growers; other kinds again, like the oak, while dependent for their full development on a large amount of light, probably by virtue of specially vigorous root action, can persist in the shade for a long time until more favorable light conditions allow thrifty growth. Especially are the young seedlings of most kinds very sensitive in regard to light conditions and some have such a small range of light and shade endurance, that while there may be millions of little seedlings sprouted, they will all perish, if some of the mother trees are not removed and more light given; and they will perish equally, if the old growth is removed at once and the delicate leaf structure under the influence of the direct sunlight and heat is called upon to exercise its functions beyond its powers.

We, can, then, understand that not only the different species, but the same species at different periods of life, make varying demands in regard to light conditions; and the art of the forest manager in securing reproduction as well as in other operations, thinnings, etc., consists mainly in a proper regulation of light conditions by a proper and timely use of the ax.

The composition of the forest, climatic, soil, and moisture conditions modify again the requirements, so that all general rules of management need to be modified according to local conditions; and it will appear at once that a considerable exercise of judgment born of experience and knowledge is expected of the forest manager.

To further elucidate these and some other considerations involved in forest management, let me briefly trace the manipulations with reference to a specific case, in the reproduction, for instance, of the beech, as practiced over large areas in Germany. The beech, like many other timbers, bears seed only periodically. Seed years occur in different localities at periods varying from three to even twenty years, records of their occurrence being kept. A few years before the seed year is expected to occur the forest is somewhat thinned out to admit air and light upon the soil, in order that the litter of the forest floor be more rapidly decomposed and humified and so may form a suitable seed bed for the sprouting of the seed and also to stimulate the mother trees to a plentiful production of superior seed. In this thinning the inferior material and the undesirable kinds are first removed and such kinds as reproduce themselves easily without aid from the forester. When the nuts fall pigs may be driven into the woods to plow them under. Under favorable conditions a soft green carpet of young beech seedlings will be found to cover the ground in the Spring next after the seed year.

Now comes the critical period. If the mother trees were left the whole crop would be lost, and while waiting for the next seed crop under the altered light conditions, which invite grasses, weeds, and other species to come in, the difficulties in securing reproduction are increased. By thinning out gradually, the proper amount of light is given to the young crop and when in three or four years the last of the mother or nurse trees are removed, a thicket of young beeches has replaced the old growth. In a similar manner, with necessary modifications in procedure according to species, climate, and soil is the natural reproduction of other species effected.

The practice of the forest manager, then, is to assist the desirable species in the struggle for existence and supremacy, to antagonize the undesirable ones, and to create proper conditions of soil, light, and composition of species for a desirable reproduction.*

The practice of thinning is based on similar principles. Regard to the danger of windfalls, of fire, of frost to the young plants, etc., will also influence the management.

So much for the technical part of forest management.

There is, as in every producing business, besides the technical part, a financial or mercantile part of the business. So in forest management we find a technique, which is based upon a thorough knowledge of natural sciences, and a mercantile part, which requires a knowledge of the factors that make such a business profitable. The technical administration and the mercantile administration must work together harmoniously, adjust and compromise their needs in order to arrive at results desirable to both.

The conditions of a proper mercantile forest management need also a brief consideration here. The absence of forest management in the United States is due to various causes, mainly arising from the state of our cultural and material development. As long as the competition of wood supplies from virgin lands, exploited for the best timber only, is to be met, forest management will be beset with great difficulties from a financial point of view. Yet it is not impossible, impracticable, untimely, or unprofitable in the location and under the conditions in which the club's property is found. A near market and facility for bringing even inferior ma-

*Reproduction from seed only is here considered, the reproduction from the stump, of which broad-leaved trees—not the conifers—are capable, may be left out of consideration at present; its desirability or undesirability on the property may be discussed at some other time.

terial to market profitably are the conditions without which forestry is financially impracticable. Accessibility, easy, cheap, and permanent means of transportation, furnish the keynote of profitable forest management.

The lumberman places only a temporary value on his property, quickly gets out the most valuable timber, taking the cream and leaving the balance, like skimmed milk, in the woods, to rot, burn, deteriorate. If nature so wills it and some cream was left in the first operation, he may return and repeat the skimming process once or twice, leaving at last an undesirable scrub-growth or "bush." The forester considers his property as a permanent investment, to produce revenue constantly and forever, in increasing rather than decreasing ratio. The factor of permanence is ever present in his methods. Like the owner of a large office building he spends part of his income from year to year to repair, improve, and enhance its value.

Here again, as in the technique, the business of the lumberman differs in methods of administration from that of the forester. The lumberman works for the present, the forester for the future. The lumberman begins his operations wherever he can get out his timber most readily; the forester has different reasons for cutting over the district in a certain order (danger from windfall, frost, fire, insects, etc.). The lumberman builds shanties, temporary roads, and waterways; the forester builds houses or at least plans them for permanent occupancy, and he plans, lays out, and builds permanent roads and other permanent means of transportation, which will enable him to utilize to the fullest extent all the product of the soil, from whatever part of his property it may appear desirable. The difficulty of doing so profitably, often, to be sure, hampers the technical management. The technical manager might see the desirability of thinning a young growth in order to bring it to a more rapid development, but not being able to dispose of the inferior material, the financial manager objects to the expenditure for the operation. The technical manager can see that in order to secure desirable reproduction, some kinds of timber should be cut first and others later, but there being no means for marketing the former, and the latter being, perhaps, floatable by the natural waterways, the financial manager insists that these be utilized first and thus the task of the technical manager may be greatly aggravated.

The demands of both technical and financial considerations constantly require adjustment. Protection of the forest against fire is a constant care both of the technical and financial manager. How to do this effectively and how to do it with the least expense is the problem. Here again a proper road system and districting of the area is an important factor, enabling the manager and his force to reach easily any part of the property that might be endangered, and secondly enabling the utilization of inferior material, which if left in the woods, increases the danger from fire.

As the aims of the technical part of forest management can be summed up in two words—natural reproduction—so can the financial policy be formulated as consisting in wise curtailment of present revenues to secure permanent and increasing revenues for the future.

* * * * * * *

For the purpose of illustrating the financial working of a forest administration, I may subjoin the following table, which exhibits the actual results of the forest administration of the Duke of Anhalt in Germany for eight years. The property consists of somewhat over 57,000 acres in all; mountainous and mostly of coniferous growth, presumably without much surplus old stock and, if the annual cut of 47 cubic feet of wood per acre—a very low average—represents the annual accretion, not of very good production. The annual cut averages in round numbers 2,675,000 cubic feet, of which 27 per cent represents lumberwood, the balance firewood; or, in round numbers, 7,000,000 feet board measure and 20,000 cords firewood. The administration is of old standing, and expenditures may be considered as current and not extraordinary; receipts other than wood refer probably to rent for meadowlands, game and fishing privileges, stones, etc. The administration cuts, but does not move the wood; prices, therefore, refer to the cut wood in the forest. Besides one forest director with three assistants and several clerks, there are fifteen district officers and forty-eight assistants and guards, the cost of the administration amounting to $30,000 annually.

Results of forest administration of the Duke of Anhalt for eight years.

[Round numbers.]

Years.	Receipts.						Expenditures.					Net profit.	
	For wood.				Other.	Total.	Wood cutting.	Roads.	Planting and other improvements.	Sundries.	Total.	Total.	Per acre.
	Total.	Per cubic foot, solid.											
		Timber.	Cordwood.	All together.									
1881	141,400	8.6	2.7	5.2	25,300	166,700	23,000	3,110	9,120	6,440	69.700	97,000	1.63
1882	137,000	8.4	2.8	5.2	28,200	165,200	21,000	2,450	9,650	5,470	67,400	97,900	1.65
1883	150,400	7.4	3.	6.	26,850	177,250	20,000	2,920	8,960	6,050	67,000	110,000	1.83
1884	153,260	8.9	2.7	5.9	26,800	180,060	20,900	2,590	9,900	5,800	68,350	111,800	1.88
1885	147,200	8.3	2.6	5.6	25,600	172,800	20,700	2,550	10,800	6,220	69.200	103,600	1.74
1886	152,500	7.9	2.4	5.3	26,750	179,250	23,950	2,630	10,000	6,570	72,200	107,170	1.79
1887	155,360	8.5	2.5	5.8	25,840	181,200	21,570	2,940	9,960	6,200	69,800	111,360	1.85
1888	161,150	9.4	2.6	5.9	25,000	186,150	22,800	3,100	9,830	7,470	74,700	111,400	1.82
Yearly average	149,780	8.5	2.7	5.6	26,290	176,000	21,740	2,786	9,660	6,275	69,700	106,300	1.78

Proportion of expenditures to gross receipts.

	Per cent.	Cents.
Wood cutting:		
Per cent of gross receipts	12.4	
Per cubic foot, solid		75
Roads:		
Per cent of gross receipts	1.6	
Per cubic foot, solid		4.8
Planting and other improvements:		
Per cent of gross receipts	5.5	
Per acre		16.2
Sundries	3.6	
Total	40	
Net profit—total	60	

From lumber wood alone the average income would be $59,500 in the woods, the cost of cutting in round numbers $5,500, leaving net income of $54,000, or over one half of the total net profit.

FOREST POLICY.

The policy of the club will have to be to find, as soon as possible, means of marketing the hard woods. This involves laying out and gradually constructing a rationally disposed, well built, permanent system of roads, the encouraging of railroad building to or through the tract, and of manufactures near to it which can utilize the inferior material. Of the latter may be mentioned pulp mills, employing both mechanical and chemical processes (the former for utilizing the hard woods, especially the beech and inferior birch), small woodenware, furniture, and carriage material manufacture, etc.

There are quite a large number of "seamy" spruce trees on the land, unfit for lumber, which would make most excellent pulp material, in addition to the top material alluded to further on.

Especially desirable is the establishment of enterprises using firewood or charcoal. The club could afford to give the wood leave for smaller-sized cord wood for almost nothing, while with cheap fuel and convenient means of transportation the manufacturer may be able to shoulder the inconvenience of using inferior material and of less convenient location.

I desire here especially to call attention to the great importance which the manufacture of pulp has acquired during the last few years. It may prove one of the most potent enemies to our forests, or else it may become the best friend of those who strive to introduce rational forest management, according to the manner in which the raw material is obtained. By using up the inferior material it may supply the one condition of profitable forest management.

Since by the present processes of manufacture the hard woods can only be used as filling material of the pulp made from coniferous woods, it should be studied how both kinds may be utilized simultaneously, in order to aid instead of impede the task of the forest manager in securing reproduction. I advise especially that you do not precipitately contract away the soft pulp woods without reference to the simultaneous utilization of the hard woods.

It may not, perhaps, be necessary for the club to do its own lumbering; this may be done under leases to lumbermen, as in the case of the spruce. In that case, however, the leases must be so formulated and executed that the object of the forest manager—proper reproduction and improvement of the property—can be attained at the same time.

To avoid complications and to make the forest management most effective, it would, however, be altogether preferable that the cutting be done on account of the club, the lumbermen to buy the logs or cord-wood cut, as it would be irksome and difficult to control the lumberman in his operations. This method of doing would have also the advantage that the men engaged in cutting and superintending the logging are under directions and may partly enlarge the permanent force of the forest administration.

The working for reproduction must be mainly directed upon the birch, maple, and spruce, except where special soil conditions and composition of the original growth demand or permit the favoring of other timbers. The detail in methods will have to be a study for the resident manager, a problem which can not be solved *ex cathedra*, but needs careful observation and consideration, and perhaps some trials first.

That the property must be guarded against fire, trespass, and improper cutting under the contract goes without saying. The cutting open of the boundary lines and proper marking of the same, with subsequent frequent revision or renewing of the marks and the districting of the property, should naturally receive early attention, as protection is facilitated by a definite knowledge of the extent and nature of the property to be protected.

FOREST FIRES.

The greatest danger against which the club has to guard is that from fire. It is miraculous almost that fire should not before have touched this tract, and this can be explained only by the comparative isolation in which the tract has been hitherto. With the opening up of the property and especially with the beginning of lumber operations, the danger increases and hence this great enemy of the forest must be anticipated.

The elaboration of regulations in regard to the use of fire on your property should engage your earliest and earnest attention. In spite of all rules and regulations and precautions against fire, it is to be expected that fires will break out, and preparations to fight the fires effectually will also have to be in the programme of your administration. I can not too strongly urge upon your committee the necessity of dealing with this subject energetically and unflinchingly at the outset. The whole fire question in the United States is one of bad habits and loose morals. There is no other reason or necessity for these frequent and recurring conflagrations. It requires only that a strong moral impression be made upon those responsible for them to reduce and ultimately remove this bugbear of American forests.

The club can afford to employ its entire income for several years solely to this object of showing its determination to break the spell and to make the appearance of fire the exception and not the rule. This can be done only by a comparatively large and well-organized force of fire guards, who will enforce the proper preventive measures and regulations rigidly and put out any fires as soon as discovered. By as much as the property is made accessible through a proper road system and convenient division into districts, by so much will the number of necessary guards and their labor be diminished.

The danger and damage from fire is increased wherever lumbering is carried on, especially from the fact that the leavings, tops of trees and limbs dry rapidly and lend intensity to any running fire. The proper disposal of these leavings should have been considered in your lumber contracts. In the absence of conditions to that affect the club must dispose of the matter on its own account. It has been urged that the leavings should be gathered and burned. This is expensive and wasteful and it is my opinion that, at least with the spruce under the conditions before us, it is unnecessary. The danger arises from the fact that the tops braced up by the branches from the soil are dried and kept dry, like tinder. By lopping the branches and letting both branches and tops fall to the ground, it is to be anticipated that the material would be kept wet from the winter snows and soon be rotted. Besides some useful material for pulp manufacture, which the lumberman would have left, might be saved from this top material. I would at least recommend the trial of this method. The lopping should be done soon after the felling and it might be possible to make arrangements for this work with the contractor for the lumber.

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ORGANIZATION.

It would be folly to undertake for the present the more refined methods of forest management practiced in Europe, or to attempt an elaborate system of organization, such as may in time become desirable. Yet, even if it were only for the purpose of properly guarding the interest of the club and its property, an organized administration must appear desirable. Such an administration would require a resident manager, three or four district officers, and a large number of permanent or temporary guards. The manager should, if possible, be a man with the knowledge of the principles of forest management as practiced abroad, yet also acquainted with the difference of conditions and methods prevailing in the United States, and, while determined and energetic, yet possessing a sufficient amount of that tact which is required to introduce new methods without unnecessarily creating antagonism and ill-will His duties would be to have the general charge of the local administration, executing the orders of your committee, assisting the members of the club in locating and constructing their camps. He will have to study, map himself in detail, and district the property and lay out the road system, supervise the construction of roads and other improvements. He should therefore be conversant with such surveying and engineering work. He will superintend the execution of the lumber cutting, make out the lumber inspector's statements for settlement, and after having familiarized himself with the prevailing forest conditions, devise in detail the plans for a proper forest management. He will be responsible for the protection of the property against fire, theft, poaching, etc., keep the force under him to its duties and attend to prosecutions of offenders in the local courts, etc. It may be difficult, though not impossible, to find a competent man of such quality and knowledge. The success of the club's enterprise must largely depend upon finding that man. I have described here only a part of the duties which are expected of the district officers in French and German forest administrations. To such a man the club can afford to pay a good salary.

The district officers should be reliable men, with some knowledge of woodcraft, and capable of acting on their own responsibility. They should be stationed each one in a different district, for which he will be held responsible. During the lumbering season they will be mainly engaged in watching the lumber operations and surveying lumber cut under contract or otherwise. Those not so engaged will assist the manager in the survey and locating of roads, etc., or they will superintend directly the work on roads, improvements, or other operations. In summer time and during the hunting and fishing season they will be especially charged, with the aid of the guards, to watch for fires and trespassers, and their energies should be entirely devoted to the duty of protection.

The permanent force of guards need not be large, only as many as could be profitably employed in the works of improvement going on during the off season, when danger from fire or poaching is passed. One assistant to each of the three or four district officers and to the manager might suffice. These officers as well as the guards must be under the direct orders of the local manager.

I have pointed out that this permanent force could be larger, if the club does its own timber cutting, the foremen of the lumber camp becoming guards during the hunting season. Otherwise this force may have to be increased temporarily during the time of need, say for the months of June to October. But the protective efficiency could be greatly enhanced without much, if any, additional cost by having only licensed guides on the property and by charging these guides, who are necessarily all the time going through the woods, with the right and duty to enforce the regulations of fire and game laws.

In order to make this force still further effective, all the officers and guides should be clothed, if that be attainable, with sheriff's power for the enforcement of the State game, fire, and trespass laws. It is the present circumlocutory manner of applying the law and absence of proper police force which make the State laws largely nugatory. Responsible people, with a permanent interest in the property they are to guard, clothed with the power to apprehend and bring to jail any offenders, will soon make that moral impression which is necessary to change present malpractices.

The permanent officers should live on the property and be so located as to guard especially the entrances to it most effectively. The cost of an efficient service like the one described I estimate in round figures at $8,000 for the permanent force, the lodges for officers to be furnished by the club. For the first few years as liberal a curtailment of the income as possible should be suffered by the club for improvements, especially roads. The value of the property will rise in excessive proportion to the expenditures made in rendering it accessible.

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In fact, as soon as the service is satisfactorily organized and the preliminary work of mapping and the location of a rational road system determined upon, the work of developing it should be pursued with all energy up to a certain point, afterward more gradually; for, as I have tried to impress upon you in the foregoing, proper and profitable forest management is dependent upon the possibility of marketing inferior material, and this is possible only with permanent and easy means of transportation.

* * * * * * *

I have dwelt at length on some elementary considerations, because with the present movement in the State of New York to establish in the Adirondack region an extensive State park it is desirable that the members of your club should be fully imbued with proper conceptions as to what is or ought to be involved in such a proposition. The State of New York has hitherto been incapable of grappling with the question of forest preservation in the Adirondacks solely because of ignorance as to what forestry and forest conservation involve, and, secondly, because the question was not treated as a business proposition. The club will fail in the same way, as far as forest management and forest conservation are concerned, unless it is placed upon a business basis.

The great State of New York, with 3,000,000 or 4,000,000 acres of woodlands reserved as a State park as proposed, ought to be able with such a park not only to protect its watersheds and to furnish hunting, fishing, and health resorts to its citizens, rich and poor, but with only half the area productive and large amounts spent for improvements and recuperation of burnt areas such a forest property should not only pay its maintenance expenses and interest on purchase money, but by and by return to the treasury and relieve of taxation its citizens to the amount of several million dollars.

FORESTRY EDUCATION.

The difficulty of introducing proper forest management into the United States, aside from that inherent in the economic development of the country in general, as pointed out in the foregoing pages, may be assigned to the absence of competent managers. The demand for such will presently arise, and it will be difficult to meet it. It is questionable whether forestry can be studied in this country to advantage as long as it is nowhere practiced, and hence practical illustration is lacking. On the other hand it is doubtful whether foresters can be imported from abroad capable of adjusting their methods to the different conditions existing in this country. It seems best, therefore, that young men with suitable preliminary preparation should go abroad to acquaint themselves, partly at the forest academies and partly by practical work in the woods, with the theory and practice of forest management. A sojourn of from one to two years abroad should suffice for anyone equipped with the necessary botanical and technical preparatory education.

For the purpose of ascertaining the present educational facilities existing in this country, letters of inquiry have been addressed to the various agricultural colleges and experiment stations. Leaving out negative replies, the following abstracts from letters received from professors of horticulture and botany show the extent of these facilities.

Students coming from these courses and wishing to prepare themselves to become forest managers, may find it advantageous, before taking a course abroad, to avail themselves of the facilities of this Division, now quite considerable, for the purpose of acquainting themselves with the literature, classic and current, and with the theories upon which forest management is practiced abroad.

VERMONT.—*State Agricultural Experiment Station;* W. W. Cooke, director: Forestry is incidentally touched upon in our course on physiography. Special attention is given to influence on rainfall and climatology. All students in agricultural course take physiography (Tyndall's work) in spring term of freshman year.

RHODE ISLAND.—*State Agricultural School:* Prof. L. F. Kinney will teach forestry two hours a week in the spring term, and discuss in lectures the propagation of forest trees. methods of planting, effect of forests on climate, etc. All students take this course. Present class, 30.

MASSACHUSETTS.—*Agricultural College;* Prof. S. T. Maynard: Forestry taught twelve weeks in junior year by lectures and text-books. Thorough botanical study of American forest trees. In horticultural lectures propagation of fruit and ornamental trees, special methods in nursery, transplanting, and arranging in forest plantations, time of cutting timber, seasoning, etc.; quality of wood and timber of common timber trees, study of condition of forests, especially in New England, importance of their preservation, influence on climate, rainfall, droughts, etc. *Bussey Institution of Harvard University;* Prof. B. M. Watson: Give thirty-six lectures on trees and shrubs, in addition to regular course on horticultural practice, bearing chiefly on ornamental planting. Instruction on methods of propagating and planting, care of nurseries, and method of treatment to bring existing plantations into good condition and to maintain them so.

NEW YORK.—*Cornell University, College of Agriculture;* Prof. A. N. Prentiss: Lecture on arboriculture once a week during the year, with collateral reading and some field and laboratory work on native trees. Some lectures on forestry in Europe and on forestry and forest problems in the United States. Study wholly elective and attended by fourteen students.

PENNSYLVANIA—*State College;* Prof. W. A. Buckhout: Lectures on forestry. Endeavors to present the subject in all its parts.

TEXAS.—*State Agricultural College, horticultural department;* Prof. S. A. Beach: Forestry is given in the senior year of the courses of agriculture and horticulture, during the fall term. Two recitations and one "practice" per week. Practice with compound microscope on structure of leaf and wood. Identification of trees. No strictly forestry course.

MICHIGAN.—*Agricultural College;* Prof. J. W. Beal: Forestry elective in senior year. Daily study twelve weeks. Lectures. Excursion to arboretum and woods. Study of the most prominent species of the neighborhood, physiology and growth, classification, something of distribution, management of forests here and in Europe. Timber, structure, and uses. About half the senior class, if any, elect forestry, say fifteen to twenty.

MINNESOTA.—*University, College of Agriculture;* Prof. S. B. Green: Give all instruction in winter, so can not demonstrate some points as I would like to do. Lectures, in connection with Hough's Elements of Forestry as text-book, and collection of plants on University grounds. Special attention to climatic effects of forests. Economic value, shelter belts, desirable species to plant, and methods of planting, identification of species. All graduates required to take the course and it is very popular.

MISSOURI.—*Agricultural College and Experiment Station;* Prof. J. W. Clark: Instruction by lectures and practical work in the nurseries. Use, durability, rapidity of growth, adaptation, modes of propagation and cultivation, diseases, insect enemies. About eight students take the course.

NORTH DAKOTA.—*Agricultural College:* College lately established. Catalogue shows contemplated lectures (six) on forestal subjects.

SOUTH DAKOTA.—*Agricultural College;* Prof. C. A. Keffer: Forestry taught by lectures and assigned reading. Students required to take field notes on characteristics. rates of growth, methods of culture, etc. Excursions to natural woodlands and plantations. Influence of forests on climate, wind-breaks, characteristics of trees suitable to South Dakota. All junior class take forestry. Ten students this year. Forty students worked on the forest plantation.

KANSAS.—*State Agricultural College:* Prof. E. A. Popenoe: Instruction in forestry given only so far as relates to propagation and management of trees for wind-breaks and ornamental planting. Instruction to all students of the second year. Plantation of 20 acres of forest trees on college grounds, set both in pure blocks and mixed. Thousands of trees experimentally propagated annually. This work and the care of plantations in the hands of students almost exclusively.

ILLINOIS.—*University of Illinois, College of Agriculture;* Prof. T. J. Burrill: Seven weeks optional instruction on forestry to senior class. Few, sometimes none, take it. In the regular course, forestry touched upon under botany and landscape gardening. Species identified in the woods and the laboratory, and characteristics studied, with some lectures on geographical distribution. Trees for ornament and shelter studied in ten lectures, with illustrations on the grounds. From ten to twenty students in this required course.

OREGON.—*Agricultural College, Experiment Station;* Prof. E. R. Lake: Forestry elective in fourth year. Institution only three years old. In second year students in the mechanical course have a course on "wood structure." Use Ward on "Timber and its Diseases," with lectures.

UTAH.—*Agricultural Experiment Station;* Prof. E. S. Richman: Nothing done yet. No class yet for second year. In the future I will make forestry a special feature, chiefly with reference to propagation and cultivation of trees valuable for lumber.

COLORADO.—*Agricultural College, Experiment Station;* Prof. C. S. Crandall: No special course in forestry, but in connection with horticulture; lectures on gathering, preservation, and sowing of forest-tree seeds, treatment of young seedlings, and best methods of culture, especially of species adapted to this region. Art of transplanting and use of trees for ornament, shelter belts, etc. Ten students in last class.

CALIFORNIA.—*University of California; Experiment Station*; E. W. Hilgard, director: Forestry taught only incidentally, as connected with the subject of economic botany.

STATISTICS OF EXPORTS AND IMPORTS OF WOOD AND WOOD PRODUCTS.

As has been customary hitherto the statistics of forest products as extracted from the report of the Bureau of Statistics is exhibited in the subjoined tables, in comparison with the figures returned for the year 1880, from which we learn that our exports have grown in value by about 75 per cent during that period, while imports have advanced only 50 per cent. It will be observed that the increase in exports is greatest in the crude material.

Exports of wood and wood products, 1880 *and* 1890.

Articles.	1880.		1890.	
	Cubic feet.	Value.	Cubic feet.	Value.
Firewood	387,600	$11,552	978,944	$16,746
Boards, deals, and planks	23,767,000	4,223,259	51,067,833	9,974,888
Joists and scantling			2,223,666	381,640
Hoops and hoop poles	5,339,800	427,187	749,725	59,978
Laths	79,575	11,936	167,856	24,951
Palings, pickets, and bed slats			238,480	30,653
Shingles	760,354	165,893	511,378	111,926
Shooks:				
Box	544,328	136,082	474,228	118,557
Other	35,109,760	3,510,976	2,299,821	766,607
Staves and headings			37,152,855	2,476,857
All other lumber	6,379,590	765,550	11,292,842	1,355,141
Timber:				
Sawed	16,365,346	2,219,320	22,[illegible]82,000	3,384,847
Hewed			8,732,761	1,381,747
Logs and other timber	9,874,100	789,927	21,004,325	1,680,346
Total unmanufactured	98,607,455	12,261,682	159,476,714	21,764,884
Manufactures of—				
Doors, sash, and blinds*	....	....	427,787	320,840
Moldings, trimmings, etc	....	....	155,060	116,295
Hogsheads and barrels, empty	349,372	262,029	567,037	425,278
Household furniture	2,205,171	1,653,878	4,118,506	3,088,902
Wooden ware	441,516	331,137	480,687	360,515
All other manufactures	2,304,867	1,728,650	2,930,420	2,197,815
Total manufactures	5,300,926	3,975,694	8,679,497	6,509,645

*Until 1884 the exports of doors, sash, blinds, moldings, etc., are included by the Bureau of Statistics in "all other manufactures," and can not be given separately. For the same reason the reports of some other articles can not be given separately for every year.

Exports of wood and wood products, 1880 *and* 1890—Continued.

Articles.	1880.		1890.	
	Cubic feet.	Value.	Cubic feet.	Value.
Naval stores:				
Rosin				$2,763,373
Tar	....	$2,452,908	....	56,105
Turpentine and pitch				35,037
Spirits of turpentine	....	2,132,154	....	4,590,931
Total naval stores and spirits of turpentine	....	4,585,062	....	7,444,446
Ashes	....	110,578	....	26,211
Bark and tanning extracts	....	210,126	....	268,754
Ginseng	....	533,042	....	605,233
Matches	39,749	119,246	20,761	62,284
Agricultural implements ... number	28,205	2,245,742	....	3,859,184
Sewing machines	65,975	1,649,367	111,751	2,793,780
Musical instruments	....	811,177	....	1,105,184
Carriages and steam and horse cars	....	1,407,423	....	4,746,678
Total miscellaneous	105,724	7,086,703	132,512	13,462,258
Total exports	104,014,105	27,909,141	168,288,723	49,181,233

Imports of wood and wood products, 1880 *and* 1890.

Articles.	1880.		1890.	
	Cubic feet.	Value.	Cubic feet.	Value.
Free of duty.				
Wood, unmanufactured, not elsewhere specified:				
Firewood	13,182,816	$266,044	19,669,376	$320,882
Logs and round timber	4,378,400	349,872	11,812,775	945,032
Railroad ties	3,565,983	213,959	6,684,177	444,513
Shingle and stave bolts	1,057,025	84,562	1,360,687	108,855
Ship timber	172,980	43,245	363,724	90,931
Ship planking	107,691	35,897	104,991	34,997
Wood pulp	....	5,740	....	100,443
Hemlock bark	....	476,149	....	163,673
Dutiable.				
Wood, unmanufactured, not elsewhere specified	154,024	19,253	89,852	11,169
Timber	49,854	6,222	*84,960	10,620
Lumber:				
Boards, planks, deals, etc.	39,542,864	4,763,441	48,334,000	6,724,716
Clapboards	727,333	19,759	1,636,000	75,672
Hubs, posts, lasts, and rough blocks	555,328	99,959	268,583	48,345
Laths	2,079,344	110,505	4,936,720	361,875
Pickets and palings	379,040	31,816	652,880	38,897
Shingles	823,788	116,608	2,728,894	414,921
Shooks and packing boxes	316,128	79,082	603,668	150,917
Staves	13,243	4,729	1,591,071	427,998
Bark extracts, chiefly hemlock	....	22,868	....	†481
Sumac	....	588,911	....	376,784
Cork and cork bark, unmanufactured	....	104,808	....	232,133
Matches	4,959	14,879	14,686	44,059
Manufactures:				
Casks and barrels		3,517		632
Cabinet ware and furniture		147,783		414,780
Osiers and willows, peeled and dried	1,209,945	21,833	1,909,381	27,646
Osier and willow baskets		142,214		372,356
All other manufactures		592,112		516,622
Free of duty.				
Cabinet woods:				
Box	....	27,568	....	36,712
Cedar	....	465,169	....	472,478
Ebony	....	84,354	....	47,794
Granadilla	....	5,050	....	2,322
Lancewood	....	14,655	....	8,993
Lignum-vitae	....	28,343	....	45,967
Mahogany	....	266,026	....	624,719
Rose	....	178,578	....	38,959
Sandal	....	3,400	....	102
All other cabinet woods	....	306,354	....	249,108
Cork wood or bark, unmanufactured	....	658,830	....	1,213,876
Total	68,520,349	10,403,044	9[illegible],845,925	15,291,269

* Quantity not all stated.

† Hemlock only.

ARTIFICIAL RAINFALL.

By an amendment in the Senate the appropriations for this Division were increased by the sum of $2,000 and the words "for experiments in the production of rain" were added to the reading of work to be performed under the appropriations.

At first sight, the reference to this Division of such experiments would appear to have been made by reason of the claimed influence of forest areas upon the distribution of rainfall. It was, however, learned that these experiments were not intended to have such a connection nor were they to be devised for the purpose of finding out any special means for the production of rainfall, but they were to be carried on upon the assumption that explosions would have the desired effect and the money was appropriated to be expended in the purchase of explosives and in their discharge.

With such a programme the reference was, to be sure, unfortunate, for aside from the fact that neither the Division nor the Department in any of its branches commands the means or the men to conduct such explosions or the instruments which should at least be observed during the explosions in order to arrive at an understanding of the results, should any be attained, the amount appropriated in the absence of such means and persons is so totally out of proportion to the needs of the experiment, and, indeed, to the expected overawing result of controlling nature's most potent and hidden forces, that an attempt to use it in the proposed manner could hardly fail to be barren of results.

On the other hand, the War Department commands cannon, explosives, and men trained and accustomed to handle them, and in its Signal Service, instruments for meteorological observations and observers, and as long as the experiments are to be carried on upon the assumption that explosives will be effective, I have submitted the propriety of asking the coöperation of the War Department in this matter. I have also submitted, as my opinion, that the assumption for such experiments is, to say the least, hazardous, and that a much better use of the money could be made and valuable results much more likely attained, by devoting it to a series of experiments, which would bring us first nearer to a conception of what forces are at work in producing rain and to learning more about the chances of substituting feeble human efforts for grand cosmical causes.

The theories in regard to the causes of storms, and especially their local and temporal distribution, are still incomplete and unsatisfactory. It can by no means be claimed that we know all the causes, much less their precise action in precipitating moisture. It would, therefore, be presumptuous to deny any possible effects of explosions; but so far as we now understand the forces and methods of nature in precipitating rain, there seems to be no reasonable ground for the expectation that they will be effective. Hence, while I do not believe, contrary opinions of high authorities notwithstanding, that such experiments are necessarily devoid of merit, as long as they are conducted upon a careful, scientific plan and a large enough scale, it would be unreasonable and contrary to the spirit of our advanced civilization to rush into a trial which does not seem warranted by our present knowledge, instead of starting with a series of carefully devised experiments, the first object of which would be to learn something of the effects of explosions upon the atmosphere, a knowledge which we do not possess and which, if not leading to the power of controlling rainfall, may considerably advance our knowledge of meteorological forces.

It sounds quite simple to try whether explosions will produce the precipitation, but when it comes to practically arranging the trial, such questions as the following it seems must be settled first: What kind of explosive shall be used? Is it intensity or frequency of explosions that should be tried? What amount should be used? What means of exploding are best adapted to the purpose and in what manner should they be employed; how high above ground would the explosions be effective? Lastly, how shall we know whether precipitation was due to the explosions? How far did other conditions influence precipitation, etc.? These are questions which it would puzzle experts to answer on any basis of present knowledge.

A large number of trials, with all sorts of differences in the conditions, might possibly settle some questions, but, unless careful observations, not easily devised, were made simultaneously as to the effects upon primary conditions, under which the result is obtained, our trials would lead us no further than we are at present, namely, to the very unsatisfactory assumption upon which we based our trials.

Under these circumstances, up to the present writing no attempt has been made to advance this problem.

Meanwhile I have tried to trace the history and scan the evidence which has led to the assumption that explosions will produce precipitation, and incidentally I have also inquired into other means of artificial production of rain which have been proposed.

It is no wonder, in view of the important office which the absence or presence of rainfall plays in the economy of man, that the desire to control it is as old as history, and various attempts to do so have been made or proposed in all parts of the world. The resort to prayer for the purpose is well known. In India the rainmaker, called *Gapogari*, is an important personage and similar professional rainmakers are found among African tribes and among the Indians. These, to be sure, have their secret methods, with which our knowledge of natural forces could hardly harmonize.

In more recent times two artificial causes of rainfall have exercised the minds of speculative meteorologists, fire and explosions.

It is a current belief that large fires and the cannonading during battles cause precipitation.

Singularly enough the belief that battles occasion rain is older than the invention of gunpowder. Thus we read in Plutarch: "It is a matter of current observation that extraordinary rains pretty generally fall after great battles;" and he explains it, that either some divine power in this way cleanses the polluted earth or that moist and heavy vapors steam forth from the blood and thicken the air, and make the moisture fall.

It should also be borne in mind by those who believe in the effectiveness of cannonades in bringing on storms, that according to Arago ("Thunderstorms," pages 164–165) during the latter part of last century, and as late as 1810, it was a popular practice in the communities of Southern France to fire off batteries, especially kept for the purpose, in order to *dispel* violent rain and hail storms, which were undesirable visitors of the region. Arago traced the history of this belief to a naval officer in that region, who had propagated the practice of navigators of that time of dispelling waterspouts and thunder clouds by that means. Before this innovation the effect was sought by the ringing of church bells. Arago tried to disprove such an effect and to prove the opposite by showing that during the artillery practice at Vincennes, out of 662 days each preceding, following and during the practice, there were cloudy 128, 146 and 158 days respectively. This seems to be a rather small percentage to establish the positive effect he claimed; however, it may prove the futility of the opposite belief.

Napoleon has been credited with making use of the experience, that battles produce rain, in the disposal and manœuvering of his troops, and the belief in cannonade and rainfall as cause and effect has since become quite current.

The most elaborate effort to obtain evidence on this point is that of Mr. Edward Powers in his book, "War and the Weather, or the Artificial Production of Rain," published in 1871, when the extraordinarily wet seasons concomitant with the war movements in France brought the subject into prominence.

Although the writer himself, who took part in the campaign and well remembers the inclemency of the season, can not recall a single instance when engagements were followed by rain that would not have been anticipated from the general conditions of the atmosphere, yet he will not deny that the evidence collected by Mr. Powers from the Mexican war and that of the rebellion, with a few other additions, appears at first sight cumulative and overwhelming. In many cases, however, even the very imperfect records allow an explanation of the rainfall as due to natural conditions without effect of the cannonading, and it may well be asked whether as many, and even more, records could not be gathered of battles which were not followed by rain. Most of the evidence is drawn from recollections with which I find other recollections at variance, and since altogether general meteorological data for the period from which these records are drawn are lacking, the evidence after all falls considerably below the standard of positive proof. The negative proposition only is proved, that not all battles are unaccompanied by rain, as not all dreams fail of realization. In the accumulation of such evidence the danger is lest we indulge too readily in the "*post hoc ergo propter hoc*" argument. It would have to be shown that there were no well-understood natural reasons present for the occurrence of precipitation. In fact a few careful correspondents of Mr. Powers point out that such reasons often existed. The position taken by Maj. Gen. Thomas I. Wood, in his letter to the author, seems to be the proper one. He says:

> Many battles have been followed by rain while others have not. This fact would seem to indicate that if the atmospheric disturbances caused by the firing in battle have any effect in producing rain, the actual accomplishment of rain depends, in a general manner, if not chiefly, on the condition of the atmosphere. The condition of the atmosphere should, hence, be one of the chief factors to be observed in the experiments you propose.

The only actual experiment that has come to the writer's notice in which a cannonade seems to have been directly effective was reported a short time ago in La Nature and is vouched for by a M. Guillaume. A French artillery division moved out for a sham battle; when ready for action a dense mist arose, which obscured the entire valley so that one could not see 300 feet. One of the officers, recalling the asserted influence of cannonades, proposed to try the remedy; four mortars fired 1-pound charges, first eight shots in succession, then two salvos of four each, when suddenly the mist disappeared, clearing the valley for 3 miles and a fine drizzling rain fell, which, as the cannonading of the sham battle continued, did not cease all day, sometimes falling in heavy showers. I have not been able to ascertain the authenticity of this report and the general weather conditions prevailing at the place and time.

Our present meteorological knowledge does not give much hope for success by this method of rain production. A method which appeared more reasonable, or at least one that seemed to be in agreement with our present theories of storm formation, was proposed by the author of these very theories.

The belief in fires and rain as cause and effect is also a very old one, but it was Espy who first, in 1839 (having shown that a column of air rising to a height where, owing to diminished pressure, it would expand, was by this expansion cooled, thereby condensing and eventually precipitating its vapor), proposed experiments "to see whether rain may be produced in time of drought, making a large body of air ascend in column by heating it."

Besides his general theories, which were accepted as most reasonable explanations of the formation of storms, he brought forward evidence to show that volcanic eruptions and large fires (he also refers to the cannonade of battles evidently as producing heat) were followed by rainfall.

The evidence is of the same kind as that brought to show the effect of cannonades. The negative cases, where conflagrations failed to produce rain would probably be found as numerous as the positive ones. In almost all those which allowed an analysis of atmospheric conditions, these were favorable to cloud formation, namely, a high dew-point and a calm and sultry air, which Espy admitted were needful conditions and which, at least the former, are rarely present in times of drought. The great fires of London and Chicago are cases in point. In forty-two large fires and two serious explosions, occurring in Australia, during twenty-one years, "there was not one instance in which rain has followed within forty-eight hours as an evident consequence of the fire."

It will again be interesting here to note that Volta, the great physicist, proposed to use fire for the very opposite effect, namely, to dispel thunder clouds.

The impracticability of this method was exposed by Mr. H. C. Russell, government astronomer at New South Wales, who showed that in order to increase by 60 per cent the rainfall at Sydney, where the average humidity is 73, and wind velocity 11 miles per hour, at least 9,000,000 tons of coal would have to be burnt daily, since it would be necessary to raise a column of air over a surface of at least 10 miles by 1,000 feet to a height of 1,800 feet; and while there may be found some flaws in his calculation, it gives an approximate idea of what forces are to be dealt with and of their enormity.

Mr. Russell, who was then (in 1884) antagonizing the idea of inducing the Australian Government to engage in experiments like those now proposed here, concludes:

> It would seem unreasonable to hope for the economical production of rain under ordinary circumstances, and our only chance would be to take advantage of a time when the atmosphere is in the condition called unstable equilibrium or when a cold current overlies a warm one. If, under these conditions, we could set the warm current moving upwards and once flowing into the cold one, a considerable quantity of rain might fall; but this favorable condition seldom exists in nature.

Professor Henry, one of our most enlightened and unprejudiced physicists, expresses himself as follows in regard to Espy's propositions:

I have great respect for Mr. Espy's scientific character, notwithstanding his aberration in a practical point of view as to the economical production of rain. The fact has been abundantly proved by observation that a large fire sometimes produces* an overturn in the unstable equilibrium of the atmosphere and gives rise to the beginning of violent storms.

To understand how precipitation may possibly be effected by artificial means, it is necessary to know how it occurs in nature. First we must have a source of moisture, and then conditions which will cause the condensation and precipitation of that moisture.

Besides the moisture carried into the atmosphere by its direct evaporation from the soil and minor water surfaces in the locality under consideration, there is an amount, and in most cases probably the largest amount, brought by currents from such large water surfaces as the seas. It may be taken for granted that the evaporation from the great oceans furnishes the largest amount of the water of the atmosphere.

To conceive the conditions under which the air is likely to give up this water held in suspension, it is necessary to know first that air can hold suspended an amount of vapor proportioned only to its temperature. If the temperature be lowered by any means the vapor will be condensed, while an increase of temperature permits a further increase of vapor. In order, then, to produce condensation, it is necessary either to cool the air to or beyond the point (dew-point) where it can no longer hold the vapor, or to add to its moisture as much or more than it can hold at its present temperature.

The next thing to know is that the air, being heated by contact with the earth, which receives its warmth from the sun, is warmest near the ground and cooler farther away from its source of heat; and warm air being lighter than cold it rises, being displaced by the cold air which sinks and takes its place to be warmed and to rise, so that there is a constant circulation of air currents established. At the same time by evaporation moisture is added to the air in contact with the surface of the ground, and vapor being lighter than air the upward movement is thereby assisted.

The third factor of importance is that air in ascending cools, because by moving into regions of less pressure (the column of air compressing it being less as it ascends) it expands, and in doing so renders a certain amount of its heat latent, namely, the amount which is necessary to do the work of expanding, hence the sensible temperature of the air is reduced, and in consequence, as we have seen, its capacity to hold moisture, and hence it is brought nearer to condensation. The exact reverse is the case in descending air, namely, as it is compressed under the increasing amount of air above it, some of its latent heat becomes sensible heat; it becomes warmer and capable of holding more water, and hence is less liable to condense its vapor. The general rain conditions of any locality depend upon its position with reference to the air currents coming from sources of moisture and especially the elevations intervening.

The cooling of the upper air strata and the condensation of the moisture which they carry, mainly derived from the great sources of water, the seas, is assumed to take place by ascending air currents.

*Should perhaps read, "is accompanied by."

The ultimate causes of these ascending currents are stated by Prof. Cleveland Abbe in Appendix 15 of the Annual Report of the Chief Signal Officer for 1889, in which he also discusses in detail all the forces now known to be at work in storm formation, as follows:

(*a*) Very local heating of, and evaporation into, the lower stratum and resulting steep vertical currents or interchange of air, due to differences of buoyancy produced by the heat and the moisture, and which differences continue to exist in the ascending mass, relative to its surroundings, until the heat is lost by radiation and the moisture by precipitation.

(*b*) Very widespread differences of temperature, such as that between arctic and equatorial regions, plateaus and lowlands, oceans and continents, the dark half and the illuminated half of the earth, these produce a nearly horizontal flow of air underrunning and uplifting the lighter air.

(*c*) The advent of the horizontal flow into a region where the coefficient of horizontal resistance on the earth's surface is increased, such as the flow from the smooth ocean to the land surface, or from horizontal smooth prairie to hilly country.

(*d*) The forcible pushing up over hills and plateaus and mountain ridges of air that would have moved horizontally toward a region of low pressure were the ground horizontal. Such cases occur systematically when a region of low pressure advances toward a mountain range.

(*e*) An updraft from the lower stratum is caused when the air immediately above it becomes abnormally buoyant, either by the sudden formation of cloud, rain, and evolution of heat, or by the warming effect of the sun on the cloud.

(*f*) An important irregular movement takes place when the air passes over hilly countries, due to the fact that the horizontal current impinging against the side of a hill is by its inertia driven upwards; it soon descends again and strikes other hills, and thus any given isobaric or isostatic surface has an undulation similar to the standing waves in a shallow stream flowing over a rocky bed. The interference of these uprising downflowing currents with the ground and with each other causes a loss of horizontal velocity, a thickening of the depth of the horizontal flow, a slight increase of static pressure.

(*g*) The local heatings and evaporation mentioned in paragraph (*a*) are most active during sunshine and sensibly zero at night time. These produce in the daytime uprising and conflicting currents and an increase of pressure.

With the fact before us that the ascending current is cooled and thereby condenses its vapor, we explain the aridity of the interior basins and the plains. The Pacific Ocean is the source of moisture, which is carried landward by the west winds. As these strike the coast range and again the mountain ranges of the Sierra Nevada they are forced to ascend, expand, and cool, and drop part of their moisture. Descending on the other side, they arrive not only much drier, but by compression much warmer. Not finding any additional source of moisture to enrich themselves from, except the scant evaporation from the ground, they pass over the interior basin and are made to ascend again the Rocky Mountain range, and that several thousand feet higher than before. Again they are drained and again they descend as warm and dry winds; hence the low relative humidity, deficient rainfall, and high evaporative power of the winds in the plains. Incidentally, I point out again here how under these circumstances the forest cover on the eastern slopes of these mountain ranges is of so much greater importance than on the western slopes, as it is likely to aid in recuperating to some extent the moisture conditions of the descending current, while with the removal of the protecting soil-cover its drying effects would be aggravated.

The amount of atmospheric moisture, then, in these regions which are, I suppose, to be mainly benefited by artificial rain production, for the reasons stated is exceedingly scanty, their mean relative humidity being below 45° during the months of vegetation. In order to bring air in such conditions to condense its vapor there must be either a considerable addition of moisture or a very considerable amount of cooling effected, for which artificial means seem entirely inadequate.

There occur, however, times when the cloud formation would indicate that a considerable amount of moisture is suspended near the point of condensation, yet no precipitation takes place, probably on account of a stable equilibrium of air masses over large areas. It is at such times that there is more hope for influencing condensation and the timely or local discharge of the clouds.

But, if our present philosophy of the causes that produce condensation is correct, it can hardly be conceived how explosions can produce the ascending current necessary to effect the cooling of the upper strata. It must not be overlooked that the effect is to be produced through heights of more than 1,000 to 2,000 feet, and the disturbance of the stable equilibrium must encompass a considerable air column. While in such cases the possibility of results from mechanical disturbances like explosions may not be doubted, the use of these means for practical purposes remains extremely doubtful in consequence of the amount of explosive material which it would be necessary to use in order to produce results. Neither the disruption and violent agitation of the air, nor the thermal changes, nor the smoke produced by ordinary explosions would appear, either singly or combined, of sufficient magnitude to change conditions, as we have only lately learned during the explosion of the Dupont Powder Works, when 100 tons of powder exploded in eight seconds without producing an effect upon weather conditions.

We are then brought to the conclusion that unless other forces than these mechanical ones, and other movements than these mass movements, play a role in rain production and can be originated or set in motion by human device, we may as well abandon the attempt.

To the meteorologist, who, with the opportunity of watching the daily weather maps, the path and progress of the great storm centers eternally moving around the earth, probably often without disintegration, like the eternal motion of the earth itself, is brought face to face with the great cosmic causes of storm formation, who knows that an area of not less than 400,000 to 500,000 square miles must be under the influence of barometric depression to the amount of say half an inch before the storm discharges, the attempt to influence this grand natural phenomenon by the explosion of a few thousand pounds of powder or a fire of practicable dimensions appears indeed puerile.

Relying upon the working theories now accepted as explanatory of storm formation, he can calculate the omnipotent immensity of forces at work, against which limited human efforts seem utterly hopeless. This very year, almost as I am writing, Professor Hann, of Vienna, the highest living authority in meteorological science, has I believe definitely proved what has been long contended that our storms are only partial phases of the general circulation of the air, and even the variation in terrestrial surface conditions, the heating and cooling of continents and seas as well as the local influx of water vapor and its condensation are only of secondary importance, while we had hitherto considered them the causes of storms, barometric differences, etc. He admits that they may strengthen or destroy the ascending or descending eddies and modify their paths and their rate of progress, but insists that they can not act as primary causes. Other meteorologists, with questionable show of good philosophy, ascribe the storm-producing air currents to magnetic forces of the earth, and the eddies and storms as a result of a readjustment of these forces.

And yet, while we may admit that the great storm movements are due to cosmic causes, we must not overlook that within their path there are minor terrestrial influences, sometimes not of entirely uncontrollable magnitude, which seem to influence within certain limits the localization of storms and the temporal distribution. We claim this influence for instance for forest areas, water surfaces, etc.

Altogether the theories for storm formation, while perhaps sufficient to explain the general philosophy, do not seem capable of explaining satisfactorily the smaller modifications and side shows, as we may call the exhibition of local showers, thunderstorms, and squalls. Nor can it be said that the detail of the manner in which the vapor condenses and the rain drop is formed, or in fact the forces active or conditions necessary in this condensation are fully known or understood. Who could, for instance, account for the fact that the dew-point may be at and above 100 without precipitation occurring? We know some seemingly necessary conditions, but we do not know all. For want of experimental knowledge meteorology seems to have lagged behind the times.

While the mass movements that are calculated to satisfy the existing theories of general storm formation may be necessary for such formation, is it altogether inconceivable or unphilosophical to think that other, molecular, forces may participate and in fact be a condition *sine qua non* in forming precipitation? Is it not also conceivable that, as in many chemical reactions, it is only necessary to give the impetus to molecular motion, to initiate the change, metabolism, which, being induced at some center of formation, spreads and assumes greater and greater proportions, similar processes may take place in the condensation of vapor from the air? If such were the case the expectation of at least a partial control by human agency might well be realized. Suggestions of this kind have been made before, not only by those who would suggest any forces to explain phenomena without understanding the possibilities of such forces to do the work, but by physicists upon experimental basis.

Laboratory experiments by Mr. Aiton seem to indicate the presence of dust particles as an essential condition for rain production; and, although Professor Abbe "dismisses from consideration at present" the influence of atmospheric electricity in storm production, he does so only because we know too little about it, and because an assumption of such influence does not seem to help the accepted theories of air movements as sole causes. Even so, he is compelled to admit that "actual measurements of electrical potential would seem to show that two masses of air in extreme conditions may attract or repel each other electrically to an extent sufficient to produce appreciable phenomena of motion even in comparison with the far more important motions produced by solar heat and terrestrial gravity."

That the air is generally negatively electric during rain storms was first established from over ten thousand observations by Herschel. Lord Rayleigh showed experimentally that moderately electrified water drops tend to coalesce, but that strongly electrified drops repel one another, from which we may infer a real causal connection between rain and electrical manifestations; and after all, even though the ascensional current may be the primary cause for cloud formation, electric conditions may determine the precipitation.

We have hitherto been told that the electrical discharges during thunderstorms are the sequel and not the cause of the condensation; but this is by no means proved. Nor is the following explanation of any assumed effect, given by Professor Abbe, the only possible one:

Even if we allow that the condensation of smaller cloud particles into large rain drops and their consequent fall to the ground depends upon the electrical discharge, yet this assumption if adopted will merely modify our mechanical views somewhat, as follows: The latent heat evolved in condensation must be considered as not wholly consumed in directly warming the air. but as partially employed in maintaining a state of electrical disturbance or tension, which latter comes to an end as soon as the flash or the silent discharge of electricity occurs. At this moment, therefore, on the one hand larger drops are formed and fall to the ground, and on the other hand the energy that had been potentially present in the electric phenomena now becomes heat and warms and expands the air. Thus the electric tension and its concluding flash have merely served to delay the communication to the air of the heat that was a few minutes before present in the vapor.

It was Sir William Thompson who first suggested that changes of weather might be foretold by the change from positive to negative electricity of the air or the reverse, and who devised the instruments for such observations in the electrometer and "water dropper." Unfortunately when, some few years ago, the U. S. Signal Service undertook some experiments in that line, under the direction of Prof. T. C. Mendenhall, this object of weather prediction was kept in the foreground, and the experiments, which form the basis of a voluminous report still unpublished, were only too soon abandoned because they did not yield readily results for the purpose in view. I am assured by the gentleman who was in charge of these investigations that, if carried on without this immediate object in view, they would undoubtedly have led to a better understanding of atmospheric conditions, and are worthy of further pursuit.

In conclusion I may refer to the observation that dust particles are found always charged with positive electricity, which may account for their office in rain production, and that experiments by Professor Trowbridge, of Harvard, on the effect of flames upon the electric conditions of the air would lend countenance to the belief in the effect of fires on rainfall, while the possible origination of electric currents as a result of friction in cannonades is suggested by Mr. Powers as an explanation of their assumed effect.

We may say, then, that at this stage of meteorological knowledge we are not justified in expecting any results from trials as proposed for the production of artificial rainfall, and that it were better to increase this knowledge first by simple laboratory investigations and experiments preliminary to experiments on a larger scale.

If explosions are to be tried at once then it would be necessary at least to take all possible precautions to ascertain the state of the atmosphere in all particulars before, during, and after the explosions, and to conduct and refer to the experiments rather as investigations into the effect of explosions upon the atmosphere than with the ultimate desired result in the foreground.

CONCLUSION.

The same recommendations which have been repeatedly made in my former reports as to the work to be pursued by the Division and as to the manner of advancing the forestry interests of the country in general may be repeated, only with more emphasis than before, although with the increased appropriations and facilities provided this year, not only can certain lines of work, which the Division had tentatively laid out, be placed upon a desirable basis, but it will also be possible to devote more time and attention to the missionary work, which must needs still form part of our endeavor to change the forest policy of the United States.

B. E. FERNOW,
Chief of Division of Forestry.

Hon. J. M. RUSK,
Secretary.