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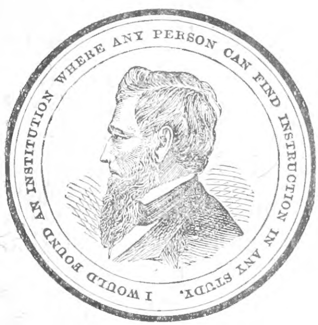

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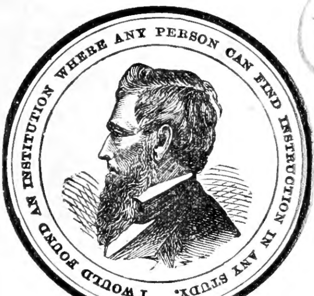

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PREFACE.

The Agricultural Experiment Station at Cornell University was established in 1879. Since that date, reports of experiments carried on at the Station have from time to time been published. Those reports, being out of print, are not now accessible to the public. The frequent requests that come to the University have led to the belief that a real service would be rendered to the cause of practical agriculture by a republication of some of the papers that seemed to be of most general and practical importance. By reason of this belief, the following papers are now offered to the larger agricultural public.

C. K. ADAMS.

Cornell University, Dec. 10, 1886.

CONTENTS.

STUDIES

IN

PRACTICAL AGRICULTURE.

I.

EXPERIMENTS ON THE COST AND VALUE OF STABLE MANURE.

BY PROF. I. P. ROBERTS.

(Analyses by Mr. F. E. Furry and Mr. A. M. Breed.)

I. The Value of Well-preserved Home-made Manure.

WHEN the University farm was taken in charge by the present Professor of Agriculture it was found to have been much exhausted by continuous cropping, with insufficient manuring. Commercial fertilizers were applied, with poor success in producing remunerative crops. Hauling manure from the village in the valley, four hundred feet below the site of the farm, proved to be little more satisfactory, on taking into account both its cost when delivered on the farm, and its poor quality. On turning attention to the supply made at home it was found to have been poorly cared for, and badly wasted on leaky floors, in large uncovered yards, or in overheated and fire-fanged piles. To prevent such waste, which subsequent experience proved to be much greater than was at first imagined, a large covered yard was built, and with such satisfactory results that we have long since ceased to buy manures of any kind ; we find that we can produce large quantities on the farm, worth three or four times as much per ton as that which was formerly bought in the village.

For two successive seasons an attempt has been made to determine the value of this stock of home-made manure, in the same manner and on the same basis as that by which the valuation of a sample of a commercial fertilizer is estimated. The accumulated layer of mixed manure of cattle and horses was at the end of the first season about two feet thick, and packed quite solid by the tramping of the cattle over it. A large number of samples of about ten pounds each were taken at the depth of about a foot, chopped up and most carefully mixed together, and a sample of this mixture was analyzed, with the following results :

Moisture	72.95	per cent.
Nitrogen	0.78	"
Phosphoric acid	0.4	"
Potash	0.84	"

Allowing for the nitrogen a commercial value of 15 cents a pound, for the phosphoric acid 7 cents, and for the potash 4.25 cents, we have the following estimate of the value of a ton of the manure :

Nitrogen	0.78	2000	15	$2.34
Phosphoric acid	0.4	2000	7	.56
Potash	0.84	2000	4.25	.71
Total				$3.61

Of this manure 311 loads were produced in the course of the season ; about every tenth load was weighed, and the average weight was estimated to be very nearly 3,000 lbs. Hence the total quantity produced was at least 466 tons, which at $3.61 per ton would have a trade value of very nearly $1,682 ; that is to say, it would have cost this sum to have purchased the same quantity of nitrogen, phosphoric acid, and potash, of about the same degree of assimilability, in commercial fertilizers.

The investigations of this season were not fully satisfactory, because all the manure was not weighed, and the number and kind of animals were not noted from month to month ; this number was, however, about forty-five.

In the second season, 1884–5, these data were all carefully taken. In five months, from October 1 to March 1, 199.25 tons of manure were produced by a herd of twelve spring calves, seven winter calves, one bull, twenty-four cows, twelve horses, and one colt, making fifty-seven animals in all: allowing that the twenty young animals would equal ten adults, we should have the equivalent of forty-seven full-grown animals.

The manure was sampled in the same manner as described above, and the analysis was made by Mr. A. M. Breed, a senior in the Course in Agriculture, with the following results:

Moisture	75.57	per cent.
Nitrogen	0.68	"
Phosphoric acid	0.29	"
Potash	0.7	"

As less cotton-seed meal was fed this season than last, it was expected that the manure would not be so rich as then, and the expectation was confirmed by the results of the analysis.

The trade value of these three nutrients in a ton of this manure, computed as before, would be:

Nitrogen	0.68	2000	15	$2.04
Phosphoric acid	0.29	2000	7	.41
Potash	0.7	2000	4.25	.60
Total				$3.05

Calling the total quantity of manure produced 200 tons—as we may without seriously affecting the computation—the nitrogen, phosphoric acid, and potash in this year's product of manure would cost in the fertilizer market, at current rates in 1884–5, $610.

In all probability we shall not get returns in crops equal in value to these estimated values of the stable manure spread on our fields from our manure yard; but nevertheless the land to which this manure has been applied has steadily increased in fertility, while at the same time producing crops whose value was more than twice as great as that of the crops yielded by the same land treated with manure made in the old style.

2

From experiments to be mentioned in another part of this report (p. 12) we have estimated that the manure from a milch cow was worth sixteen cents per day. Taking this as a fair sample of the herd, we make the following computation of the value of the manure of the first season in another way. As near as can be estimated, 80 tons of straw were used for bedding, the manure from which is estimated at $3.50 per ton; hence, for the herd of 45 animals, for 195 days:

45 animals, 195 days, at 16 cents per day	$1,404
80 tons of straw, at $3.50 per ton	280
Total	$1,684

The result is very close to that obtained by the other method of computation.

That the quantity of manure obtained in the first year is not excessively large, as it might seem to be, appears from the results of a computation by Boussingault. He estimated that a horse weighing 900 lbs., and a cow (weight not given), would produce in a year the following quantities of liquid and solid manure:

Horse, liquid,	12,000 lbs.
" solid,	3,000 "
Cow, liquid,	20,000 "
" solid	8,000 "

On this basis, a computation for six and a half months would give for twelve horses 48.75 tons, and thirty-three cattle 250.25 tons. These amounts, together with 80 tons of bedding, would make a total of 397 tons. The animals kept on our farm are without doubt above the average in weight, and would consequently yield a larger quantity of manure.

II. The Quantity and Value of Manure Made by Milch Cows.

These experiments were made on March 18, 19, and 20, 1884, with three cows, weighing 1,395, 1,120, and 1,060 lbs. —total weight, 3,575 lbs.; average weight, 1,192 lbs., very nearly.

The food consumed in the three days amounted to 122 lbs. clover hay, 41 lbs. corn-stalks, 45 lbs. cotton-seed meal, 42 lbs. corn meal, 42 lbs. malt sprouts; and 45 lbs. of cut corn-stalks were used for bedding, making a total of 337 lbs.

The total weight of manure, including bedding, was 802 lbs., exceeding the weight of food and bedding by 465 lbs. The yield of milk was 285 lbs. for the three days, or an average of 31⅔ lbs. per cow and day. Each cow used, including bedding, 37⅘ lbs. of hay, meal, etc., per day, and the product for each cow per day was 89⅕ lbs. of manure and 31⅔ lbs. of milk. This would show that each cow drank 83⅓ lbs. of water, at least; a portion of the water consumed is exhaled through lungs and skin, and does not therefore appear in the manure

The market value, at the barn, of the food consumed was as follows:

122 lbs. clover hay,	at $8.00 per ton	$0.49
41 " corn-stalks,	at 4.00 " "	.08
45 " cotton-seed meal,	at 26.00 " "	.59
42 " corn meal,	at 26.00 " "	.55
42 " malt sprouts,	at 14.00 " "	.29
Total value		$2 00
45 lbs. cut corn-stalks, bedding, at $4.00		09
		$2.09

The composition of this food, computed from Wolff's table, was as follows:

	Nitrogen. Pounds.	Potash. Pounds.	Phos. Acid. Pounds.
122 lbs. clover hay	2.40	2.23	.68
41 " corn-stalks	.20	.39	22
45 " cotton-seed meal	2.70	.66	1.26
42 " corn meal	.67	.07	.11
42 " malt sprouts	1.55	.87	.76
45 " bedding	.22	.43	.24
	7.74	4.65	3.27

Much less bedding than usual was supplied to these animals, and the manure was correspondingly richer in soluble, and therefore more valuable, plant food.

Its trade value for manure is estimated as follows:

7.74 lbs. nitrogen,	at $0.18	$1.39
4.65 " potash,	at 0.5	.23
3.27 " phosphoric acid,	at .08	.26
		$1.88

It appears from the above that the food consumed by the three cows in three days was worth, as a manure to spread directly upon the land, $1.88 ; or, in other words, it would have cost $1.88 to have purchased the same amount of plant food in the form of fertilizers.

Numerous experiments in Germany appear to show that cows in milk take from their food about 20 per cent. of its manurial value. Deducting this 37 cents from the above, we have $1.51 as the value of the manure of three cows for three days, or $16\frac{7}{9}$ cents per cow per day.

It will be noticed that the cows selected for this experiment were above the average in weight, and that they were liberally fed.

As to the question of profit, we have the following exhibit, the milk being reckoned at $2\frac{1}{2}$ cents per pound ; that being its value to the University, in the barn, after it was drawn from the cow. Ordinarily, however, it is worth but $1\frac{1}{2}$ cents, for the manufacture of butter and cheese.

Cost of keeping 3 cows 3 days	$2.09	
Value of manure produced		$1.51
" " milk		7.13
Balance in favor of products	6.55	
	$8.64	$8.64

At $1\frac{1}{2}$ cents per pound for the milk, the balance would be $4.27.

The cost of the food required to produce a quart of milk was a trifle less than $1\frac{1}{2}$ cents.

The cows had been fed for some time previous to the experiment on virtually the same amount and kind of food as given above, the only difference being that nothing was weighed or measured. During the experiment the cows were kept in their stanchions the entire twenty-four hours ; whereas, before this they were allowed to exercise most of the day in a covered yard. The yield of milk of these three cows for the three days previous to the beginning of the experiment, when they were allowed the liberty of the covered yard, was $293\frac{1}{2}$ lbs., or $8\frac{1}{2}$ lbs. more than the yield of the three days when they were closely confined.

II.

FEEDING EXPERIMENTS — ENSILAGE FOR YOUNG CATTLE.

BY PROF. I. P. ROBERTS.

Two yearling heifers, one a thoroughbred, the other three-quarters Holstein, were kept together from fall to January 13. They were of nearly the same age, and looked so nearly alike in all particulars that it was difficult for a stranger to distinguish one from the other. They had grown rapidly during the earlier part of the winter, on hay and a little meal. The following table shows the weight and dates of weighing. Dena, the thoroughbred animal, was fed from January 13 on 10 lbs. of hay, 22½ oz. cotton-seed meal, 25 oz. of corn meal, and 9 oz. of bran; Estelle was fed on ensilage alone, the first week, beginning with January 13, 20 lbs. per day; the second week, 30 lbs.; after that, 40 lbs.

Date of Weighing.	Dena. lbs.	Estelle. lbs.
Jan. 13	540	545
" 20	530	540
" 27	540	562
Feb. 3	554	580
" 10	500	538
" 17	564	564
" 24	580	570
Mar. 3	592	592
" 10	610	612
" 17	620	620

From March 17 on, the ration of Estelle was the same as Dena's.

Mar. 24	630	620
" 31	652	636

GAINS IN WEIGHT.

Dena, January 13 to March 17, 63 days, 80 lbs; January 13 to Mar. 31, 112 lbs.
Estelle, " " " " " 75 " " " " " 91 "

III.

THE EFFECT OF SUDDEN CHANGES IN THE RATION ON THE COMPOSITION OF THE MILK.

BY PROF. I. P. ROBERTS.

(*Analysis by Mr. F. E. Furry.*)

THESE trials were made for the purpose of ascertaining, if possible, how soon a decided change in the fodder manifests itself in the composition of the milk. Three cows were included in the experiment, all being fed alike, and their milk was mixed together before the sample for analysis was taken.

DATE.		RATION.	Dry Substance.	Fat.	Albuminoids.
Jan'y	30		13.01	4.23	3.01
"	31		12.97	4.18	3.01
Feb'y	1	Hay.	12.48	3.56	2.75
"	2		13.05	3.41	2.98
"	4		13.06	3.99	2.95
"	5				
"	6	Hay, ensilage, 1 bu. of roots,	12.48	3.75	3.08
"	9	6 qts. cotton-seed meal, 6	11.76	3.11	2.87
"	11	qts. corn meal per ea. cow.	13.04	lost.	3.12
"	12		13.6	3.84	3.47
"	13		13.32	[illegible]	3.36
"	14		13.37	4.00	3.48
"	15	Hay.	14.34	4.97	3.57
"	16		13.62	4.12	3.01
"	18		13.26	lost.	2.87
"	19		13.61	4.03	3.69
"	20		12.49	3.92	2.81
"	21	Hay, ensilage, 6 qts. cotton-	11.71	[illegible]	2.72
"	22	seed meal, 6 qts. corn	12.00	3.26	2.70
"	25	meal, 1 bushel roots.	13.53	lost.	3.58
March	4		13.23	3.65	3.33
"	5		13.04	3.54	3.20
"	6		13.20	3.78	3.26
"	11		13.33	3.98	3.30
"	12		13.51	4.18	3.33
"	13		13.31	4.02	3.32
"	18	Hay.	13.23	3.85	3.26
"	19		13.25	3.88	3.21
"	20		13.18	lost.	3.20
"	25		12.52	3.79	2.96
"	26		12.52	lost.	2.91
"	27	Corn-stalks, 12 quarts corn	12.46	3.66	2.90
April	2	meal.	12.77	3.52	3.18
"	3		12.28	3.30	3.07
"	8	Corn-stalks, 8 quarts corn	12.76	3.31	3.25
"	9	meal.	12.82	3.34	3.27
"	10		13.06	3.43	3.13
"	15	Corn-stalks, ensilage, 4 qts.	13.30	3.76	3.34
"	16	cotton-seed meal, 4 qts.	13.36	3.78	3.37
"	17	corn meal.	13.34		

These figures show no important change in the milk, following immediately on a decided change in the ration; but very great differences in composition sometimes appear in passing from one day to another while the cows are fed on the same ration—as, for instance, in passing from the 13th to the 16th of February, or from the 6th to the 12th of the same month, or from the 19th to the 22d. On the other hand, the slight changes in composition will be noticed when the very decided changes in ration were made on March 6 and March 27. The greater uniformity in respect to the proportion of protein, and the more gradual changes in the proportion are especially noticeable. Evidently there are disturbing causes independent of the feed, working sometimes powerfully on the composition of the milk, and affecting the proportion of dry substance and fat more than the albuminoids.

While there is nothing specially new or unexpected in these results, they may serve to strengthen the principle that in milk feeding experiments a ration should be continued at least from twelve to twenty days before attempting to study its effect on the milk, and that even then all the milk of the last three or four days should be sampled for analysis, or that it is dangerous to depend on the analysis of the milk of a single day.

IV.

A COMPARISON OF THE PRODUCTIVE EFFECT OF THE SAME RATION WITH DIFFERENT BREEDS OF COWS.

By Prof. G. C. Caldwell.

(Analysis by Mr. F. E. Furry.)

Two lots, of three animals each, were selected, of average quality, one of which consisted of native stock, the other of half-breed Holsteins. The make-up and composition of the ration, the weights of the animals at different periods, and the yield and composition of the milk are given below. The weighings were taken once during each of the periods given in the first column, immediately after having been fed in the morning and before they were watered. Samples of all the milkings for the last four days of each fortnight by period were taken for analysis. The greater productive effect of the ration when fed to the grade cows is clearly shown in the yield of milk, its composition, and the weight of dry substance and fat per cow and day, in the last six columns of the table. But while the native cows maintained very nearly the same yield to the end of the period, there was a notable falling off in the case of the grade cows. Of course a single trial like this does not establish a principle; without doubt a herd of native stock, selected with special reference to their milking qualities, might make a better showing than a herd of poor grade Holsteins. The results obtained here are offered only as a contribution to our knowledge of the subject, so far as it pertains to average stock, of the breeds tested.[1]

[1] These feeding experiments that follow, suggested by Prof. C., were made possible only by the kind co-operation of Prof. Roberts.

The ration consisted of, in pounds per cow and day: hay, 2; ensilage, 40; oat straw, 4; corn-stalks, 2; corn meal, 2; cotton-seed meal, 4.

It supplied of *crude* nutrients, in pounds per cow and day: dry substance, 22.5; protein, 3.2; ether extract, 1.2; carbhydrates, 11.3.

It supplied of digestible nutrients, in pounds per cow and day: protein, 2.3; fat, 1.0; carbhydrates, 11.3. In respect to this last estimation it must be observed that we have very few and quite insufficient data upon which to base our calculations in regard to the digestibility of some of the kinds of fodder used; that, as usual in such calculations, the portion of the fiber that is digested is allowed to compensate for the portion of the nitrogen-free extract or carbhydrates not digestible, the digested part of the fiber being regarded as genuine carbhydrates, and capable, therefore, of doing the same work in the animal economy; but that Tappeiner's well-known conclusions, which have been accepted in all their significance by Weiske, indicate that the digested part of the fiber does not serve for the production of heat or fat, as the starch or sugar of the genuine carbhydrates does. Nevertheless, in order that these results may be compared with others of a similar character, in which the effects of a certain amount of digestible nutrients was tested, we have also followed the same plan.

The digestible nutritive ratio of the ration, expressing the proportion of protein or flesh-forming substance to the non-nitrogenous matters not capable of being converted into flesh or tissue of any kind, was in this ration 1 to 6.[1]

The first set of results given in the following table refers to the native cows, the second to the grade Holsteins.

The rations were in all cases practically eaten clean.

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[1] $\frac{\text{Per cent. carbhydrates} + \text{per cent. fat} \times 2.5}{\text{Per cent. protein.}} = \frac{6}{1}.$

RESULTS IN MILK.						
		YIELD.	COMPOSITION.			
PERIOD.	WEIGHTS.	Average	Per cent. of		Pounds per cow and day of	
		per cow and day.	Dry Substance.	Fat.	Dry Substance.	Fat.
Dec. 17-26,	3050	21.7				
" 27-Jan. 5,	3104	21.7	lost.	3.9		0.84
Jan. 6-15,	3214	19.2				
" 16-26,	3118	20	12.7	3.8	2.5	0.76
" 27-Feb. 4,	3144	20.6				
Feb. 5-10,	3296	19.9	12.7	3.49	2.5	0.69
" 11-24,	3152	19.6				
" 25-Mar. 3.	3248	19.8	12.7	3.56	2.5	0.71

RESULTS IN MILK.						
		YIELD.	COMPOSITION.			
PERIOD.	WEIGHTS.	Average	Per cent. of		Pounds per cow and day of	
		per cow and day.	Dry Substance.	Fat.	Dry Substance	Fat.
Dec. 17-26,	3380	28.2				
" 27-Jan. 5,	3390	29	14.2	4.53	4.0	1.31
Jan. 6-15,	3492	27				
" 16-26.	3426	27.3	14 2	4.5	3.9	1.23
" 27-Feb. 4,	3474	25.9				
Feb. 5-10,	3472	27.4	14.2	4.42	3.9	1.21
" 11-24,	3462	26.6				
" 25-Mar. 3,	3500	26.1	14.8	4.33	3.7	1 13
Mar. 4-18.	3540	25.7				

V.

THE GAIN OF STEERS ON A FATTENING RATION.

By PROF. G. C. CALDWELL.

THESE rations were simply such as were suggested by the Professor of Agriculture as in accordance with common practice; the object of the experiment was to test the fitness of such a ration, made up without any reference to its chemical composition as a whole, and then to compare its composition with the German feeding standards, so much written about in recent years.

Five steers two years old were selected, of nearly the same weight. Their weights at the beginning of the feeding trial, December 29, were 1,112, 1,120, 1,066, 1,010, and 1,040 pounds. They had been kept for six weeks on the ration specified in the first period below. They were weighed on the dates given in the table, and, as usual, just after eating their morning meal, and before drinking.

Date of Weighing and of Change of Ration if any.	Ration per Steer and Day.	Total Weight.
Dec. 29	Ensilage, 20 lbs. Corn stalks, 5 lbs. Corn meal, 3 lbs. Cotton-seed meal, 5 lbs.	5348
Jan. 20	Ensilage, 20 lbs. Poor clover hay, 10 lbs. Corn meal, 3 lbs. Cotton-seed meal, 5 lbs.	5612
Jan. 27	No change.	5724
Feb. 5	"	5668
" 10	"	5820
" 17	"	5840
Feb. 24	Hay, 20 lbs. Corn meal, 4 lbs. 9 oz. Cotton-seed meal, 5 lbs.	5858
March 3	No change.	5938
March 11	Hay, 20 lbs. Corn meal, 6 lbs. Cotton-seed meal, 5 lbs.	6158
March 17	No change.	6098
" 24	"	6252
" 31	"	6248
April 7	No change.	6256
" 16	"	6320

The weights of the five animals were at the close, taken in the same order as at the beginning, 1,300, 1,324, 1,296, 1,190, and 1,210 pounds.

The total gain was 972 lbs., or, per day and thousand pounds live weight, 1.66 pounds.

The following table exhibits the proportion of the several nutrients, in pounds and fractions thereof, per day and thousand pounds live weight, and the nutritive ratio in the several rations given to these steers :

	Protein.	Fat.	Carbhydrates.	Nutritive Ratio.
Ration of Dec. 29	1.85	0.75	6.94	1:48
" Jan. 20	2.22	0.85	7.82	1:4.5
" Feb. 24	2.24	0.85	9.03	1:4.9
" Mar. 11	2.23	0.84	9.31	1:5.1
The better ration given after the maintenance ration of the 2d lot of steers,	1.64	0.61	7.77	1:5.7

Wolff gives for a fattening ration the following, of digestible nutrients, in lbs. per day and 1,000 lbs. live weight :

	Protein.	Fat.	Carbhydrates.
First Period	2.5	0.5	15
Second Period	3	0.7	14.8
Finishing Period	2.7	0.6	14.8

Our rations do not agree at all with these, except approximately as to the protein. That a ration more in accordance with Wolff's might give better results, is indicated by the gain of 4.4 lbs. per day and 1,000 lbs. live weight (see 2d Report of Cornell University Experiment Station) on a ration very nearly like that given by Wolff for the first or beginning period of the fattening.

VI.

THE EFFECT OF A MAINTENANCE RATION.

BY PROF. G. C. CALDWELL.

IN another feeding trial four animals were put on an approximate maintenance ration, calculated on the basis of Wolff's standards, and from our analyses of the fodder used.

The ration per day and steer consisted of hay, $4\frac{1}{2}$ lbs.; corn-stalks, 13 lbs.; corn meal, $1\frac{3}{4}$ lbs.; cotton-seed meal, 9 oz. In the following table the dates are given when weights were taken, and the sum of the weights of the five animals :

Jan. 20,	3492	Feb. 10,	3588	Mch. 2,	3584
22,	3456	12,	3202	3,	3600
24,	3412	14,	3532	5,	3590
26,	3462	16,	3520	7,	3640
27,	3444	17,	3524	9,	3662
29,	3410	19,	3532	10,	3666
31,	3432	21,	3538	13,	3570
Feb. 2,	3458	23,	3518	15,	3662
5,	3444	24,	3558	17,	3676
7,	3428	26,	3542	19,	3694
9,	3366	28,	3504	21,	3672

Here the trial with the maintenance ration ended, with a gain, estimated by comparing the average of the first four weighings with the last four, of a little over 1.1 lbs. per day and 1,000 lbs. live weight.

The last weights of the four animals, taken in the same order as the first, were 1,020, 924, 864, and 864 lbs.

For the next four weeks the steers were put on a better ration, as follows: Hay, 20 lbs.; corn meal, $3\frac{1}{4}$ lbs.; and cotton-seed meal, $2\frac{15}{16}$ lbs. The total weights at the end of each week were 3,702, 3,764, 3,810, and 3,834 lbs. A gain was made of about 1.53 lbs. per day and 1,000 lbs. of live weight at the start on March 21. The digestible composition of this ration is given in the table on p. 19.

Wolff's maintenance ration (I) and our own in this experiment (II) in pounds of digestible nutrients per day and 1,000 lbs. live weight are given in the following table:

	I.	II.
Total dry substance	14.5	15.3
Protein	0.7	0.68
Carbhydrates and fat	8.25	8.6
Nutritive ratio	1:12	1:13.2

Our ration is therefore a poorer one than Wolff's, having a somewhat smaller proportion of protein to non-nitrogenous matter; but for all that there is a notable gain in weight. It is poorer also than the maintenance ration used in a similar experiment in 1881–2 (Second Report of the C. U. Experiment Station, pp. 19, 20), and, as the theory would require, the gain in weight is less on this ration than on the earlier one, 2.2 pounds.

In regard to these standard rations, the results of the many tests to which they have been subjected at various places in the country [1] make it evident that, with such data as we at present have at command, no ration can be calculated that will do the same work, or produce the effect for which it was calculated, in all cases, and perhaps not even in a majority of cases, and that sometimes such rations en-

[1] See reports of the feeding trials at the New Hampshire Agricultural College, Pennsylvania Agricultural College, New York State Experiment Station, Wisconsin Agricultural College.

tirely fail to accomplish the purpose for which they are calculated and used. The individual productive capacity of the animals fed undoubtedly affects the result; this is shown in a striking manner by a comparison of the results obtained with the approximate maintenance ration of 1881–2 with an ordinary fattening ration: the poor maintenance ration gave 2.2 lbs. increase of live weight per day and 1,000 lbs. live weight, while the undoubtedly much richer ration of 1882–3 gave only 1.66 lbs. This last ration also gave only a little better result than the very much poorer and cheaper ration of 1882–3, selected for mere maintenance. Other illustrations of this point may be found in the Second Report of this Station.

Of many kinds of fodder included in such experiments not enough determinations of digestibility have been made to furnish a sound basis for making up a mixed ration, calculated according to digestibility; and it has recently even been questioned whether any of the results of the vast amount of labor that has been spent in the investigation of the subject of the digestibility of fodders are sufficiently reliable to be of much use to us.[1]

It would seem to be of less importance to make further experiments on rations calculated according to the German standards than to make actual digestion experiments with such different rations as actual experience, in this country or elsewhere, has shown to be most useful for the particular purposes for which they are fed. Thus we may learn what part of such rations, as a whole, are actually digested and go toward making growth or milk; with a mass of information of this kind in our possession we would then be in a better position to calculate other rations made up of other mixtures. By such experiments, also, the value of Prof. Armsby's suggestion could be easily tested—that the effect of a ration is due more to the total amount of digestible material contained in it than the precise composition of the digested matter, provided only that the ration contains a

[1] Armsby, Am. J. Science, 1885, p. 335.

reasonable proportion of the three nutrients, protein, fat, and carbhydrates. Unfortunately there are very few places in this country where such digestion experiments can be carried on.

VII.

FIELD EXPERIMENTS WITH CROPS.

BY PROF. I. P. ROBERTS.

CORN, 1882-84.

AT the N. Y. Experiment Station experiments were conducted in 1882 with grains from the butt, middle, and tip of ears of corn.

Those from the tips showed greater vitality and germinating power than either those from the butt or middle. At the request of the Director of the Station duplicate experiments were begun on the University farm in 1883.

The seed selected was taken from the crib and had the appearance of being a little weak. The corn was planted in a good, warm, fertile soil, with results given in the following table; the figures represent the number of plants that appeared above ground:

Seeds from the	1882. 50 Hills—5 seeds to the hill.	1883. 50 Hills—5 seeds to the hill.	1884. 50 Hills—3 seeds to the hill.
Tips	191	171	121
Butts	120	165	73
Middle	218	242	115

Many experiments will have to be performed to settle this question, and in soil free from insect pests.

WHEAT, 1882-83.

On September 7, 1882, a small field was prepared for testing twenty varieties of wheat as to their yield and value when treated to a very liberal dressing of manures and fertilizers. Some ten loads of well-rotted manure were applied per acre, and 200 lbs. of high-grade superphosphate were scattered broadcast about one week before sowing the wheat. The wheat came up and grew most luxuriantly, the leaves standing quite erect instead of bending over and keeping close to the ground, as is common and desirable in ordinary culture. The first hard freeze of winter browned the tops perceptibly. By the last hard freeze of spring there were no plants left to destroy. While the experiment taught a lesson, it was quite a different one from what was expected. It was evident from the outset that the wheat was making too tender and succulent a growth to withstand a hard winter. While this piece entirely failed, the ordinary treatment of the other wheat fields gave an average of upwards of twenty-six bushels per acre. It will be remembered that the winter of 1882–3 was a very severe one on wheat in this locality.

Wheat, 1883–84.

In the fall of 1883 a few varieties which had, during our former experiments, proved the most promising, were selected and drilled in, in long, narrow strips across a fifteen-acre field which had been prepared for the general wheat crop.

The whole field had been in oats during the earlier part of the season, had been plowed immediately after the oats were removed, and treated to about ten loads of farm-yard manure per acre.

The entire field was then rolled, harrowed, and fitted in the best possible manner. Strips two feet wide between the plots left vacant, letting in light and air, without doubt increased the yield over what it would have been had there been no open spaces. The plots contained $\frac{1}{10}$ of an acre each.

Plot No.	Variety.	Yield per Plot.	Yield per Acre.
		Pounds.	Bushels. Lbs.
1	Clawson	246½	41 — 5
2	Champion Amber	276¼	46 — 2
3	Egyptian	264½	44 — 5
4	Lost Name	225	39 — 10
5	York White Chaff	237½	39 — 55
6	Velvet Chaff	199	35 — 10

All the seed except the Clawson was sent to me by Prof. W. R. Lazenby, Director of the Ohio Experiment Station, we having lost these varieties in the failure of the previous year.

Oats, 1884.

The plots were sown April 22, on good and well-prepared ground. The season was fine up to the time of wheat harvest, when a heavy rain and wind storm laid down the entire field. This caused the oats to be light in weight, and hence a decreased yield.

The plots contained one-ninth of an acre each, and extended the entire length of a fifteen-acre field. They were divided from each other by vacant strips of two feet.

No. of Plot.	Quantity of Seed per Acre.	Special Fertilizing, if any.	Manner of Sowing.	Yield of Plot.	Yield per Acre.
	Pecks.			Lbs.	Bu. Lbs.
1	8		Drilled.	191½	53 — 27½
2	5		"	190½	53 — 18½
3	12		"	177	49 — 25
4	16		"	161	45 — 9
5	5	50 lbs salt applied.	"	196	55 — 4
6	5		"	163½	45 — 31
7	8		"	150½	45 — 14½
8	8		Broadcast.	155	43 — 19
9	8	50 lbs salt, 50 lbs plaster	Drilled.	170½	47 — 30½
10	8	50 lbs salt.	"	142½	43 — 6½

In comparing the yield of a large number of plots, it is never safe to compare those which are widely separated. The above should be divided into two groups, the first extending from one to six, the second from seven to ten.

MANGOLDS, 1883.

To test varieties, twenty short rows, equally divided and unfertilized, gave yields as follows:

Yellow Ovid, seed from H. Sibley & Co., yield..............	530 lbs.
Long Red, " " " " "	630 "

MANGOLDS, 1884.

The rows were sixteen rods long and 3 ft. 4 in. apart; two rows, or a little over $\frac{1}{25}$ of an acre, constituted a plot. The soil was a clay loam, timothy and clover sod. In December, 1883, about ten loads per acre of good farm-yard manure were spread upon the surface, and plowed under in May.

TO TEST VARIETIES.	FERTILIZERS USED.	YIELD.
		Lbs.
1. Yellow Champion from Agr. Dept.,	12 lbs. potash salts.	2270
2. Sugar beet, " " "	" " " "	2100
3. Yellow Ovid, [seed poor].	" " " "	1692
TO TEST FERTILIZERS.		
4. Long Red,..........................	12 lbs. potash salts,	2160
5. " "	12 lbs. cotton-seed meal,	1794
6. " "	No fertilizers,	1944
7. " "	4 lbs dissolved bone, 4 lbs. blood, 4 lbs. potash salts,	1954
8. " "	No fertilizers.	1820
9. " "	8 lbs. dissolved bone, 8 lbs. dried blood, 8 lbs. potash salts,	2100

VIII.

SELF-FERTILIZATION OF CORN.

BY PROF. I. P. ROBERTS.

AN attempt was made, in the following manner, to determine the productiveness of self-fertilized corn. Two hills of corn were planted side by side, and allowed to grow with three stalks in a hill until the ear and tassel began to form. The two weaker plants were then removed from one of the hills, and a frame two feet square and seven feet high, formed of glass on two contiguous sides, and of white muslin on the other two sides and the top, was placed over the remaining stalks. This prevented all contact of foreign pollen ; the glass permitted full access of light, and the muslin of air. No perceptible interference with the normal temperature and moisture was observed, as the glass sides of the frame were turned to the north and east. It has been shown by Italian investigations that the only effect of a white muslin screen on the growth of corn is to make it slender, but with an increase in total weight. This, in the present experiment, unimportant influence was neutralized by having half of the screen made of glass ; and, on the other hand, the harm that might arise from confinement under glass was neutralized by combining cloth with it, which offers little resistance to the passage of air and moisture. We therefore had our single corn plant under normal influences, practically ; only preventing the access of foreign pollen. The plant continued to grow finely ; pollen in the greatest abundance was produced, and covered the leaves, ear, and ground beneath with a thick yellow dust. The silks were pollenized in the same prodigal manner, and there seemed no reason why the ear should not mature a full complement of kernels. In the fall the frame was removed, when it was found that the ear which had only received pollen from the same plant contained no kernels at all, while the three stalks which were free to receive pollen from each other or elsewhere had the ears well filled out with sound kernels. Although this is but a single instance, it yet points strongly toward the incapacity of the corn plant to close fertilize, and the great advantage in productiveness of cross fertilization.

IX.

MISCELLANEOUS ANALYSES OF FERTILIZING MATERIALS.

BY PROF. G. C. CALDWELL.

(Analyses by Mr. F. E. Furry.)

Ashes.—These samples were sent to the Station for analysis, partly by members of the Western New York Horticultural Society, in connection with the experiments on the effect of potash salts when used as a fertilizer for grapes :

	Potash.	Phosphoric Acid.
Wood ashes, No. 1	5.8	1.76
" " " 2	8.24	0.04
" " " 3	2.51	1.43
" " " 4	5.07	1 72
" " " 5	2.82	0.81
" " " 6	7.40	1.38
Tan bark ashes	0.84	1.14
Lint ashes	17.19	6.55

Some of these samples evidently represented leached ashes, although they were not stated to be so by those who sent them. Of those that were not leached, some of the differences in composition are sufficiently great to make differences in fertilizing value of no small account, and to suggest very positively the wisdom, in purchasing large lots, of first procuring an analysis.

The tan bark being so thoroughly leached in the operations of tanning yields ashes of little value. The "lint ashes," so excessively rich in both potash and phosphoric acid, are the product of burning the waste in the manufacture of flax.

Land Plaster.—Some analyses of land plaster given in the 2d Report of the Station, only for the purpose of showing the differences in composition of the product from different layers of rock in the quarry, were criticised as unjustly discriminating against the plaster in general from that quarry. At our request a gentleman of Union Springs procured three samples which, in his opinion, fairly represented the product; the analyses of these are given below. No. 1 was ground in 1881, and Nos. 2 and 3 in 1883. No. 4 was ground in March, 1885, at the mill in Ithaca.

	Insoluble residue.	Pure plaster.
1	5.29	68.8
2	7.37	73.7
3	2.47	89.4
4	5.93	63.75

Even these figures show no little degree of variation in quality.

Determinations of potash were made in twelve samples of commercial potash salts used in connection with the experiments on fertilizing grapes reported below. They were in general, especially if muriates, of good quality. Two samples, however, that came to the Station labeled "sulphate of potash," and which, if of good quality, should have contained about 80 per cent. of the substance, really contained less than 25 per cent., and a third contained but 43 per cent. The first two were probably kainite, and if sold at the prices usually charged for kainite were what they should be, except as to the name.

X.

EXPERIMENTS WITH VARIOUS FERTILIZERS ON INDIAN CORN.

By Prof. G. C. Caldwell.

This series of experiments was begun with the expectation of continuing it through a number of years, or at least till conclusive answers should be obtained to some of the questions put in regard to the manuring of this important crop. A field of about two acres, with a stiff clay soil, which by previous cropping had been reduced to a low condition of fertility, was divided into 33 plots, each wide and long enough for three rows of corn with eighty hills to the row. The chief object of the experiments was to contribute something to the settlement of the question as to which of the three most important constituents of manures—phosphoric acid, nitrogen or potash—will produce the best effect when used alone on corn, or what combination of these substances is most effective ; in addition to this the attempt was made to compare the effectiveness of different forms of combination in which these substances may be procured in the market, and also the effect of sulphates, especially sulphate of lime or plaster.

The manner in which this plan was carried out is sufficiently explained in the following statement of the arrangement and manuring of plots, and the results.

In the first three years the results of the experiments were entirely unsatisfactory, as all the plots except those treated with stable manure gave smaller yields than the unmanured plots. While an apparently satisfactory explanation could in some cases (and especially in the first year) be given for this failure to respond to the fertilizers, by referring it to exceedingly unfavorable weather at the time of planting and during the early stages of growth of the crop, in other cases the result is inexplicable, and can serve the only useful purpose of illustrating the difficulty that is liable to attend field experimentation. After several plots had received their respective charge of manure for three years the soil appeared to begin to acquire distinctive characters in the several experiments. The statement of these results in detail would not be worth the space they would occupy, and the report is therefore confined to the last two years ; in the second of these years, or the fifth of the whole series, all manuring was discontinued in order to ascertain the effect of the residues of previous manuring left in the soil.

The results are all calculated to a standard of a yield of 100 lbs. of ears on the unmanured plots ; plot No. 3, for instance, yielded in 1878 117 lbs. of ears and 56 lbs. of stover for every 100 lbs. of ears on the unmanured plot No. 8.

Plot.	Fertilizer.	Pounds fertilizer per acre.	Cost per acre.	Yield. 1878. Corn.	Yield. 1878. Stover.	Yield. 1879. Corn.	Yield. 1879. Stover.
1	Phosphate of Soda	225	$45.00	79	43	52	65
2	Same and plaster, 360 pounds		45.71	116	50	111	89
3	Superphosphate, plain, high grade	360	7.20	117	56	121	94
4	Superphosphate, " "	360					
	Nitrate of soda	135	17.45	120	68	125	95
	Sulphate of ammonia	100					
5	Same as 4 and plaster 360 pounds		18.16	129	66	129	96
6	Superphosphate, ordinary kind	360	7.20	106	51	91	62
7	Superphosphate	360					
	Sulphate of ammonia	100	17.45	114	52	108	72
	Nitrate of soda	135					
8	No manure			100	64	100	55
9	Stable manure, 14 tons		17.50	120	67	164	128
10	Ground rock phosphate	750	7.50	107	42	111	83
11	Ground rock phosphate	750	19.92	114	42	100	81
	Peruvian guano	360					
12	Nitrate of soda	135	6.00	99	44	92	84
13	Nitrate of soda	135	13.20	112	52	111	85
	Superphosphate	360					
14	Sulphate of ammonia	100	4.25	109	52	104	81
15	Sulphate of ammonia	100	11.45	114	52	103	80
	Superphosphate	360					
16	Peruvian guano	360	12.42	114	55	88	71
17	Fish guano	1200	15.00	103	52	81	71
18	Fish guano	1200	19.20	117	54	119	82
	Superphosphate	360					
19	Fish guano	1200					
	Superphosphate	360	23.45	113	59	117	89
	Sulphate of ammonia	100					
20	Fish guano	1200	15.71	115	52	107	82
	Plaster	360					
21	Sulphate of potash	200	2.50	106	55	82	76
22	Sulphate of potash	200					
	Sulphate of ammonia	100	12.75	98	65	93	91
	Nitrate of soda	135					
23	Sulphate of potash	200					
	Sulphate of ammonia	100					
	Nitrate of soda	135	19.95	128	67	123	92
	Superphosphate	360					
24	Sulphate of potash	200	3.21	129	60	122	101
	Plaster	360					
25	Sulphate of potash	200	9.70	125	55	121	108
	Superphosphate	360					
26	No manure			100	39	100	75
27	Stable manure, 14 tons		17.50	128	70	165	99
28	Stable manure, 14 tons		18.21	159	75	166	119
	Plaster, on young corn	360					
29	Stable manure, 14 tons		18.21	135	79	145	102
	Plaster in hill with seed	360					
30	Plaster	360	.71	83	41	72	68
31	Sulphate of magnesia	200	3.00	88	48	58	69
32	Peruvian guano	360	13.13	101	51	71	72
	Plaster, on young corn	360					
33	Peruvian guano	360	15.42	118	50	80	69
	Sulphate of magnesia	200					

In the following table is given the actual yield in weight of corn and stover of the two unmanured plots, and the two plots manured with stable manure, calculated for an acre:

Plot.		1875.		1876.		1877.		1878.		1879.	
		Corn.	Stover.	Corn.	Stover.	Corn.	Stover.	Corn.	Stover.	Corn.	Stover.
8	No manure..................	4590	3323	3083	2235	2730	1965	3975	2550	1635	900
9	Stable manure, 14 tons.......	4800	4403	3773	3400	3075	3275	4755	2655	2685	2085
26	No manure..................	3983	2558	2835	1620	2265	1290	3248	1260	1350	1005
27	Stable manure, 14 tons.......	4830	4095	2625	3035	2835	2400	4140	2265	2220	1335

The two unmanured plots and the two plots treated with stable manure, located midway between the middle and ends of the field, were supposed to be sufficient to provide standards by which to measure the effect of the fertilizers. But as the yield of one pair of plots was invariably larger than that of the other, it was made evident that the field was not so uniform in quality as was expected; and in the calculation of these results of the last two years, each half of the field was considered by itself instead of taking the mean of the two unmanured plots as the standard for the whole; this mean was taken as the standard, however, for plots 13, 14, 15, 16 and 17, occupying the central portion of the space between the unmanured plots.

Notwithstanding that so large a share of the work resulted in failure, still many interesting results appear in these last two years. In respect to stable manure its general reliability for yielding sure if not always profitable returns is shown throughout the whole series of years; the return is often not commensurate with the outlay, however. Fourteen tons of good manure to the acre would need to give an increase of more than one-fourth over no manure in order to be profitably used; and yet this was more than has been obtained in most of these experiments; and a careful observation of field experiments generally will show that in a large number, if not, indeed, in the majority of cases, stable manure appears to give unprofitably small returns, at least so far as regards the crop to which it is directly applied. But the value of time in bringing its constituents into more assimilable forms, as well as the large amount of valuable residue which may remain in the soil after liberal treatment with the manure, is shown by the figures for plots 8 and 9, and 26 and 27 for 1879, when the manuring was discontinued. Both plots which had received stable manure in previous years gave an increase of more than one-half over the yield of the unmanured plot.

The value of plaster in connection with stable manure is well illustrated in these results; in every instance, excepting in 1876, it has increased the effect of this manure when applied on the young corn, and in some cases to a very profitable extent (plot 28). It will be observed that in the last two years it increased the yield of stover to a much smaller extent than that of corn; as might be expected, its effect does not continue beyond the year when applied. Plaster in the hill with the seed (plot 29) is not without effect; and under some conditions, probably of the weather, such as obtained in 1877, it produced a better result than when applied in the usual manner. Plaster alone, as well as the other sulphate—sulphate of magnesia—appeared to do more harm than good (plots 30 and 31); but the latter with Peruvian guano (plot 33) appeared to bring out the virtues of that fertilizer to some extent, since a much better yield was obtained than on plot 32; but a single result like this has but little value. In other cases where plaster was used with fertilizers containing phosphoric acid or nitrogen or potash (plots 2 and 5, and 24 compared with 21), it increased the yield and, as in the case of stable manure, without affecting the yield of stover to a corresponding extent.

The question so much discussed just now, as to the importance of nitrogen in manure for corn, receives some light from the results of these experiments: comparing plots 3 and 4, it is seen that with a high grade phosphate almost as good a yield is obtained, both in the year when applied and in the following year, from the residues of the previous year, as with the phosphate and nitrogenous manures.

Again, in plots 12 and 13 we have no increase with nitrate alone, but a notable increase with nitrate and superphosphate. A study of plots 21 to 25 shows the value of manures containing no nitrogen, especially if they contain both potash and phosphoric acid, as in the case of the last three. Plot 22, with nitrogenous manures added to potash sulphate, shows no indication of value for nitrogen, while all the three following plots, to which superphosphate is added but no nitrogen, give nearly or quite as large an increase as stable manure. Nitrogenous manure is not altogether without effect, however, as is shown by nearly all the plots which received it, such as 4, 7, 14, and 15; but in no case does their use increase the crop to a profitable extent, while on the other hand the use of potash and phosphoric acid without nitrogen, and, in some cases, of one of these alone, produces a marked increase (plots 3, 13, 23, 24, and 25).

A few years ago Prof. Lehmann,[1] of Germany, performed some experiments which went to show that Indian corn requires its nitrogen in the form of ammonia in the earlier stages of its growth, and in the form of nitrate during the latter part of the season. In an ordinary, arable soil, and under ordinary conditions, while no conversion of nitrate into ammonia takes place, there is a steady oxidation of ammonium salts to nitrates; hence, if a crop requiring (as was shown by Lehmann's results) ammonia salts first and nitrate afterwards, is supplied with nitrates only from the beginning, it must suffer in the first part of the season for want of proper food, to such an extent as hardly to recover, even though it afterwards has the right kind of food; while, if supplied with ammonia salts only, it is provided directly with what it needs in the beginning of its growth, and later, indirectly by oxidation of ammonia, with the nitrate that it is supposed to require. The results of the use of nitrate of soda alone, on plot 12, as compared with the yield of plot 14, are in accordance with Lehmann's results. In such of the experiments conducted under the direction of Prof. At-

[1] Biederann's Centralblatt, Bd. 7, p. 405.

water,[1] in 1878, as furnish any comparison between these two compounds of nitrogen, the average effect of a given quantity of nitrogen—forty-eight pounds to the acre, in the form of ammonia salts—was 30 per cent. better than its effect when applied in the form of nitrates, although neither fertilizer paid for itself. In future experiments on the value of nitrogen in fertilizers for corn, it would be only just to the element to give it the best chance, and supply it in that form in which it can make the best showing for itself.

Although the annual cost of the fertilizers is given in the table, the estimation of profits is a somewhat complicated problem, since it is impossible to determine the extent to which the crops of these two years are due to the manure applied to the several plots previous to the year 1878. We therefore postpone the discussion of this question till we shall have the results of further experiments.

Other interesting points might be made out by further study of these results; but as much space has already been given to the matter as our limits will allow, and more consideration has perhaps been bestowed on them than should be on a series of experiments comprising but a single year's manuring.

XI.

THE INFLUENCE OF THE RATION ON THE COMPOSITION OF THE MILK.

By Prof. G. C. Caldwell.

The influence of the character of the feed of milch cows on the composition of the dry substance of the milk—that is to say, on the relative proportions of its several constituents, the fat, sugar, casein, etc.—has been made the subject of several investigations. Of the possible variations in these

[1] Report of work of the Agricultural Experiment Station, Middletown, Ct., 1877–8, p. 101.

proportions, those which relate to the fat and casein are the most important, since special richness in one of these constituents makes the milk more valuable for butter, and special richness in the other makes it better for cheese.

Boussingault, in 1838 and again in 1858, investigated the subject, with results showing that the ratio of fat to casein in the milk is by no means constant.[1]

In the case of one cow, for 100 parts of casein the fat ranged from 85 to 127, and of the other cow from 85 to 187 parts; with the first cow the smallest proportion of fat was yielded on wheat flour fed with hay, and the largest on hay alone; with the other, the smallest proportion of fat was yielded on molasses fed with the hay, and the largest on green clover.

Dr. Playfair[2] found a great difference in the relative proportions of fat and casein even between milk of morning and night. In the former case, for 100 of casein the milk contained but 69 of fat, and in the latter 144, the cow being fed on grass; but when the same cow was fed on potatoes and hay there was but little change in the ratio of casein to fat, in passing from morning to night.

In a series of experiments by Rohde and Frommer[3] with four cows and various rations the following results were obtained with respect to the relation between fat and casein:

Feed added to the hay.	Fat to 100 of Casein.
Nothing	74
Potatoes	88
Potato mash	62
Sugar beet mash	108
Sugar beets	100
Carrots	88
Rye mash	99

Karmrodt[4] also observed in the case of one cow the same great change in the proportion of casein to fat as was found by Dr. Playfair, in passing from morning to night; the

[1] Martiny, Die Milch, I, p. 283.
[2] Journal of Royal Agricultural Society, XIII, p. 25.
[3] Martiny, Die Milch, p. 268.
[4] Martiny, Die Milch, p. 271.

morning's milk contained 79 parts, and the evening's milk 128 of fat for 100 of casein.

Experiments by Stohmann[1] with two goats, extending from April to September, on different rations, also show how the ratio of fat to casein varies, and, further, the steady increase in the proportion of casein with the duration of lactation since the time of calving.

Feed added to the ration of hay.	Goat No. 1.		Goat No. 2.		Fat to 100 of Casein.	
	Per cent. of Fat.	Per cent. of Casein	Per cent. of Fat.	Per cent. of Casein	No. 1.	No. 2.
Nothing	3.8	2.4	3.0	2.8	158	107
Starch	3.4	2.5	2.5	3.0	136	83
Oil	4.0	2.8	3.2	3.1	143	101
Nothing	5.2	3.1	3.6	3.3	168	109
Sugar	4.6	3.3	2.5	3.5	139	71
Nothing	5.6	3.7	3.9	3.7	151	106

It also appears that the change in this ratio of fat to casein is dependent, at least to some extent, on the character of the fodder, since it takes place alike in the milk of both animals with the changes in the ration.

The important practical question in connection with the variation in this ratio of fat to casein is whether it can be brought under control, so that by feeding a cow in such a way as to increase the yield of milk, this increase may be turned into casein rather than fat, or *vice versa.* This question has been investigated very carefully by G. Kühn[2] in connection with other chemists, and, as is known, with results which show that such a thing is not in general possible, and that palm nut meal is the only kind of concentrated fodder which has been found to cause a decided special increase in the richness of cow's milk in any one of its several constituents.

Such is clearly the result of his experiments of 1870 with four cows, when the ration was varied only by changing the proportions of fat and albuminoids in it, by adding ordi-

[1] Zeitschrift f. Biologie, 1870. Jahresbericht ueber Agrikultur-Chemie XIII, p. 161.

[2] Journal f. Landwirtschaft, 1874, pp. 168, 295; 1875, p. 481.

nary concentrated fodder to the hay ; in the milk of one cow the ratio remained just the same, in that of another it varied from only 122 to 123 of fat for 100 of casein ; in another the ratio ranged from 125 to 131 of fat to 100 of casein, and in the fourth, where there was a slight one-sided increase in fat, the ratio changed from 135 to 148 to 100 of casein.

In the experiments of 1871, 1872 and 1873 palm nut meal was specially tested, since it had been found by Freitag that it very materially increased the proportion of fat in milk of cows to whose ration it was added. In experiments with five cows, conducted with each cow separately, the addition of 6.5 lbs. of this meal to the normal ration of hay, straw and roots did increase the proportion of fat, without notably altering that of the albuminoids, in every case but one, when it raised slightly the proportion of albuminoids, and left the fat unchanged. The increase in fat ranged from 0.3 to 0.5 per cent. and the amount of fat to 100 of albuminoids rose from 133 to 153 parts in one instance, from 110 to 122 in another, and from 122 to 130 in another.

Bean meal, a feeding stuff rich in albuminoids, either produced no effect on the ratio of fat to albuminoids, or reduced the fat ; in one case 6.5 lbs. of this meal added to the normal ration lowered the proportion of fat, and raised that of the albuminoids, so that the amount of the former for 100 of the latter fell from 135 to 112 parts. Brewers' grains, tried in two experiments, in one case did not change the ratio of fat to albuminoids, and in the other slightly lowered the proportion of fat.

Such in brief is the history of the most important researches that touch this question of the possible changes in the relative proportions of fat and albuminoids in the milk. They show that this proportion differs widely in the milk of different cows, that it is not constant for the milk of the same cow, that certain articles of fodder may cause an increase in the proportion of fat and not of casein, and so cause a change in the ratio of the one to the other, and also that the individuality of the cow may modify the influence of the fodder on the composition of the milk.

In order to eliminate at least to a large extent the effect of the individuality of the animal, and also to test the influence of such changes in the ration of cows as may come within the usual line of practice of dairymen in this country, the following experiments were performed, with the kind co-operation of Prof. Roberts. Four (or three) cows that had been in milk for about the same length of time were set apart from the rest of the herd belonging to the University Farm, for special methods of feeding. Their ration was changed every fortnight, gradually from less to greater richness or *vice versa*, the milk was weighed, and samples of the mixed milk of each milking taken to the chemical laboratory for analysis. There, to a weighed quantity of washed and ignited sand sufficiently large to receive about 100 cubic centimetres of milk about 10 cc. of each portion of milk, accurately weighed, was added as soon as it was brought in, and evaporated down till the sand was moderately dry again. In this manner samples of all the milk of a week were added in succession to the same quantity of sand, and after the last charge had been added and evaporated, the whole was thoroughly mixed and pulverized with the aid of a small platinum wire spatula, and a pestle made of glass rod, dried as thoroughly as possible over the water bath and then for an hour at 100°, and finally for several days in the desiccator.

Repeated determinations of fat and nitrogen in this residue, yielding results that for the same residue agreed very closely together, proved that the mixture was uniform. By working according to this method the product of every milking is brought under examination with far less labor than is required for the examination of each milking separately. The nitrogen was determined by the absolute method, and the fat by extraction with ether in the usual manner.

These feeding experiments were repeated for three seasons, with four cows in the first two winters, and three in the last. The results of the analysis of the milk residues of the second week on each ration are given in the following table. Most unfortunately all the records of the feeding for the first season were lost ; but the ration was changed from fortnight to fortnight somewhat after the same manner as in the third season, and, as in that season also, the cows were turned into the pasture towards the end of the experiment. Hence the results, so far as they relate to the ratio of fat to albuminoids, are not without value, especially since in their general tenor they agree with those of the third season. In the column headed "ratio of fat to albuminoids" the number of parts of fat to 100 parts of albuminoids are given.

First Series of Experiments.—

	Ratio of fat to Albuminoids.
First ration	111
Second ration	121
Third ration	126
Fourth ration	137
Fifth ration	124
Sixth ration	121
Seventh ration	118
Eighth ration	100

Second Series of Experiments.—In the second series of experiments the records of the feeding were also mostly lost : the ration consisted of hay with more or less of a mixture of grain consisting of a mixture of equal parts of bran and corn meal. Eight quarts of this concentrated fodder were added to the daily ration of hay in the first fortnight, and this was increased and then diminished by four quarts at a time in successive fortnights.

	Ratio of fat to Albuminoids.
First ration	127
Second ration	121
Third ration	121
Fourth ration	131
Fifth ration	130

Third Series of Experiments.—Three cows were taken for this experiment. The grain in the ration was a mixture of one-half bran, one-fourth oats and one-fourth corn meal. The milk of the three cows was mixed, and each morning and evening a sample was brought to the laboratory for analysis, which was immediately dried down with sand as usual.

The following changes were made in the ration, each one being continued a fortnight. The quantities represent each day's feed in pounds :

	Grain.	Roots.	Hay.
I	8	14	15.5
II	16	14	12.0
III	8	14	15.0
IV	4	14	17.3
V	0	0	19.0
VI	8	0	13.5
VII	16	0	10.0
VIII	0	0	Grass ad lib.
IX	4	0	Grass ad lib.

No. of Experiment.	Total yield of Milk. Pounds.	Per cent. Fat.	Per cent. Albuminoids.	Fat to 100 of Albuminoids.
I	696	3.71	5.50	67.5
II	736	3.68	4.00	92.0
III	671			110.0
IV	640	3.52	3.13	113.0
V	568	3.67	3.41	108.0
VI	644	3.14	3.22	97.4
VII	700	3.25	3.88	83.9
VIII	709	3.69	4.59	80.2
IX	700	3.46	4.88	71.0

The results of the second series of experiments furnish no important contribution to the solution of the question under discussion. But on comparing together the first and third series, which were continued for about the same length of time, it is seen that both show a gradual change in the ratio of fat to albuminoids, beginning with a low proportion of fat, which rose till about the middle of the period and then fell to about the point at which it started; and in the case of the last series of experiments where, except in one instance, the actual per cent. of fat and albuminoids in the milk was determined, it is shown that there was a larger proportion of albuminoids in the milk at the beginning of the period, and that this proportion fell gradually up to the time when the ratio of fat to albuminoids was largest, and then rose at a nearly uniform rate thereafter. This does not appear in the first series of experiments, since nothing was determined but the relative proportions of fat and albuminoids in the dried residue of the milk.

In regard to the composition of the milk at different stages of the period of lactation, Kühn concluded from the results of his experiments[1] that in general the proportion of fat to albuminoids became smaller as the period of lactation, from the time of calving, lengthens, and that this is brought about by a gradual increase in the proportion of albuminoids in the dry substance of the milk, and a decrease of fat; but such a result was not obtained in all his experiments, and the change in the ratio of fat to albuminoids was very much smaller than in ours. Stohmann, in experiments with goats,[2] obtained results quite similar to our own, the milk being at first richer in albuminoids, then poorer, and finally richer again.

These records also show that these progressive changes in the composition of the milk follow their steady course, independent of changes in the ration, or in other words, that the composition of the dry substance of the milk does not appear to be affected even by important changes in the composition of the ration, at least when those changes are such as may come within the scope of ordinary dairy practice. In this respect our results agree with those obtained by Kühn, Fleischer,[3] and others.

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[1] Journal f. Landwirtschaft, XXIII (1875), p. 516.
[2] Journal f. Landwirtschaft, XVII (1869), p. 168.
[3] Jahresbericht ueber Agrikultur-Chemie, 1870-2, p. 174.

XII.

PLEURO-PNEUMONIA.

By Prof. James Law.

[Notwithstanding the length of this article, the great importance at the present time of the subject treated seems ample justification for its republication. The reader who is at all familiar with the course of this disease during the past few years will not fail to note the singular accuracy with which Prof. Law's anticipations have been fulfilled. The paper is reprinted without revision as it first appeared in 1879.—C. K. A.]

As the writer has been engaged during 1879 in the direction of measures for the extirpation of this foreign plague from our territory, it seems reasonable that this Bulletin should set forth a summary of what has been accomplished, and what lessons have been learned from the experience. It must, however, be premised that no means were provided for experimental observation, so that questions of the deepest interest to the pathologist and epidemiologist have had to lie unaffected by such crucial tests as the experimentalist alone can apply. In some respects this is to be regretted, as doctrines which are now but the deductions of empirical observations might have been placed on an irrefragable basis, and certain fields of pathological science might have been illumined with a clearer light.

Yet the observations inseparable from the daily application of suppressive measures are far from being unimportant, and in many respects the results obtained are no less conclusive than if they had been the outcome of the most carefully devised experiment. The width of the field under observation, so far exceeding what could have been subjected to experiment, served to give a conclusiveness to obvious causations and results, that appeared unvaryingly for an indefinite number of times in succession, which could not have been obtained by a limited number of experiments, liable as these are to be invalidated by the introduction of an unsuspected disturbing element.

Question of the Generation *de novo* of Lung Plague. —This is the fundamentally important question with reference to the possibility of the final extinction of this disease here or elsewhere. If the malady can and does originate on this continent, no present outlay in money and no effort for its present extinction can give us any guaranty of permanent immunity. After we have rooted out the last existing contagious germ new germs will still continue to appear, at more or less frequent intervals and in more or less remote localities, demanding in every such case the repetition of the work, of the outlay and suspense that have already repeatedly taxed the energies of the nation. And if such a spontaneous generation of the germs be possible, new spontaneous outbreaks of the disease must become increasingly common as our waste lands become more uniformly settled, as our farms become more fully and carefully tilled, and as the herds of cattle become more numerous. When our present stock of cattle shall have been doubled we shall have just double the number of such outbreaks; when trebled, quadrupled, and quintupled, so will the newly developed germs and infected localities be three, four, or five times as many as at present; and the question might well arise whether the nation could afford to continue the suppression of such an uncertain, intangible and unconquerable enemy.

But if we can demonstrate that this plague has never been shown to exist on the Western Continent, except at points to which we can clearly trace the germs from the bodies of infected animals imported from Europe; if we can show that wherever such imported germs have been carefully destroyed the plague has been definitely and finally exterminated; and if we can show that the testimony to this effect is not confined to America, but that the long experience of Western Europe and the more recent history of the disease in the Southern Hemisphere show with equal clearness that this affection never appears in a new country save as the result of imported infection, it follows that national measures for its extinction are fully warranted and, indeed, imperatively demanded. In this case the outlay of to-day is but a trifle as compared with the vast sums that the present suppression of the disease will so certainly save to the country in all future time.

This subject is placed first as furnishing the *raison d'être* of the law which has been to some extent put in force during the past year, and as being a matter which is apparently no better understood by the general public to-day than it was a year ago. Those great public educators, the daily newspapers, still speak of the plague as inseparable from feeding on distillery swill; and in place of recognizing the fact that the infection is restricted to a very limited area on the Atlantic seaboard, they affirm that "it has been found wherever it has been sought for." (See *New York Herald*, April 19, 1880.)

Origin of the Lung Plague in America.—Though the bovine race represented by the buffalo have been undoubtedly coeval with man on the Western Continent, and though domesticated cattle have been in existence in all the settlements since first introduced in the beginning of the sixteenth century, the Lung Plague of cattle was unknown on these shores until 1848. In that year Peter Dunn, a milkman near South Ferry, Brooklyn, purchased a cow from an English ship and placed her with the rest of his herd. Some weeks later this cow sickened and died, and infected other cows in his stable. From this the plague soon spread to other stables in the vicinity, including the great distillery stables in Skillman St., and in a few years it had overrun Brooklyn, New York, and Jersey City, and extended somewhat into the country. Many are still living who recollect all the facts of the advent of the plague and of the ruinous losses that overtook many of the unfortunate dairymen.

Wm. Meakim, of Flushing, informs us that his father, William Meakim, kept a large dairy at Bushwick, L. I., which was infected in 1849 by the carelessness of an employee, who hauled a dead cow from a Brooklyn stable with his (Meakim's) working oxen. In a few weeks the oxen sickened and died, followed by forty of his dairy cows in the short space of three months. For the remaining twenty years that he remained in the business he continued to lose from six to ten cows yearly.

Twenty years ago (1859) Benjamin Albertson, of Queens, L. I., purchased four cows from a herd from Herkimer Co., but which had been kept over night in the cattle market, Sixtieth St., New York. These cows sickened soon after, and conveyed the plague to his remaining herd of 100 head, 25 of which died in rapid succession and 19 more slowly. He was left with but 60 out of a herd of 104 animals, and these he sold into already infected Brooklyn stables.

Dr. Bathgate, of Fordham Ave. and 171st St., New York, reports that in the same year (1859) his father's herd of Jerseys contracted the Lung Plague by exposure to infection, and that the disease prevailed in the herd for several years, and until the infected buildings were accidentally burned. He reports further that the plague has never been entirely absent from the neighborhood since.

Cases of this kind might be recorded indefinitely. Enough has been given, however, to show that with the advent of Peter Dunn's cow, purchased from the English ship, and of the infection she carried, there came upon the cities clustered around the port of New York a pestilence, which has never since relaxed its hold on the bovine population. In the Skillman St. (Brooklyn) stables alone, which were infected in 1848, the plague prevailed as long as they stood, and its prevalence there was reported by the Massachusetts Commissioners who visited this city in 1861. From that time to this it has been constantly extending, not only in the cities named, but through the cities and villages of New Jersey, Delaware, Pennsylvania, Maryland and Virginia, as the demand for cows caused these to draw upon the market of New York, or as the owners of infected herds saw fit to unload their dangerous property upon unsuspecting purchasers in new and uninfected districts.

Where the plague was introduced into herds on inclosed farms, the unfortunate owners of which were not so selfish as to sell out the herd and infection to a new victim, the duration of the pestilence was necessarily limited. Sooner or later all the cattle on the place had passed through the disease, and become proof against a second attack, and if no calves were raised, as is the rule on farms supplying the large cities with milk, and if no new stock was brought in, the disease expired for the lack of fresh cattle capable of contracting it. In the towns and villages the case was altogether different. Here numerous herds mingled on open commons and unfenced lots, so that infection spread easily from herd to herd, and as fresh cows were being constantly purchased to replace those that had become dry or fat, there was at no time any lack of susceptible animals for the infection to lay under its malignant spell.

Causes Influencing the Spread of the Lung Plague Southward.—A glance at the connections of New York southward will show why the plague should have extended in this direction rather than west or north. In the first place the cities of Newark, Elizabeth, New Brunswick, Trenton, Easton, Reading, Burlington, Germantown, Camden, Philadelphia, Wilmington, Baltimore, Washington, Alexandria, etc., drew their supplies of fresh dairy cows from the great marts to which western cattle were sent. From the comparatively close proximity of these cities they respectively drew their supplies from New York, Philadelphia or Baltimore, according to which market was at any moment overstocked, so as to depreciate the value of the stock. Thus Philadelphia and Baltimore were early infected from New York and Jersey City, and once infected they reciprocated freely by furnishing contaminated cattle to the market of New York, whenever that market was poorly supplied, or they themselves glutted. Thus, too, it soon came about that all the lesser cities drew constant supplies of infection from these three great plague-stricken centers. All of the cities named were growing places with much unfenced land laid out for building, or held by speculators in waiting for purchasers, and upon these the herds of different owners pastured in common, and infected each other, so that once introduced the infection became permanent, and each city became an independent pestilential center, from which the plague extended in different directions at varying intervals.

If we trace the Erie Railroad westward we shall find that beyond New Jersey there is no city for the space of 200 miles, and this, together with the fact that cattle could be drawn so much more cheaply from the west, has hitherto prevented the extension of pestilence westward. What few infected cattle have found their way west along the line of the Erie Railroad have gone upon inclosed farms, where the plague reached its limit and died out, in place of finding the malign conditions of unfenced grounds and pasturage in common, which would inevitably have perpetuated it. The non-infection of the west we owe not alone to the immense cattle traffic from the west, and the fact that comparatively few cattle follow a contrary course, but also to the barrier of the Allegheny Mountains, and the entire absence of large and growing towns and cities over a long stretch of country.

If we follow the New York Central Railroad we find a similar comparative absence of large cities, but we find besides that the east bank of the Hudson is well fenced, so that though the Lung Plague had been introduced, it would have had less opportunity for permanence than in the district south of New York. North of Yonkers, where the open pasturages end, the plague has never gained a permanent footing on the east bank of the Hudson.

On the Harlem Railroad there is a similar absence of large cities and common open pasturages, and although the plague has extended on this line as far north as the borders of Dutchess Co., it has been more easy to deal with it than where there was a common grazing ground for different herds. From Mt. Vernon southward, however, the common pasturage was more or less in vogue, and with it the prevalence of the plague and the difficulty of dealing with it.

Along the New Haven Railroad the condition of things was more favorable to the propagation of the plague, and it would have been certainly perpetuated in some of the cities of Connecticut but that the State Cattle Disease Commission repeatedly interposed to stamp it out.

Extinction of the Lung Plague in Massachusetts.—Into Massachusetts the Lung Plague was introduced in 1859 in the bodies of four Dutch cows imported from Rotterdam by Mr. Chenery, of Belmont. All four suffered from the disease, two having been very ill on arrival. Three died, the fourth recovered, and the plague spread into nineteen towns in five counties, and was only crushed out after five years of uninterrupted effort on the part of a cattle commission This work cost the State $67,511.07, and the different towns $10,000 more; but this was a cheap investment, as the plague has never since made its appearance in the commonwealth.

Evidence of the Non-existence of Lung Plague in the West.—The fact that the Lung Plague has been unknown in Massachusetts for the past fifteen years, as it was unknown prior to the introduction of the four diseased Dutch cows in 1859, speaks volumes for the freedom from the infection of the great cattle-raising States of the west. At the one cattle market at Brighton thousands of cattle arrive weekly from the west, yet for fifteen years not only has no cow nor lean beast brought this pestilence to the Massachusetts herds, but no ox has shown the characteristic disease of the lungs when slaughtered. The same remark may be made of Central and Western New York, and of all the New England States north of Massachusetts. In a twelve years' residence at "Cornell," and with the widest acquaintance of the herds of the State, I have never seen a case of Lung Plague west of the Hudson excepting in one herd in the vicinity of Newburg, to which the infection was brought by a cow from New York city. Yet all over the State are to be found cattle drawn from the west, and filling up the dairy and fattening herds of the Empire State. And although these herds are frequently decimated, and sometimes all but exterminated by other diseases (Texas fever, Malignant Anthrax, Tuberculosis, etc.), no such thing as Lung Plague has ever appeared amongst them. The same remarks apply to western Pennsylvania, West Virginia, and, indeed, all parts west of the Allegheny Mountains. Though all supplied by the cattle from the west, all alike have hitherto kept clear of the plague. The same is true of our Gulf Coast States and Pacific States. No such plague has appeared in any of these, though their cattle are multiplying by the million.

Non-existence of the Lung Plague in Other States of America.—No Lung Plague has ever been found in any other American state. Mexico, Central America, the West Indian Islands, the South American republics, Brazil, and even Canada have failed to import this Old World pestilence, and all of them maintain to-day a perfect immunity.

Lung Plague not Indigenous to America.—From far-reaching facts like the above it becomes certain that American soil has no such sad fecundity as to produce the germs of the Lung Plague, for this affection has appeared at no point of the continent where the descendants of the imported European germs have not been first carried; and the disease is to-day confined to a narrow area on the Atlantic coast, where the imported germs were planted, and where the conditions favored its preservation and propagation. The presence of the disease where the malign European infection has been implanted, and its persistence and spread there for thirty-seven years, when contrasted with the fact of its entire absence from all other parts of the New World, shows beyond dispute that the disease is the result of imported virus, and of this alone. Cattle exist and have long existed from Labrador to Brazil, and from Brazil to Patagonia, in the most trying climates—arctic and torrid—and under all conditions of life, and every form of abuse and neglect; but in no one instance has this fatal plague been generated on the Western Continent and propagated from a new point independent of importation. Like the Canada Thistle (*Cirsium Arvense*), the Lung Plague is an exotic, dependent altogether upon the foreign seed for its existence, and it could be as easily and permanently eradicated as the thistle has been from Wisconsin and certain other States.

Lung Plague not Spontaneous in Africa and Australia.— For many centuries the nations of Africa have owned herds of cattle, being dependent on them for labor as well as for meat and milk in those districts where the "tsetse" proves so fatal to solipeds. Since the colonization of South Africa by Europeans the settlers have imported many herds from Europe, but until 1854 the Lung Plague was utterly unknown. In that year, as testified by Rev. Mr. Lindley, a missionary, a Dutch bull, imported by a gentleman of Cape Town, manifested the plague six weeks after his arrival and fourteen weeks after his shipment from Holland, and from him the pestilence has since spread over the whole unfenced ranges of Cape Colony, Orange Free State, Natal, Zululand, Transvaal, etc. Here no such plague was known in all antecedent time, but once introduced in the body of a single infected animal it has desolated the whole southern part of the continent.

When discovered, Australia was destitute of cattle. The whole bovine stock is therefore the progeny of those introduced by the colonists. On the rich native grasses and in the exceptionally salubrious climate, the cattle throve and multiplied until the name of Australian "squatter" became a synonym for a man of wealth and influence. But in 1859 Mr. Boodle, of Melbourne, imported from England a Shorthorn cow, which fourteen days after its arrival from its three months' voyage manifested the symptoms of Lung Plague. The whole herd was slaughtered and paid for by public subscription, and his lands were inclosed and proscribed; but a teamster turned his oxen into the inclosures under cover of night, the disease spread through their means, and on the unfenced pastures it was found to be impossible to control it. No conditions produced the disease until the importation of the infected English cow, but, after the entrance of the infection, it received no check from the healthful climate nor from the enforced slaughter of tens of thousands of animals, and to-day the rich pastures of Australia are ravaged by the pestilence.

Lung Plague not Spontaneous in the British Isles.—In Great Britain the pestilence was unknown in modern times until in 1839, when it was imported into Cork, Ireland, in the bodies of Dutch cattle sent to a friend by the British Consul at the Hague. It spread rapidly over Ireland, and entered England and Scotland before 1842. From this time it has been kept up by constant accessions of disease from the continent, brought in the cattle then for the first freely admitted to the English markets.

Yet the striking fact remains that for the forty years during which the plague has prevailed on the British Isles, the Highlands of Scotland have kept clear of infection. The explanation is found in the fact that native cattle are bred in the Highlands and shipped thence to market, but no strange cattle are ever introduced. The Highlands are the coldest, bleakest, and most exposed parts of the island, the places where lung diseases are above all to be expected; and their exemption, while the more genial plains are ravaged by the plague, shows plainly that the affection is no product of Britain, but an exotic that has spread wherever the foreign cattle and their infected victims have come.

NO EVIDENCE OF SPONTANEOUS LUNG PLAGUE IN WESTERN EUROPE.—

The Channel Islands.—These, lying directly between the infected shores of France and England and famed in all times for the abundance and excellence of their cattle, have never suffered from the Lung Plague for the very sufficient reason that no strange cattle are allowed on the islands.

Spain and Portugal.—These countries, lying out of the line of cattle traffic from Eastern Europe, and accustomed to breed and export cattle, but to import none, have hitherto kept free from this as from other cattle plagues.

Norway, Sweden, Denmark, Schleswig-Holstein, Oldenburg, Mecklenburg-Schwerin and Switzerland.—These are countries into which the Lung Plague has been introduced at different times, but from which it has been completely expelled by well-directed suppressive measures.

Extinction of Lung Plague a National Duty.—From all that has been said it follows with certainty that this plague has never been known to arise spontaneously in Western Europe, and that out of the center of the Eastern Continent, to use the words of the immortal Haller, "the disease never appears but as the result of the introduction into a country or district of an animal from an infected place." This being granted it must be allowed that it is quite possible to eradicate from the United States the deadly virus which has been introduced from the Old World and maintained by continuous descent in the bodies of our home herds. The disease being produced by infection, and by infection only, it results of necessity that if we can limit that infection we shall in the same ratio limit the ravages of the plague, and if we can render infection impossible, we render impossible the continued existence of the pestilence in our midst.

MORTALITY.—In estimating the mortality from this plague, we will meet with the most varied results according to the conditions of life and as to whether we take the ratio of deaths in infected herds, or in the whole cattle of a district or country. Loiset states the losses for the entire bovine population of the *département du Nord*, France, at 40 per cent. per annum, divided as follows: In city dairies 26 per cent., in distillery and sugar factory stables 12 per cent., and on farms 2 per cent. Here the deaths are in exact ratio with the frequent changes of stock, and the exposure of new and susceptible animals to infection. In the Nord in 19 years it had killed 212,800 beasts of a total value of 52,000,000 francs (over $10,000,000).

Yvart gives the losses in infected herds only, in Avignon, Cantal and Lozère at 30, 40, 50, 60, and even 77 per cent. (average 35 per cent.).

Gamgee gives the losses in the city of Edinburgh in 1861–2 at over 58 per cent., and the money loss at £14,512 ($70,000). Finlay Dun shows from the English Cattle Insurance Co. statistics that the losses from this plague from 1863 to 1866 were 50 to 63 per cent. per annum. The losses for the British Isles, computed from agricultural statistics, the records of insurance companies, etc., were close upon £2,000,000 ($10,000,000) per annum.

In Holland Sauberg reports a yearly loss of 49,661 head, while in Würtemberg it amounted to 39 per cent.

Mortality Greater in Warm Climates and Seasons.—Mr. Lindley reports that in the hot climate of South Africa it is no uncommon thing to find a whole herd of 100 or 200 cattle perish without exception, and other colonists have furnished me personally with accounts precisely similar. With these agree our experiences with the disease in the summer season in New York. When we entered on our work in February, 1879, it was loudly claimed by a party of obstructionists that the affection was the simple result of exposure to the changeable weather, and to the transitions from the hot, close, reeking stable to the chilly blasts out of doors. But from June onward, so long as the really hot weather lasted, the number of victims in a herd was greatly increased, the cases succeeded each other with a hitherto unexampled rapidity, and nearly every case proved severe and rapid in its course, so that death frequently resulted in two or three days after the animal was noticed to be ill. In our cool, dry winters the course of the disease is mild, so that the patients survive for weeks, and even months, often becoming frightfully emaciated and presenting the spectacle of walking skeletons; whereas in the burning summer and autumn death often comes so speedily that the carcass may present the round, plump, fat appearance of an animal that has died suddenly by accident. Of this high summer mortality, the cases of Meakim and Albertson (pages 45 and 46) are illustrative examples. As further illustrating this point: Joseph Schwab, 149th St. and Southern Boulevard, New

York, bought a cow, which soon sickened and infected his herd, so that he lost twenty-three head in two months, and but seven recovered. In autumn, 1878, Bischoff, Long Island City, bought four cows of a dealer, all of which sickened, and only one was saved. Mr. Valentine, of Jamaica, L. I., bought some infected cows from two Brooklyn dealers, and by August, 1879, his herd was so badly diseased that we were compelled to slaughter the whole. Patrick McCabe bought five cows from a dealer; sickness appeared among them six weeks later. He lost the whole five, and within two months thereafter four more that he had laid in later.

The Losses must Increase as the Plague Reaches the Warmer States.—It is needless to multiply instances such as those given above. A mortality of seventy, eighty, or ninety per cent. in South Africa, and in the warm season in New York, implies that we should suffer an equal mortality in the Southern States throughout the greater part of the year, and in the hot summers of the Mississippi Valley, so that no estimate of losses deduced from the statistics of England or Western Europe will furnish fair data for estimating our own in case of a general infection of the United States. England, with 6,000,000 head of cattle, has lost $10,000,000 a year for forty years past. We, with 37,000,000 head, should therefore lose $60,000,000, plus the extra losses consequent on the spread of the plague in the semi-tropical summers of Texas, the Mississippi Valley, and the plains, where the great bulk of our cattle is kept.

Present Losses from the Lung Plague in the United States.—Of the present losses from the Lung Plague in the United States two items may be quoted as being more tangible than such incidental ones as the losses of pasture, fodder, buildings, current business, and prospective increase of stock. The items referred to are the depreciation of our beef in the English market and the losses by death in our home herds. The difference in value of American cattle when, as at present, compulsorily slaughtered at the port of debarkation, and when they can be moved inland and held for a market, is variously stated at from $7 to $10 per head in favor of the latter. From the port of New York alone the shipments during 1879 amounted to 95,380 head, which are therefore depreciated in value to the extent of $800,000. If we add the exports from Portland, Boston, Philadelphia, and Baltimore there must be a gross depreciation of no less than $1,500,000 per annum. The yearly losses from deaths in our herds cannot be less than $500,000 more, so that in these two items alone we are probably losing $2,000,000 per annum, though the plague has invaded but the merest fragment of our immense territory.

MEDIATE CONTAGION.—As our observations throw some light on this disputed question, a few illustrations may be given to show that direct contact is not essential to infection.

Infection through the Air.—It has long been noticed that successive victims in the same buildings are not attacked in the order in which they stand, but that the plague usually passes over two or three cattle to strike down a more susceptible subject at a greater distance. We have also noticed repeatedly that when the cattle of different owners stood under the same roof, but separated by a board partition, that infection spread quickly from the one to the other, though it was impossible for them to come in contact.

And yet a free dilution in the air seems to destroy the contagium in a very short distance. At Ridgewood, Queens Co., in the spring and summer of 1879 the herd of T. Ryan was almost exterminated by the Lung Plague, as many as twenty head having perished; while over the fence, in a building not over forty feet distant, the herd of George Van Size kept healthy throughout. Röll quotes instances of infection at fifty and one hundred feet, and others at two hundred and even three hundred; but in such cases there is always the possibility of the conveyance of the virus on light objects like paper, hay, straw, etc., blown by the wind, or on the surface of men or animals.

Contagion through the Clothes of Attendants.—1. In February, 1879, Ditmas Jewell, of East New York, interested himself in the cause of the suffering milkmen, and daily visited several of the worst infected stables in the locality. He also paid a good deal of attention to a favorite Jersey cow of his own, which was kept in a stable surrounded by spacious grounds and was never allowed to go out. In the end of March she sickened and died of Lung Plague.

2. Joseph Hyde, Seventieth St. and North River, New York, had lost twenty cows in four months, in the spring and summer of 1879, and was allowed to put up a new stable for fresh cows, two lots distant from his former one, on condition that separate attendants should be furnished for the two stables. The fresh cows were all from healthy country districts and the stable was built of new wood, yet a month later the plague showed itself in that as well. It was then found that the attendants in the different stables had helped each other in the owner's absence. As showing that the infection was not conveyed through the air, the lot between Hyde's two stables was occupied by the house and cow stable of a different party, whose stock kept sound throughout.

3. George Youngblood, Little Britain, Orange Co., sent a cow to New York by the Newburg boat May 29. She never left the pier, nor came in contact with other cattle except those coming by the boats from healthy country districts, but, like others, was handled by milkmen and dealers. She was taken back by the Newburg boat the same day she arrived (May 30), and two weeks later she sickened with Lung Plague, and conveyed it to Youngblood's herd. The cow was sent back to New York for sale September 30, when she was killed as a diseased animal, and nearly a third of one lung was found to be necrosed and encysted. (For other cases see my Report to General Patrick, presented to the Legislature.)

To deny the spread of the disease by this channel, as has been done, and to act upon this, is but to offer facilities for the plague to extend its ravages, and to render doubtful or impossible its final extinction.

Contagion through Infected Buildings.—Beside the fact, notorious in all countries where Lung Plague prevails, that dealers' stables are the grand foci of infection, and that animals sold by dealers are the most prolific causes of its spread, it may be well to name one or two instances in which empty infected stables served to propagate the pestilence.

1. John Müller, Farmingdale, L. I., on January 1, 1879, got from a dealer a cow which soon sickened and died. Soon after he bought another cow, which speedily died in her turn. Later he got a calf from the healthy stock of a neighbor; but it, too, sickened and died, and the stable was left tenantless.

2. Messrs. Niedlinger, Schmidt & Co., 406 E. Twenty-seventh St., New York, lost a cow from Lung Plague August, 1878. Three months later another cow was placed in the same stable, soon began to do poorly, and after a whole year (August 18, 1879) died of Lung Plague.

3. Patrick Green, West Farms, N. Y., entered the Bleach in April, 1879, and stocked it with thirty-two cows fresh from a healthy district. About May 1 sickness appeared in his herd, and then he learned that the tenant of the previous year had lost heavily with Lung Plague. Eleven of the stock had to be sacrificed before the disease was finally arrested.

4. Mr. John H. Cheever purchased of Mr. Odell a farm at Yonkers, on which a cow had died of Lung Plague one month before. In the end of September, 1879, he moved on fifteen favorite Jerseys from the Tilly Foster Mine farm, near Brewsters, placing them in the infected stables. Soon the plague attacked the Jerseys, and all died or were slaughtered.

Such cases could be adduced in great number; but these must suffice to show the urgent necessity for the thorough disinfection of stables, yards, cars, boats of all kinds, loading-banks, piers, etc., etc., where infected cattle have been, in order to a permanent extinction of this plague. This disinfection should of course be the more thorough the closer the infected building and the greater the accumulation of rubbish, fodder, etc., in which the virus may find a resting place. With free exposure to the open air disinfection takes place naturally and early.

Contagion through the Food.—1. Contagion through pastures is exceedingly rare. In the open air and in climates with frequent alternations of rain and sunshine, at seasons when the virus, like other organic matter, is not locked up in frost, a spontaneous disinfection takes place in a very short period. But with continuous frost or with a very dry, rainless climate the infection may be preserved for an indefinite length of time. A striking instance of the conveyance of the infection through pastures in a dry climate is furnished in the infection of Australia (page 51). The working oxen put upon the pastures where the sick cattle had been were themselves infected, and became the means of infecting the entire country.

The same is unquestionably often re-enacted during the dry seasons of our infected States, on the common or unfenced pasturages on which the herds of different owners graze successively. It has been a common practice for boys to watch such herds in order to keep them apart and prevent infection; but as they are allowed to browse successively on the same soil, the virus is transmitted and the disease spreads, in spite of this precaution, precisely as it did at the start of the plague in Australia.

The significance of such results cannot be overestimated. It has been amply shown above that the one great cause of the perpetuation of the plague on this continent has been the mingling of cattle on unfenced grounds; and it is now clear that it is not the mingling alone, but also the pasturage on the same place successively that is particularly dangerous. The contrast in results, as seen on a large scale, is sufficiently important to be quoted. In New Jersey and Pennsylvania, where the use of common unfenced pasturages was allowed, the Lung Plague is still very widely prevalent, after a year's work for its extermination. In New

York wherever it was possible to prevent such common pasturage the plague was definitely exterminated, though for half of the year lack of means prevented the prosecution of the work of extinction so vigorously as could be wished. Six out of eight infected counties were virtually cleared, and the seventh (Queens Co.) was also purified, except on its border adjoining Brooklyn (Kings Co., the eighth). In Brooklyn alone did the plague continue with little mitigation, for in Brooklyn the Aldermen passed an ordinance authorizing pasturage in common on unfenced lots, in defiance of the State law, and abolished the cattle pounds ; and in Brooklyn the police magistrates dismissed delinquents brought before them for violation of the State law, and reprimanded the officers who arrested them. The future may be predicted from the past. If the other infected States continue to allow the propagation of the plague by the common use of unfenced pasturages, and to allow cattle of all kinds to mingle and infect each other in their markets, they may spend hundreds of thousands on suppressive measures, but the plague will survive and the nation will continue to lose its millions annually ; whereas the loss now sustained in a single year, if faithfully and intelligently applied, would forever rid the country of the pestilence. If the Brooklyn city officials are to be allowed to defy the law in the future, as in the past, the splendid success of the first year's work outside that plague-spot will not be consummated for the entire commonwealth, but appropriations will be demanded ; and an expensive guardianship must be maintained year after year, with the greatest uncertainty as to the final extinction of the virus.

2. "*Swill.*" That "swill" is not the cause of Lung Plague is well enough known to all who have made a study of the affection. Distillers' and brewers' "swill" is fed in all the large western cities, where the Lung Plague is absolutely unknown. The same is true of swill-fed cattle kept in infected districts, but which have never been exposed to contagion. For three months in the end of 1879, and three

more in the beginning of 1880, over 700 western steers were kept in the Blissville distillery stables that had proved so fatal in the spring of 1879. The stables had meanwhile been thoroughly disinfected, and the greatest precautions were taken to shut up all channels of infection, and not one of these steers contracted Lung Plague. Yet the popular prejudice against swill is not devoid of foundation. To the distillery stables gravitate cattle from all regions, for fattening. If Lung Plague exists in the district such stables therefore become early infected, just as dealers' stables do in the same localities. In the swill stables the warmth and close, reeking atmosphere greatly favor the preservation of the virus and its conveyance from beast to beast. But it is further to be noted that in these stables the stock is arranged in rows, and a whole row of fifteen to twenty cattle is fed from the same trough. The trough is gently inclined from end to end, and the liquid swill runs into the trough from a pipe at the one end, and slowly passes in front of each animal in succession to the other. If a sick beast stands in such a row, the infected breath blows on the passing liquid and the virulent expectorations drop into the feed, to be carried on, to be inhaled and swallowed by all susceptible animals farther on in the same row. It may be that the virus introduced into the stomach is harmless, as implied in a solitary experiment at the Alfort Veterinary College; yet as cattle breathe on their food there cannot be a doubt that the virulent matter in swill, as in other fodder, makes its way to the lungs in the breath, and that infection from this food takes place in the ordinary way.

The Lung Plague Peculiar to Bovine Animals.—While cattle of all kinds are susceptible to the virus of Lung Plague, this susceptibility is limited to the bovine family. In the zoological gardens of Europe buffaloes and yaks, etc., have fallen victims to it, but in no instance has it been shown to extend to the smaller ruminants (sheep, goats, deer). This is the more remarkable that the small ruminants have often mingled freely in pastures and even in close buildings with cattle suffering from this complaint. In this respect, therefore, the Lung Plague differs essentially from the other great scourges of cattle—Rinderpest, Aphthous Fever, Anthrax, Tuberculosis, and Milk-sickness.

Incubation, its Limits.—The occasionally prolonged period of incubation, during which the virus remains dormant in the system of an infected animal, is one of the most redoubtable features of this disease, and demands from the official sanitarian a series of precautions which are not required in other cattle plagues. While incubation may be as short as six days in hot weather, it may none the less be extended to sixty days (Delafond, Verheyen), sixty-seven days (French Commission), ninety days (Reynal), or 104 (Röll, Gamgee).

In support of the last-named period three remarkable instances of the infection of new countries may be named.

Norway.—In 1860 some Ayrshire cattle were imported to the Agricultural College of Aas, direct from Scotland. Three months later some of them were noticed sick, and the country was only saved by the slaughter of all native stock with which they had come in contact, and the long seclusion of the surviving Ayrshires, so that danger of infection from them might be obviated.

Australia.—In 1858 a Shorthorn cow that had been three months at sea was landed at Melbourne, and a fortnight later she manifested the Lung Plague. This was 104 days after shipment from England, and the nature of the disease is only too sadly certified by the steady extension of the plague over Australia from the date in question.

South Africa.—In 1854 a Dutch bull was landed at Cape Town, after having passed two months at sea. Six weeks after his arrival he showed signs of Lung Plague, and from him the pestilence spread to the whole of South Africa, and still prevails. Here again was an interval of 104 days from the time of shipment in Holland to the first manifestation of the disease in Cape Colony.

To these may be added some instances that happened under our own observation, and the first two of which are as clear and unequivocal as the instances above mentioned.

In East Lothian, Scotland, in 1855, a farmer who had had his stock clear of disease for years, purchased a cow, which for three months after purchase kept in low condition, and occasionally knuckled over at the fetlock as if rheumatic, but fed and milked well. At the end of ninety days she was taken with Lung Plague, and conveyed it to all the cattle on the farm. There was no other Lung Plague in the neighborhood, nor had there been for a length of time.

Josiah Rogers, of Sag Harbor, Suffolk Co., N. Y., whose herd had been exposed by contact with a cow from an infected herd, but which did not herself show sickness, turned a cow out on the grounds of Montauk April 28, 1879. On August 10 she was found suffering from the Lung Plague, and was slaughtered in consequence. This was 104 days after she had left the home herd, and probably 110 or more after she had taken in the germs of the plague. The cow would not have been left to sicken on Montauk but that she was entered in the name of Mr. Rogers' son, and her connection with an exposed herd thus failed to be recognized. Four more of Mr. Rogers' herd suffered at home, and one after it had been sold and removed to Old Westburg, Queens Co., the sale having been made before we had any knowledge of disease in Suffolk Co. This cow sickened forty-nine days after she had left Rogers' place.

Messrs. Niedlinger, Schmidt & Co., 406 East Twenty-seventh St., New York, had a cow die of Lung Plague August, 1878. Three months later a fresh cow was put in the same stable (without disinfection). She did poorly since, and August 18, 1879, was found to have Lung Plague and was sacrificed. A case like this is inconclusive, as we cannot tell the date of infection from the contaminated stable; but in the continued unthriftiness it bears a striking resemblance to the Scotch case quoted above, and if it cannot be advanced as an incubation of nine months, it shows the great danger of passing as sound animals that have been in an infected and uncleansed building, though no active disease may have been shown there for many months.

John McGuigen, 173d St. and Central Avenue, New York, purchased in July, 1879, a fresh cow which milked well but looked unthrifty for five months. He had had no Lung Plague before, and purchased no new cows in the interval, yet in the end of November, 1879, she sickened and died a most characteristic case of the plague.

These two last cases are not advanced as proof of such protracted incubation, for in an infected city it is possible that the virus was conveyed to them by visitors. Yet their continued unthriftiness, so like what appears in certain other cases of prolonged incubation or delayed development of the plague, makes them specially suggestive, and should make observers watchful for other cases in which the incubation may possibly have exceeded the present certified limit of 104 days.

Official Action in View of such Prolonged Incubation.— Seeing that the germs may be carried in the system of the infected animal unseen and undetectable for 104 days (fifteen weeks), it follows that, to secure stock against danger from a single animal coming from an infected district, such animal should be secluded in quarantine under special attendants for this period of time. In the case of a single animal arriving from a foreign country, he should be detained at the port or landing until the expiry of fifteen weeks from the date of shipment from the foreign port. With herds more latitude may be given ; for if infection should be present it is almost certain that the incubation will be shorter in some, and thus symptoms will be shown at an earlier date. Yet a period of detention of ninety days cannot be safely abridged. In case of the transportation of cattle from infected States and districts a quarantine for at least the same length of time is essential, while in the case of single animals it cannot be considered as protective unless it has been extended to 104 days.

As the different States have not recognized the need of veterinary sanitary specialists to direct their suppressive measures, the most egregious blunders in this respect have been committed in practice.

In the autumn of 1879 two herds of cattle from infected Holland were entered at the port of New York, examined by the New Jersey officials, and at once sent on to Illinois to mingle with herds from which sales were being constantly made, and even to be carried around and exhibited at various State fairs.

The same New Jersey authorities kept on their frontier inspectors with instructions to examine all cattle coming from the infected regions of Pennsylvania, Delaware, and Maryland, to turn back all the diseased, but to allow the sound to enter. It was well, truly, to shut out the actually sick; but where was the protection when cattle from infected herds, and bearing diseased germs which would not manifest themselves for one to three months to come, were allowed free entrance?

In Pennsylvania the attention of the officials seems to have been confined to the quarantining of infected herds and the slaughter of the incurably sick, and there is reason to believe that in many cases the quarantine was raised at far too early a date. In Pennsylvania, as in New Jersey, store and fat cattle from all quarters—infected and otherwise—were admitted together or successively into the same stock-yard for sale. In short, suppressive measures were largely restricted to the dealing with herds after they had become infected, while the main sources of the pestilence, the cattle coming from infected districts and those sold in infected markets, were left free to carry disease into new herds.

To crown this series of blunders, the present officials of New Jersey threaten those of New York with litigation in the Supreme Court of the United States, with the view of forcing the latter to admit New Jersey store cattle into the New York markets. Had these officials had an intimate acquaintance with every herd in New Jersey for six months past, there would have been a shadow of reason in their course ; but, having just come into control of the veterinary sanitary work, the best construction that can be put upon their course is that they are wofully ignorant of the subject, and are judging this disease from some supposed but unreal analogy with certain plagues of men, in which incubation does not extend over a few days.

Some of the officials in question claim special credit for husbanding the country's money, and it is claimed that Pennsylvania has expended less than $3,000 in indemnities for slaughtered cattle. No reflection could be more condemnatory of their system. In place of a vigorous plan of extinction founded on an intimate knowledge of the plague, and which bars all channels for its further diffusion, while the infection that is already in existence is being remorselessly *stamped out*, they adopt measures that are defective at every step ; and, while they restrict the pestilence at one point, they actually favor its spread to other parts of their territory and that of their neighbors. They cut down a few shoots that have already grown up into plants, but pay no attention to the incessant sowing of the same noxious seed going on all around them. They save a few thousand dollars to the treasuries of their respective States, but in doing so they are perpetuating the Lung Plague on the continent at a present cost of $2,000,000 per annum to the nation (see page 56), and they are every day endangering the spread of the plague to our Southern and Western cattle ranges at a prospective loss of $60,000,000 per annum (see page 55). An economy which puts men who are unacquainted with a plague in charge of the measures to be carried out for its extermination is the most reprehensible misappropriation of public money, since it leads the people to believe that all necessary precautions are being taken, while in fact it is but maintaining a heavy expense with no adequate result.

TENDENCY TO THE ENCYSTING OF DEAD MASSES OF LUNG. —The limits allotted to this article will not allow a consideration of the distinctive symptoms and pathological lesions of this disease (for this see my *Lung Plague*, or my *Report for* 1879); but there is one pathological feature of this complaint with such all-important bearings that it cannot be passed over unnoticed : This is the constant tendency to the death of large portions of the lung by the plugging of its blood-vessels, and to the inclosure of such necrosed masses in a complete fibrous cyst formed by the organization of the surrounding exudation. The blood-vessels leading to a particular group of lobules become implicated in the inflammation even to their internal coats ; the blood contained within them immediately coagulates ; the normal circulation in such parts ceases ; the blood that filters into their capillaries from those adjacent loses its liquid portion by quick transudation through the coats of the vessels, so that they are left filled to repletion with blood-globules only ; the circulation and life in such parts cease, and around their margin where the blood still circulates the exudation is slowly built up into fibrous tissue, forming a complete and unbroken envelope in case of recovery The imprisoned mass of dead lung, completely excluded from contact with air and aërial germs, does not putrefy, and never exhales a septic odor. It undergoes a slow metamorphosis through its contained cells and granules into a purulent liquid, which is absorbed with equal tardiness. The liquefactive metamorphosis commences at the surface, separating the dead mass from the sac, so that it appears for the future as a great solid nucleus floating in a variable amount of purulent fluid. When large masses are encysted in this way it may be over a year before the whole has been liquefied and removed, and not unfrequently after nine months the outline of lobules, air-tubes, blood-vessels, and nerves can still be traced with ease in the necrosed lung.

The important bearing of this is related to the lack of all putrefaction or other important changes in the mass of necrosed lung, which, in the absence of such metamorphosis, remains an encysted mass of infecting material so long as it continues solid and unchanged. To the average mind—and even to the medical one who has made no special study of this disease—the danger even of infection seems past when the patient has for some time resumed its appetite, rumination, milking, natural breathing, and, above all, its disposition to lay on fat. Yet the majority of patients that have apparently recovered carry within their chests the encysted necrosed masses above described; and so long as these remain they cannot be considered otherwise than as exceedingly dangerous to other stock. It is true that the bearers of these encysted masses will often stand for months beside other cattle without infecting them; but it is none the less true that each bears within its chest a sealed-up store of infection, and there is only wanted a breach or change in the surrounding fibrous envelope to allow the deadly virus to escape.

Instances of Infection from Encysted Necrosed Lung.—Charles Reeves, Success, Suffolk Co., N. Y., bought two calves from the infected Isaac Billard herd about January, 1879. They did badly. In June he lost several animals infected from these, and on July 19 I visited his place and found a cow, a steer, and a calf infected from the same source.

George Patrick, Patterson, Putnam Co., purchased a cow in February, 1879, which sickened in April, but recovered. Others died in June, July, and August. On Sept. 15 I found four sick and had them disposed of; and Oct. 15, when the whole herd was slaughtered, the cow that had recovered in April was found to carry still a solid encysted mass as large as an egg. This is more interesting as showing the long retention of the encapsuled mass, even after a very mild case, than as positive proof of the infection from this source.

R. Braun, Lorimer St., Brooklyn, had a yearling heifer that had been kept in the Blissville distillery stables prior to their quarantine in Feb., 1879. Her infection, therefore, dated back to January. July 26 he applied for a permit to send this heifer to the country, but on examination she was found to carry a large mass of encysted lung. She was sent to the slaughter-house, being in fine condition, and a large encysted mass was found as expected. On August 22 a fine Shorthorn cow that had been sent from a healthy district through our inspection yards direct to Braun's stable was found very ill with Lung Plague, and had to be slaughtered.

In place of furnishing further cases of my own it may be well to quote one from another source confirmatory of mine.

In the *Récueil de Médecine Vétérinaire*, March, 1879, M. Raboüam records the case of an ox supposed to have chronic bronchitis, and brought from a stable where Lung Plague formerly prevailed, transmitting the disease to the healthy stock of his purchaser.

The dangers from animals bearing these encysted masses are hardly less than from those still in the incubative stage of the disease. Be it understood that many cattle that bear such masses have natural pulse, temperature, and breathing, will lay on flesh, or yield as many as fifteen quarts of milk per day ; and it can be easily perceived how such animals will change hands, and pass into fresh and susceptible herds without any consciousness of wrong on the part of either buyer or seller. Such animals may any day carry infection from State to State, or from the infected States to our unfenced Territories, where, owing to the constant commingling of herds, it will be impossible to eradicate the virus. Many such cases can with difficulty be detected even by the most carefully conducted professional examination ; much less are they likely to be recognized in the hurried examinations that can be given to a large number of animals at a frontier. In short, these chronic cases with encysted necrosed lung and the long period of incubation of the Lung Plague condemn absolutely the passage of animals on a mere examination and without the attendant quarantine of three months. Cattle for immediate slaughter may be passed under such precautions as shall prevent their contact with or proximity to store cattle ; but the passage of store cattle on examination only betrays the unfitness for his office of him who prescribes it.

The same considerations show the utter inadequacy of any measures that fail to reach every infected locality and every infected herd, and to prevent the shipment of any cattle from any infected district.

To have suppressive measures effectual, either there must be a central controlling Federal authority that will grapple intelligently with the plague in every State, district, and herd simultaneously, and thus prevent its spread; or every State bordering on an infected one, or having maritime commercial relations with it, must impose a three months' quarantine on all cattle from such infected State. The folly of the present system is stupendous, and the common markets for store and fat cattle from infected and healthy districts, the passage of animals from an infected State on a simple examination, and the threats of one class of officials of forcing upon their neighbors the stock from their infected territory furnish a spectacle that is a disgrace to the intelligence and science of the nineteenth century, and a travesty on all national sanitation.

Value of Fumigations with Sulphurous Acid.—As a disinfectant for Lung Plague no better agent exists than sulphurous acid, produced by burning flowers of sulphur in the contaminated building. But the value of this agent is perhaps even greater as a prophylactic agent for cattle that have been exposed to the contagion. I shall quote but three illustrative cases, and refer the reader for further evidence to my *Report for* 1879.

Timothy Ryan, Ridgewood, L. I., kept on an average twenty-five cows, and had lost twenty head within the year. The stables were so thoroughly saturated with infecting materials that our own inspectors and eminent veterinarians from a distance concluded that it would be impossible to disinfect the premises. The wooden flooring was replaced by new, a quantity of filth was removed from beneath, the soil was sprinkled with quicklime, and the building whitewashed with chloride of lime. Whitewashing had been resorted to before, but with no good result. On June 15, 1879, he commenced fumigating the cows twice daily with sulphurous acid, and, although he had some fresh and susceptible cows in the stable, not one more contracted the plague.

Patrick Green, West Farms, New York Co., entered infected premises in April, and by July had lost by the plague twelve out of a herd of thirty-two head. After the sickness appeared the cattle were kept at pasture to avoid the infected buildings and secure pure air; but as the plague continued, I now directed him to turn the herd into the buildings for half an hour twice a day, and make them breathe as much sulphur smoke as they could bear without violent coughing. From that time not one more case of the plague developed.

James Cowan, Yonkers, in April, 1879, bought a cow from Hog Hill, which infected his herd. By July 12 he had lost eight out of a herd of twenty-three, notwithstanding that they were kept in the open field and fed tonics (including sulphate of iron). I now enjoined him to turn them into the stables twice daily, and fumigate for half an hour each time with sulphurous acid. This was done, and not another case of sickness occurred.

A wide experience enables me to place a high value on this measure as an auxiliary to the slaughter of the sick and the purification of the premises by aqueous disinfectants. To its proper application certain conditions are indispensable: 1. All virulent matters in the buildings, drains, manure heaps, etc., must be destroyed. 2. No animal with manifest disease must be retained in the herd, nor have access to it or its pasturage. Chronic cases with necrosed encysted lungs must be removed, as well as the acutely diseased. 3. The attendants should not be allowed near diseased animals. 4. The buildings must be close enough to confine the fumes of sulphurous acid so that it may be breathed of sufficient strength for half an hour in succession each time. 5. The administrator must be intelligent and reliable, and must shut himself in with the animals, so that he may watch the result and push the production of the gas as far as the animals can breathe without irritation, and at the same time be ready to open doors and windows and admit the air promptly in case of an overdose.

Suppression of Lung Plague on the Large Common Pasture of Montauk.—On May 7, 1879, while on a visit to infected herds in Suffolk Co. I learned that some yearlings from the same herd that had infected the county had been turned out on the great pasture of Montauk, a stretch of 12,000 acres at the east end of Long Island, on which were 1,100 head of cattle, the property of about 200 owners. As the yearlings from the infected herd were alleged to be sound we had no power to act until the passage of a bill then pending, which empowered us to deal with animals that had been exposed to infection. On May 21 and 22 twenty head of cattle—all that could be traced to the infecting herd or to herds with which cattle from the infecting one had mingled—were killed, about half of those that were opened showing the disease in the chronic form. Two more cases of sickness occurred on the range on July 15 and August 10 respectively, both in cattle that had had communication with the infecting herd, though this information had been withheld at the earlier slaughter. Aside from them the whole herd had escaped. The reasons of our unprecedented success in Montauk are manifestly these: 1. The Montauk pasture was large enough to allow ten acres to every animal. 2. The cattle belonged to many different owners, in lots of from one to fifty head. The cattle of different owners, being strange to each other, herded widely apart, so that there was virtually no chance of infection from the herd of one owner to that of another. 3. They were never yarded nor turned into buildings *en masse*, so as to concentrate the virus. 4. There was no meeting at any common watering place, for ponds abound all over the range. 5. Whenever a herd was known to have had any communication with cattle from the infected herd, such herd was slaughtered without exception. 6. The two cattle that suffered later in the season were the only cattle from their respective owners, and had never herded with any other stock on the range.

Had these cattle been crowded more closely on a smaller pasture; had they pastured successively on the same ground; had they been frequently rounded up, yarded, or stabled; had they all been watered from a common pond or trough; had they been accustomed to meet to eat grain or salt from troughs; or had they become acquainted so as to congregate at night in one vast herd, as occurs on Montauk later in the season, it would have been impossible to prevent infection. The prevalence of this plague for ages on the unfenced steppes of the Old World, and for decades on the open ranges of South Africa and Australia, in defiance of all the efforts of owners and governments, shows only too clearly that in all but very exceptional conditions the advent of this plague to such unfenced territory means its spread and permanent prevalence in such a district. It is but repeating on a large scale what has for thirty-seven years preserved and extended the infection on our own eastern seaboard, and what must continue to maintain it until common pasturage is abolished. Our Montauk triumph gives no hope of the extermination of the plague from our great grazing lands in case they should become infected, so that the imminent risk of infecting these means the risk of imposing a perpetual annual tax on the nation of $60,000,000 and upward.

Results of One Year's Labor.—In the course of the year we have caused the slaughter of 1,400 cattle that had either developed the Lung Plague or had been exposed to its infection; we have abolished common pasturages in all infected districts excepting one (Brooklyn, where circumstances prevented this); we have controlled the movement of cattle in all infected districts, and have virtually rooted out the plague from seven counties, leaving but one (Brooklyn and suburbs) in which the affection still prevails.

While a multitude of details were needful for each district, it will be instructive to notice the main restrictions in force in New York city, where the disease was suppressed, as compared with Brooklyn, where it still remains to be dealt with.

By July 1, 1879, we had perfected arrangements to receive fresh cows and other store cattle, from healthy districts only, into new inspection yards from which all other stock were excluded, and to allow no other animals to be distributed as store cattle in or from New York. Pasturage was allowed in inclosed ground only where herd would be safely secluded from herd. The police seconded our efforts, so that no cattle could be moved on the streets without a special permit, granted after inspection of the herd to which such belonged. Dealers' stables, which in such localities soon become simple pest-houses, were abolished; no cows were allowed to leave city stables except for slaughter; and, as the fountain of infection was thereby stopped, every subsequent step made in dealing with disease in individual herds was a decided and permanent gain. New infections were exceedingly rare, and the old ones only had to be stamped out. With such measures success was assured.

I urged strongly that Brooklyn should be put under a similar system; and had this been resorted to there can be no doubt that the results would have been similar in that city, and that the State of New York would have been to-day practically free from Lung Plague. But the prospective lack of means, the existing opposition of the city magnates and magistrates, and other considerations which need not be mentioned here stood in the way. The adoption of the approved measures was deferred until there should be less to hinder; and, although money has at last been appropriated by the Legislature, three months have elapsed without any satisfactory movement in this direction. With regard to this it need only be said that any ostensible economy that entails delay in the extinction of the disease is the most wasteful prodigality. The perpetuation of a force of officials and inspectors becomes much more expensive than the execution of the work in a sharp and decisive manner and in a much shorter period of time; the maintenance of the plague in the infected district leads to a continuous and, in the end, a far greater outlay in indemnities for cattle slaughtered; the continued interference with the normal channels of home trade heightens the burden in a way that cannot easily be estimated; the persistence of the plague loses to the nation $1,500,000 a year on our exports to England; and, finally, every day of delay endangers the infection of the Middle States and of the Western and Southern grazing ground, which would perpetuate the plague forever, and entail an annual tax equal to that imposed by the late war.

Already we see the evil effects of a relaxation of efficient work in other parts of New York than Brooklyn. When the appropriation was made in February I at once took measures to increase the veterinary staff and actively resume the aggressive work that had been so long and injuriously delayed. But orders were received to reduce the force of inspectors still further, and at the same time the system of distributing fresh cows and other store cattle from the inspection yards only was seriously relaxed; and though there is as yet little time for more than the incubation of the plague, cases have appeared in fresh cows taken into sound stables in New York and Brooklyn, and Staten Island, which has been sound for over a year, has again become extensively diseased.

XIII.

FIELD EXPERIMENTS WITH VARIOUS CROPS.

By Prof. I. P. Roberts.

A.

Experiments with Wheat.—All quantities given, whether of manure, seed, or crop, are given for the acre, *unless otherwise specified.*

I.

Wheat—Different Fertilizers. 1874–5.—Plots 1 acre in size.

	Treatment.	Yield. Pounds.
1	16 tons farmyard manure, moderately well rotted, applied on surface and harrowed in	583.5
2	100 bushels lime ashes from lime-kiln, applied on surface; cost 15 cents per bushel	561.5
3	200 pounds Ralston's superphosphate, drilled with wheat	603
4	200 pounds Woodruff & Chamberlain's superphosphate, drilled with wheat	648.5
5	Nothing	441.5
6	200 pounds Phillips's improved superphosphate, drilled with wheat	513.5

The season was poor and the winter severe, and many pieces of wheat were plowed up. The soil was clayey ; the clover and timothy sod was plowed in July ; the seed (Clawson) was drilled September 8 and 9. Land in fine order. All the plots were sowed to timothy a few days after the wheat was sowed. The great injury to wheat which occurred in March permitted the timothy to make a very rank growth, especially on plot No. 1, where farm manures were applied ; from this fact the yield of No. 1 was diminished far more than that of any other. The increased growth of the grass on this plot over the others was very noticeable the next year.

II.

Wheat by the Lois-Weedon System. 1874.—This experiment was tried on a field of clayey land, which in 1873 produced oats, without manure, and in 1872 and for several years previous was a blue-grass pasture, and considered very poor ; it was in a bad, lumpy condition after the oat crop of 1873. It was summer fallowed in 1874, and not manured.

The plot, 20⅔ rods long, was cut up into strips 5½ feet broad, which were numbered 1, 2, 3, etc. The odd strips were drilled and the even strips cultivated ; the following year, as will be seen further on, the even strips were sowed, and odd strips cultivated. The ground was was in good condition when sowed with Clawson wheat at the rate of two bushels. These experiments were conducted with a view to ascertaining the effect of superior culture without manures on poor lands. By this alternate method each plot was under summer fallow every alternate year.

Yield First year,	1874–5,	season	poor,	158 lbs.
" Second "	1875–6,	"	fair,	369 lbs.
" Third "	1876–7,	"	superior,	694 lbs.
" Fourth "	1877–8,	"	fair,	637 lbs.

No wheat was sown on these plots in the fall of 1878 ; in the summer of 1879 all plots were given a thorough summer fallow ; the odd numbers are now in wheat.

III.

Wheat—Different Methods of Seeding. 1874–5.—The soil, etc., were the same as in I.

	Treatment.	Yield.	
		bu.	lbs.
1	Drilled, 2 bushels,	24	55
2	Broadcast, 2 bushels,	22	30
3	Drilled, 3.5 bushels,	20	50
4	" 3 "	20	50
5	" 2.5 "	16	30
6	" 2 "	11	30
7	" 1.5 "	4	5
8	" 1 "	—	—
9	" .5 "	—	—

Plot No. 1 was nearest to, and plot No. 9 farthest from, a north and south fence ; as the distance from the fence increased, the exposure to high winds increased. Therefore they *should be compared by couplets or triplets, rather than by extreme numbers.* The plots were 0.1 of an acre each.

IV.

Wheat—Different Methods of Seeding and Manuring. 1875–6. The field and arrangement of plots were the same as in III, except that the numbers were reversed, and the thin seeding was next to the fence.

	Treatment.	Yield. bu.	lbs.
1	Drilled, 2 bushels, 2 bushels plaster	22	55
2	" 2 " no fertilizer	20	40
3	" 2 " "	18	40
4	" 2 " 200 pounds superphosphate	23	30
5	" 3 " " "	28	20
6	" 2.25 " " "	21	15
7	" 2 " " "	21	—
8	Broadcast, 2 bushels, " "	18	30
9	Drilled, 1.5 " " "	*23	50
10	" 1 " " "	*25	—

* Protected by fence and snow.

V.

Germinating Power of Old Wheat. 1874.—Two hundred varieties from the museum, which had been five years from England, were sowed and all failed to germinate. These varieties had been kept unthreshed in the museum under the most favorable circumstances.

VI.

Wheat—Different Methods of Seeding or Culture, Different Manuring and Varieties. 1876–7.—Plots 0.1 of an acre. The field was the same as in IV. Every other drill mark in plot No. 1 was hoed out, leaving the drills sixteen inches apart, and really but one bushel per acre of seed. Three hoeings in all were given to this plot. The quality of plot 13 was not nearly so good as of 14. The ground was plowed twice after the previous crop of wheat, with liberal top-culture.

	Treatment.	Yield.	
		bu.	lbs.
1	2 bushels, drilled, hoed	24	20
2	2 " plastered Sept. 6, 300 lbs.	26	5
3	2 " Stockbridge fertilizer, 270 lbs.	28	50
4	2 " nothing	28	
5	2 " superphosphate, 355 lbs.	25	40
6	2 " nothing	24	10
7	1.25 " "	18	10
8	3 " "	24	30
9	2 " "	25	30
11	2 " broadcast	24	45
12	2 " mulched with straw	25	
13	2 " new variety from Cayuga Co.; donor unknown	26	
14	2 " Clawson	24	20

VII.

Wheat—Different Methods of Seeding or Culture, Different Manuring or Varieties. 1877–8.—Plots $\frac{1}{16}$ of an acre. The ground was clayey and had been in wheat the three preceding years. Plots 4, 5 and 6 were left without manure for the purpose of testing the uniformity of the soil. Plots whose numbers and yield are not given were discarded.

	Treatment.	Yield.	
		bu.	lbs.
1	9 pecks, no fertilizer	28	2⅔
2	9 " 400 pounds Lister ground bone	29	52
3	9 " 400 pounds Crocker's Buffalo superphosphate	31	52
4	9 " no fertilizer	22	48
5	9 " "	21	36
6	9 " "	22	16
7	9 " subsoiled, no fertilizer	16	32
10	9 " 400 pounds plaster	24	40
11	9 " 400 pounds Preston's superphosphate	22	
12	9 " no fertilizer	30	24
13	9 " 400 pounds Sol. Pacific guano phosphate	24	40
14	9 " no fertilizer	23	52
16 17 18	Selected seed, 600 pounds Sol. " " Pacific guano " " phosphate.	29	30⅔
19	5 pecks, no fertilizer	21	12
20	9 " broadcast	22	
21	9 " drilled	24	24

VIII.

Wheat—Different Fertilizers and Methods of Culture. 1878–9.—Plots $\frac{1}{50}$ of an acre. Seed was sown at the rate of two bushels per acre, unless otherwise designated, except in plot 30, which was actually seeded at the rate of one bushel, as half of the drills were hoed out.

	Treatment.	Yield.	
		bu.	lbs.
1	1.5 bushels of seed, no manure	18	20
2	3 " " "	20	50
3	.75 " " "	19	10
4	2 " " "	20	
5	1.75 " " "	20	
6	500 pounds soluble Pacific guano	25	
7	Nothing	21	40
8	500 pounds White & Son's superphosphate	30	
9	Nothing	15	50
10	500 pounds Poplein's silicated phosphate	19	35
11	4 bushels of plaster	22	5
12	Nothing	25	
13	New variety		
14	800 pounds soluble Pacific guano	23	20
15	Nothing	25	25
16	"	25	
18	"	21	40
19	800 pounds Poplein's silicated phosphate	24	10
20	800 pounds soluble Pacific guano and 800 pounds White's superphosphate	21	40
21	14 loads farm manure, 4 plots together	26	15
22	400 pounds salt, 2 plots together	20	25
23	80 bushels lime	22	5
24	400 pounds sulphate of ammonia, applied in fall	19	35
25	Nothing	18	20
26	400 pounds sulphate of ammonia, applied in spring	22	5
27	400 pounds Pacific guano, 400 pounds sulphate of ammonia, applied in fall, and 400 pounds sulphate of ammonia, applied in spring	17	30
28	400 pounds sulphate of ammonia, applied in fall	20	
29	400 " " " " spring	17	30
30	Drilled double width and hoed	13	20

IX.

Wheat—Summary of Results.—

Drilled and Broadcast Sowing.

	Drilled.		Broadcast.	
	bu.	lbs.	bu.	lbs.
1875	24	55	23	30
1876	21		18	30
1877	25	30	24	45
1878	24	24	22	
Average,	23	56¼	21	56¼

Thick and Thin Seeding.

			bu.	lbs.
1 year,		3½ bushels,	20	50
4 years,		3 "	23	23½
4	"	2 "	20	15
2	"	2¼ and 2½ bushels	18	22½
3	"	2 years 1½ bushels and 1 year 1¾ bushels	15	25
1	"	¾ bushel (protected by fence, and snow, hence cannot be fairly compared with others)	25	

Comparison of all plots phosphated for four years with adjoining plots on which no fertilizers were used.

	bu.	lbs.
Average of all phosphated plots	21	31⅔
" " adjoining unfertilized plots	22	33

Phosphates do not seem to produce marked results on pine and hemlock lands of drift formation; results upon similar soils in other localities sustain us in this inference from our experiments. On maple and beech lands of a different formation they have produced marked results.

Comparison of plots plastered for three years with adjoining plots unplastered.

	bu.	lbs.
Plastered, average	24	33⅓
Not plastered, average	23	41⅔

Comparison of plots hoed for two years with adjoining plots not hoed.

	bu.	lbs.
Hoed	18	50
Not hoed	23	10

It must be remembered that while the plots were of the same size, there were twice as many drill marks in the plots not hoed as in the hoed, and consequently twice as much seed upon these plots.

B.

Experiments with Oats.—All quantities specified relate to the acre.

I.

Oats—Different Methods of Culture. 1875.—The land was clayey and had been in clover and timothy in 1873 and in corn in 1874. The ground was mellow and in good condition when sowed with common white oats, May 1, 1875. Plots were $\frac{1}{24}$ of an acre.

	Treatment.	No. pks. seed.	Yield.	
			bu.	lbs.
1	Broadcast, spring plowed	12	60	18
2	Drilled, " "	16	58	14
3	" " "	12	53	21
4	" " "	7	47	26
5	" " "	5	54	6
6	" fall plowed, replowed April 30	12	52	19
7	" " cultivated with Western Cultivator April 30	12	54	6
8	Drilled, spring plowed	12	54	6
9	" not plowed, surface cultivated twice	12	56	10
10	" plowed and subsoiled, May 1	12	58	14
11	" plowed 5 inches deep, April 30	12	66	30
12	" plowed 9 inches deep, April 30	12	60	18
13	" spring plowed, sowed May 1	12	41	14
14	" fall " " "	12	30	26

The straw on plot 14 was larger and the berry plumper and larger than in plot No. 13. These two plots did not adjoin the others ; the soil was a poor clay.

II.

Oats—Different Methods of Culture, Seeding and Fertilizing. 1876.—Plots $\frac{1}{24}$ of an acre.

	Treatment.	Variety of Oats.	Pecks of seed.	Yield.	
				bu.	lbs.
1	Drill culture	Ovid	12	54	
2	Broadcast	"	12	63	
3	Unrolled	"	12	58	16
4	Rolled	"	12	55	4
5	Plastered	"	12	53	8
6	Not plastered	"	12	46	16
7	50 bushels lime	"	12	50	8
8	200 pounds salt	"	12	52	16
9	Not salted	"	12	44	8
10		"	16	40	16
11		"	10	36	24
12		"	8	36	24
13		"	14	42	
14		Univ. White,	14	40	16
15		Waterloo White,	14	46	28
16	408 pounds salt	Ov. & W'loo m'x'd	12	41	20
17	600 " "	Ovid	12	48	12
18	Hoed three times, every alternate drill-mark vacant	"	12	37	28
19	Not hoed	"	12	37	16

The University White were ripe July 20 ; the Waterloo White, July 24 ; the Ovid, August 4. Plot No. 18 really had but six pecks per acre, as one-half of the drills were hoed out.

III.

Oats—Different Fertilizers, Varieties of Seed, or Different Cultivation. 1877.—Plots were $\frac{1}{40}$ of an acre. The ground was clayey and in fine condition.

Three bushels of seed per acre were sown, unless otherwise stated ; the seed was put in early, but drilled in too deeply; heavy, cold rains fell in a few days, the ground ran together and baked ; probably not more than one-half of the plants appeared above ground. Plots 13 and 14 were in another field, and sowed under more favorable conditions, except that the soil was much poorer.

	Treatment.	Yield.	
		bu.	lbs.
1	400 pounds of Lister Bro's' superphosphate of lime	42	11
2	400 " " " ground bone	37	31
3	400 " of Crofut & Co.'s Syracuse superphosphate	39	7
4	Nothing	34	7
5	400 pounds of Stockbridge oat manure	35	15
6	400 " refuse salt	31	23
7	Nothing	28	19
8	400 pounds of Cayuga plaster	26	23
9	Seneca Falls seed, 3 bushels	12	6
10	Cornell University seed, 4 bushels	35	15
11	" " " 2 "	22	11
12	" " " 3 "	33	4
13	Subsoiled	38	6
14	Not subsoiled	34	14

IV.

Oats—Different Fertilizers. 1879.—Plots $\frac{1}{10}$ of an acre in size.

	Treatment.	P'cks of seed.	Yield.	
			bu.	lbs.
1	500 lbs. Pacific guano phosphate and 250 lbs. sulphate of ammonia	10	41	8
2	No fertilizer	10	38	29
3	750 lbs. plaster and 75 lbs. refuse salt	10	25	25
4	No fertilizer	10	22	21
5	"	10	22	6
6	" harrowed when about 2 inches high	10	17	6
7	"	7	26	28
8	"	5	25	20
9	"	16	37	16
10	"	12	39	12
11	130 lbs. sulphate of ammonia and 260 lbs. Pacific guano phosphate	10	23	14
12	No fertilizer	10	17	26

Nos. 1 and 2 on ground in roots the previous year. Nos. 3 to 6 inclusive in oats the previous year. Nos. 7 to 12 inclusive were in corn in 1878. Nos. 11 and 12 did not adjoin the others. In studying the table, comparison should be made between plots situated near together, as 1 and 3 or 7 and 10, and not between those situated far apart, as 2 and 11.

V.

Oats—Summary of Results.—

Averages of Thick and Thin Seeding for Four Years.

	bu.	lbs.
5 pecks per acre	39	29
7 and 8 pecks per acre	41	25
12 " "	42	20
16 " "	42	31

	bu.	lbs.
Two years' average of all plots treated with commercial fertilizers	35	2
Two years' average of unmanured plots	30	4⅔

	bu.	lbs.
Broadcast, 2 years	61	16
Drilled, 2 "	56	

	bu.	lbs.
Subsoiled, 2 years	46	19
Not subsoiled, 2 years	48	33

	bu.	lbs.
Salt, 2 years, 4 plots	43	18
Not salted, 2 years, 4 plots	39	7

	bu.	lbs.
Plastered, 2 years, 2 plots	40	
Not plastered, 2 years, 2 plots	37	19½

The results of experiments conducted but one year appear in the previous tables, and a recapitulation would add nothing to their clearness.

Phosphates, including application, cost on an average about $40 per ton ; plaster, $5 ; salt (refuse), $4.50 ; lime, $8.75. Our experiments and observation lead us to believe that oats drilled early on mellow, clay land, and especially if followed by heavy, cold rains, do not germinate so well as when sowed broadcast. Our drill is the "Farmer's Favorite."

C.

Experiments with Corn.—All quantities, unless otherwise designated, relate to the acre, and as to the crop relate to bushels and pounds of ears, seventy pounds of ears being allowed to the bushel. All plots were separated by one vacant row. All manures, unless otherwise stated, were dropped in the hill and mixed with the soil.

I.

Corn—Different Culture, Liming, Suckering. 1875.—Plots 1 to 13 inclusive were planted with Eastern, 8-rowed, yellow corn. In 1874 the ground was in corn, without manure, and in 1872 and 1873 in clover and timothy. The soil was a sandy loam.

	Treatment.	Yield lbs. per plot.		Yield.	
		Sound.	Soft.	bu.	lbs.
1	Ridge culture	352	55	58	10
2	Deep "	290	19½	44	15
3	Shallow "	324	43½	52	35
4	Continuous culture, 7 times	362	22	54	60
5	Drilled culture, 1 stalk per foot	365½	18	54	55
6	5 stalks in a hill	369	29	56	60
7	4 stalks in a hill	438	44	68	60
8	3 stalks in a hill	301½	127	61	15
9	2 stalks in a hill	266	49	45	
10	Not limed, eastern variety	335	51	55	10
11	Limed, 200 bushels per acre	493	57	78	40
12	Not suckered	338	50	55	30
13	Suckered twice	306	42	49	50
14	Not limed, western variety	not fully ripe.		48	55
15	200 bu. lime, western variety	"		77	60

II.

Corn—Different Seeding, Culture, and Manuring. 1876.—The soil was very sandy and gravelly, and suffered from drouth. Four stalks were left in each hill, unless otherwise specified; the hills were 3.5 feet apart, both ways. The corn was cultivated four times and hoed once.

	Treatment.	Yield.	
		bu.	lbs.
1	5 stalks per hill	41	10
2	4 " "	42	20
3	3 " "	42	20
4	2 " "	34	20
5	2 spoonfuls plaster to hill applied June 5, corn coming up	39	30
6	Not plastered	36	40
7	Suckered	38	60
8	Not suckered	39	10
9	Seed soaked two hours in hot water and rolled in plaster	41	50
10	Seed from tips of ears	31	30
11	" butts of ears	29	10
12	" middle of ears	33	10
13	500 pounds Ralston's superphosphate	38	20
14	500 " Peterson & Son's superphosphate	34	20
15	Nothing	35	30
16	500 pounds Bradley's superphosphate	37	10
17	Plaster applied June 5	28	40
18	Ashes, 2 spoonfuls per hill, June 5	38	20
19	5 stalks per hill	38	60
20	4 " "	34	60
21	3 " "	32	40
22	2 " "	29	10
23	2 spoonfuls plaster, June 5	35	30
24	Not plastered	29	50
25	Seed soaked 12 hours and rolled in plaster	40	40
26	Suckered	28	40
27	Not suckered	33	50
28	Seed from tips of ears	38	20
29	" butts of ears	40	40
30	2 spoonfuls ashes, June 5	38	50
31	2 " plaster and ashes, June 5	37	50
32	Peterson & Son's superphosphate, same as 14	34	20
33	Nothing	34	20
34	Bradley's superphosphate, same as 16	36	40
35	Nothing	33	50
36	Ralston's superphosphate, same as 13	34	60
37	Cayuga plaster, applied in hill, unsoaked seed	33	18
38	Syracuse " " on hill, June 5	36	
39	" " " in hill, unsoaked seed	30	60
40	Western corn, no fertilizer	34	60

Many of the preceding plots are duplicates, in order to make allowance for variation in soil.

Average of duplicates.

Plots and Treatment.	Yield.	
	bu.	lbs.
Nos. 1 and 19, 5 stalks	40	
" 2 and 24, 4 "	38	41
" 3 and 21, 3 "	37	30
" 4 and 22, 2 "	31	50
" 5, 23 and 17, plaster on hill	34	23
" 6 and 24, no plaster	33	10
" 7 and 26, suckered	33	50
" 8 and 27, not suckered	36	30
" 9 and 25, seed soaked and rolled in plaster	41	16
" 10 and 28, seed from tips	34	60
" 11 and 29, " " butts	34	60
" 12, " " middle	33	10
" 13 and 36, Ralston's superphosphate	36	40
" 14 and 32, Peterson & Son's superphosphate	34	20
" 16 and 34, Bradley's superphosphate	36	60
" 18 and 30, ashes	38	40
" 2, 8, 15, 24, 27, 33, 35, nothing	35	33

III.

Corn—Stockbridge Fertilizer. 1876.—The soil was clayey. In 1873 the land produced wheat, no manure being used, and in 1874 clover and timothy, mowed for hay in June and for seed in September; in 1875 it was mowed for hay twice. It was plowed in September, 1875, and replowed May 23, 1876.

A plot, numbered 2, of .25 of an acre, received a dressing of 180 pounds of Stockbridge corn manure, said to contain 16 pounds of nitrogen, 19.5 pounds of potash, 7.75 pounds of soluble phosphoric acid, and costing $6.25; it was claimed that this quantity applied to a quarter of an acre would produce 12.5 bushels more than the natural yield. On the two sides of this plot were plots of one-eighth of an acre, numbered 1 and 3, which were unfertilized.

The fertilizer was sowed broadcast after plowing, and harrowed three times before planting. Plot No. 2 contained 1,102 hills, and yielded 1,070.5 pounds of corn in the ear, all of which was good and sound. Plots Nos. 1 and 3 contained the same number of hills, were planted, husked and weighed at the same time as No. 2, and weighed 1,071.25 pounds. This also was sound, but not of as good quality nor as highly colored as that of No. 2. The stalks on No. 2 were perceptibly larger than on Nos. 1 and 3, and all through the season had a darker and more luxuriant color.

IV.

Corn—Different Fertilizers and Culture. 1876.—The land had been in clover and timothy for two years. The soil improved in quality in passing from plots 1 and 17 to the middle of the field. The "Vitative Compound" (plot 12) was received in a 2 oz. package, with directions to dissolve it in sufficient water for complete immersion of half a bushel of seed, and to soak the seed in this solution 36 to 48 hours. On analysis the substance was found to consist of lead oxide and zinc sulphate ; it was an evident fraud. The amounts of fertilizers refer to the plots.

	Treatment.	Yield.	
		bu.	lbs.
1	25 pounds Stockbridge corn manure	25	5
2	Nothing	31	5
3	20 pounds soluble Pacific guano phosphate	40	57
4	20 pounds Lister Brothers' ground bone	48	10
5	20 " " " superphosphate	56	10
6	Nothing	59	10
7	20 pounds Crofut & Co.'s superphosphate	58	5
8	Seed soaked 12 hours, rolled in plaster, 1 tablespoonful damp plaster in each hill	53	55
9	20 pounds plaster sowed broadcast, harrowed in	60	15
10	Nothing	51	5
11	25 pounds Stockbridge manure, broadcast, harrowed in	46	20
12	Seed soaked in "Vitative Compound"	45	30
13	Suckered	51	43
14	Not suckered, 4 stalks (compare with 13 and 15)	48	
15	5 stalks	48	
16	3 "	53	40
17	2 "	47	10

V.

Corn—Different Varieties. 1877.—The soil of the field was poorest at the extreme numbers, growing slightly better as it approached the center, and was a little too gravelly and light for best results. It had been in clover the preceding year. The plots were one-fortieth of an acre each, and were separated from each other by three rows of potatoes.

	Treatment.	Yield.	
		bu.	lbs.
1	8-rowed Yellow, Bates	36	60
2	8-rowed One-Hundred-Day Corn	36	20
3	8-rowed reddish tipped from Pennsylvania	41	30
4	8-rowed Gold-drop	34	40
5	Western corn acclimated two years	36	60
6	8-rowed White Corn, Ayers	54	20
7	8-rowed Yellow, planted with pumpkins every 3d hill	38	40
8	8-rowed Yellow, no pumpkins	45	
9	8-rowed Cook's Yellow	70	30
10	Western Hicks, acclimated four years	69	50
11	8-rowed Yellow, Bates	69	10
12	8-rowed One-Hundred-Day Corn	55	30
13	8-rowed reddish tipped from Pennsylvania	55	10
14	8-rowed Gold-drop	61	30
15	Western, acclimated two years	36	
16	8-rowed White, Ayers	38	10
17	8-rowed Cook's Yellow	54	60
18	Western Hicks, acclimated four years	33	30

Average of duplicates.

Plots and Kinds of Seed.	Yield.	
	bu.	lbs.
Nos. 1 and 11, Bates seed	53	
" 2 and 12, One-Hundred-Day Corn	45	60
" 3 and 13, Pennsylvania	48	20
" 4 and 14, Gold-drop	49	
" 5 and 15, Western, acclimated two years	36	30
" 6 and 16, White, Ayers	46	15
" 9 and 17, Cook's Yellow	62	45
" 10 and 18, Western Hicks	51	40

VI.

Corn—Different Varieties. 1876.—These plots adjoined No. 3 ; the preparation of the ground and the culture were the same. Each plot contained three rows of forty hills each, and the ground had been heavily manured during the previous winter.

	Treatment.	Yield lbs. per plot.		Yield.	
		Sound.	Soft.	bu.	lbs.
1	8-rowed Yellow, home-raised seed	141	17	73	69
2	Maryland Yellow, from Washington, D. C.		97		
3	8-rowed reddish tipped from Pennsylvania.	155½	37	81	28
4	" " " " " but acclimated one year in New York	130	17	68	14
5	8-rowed, Bates variety, South Hill, Ithaca	145½	22	76	23
6	One-Hundred-Day Holden Corn from McLean, N. Y.	104½	11	54	60
7	White Ayers from West Hill, Ithaca	131	20	68	53

The two years' experiments in varieties show marked results. The Pennsylvania Red-tipped Corn produced by far the largest yield, and next to it the home-raised eight-rowed yellow. General field culture has proved the superiority of these same varieties over the others. The advantage of care in the selection of seed is thus demonstrated.

VII.

Corn—Different Combinations of Fertilizers. 1879.—These experiments were suggested by an article and diagram in the *Rural New Yorker* in the spring of 1879.

The upper number indicates the number of the plot ; the second number, the number of pounds of corn in the ear ; the third number, the number of pounds of stalks per plot.

The ground was in wheat in 1877 with manure, and in clover in 1878; the clover was mowed early (June 18), the ground plowed immediately and drilled to fodder corn. Clover and corn were both good. The corn ground was plowed May 18 and planted May 24, although very dry.

Each plot was entirely surrounded by a vacant row and contained thirty-five hills, planted thickly and reduced to four stalks in a hill. To understand the diagram, suppose numbers 57 to 63 inclusive to be a land containing five rows, upon which has been applied twenty pounds Pacific guano; one vacant row left between it and the next land, upon which has been applied twenty pounds sulphate of ammonia. Suppose numbers 1 to 57 north and south to constitute another land, upon which has been applied 10 lbs. muriate of potash; then No. 36 has had an application of $\frac{1}{7}$ of 20 lbs. of sulphate of magnesia and $\frac{1}{9}$ of 10 lbs. of muriate of potash; while No. 1 has had $\frac{1}{9}$ of 10 lbs. of muriate of potash, and No. 3 has had no manure.

	10 lbs. muriate of potash.	10 lbs. sulphate of ammonia.	Nothing.	15 lbs. Pacific guano.	10 lbs. sulphate of lime.	15 lbs. sulph. of am. and 15 lbs. Pacific guano.	Nothing.
20 lbs. Pacific guano.	**57** 49 50	**58** 42½ 45	**59** 41 39	**60** 47 50	**61** 37½ 45½	**62** 45½ 50	**63** 44 38½
20 lbs. sulphate of ammonia.	**50** 58½ 73½	**51** 53 52½	**52** 48½ 43½	**53** 42½ 44½	**54** 43½ 47½	**55** 56 55½	**56** 37½ 43
Nothing.	**43** 56½ 62½	**44** 44½ 58½	**45** 58 45½	**46** 56 44½	**47** 51 43½	**48** 57 48½	**49** 36 39½
20 lbs. sulphate of magnesia.	**36** 41 45½	**37** 30½ 46½	**38** 42½ 43½	**39** 36 34	**40** 36½ 36½	**41** 41 42½	**42** 40½ 35½
Nothing.	**29** 37½ 44	**30** 38 38	**31** 48 46½	**32** 45½ 29½	**33** 48 32	**34** 35 25	**35** 36½ 27½
20 lbs. dissolved bone.	**22** 41½ 44½	**23** 22 29	**24** 35 38	**25** 36 31	**26** 34 36½	**27** 33 39	**28** 14 16
20 lbs. muriate of potash.	**15** 40½ 36	**16** 34½ 41	**17** 36½ 45	**18** 17½ 25½	**19** 20 26	**20** 30½ 42	**21** 11 22½
20 lbs. sulphate of soda.	**8** 37½ 59	**9** 37 43	**10** 32 37	**11** 33½ 39	**12** 30½ 46½	**13** 33½ 40	**14** 29 35
Nothing.	**1** 38½ 51	**2** 20 32	**3** 33 35	**4** 31½ 38½	**5** 27 28	**6** 29 33½	**7** 26½ 29½

It is evident that the complication of the system makes it impossible to draw any definite conclusions from the almost endless combinations which can be made of the diagram.

VIII.

Corn—Summary of Results.—

Comparison of all plots phosphated, for three years, with adjoining plots on which no fertilizers were used.

	bu.	lbs.
Phosphated, average........	42	10
No fertilizer.................	40	55

Comparison of all plots plastered, for three years, with adjoining plots not plastered.

	bu.	lbs.
Plastered, average..........	45	3
Not plastered, average......	39	6

Comparison of all plots suckered, for three years, with adjoining plots not suckered.

	bu.	lbs.
Suckered, average...........	46	51
Not suckered, average......	47	36

Comparison of plots having various numbers of stalks per hill, for three years.

	bu.	lbs.
2 stalks per hill, average.....	42	10
3 " " "	52	25
4 " " "	53	3
5 " " "	48	46

Comparison of the average of unfertilized plots which *adjoined* both phosphated and plastered plots with them; and also a comparison of adjoining plastered and phosphated plots.

	bu.	lbs.
No fertilizer............	40	1
Phosphated............	42	10
Plastered...............	45	

D.

Experiments with Grass.

I.

Grass—Different Fertilizers. 1876.—The crop consisted of clover and timothy in about equal proportions, and was cut June 24. The soil was gravelly, inclining to a sandy loam. The plots were one square rod each, divided accurately by 2×4 scantling. The plaster used was from Cayuga beds unless otherwise designated. The results should be studied with regard to the yield of grass rather than hay, as the latter cannot be uniformly cured. The quantities of fertilizers relate to the acre, and of the crop to the plot.

	Treatment.	Grass.	Hay.
1	½ bushel plaster	161	96
2	1 " "	173	97½
3	1 " Syracuse plaster	155	94½
4	400 pounds refuse salt	149	92
5	50 bushels lime	156	95
6	50 bushels wood ashes	171	100
7	Nothing	133	90
8	3 bushels plaster, applied three separate times	150	93
9	2 " Syracuse plaster	152	94
10	Nothing	140	90
11	200 bushels coal ashes	146	92
12	100 " leached wood ashes	164	98
13	2 " plaster	155	96
14	2 " " applied at two separate times	148	94
15	Nothing	139	90½
16	40 bushels fresh lime	121	85
17	25 " lime and ½ bushel plaster	128	88
18	16⅔ " " 16⅔ bushels ashes and 1 bushel plaster	132	84

II.

Clover—Different Manures. 1877.—These plots contained an exact square rod, and were divided by laying down 2×4 scantling, which were fastened together by strips of board nailed on top. The grass was mowed very close after the removal of the scantling, and immediately weighed; for shrinkage in curing, see No. I, D. At the time of locating the plots they all appeared perfectly uniform. The second growth of clover on the plots treated with ground bone was relished very highly by the cattle, these plots being eaten close to the ground, while the clover on the others was still of a considerable height.

1 2½ lbs. Syracuse phosphate. 117 lbs. clover.	12 2½ lbs. Stockbridge manure. 113 lbs. clover.	13 2½ lbs. Lister's phosphate. 113 lbs. clover.
2 2½ lbs. Lister's ground bone. 118 lbs. clover.	11 Nothing. 130 lbs. clover.	14 2½ lbs. Pacific guano phosphate. 132 lbs. clover.
3 2½ lbs. Lister's superphosphate. 128 lbs. clover.	10 Nothing. 129 lbs. clover.	15 2½ lbs. Cayuga plaster. 129 lbs. clover.
4 2½ lbs. Pacific guano phosphate. 125 lbs. clover.	9 2½ lbs. Lister's ground bone. 134 lbs. clover.	16 2½ lbs. Syracuse plaster. 129 lbs. clover.
5 Nothing. 115 lbs. clover.	8 2½ lbs. Cayuga plaster. 120 lbs. clover.	17 2½ lbs. Syracuse phosphate. 116 lbs. clover.
6 2½ lbs. Stockbridge manure. 118 lbs. clover.	7 2½ lbs. Syracuse plaster. 122 lbs. clover.	18 Nothing. 111 lbs. clover

Average of duplicates.

Plots and Treatment.	Fertiliz'r pounds.	Yield per acre green clover, lbs.
Nos. 1 and 17, Syracuse phosphate	116½	18,640
" 2 and 9, Lister's ground bone	126	20,160
" 3 and 13, " superphosphate	120½	19,280
" 4 and 14, Pacific guano phosphate	128½	20,560
" 5, 10, 11 and 18, nothing	121¼	19,400
" 6 and 12, Stockbridge manure	115½	18,480
" 8 and 15, Cayuga plaster	124½	19,920
" 7 and 16, Syracuse "	125½	20,080

III.

Grass—Different Fertilizers. 1876–7.—One plot 4 rods by 5 was flanked on either side by a plot 4 by 2½ rods. The plots were divided by shallow trenches carefully cut to line. The grass consisted of timothy and clover about equally mixed. The large plot, numbered 3, received a dressing of 50 lbs. of the Stockbridge Fertilizer for grass; the other plots, numbered 1 and 2, were unmanured. One of these plots yielded 640 lbs. of grass, or 260 lbs. of hay; the other, 697 lbs. of grass, or 274 lbs. of hay. The totals and the yield of plot 3 are given in the following table, in pounds:

	Grass.	Hay.	Grass per acre.	Hay per acre.
Nos. 1 and 2.	1331	534	10,712	4,272
No. 3.........	1697	618	13,576	4,944

The experiment was repeated in 1877, when the unfertilized plot, of the same size as one of the unfertilized plots of the previous year, yielded 765 lbs. of grass, and the plot with Stockbridge manure, half as large as the manured plot of last year, 1,008 lbs. For shrinkage, when converted into hay, see the statement of result of the previous experiment; the grass this year consisted of timothy mixed with a little clover. The same per cent. of shrinkage should not be applied to clover (II), as it would be far too small.

E.

Experiments with Mangel-Wurzels. 1879.—The summer was dry and unfavorable, and the crops of all the plots were damaged by grasshoppers, that ate off the top in July. The amounts of manures and crops refer to the plots.

	Treatment.		Yield.
			lbs.
1	11 lbs. sol. Pacific guano, 4 lbs. sulphate ammonia,	5 rows,	1120
2	No fertilizer	5 "	1260
3	16½ lbs. soluble Pacific guano	5 "	1120
4	No fertilizer	5 "	1140
5	16½ lbs. sulphate of ammonia	5 "	1260
6	No fertilizer, Norbitton's Giant	3 "	1340
7	" " Yellow Globe	3 "	880
8	7½ lbs. sol. Pacific guano, 5 lbs. sulphate ammonia,	3 "	1080
9	No fertilizer	3 "	940
10	12 lbs. soluble Pacific guano	3 "	880
11	No fertilizer	3 "	700

XIV.

EXPERIMENTS IN CATTLE-FEEDING.

By Prof. I. P. Roberts.

Ensilage for Young Cattle and Beef Cows.—

Three two-year-old, half-blood Holstein heifers were selected, which had previously been fed on hay exclusively.

First period.—The ration consisted of ensilage, 50 lbs., and malt sprouts, 0.5 lbs., per day and animal.

For the composition of these fodders see report of Department of Agricultural Chemistry.

All weights were taken at 8 o'clock A. M., after feeding but before watering.

When weighed.	No. 14.	No. 16.	No. 17.	Total.
	lbs.	lbs.	lbs.	lbs.
February 24	770	750	780	2300
March 3	832	850	834	2516
" 10	830	890	850	2570
" 17	840	900	820	2560
" 24	824	882	824	2530

The total gain during the twenty-eight days was 230 pounds, or 2.73 pounds per day and animal. The apparent gain of 216 pounds during the first week was largely due, without doubt, to an increase in the contents of the stomach.

If the weight of March 3 is taken, the total gain in the following three weeks is but 14 lbs., or 0.22 lb. per day and animal. It is evident that this was about as near a maintenance ration as it is possible to get, for while one animal gained 32 lbs., the others lost 8 and 10 lbs. respectively.

Second period.—On March 25 2 lbs. of cotton-seed meal was added to the daily ration of each animal. On April 14 their total weight was 2,672 lbs., a gain in the three weeks of 142 lbs., or 2.25 lbs. per day and animal.

This experiment indicates that Southern-corn ensilage forms a maintenance ration when fed in suitable quantities, and that it is economy to feed it in conjunction with some more concentrated food. During the first as well as the second period the animals appeared to be making rapid growth, yet the scales showed that the weight of two of them decreased.

For several months after being turned out to pasture the ensilage-fed animals appeared far thriftier than others of like age and size which had been wintered on hay.

Beef Cows.—The cows had been "dry off" about three weeks previous to the first weighing; two were natives and one (No. 10) was a half-blood Holstein; all had been milked for about ten months and were thin in flesh. They were offered for sale at three cents per pound, or $99.00, but owing to the high price of feed no purchaser was found. From February 21 to April 5 their ration consisted of ensilage 52 lbs., and corn meal 12.5 lbs.; from April 5 till sold, ensilage 50 lbs., corn meal 9.4 lbs., and cotton-seed meal 2.8 lbs.; or in volume-measure in the last case, six quarts of corn meal and two quarts of cotton-seed meal.

When weighed.	No. 10.	No. 1, N.	No. 2, N
February 21, 1882,	1150	1000	980
" 28, "	1200	1116	1024
March 7, "	1226	1146	1007
14, "	1242	1147	1068
21, "	1242	1182	1070
April 5, "	1320	1180	
12, "	1360	1192	
20, "	1320	1150	

They were all sold at $ .09½ per pound, dressed weight. The average gain per animal was 2.84 lbs. per day.

Gain in Weight by Steers on a Moderate Fattening Ration, and on Grass.—

Three steers, purchased March 4, were weighed daily at first, beginning March 13, after they had become accustomed to their new surroundings, and afterwards every other day for two months, while fed on the following ration: March 13 to 16, ensilage 30 lbs., cut corn-stalks 4 lbs., malt sprouts 5 lbs., and corn meal 3 lbs. March 16 to 23, the same, except that 2.5 lbs. of bran were substituted for 2.5 lbs. of malt sprouts. From March 23 on, 1 lb. of cotton-seed meal was added to the ration. From March 27, 1 lb. of corn meal was replaced by 1 lb. of cotton-seed meal. All weights were taken after eating and before drinking. The weights are given in detail to show the frequent wide variations from day to day.

March.	lbs.	lbs.	lbs.	April.	lbs.	lbs.	lbs.
13	694	650	620	1	744	701	699
14	678	638	638	3	741	699	699
15	680	659	630	5	762	715	704
16	687	637	644	7	780	722	720
17	689	650	643	8	780	737	736
18	725	664	650	10	750	716	728
20	700	662	663	12	780	717	740
21	720	662	664	14	800	719	730
22	724	664	664	15	800	730	739
23	730	680	680	17	798	720	750
24	715	680	678	20	804	732	765
25	730	683	670	22	804	750	780
27	720	685	680	24	822	750	776
28	740	701	598	27	826	766	784
29	750	690	678	29	815	770	780
30	742	702	699	May 1	825	764	794
31	744	701	699	Gain in 40 days,	131	114	174

The gain in live weight per steer and day was 2.85 lbs., or, per 1,000 lbs. live weight at the beginning, 4.37 lbs.

The weights of the animals on July 3, after having been in pasture and on grass alone for sixty-three days, were as follows: No. 1, 1,038 lbs.; No. 2, 962 lbs.; No. 3, 940 lbs. The total gain for sixty-three days was, therefore, 557 lbs., or per steer and day, 2.94 lbs., or per 1,000 lbs. live weight, 4.5 lbs.

FIELD EXPERIMENTS WITH CROPS.

Oats, broadcast and drilled seeding compared:

	No. of plot.	Pecks of seed per acre.	Yield.	
Experiments of 1880-1			bu.	lbs.
Drilled	1	9	25	10
Broadcast	2	9	35	20
Drilled	3	9	35	20
Broadcast	4	9	37	16
Average of the 2 years 1878 and 1879				
Broadcast			61	16
Drilled			56	

Oats, thick and thin seeding compared:

	No. of plot.	Pecks of seed per acre.	Yield.	
			bu.	lbs.
Experim'ts of 1880. Soil gravelly and poor	1	7	24	12
	2	12	21	3
	3	16	18	9
	4	7	25	10
Experiments of 1881. Soil fair	1	5	59	11
	2	8	61	24
	3	12	68	14
	4	16	65	16
Experiments of 1882	1	5	57	8
	2	8	56	17
	3	12	69	19
	4	16	58	28
Average of results for 4 years—1876 to 1879		5	39	30
		7 and 8	41	25
		12	42	20
		16	42	31

Oats, varieties compared:

	No. of plot.	Pecks of seed per acre.	Yield.	
Experiments of 1880. All plots manured with 100 lbs. superphosphate per acre.			bu.	lbs.
Batavia	1	9	59	15
Mitchell	2	9	74	11
University	3	9	57	6
University	4	9	58	8
Experiments of 1881				
University	1	8	74	7
Mitchell	2	8	56	19
Batavia	3	8	64	27
White Russian	4	8	60	31

Oats, different Fertilizers, 1880:

	Plots	Yield.	
		bu	lbs.
Salt, 300 lbs.	1	34	22
Plaster, 300 lbs.	2	31	28
No fertilizers	3	29	17
Salt, 300 lbs., and plaster, 300 lbs.	4	27	1
No fertilizers	5	28	19
Sulphate of ammonia, 300 lbs.	6	29	2
Swiftsure phosphate, 300 lbs.	7	42	21
No fertilizers	8	37	31
Pacific guano, 300 lbs.	9	39	31
" " 300 lbs, and sulphate of ammonia 5 lbs.	10	39	28
No fertilizers	11	35	20

Summary of results:

	bu.	lbs.
Average yield of all phosphated plots	37	26
" " " unfertilized "	34	2
" " " phosphated plots, 1878–9	35	2
" " " unfertilized " "	30	4⅔
Average yield plastered plots, 1880	31	28
" " adjoining unfertilized plots, 1880	29	17
Average of 1878–9, plastered	40	
" " unfertilized	37	19½
Average yield of salted plots, 1880	34	22
" " unmanured plots, 1880	29	17
Average yield, 1878–9, salted	43	18
" " " unfertilized	39	7

The salt and plaster applied to plot 4 appeared to have drawn moisture or prevented evaporation. The marked difference between this plot and plots 3 and 5, two weeks after the grain was sowed, led to a careful determination in the laboratory of the amount of moisture present in the first eight inches of soil. Plot 3 contained 11 per cent. water, and plot 4 11.6 per cent. This difference shows that there was present in the soil 12,903 lbs. more of water per acre in the first eight inches of plot 4 than of plot 3.

Wheat, broadcast and drilled seeding compared. Summary of results for seven years:

	Broadcast.		Drilled.	
	bu.	lbs.	bu.	lbs.
1876	22	30	24	55
1877	18	30	21	00
1878	24	45	25	30
1879	22	00	24	24
1880	29	10	38	30
1881	23	10	22	30
1882	34	38	44	30

Wheat, thick and thin seeding compared:

	Plots.	Pecks seed per acre.	Yield.	
			bu.	lbs.
Experiments of 1881–2. Seed sown Sept. 5th; variety, Clawson; fertilizer, 200 lbs. superphosphate per acre; land poor and clayey, and had produced wheat previous year.	1	4	15	20
	2	6	19	10
	3	8	22	30
	4	12	23	50
Experiments of 1881–2. Seed sown Sept. 13th; variety, Clawson; fertilizer, 400 lbs. superphosphate per acre.	1	5	34	33
	2	8	35	36
	3	8	35	5
	4	12	44	5
Summary of results of previous years:				
1 year		14	20	50
4 years		12	23	23
4 years		8	20	15
2 years, 9 pecks and		10	18	22
2 years, 6 pecks and 1 year		7	15	25

The above experiments are so easily understood that comment appears unnecessary; but to the experimenter who watches the growing wheat throughout the year many things are revealed which do not appear in the ascertained yield. There is a very noticeable variation from year to year in the per cent. of seed that germinates, and in the amount destroyed by insects and other enemies before the winter sets in. The thin seeding frequently does well until freezing and thawing occurs during the last of winter, when it is injured far more than thick seeding.

If every condition has been favorable up to spring it sometimes happens that dry, windy weather prevails, and the thin seeding does not tiller as it should, or tillers so late that a large proportion of the heads are low in the standing grain, small, and poorly filled, while the heads of the thick seeding will be more uniform in size and have less small and shrunken grain. One bushel of seed per acre would be ample if all the conditions were at the best; but they seldom are. Therefore it appears wiser to be liberal with the seed than to take so many risks.

Wheat, varieties, Experiments of 1880–1:

Farm-yard manure was applied to the surface and harrowed in at the rate of six cords (twelve loads) per acre, and 200 lbs. of phosphate per acre was drilled in with the seed.

No injury to the germination of the seed appeared, as the ground was quite moist at the time of sowing.[1]

Variety.		No. of plot.	Yield per acre
			bu. lbs.
Fultz	s.	1	37 35
Clawson	s.	2	39 25
Gold Medal	s.	3	41 26
South Wales		4	Total failure.

In the same field, on land which was far poorer, drier, and more exposed to the wind than was the land on which the above varieties were tested, the following experiment was made with fertilizers:

Variety of Wheat.	Kind of fertilizer.	No. of plot.	Yield.
			bu. lbs.
Clawson	Farm-yard manure as above.	1	22 49½
Clawson	Yard manure as in No. 1 and 200 lbs. of phosphate per acre.	2	22 00

Wheat, varieties, Experiments of 1881–2:

The ground had produced wheat the previous year, and before sowing had received twelve loads of farm-yard manure and 200 lbs. of phosphate per acre. The land was plowed once, immediately after the previous wheat crop had been removed, and was again treated to the same quantity and kind of fertilizers as above. Liberal surface cultivation was given up to the time of sowing.

Variety.		No. of plot.	Yield.
			bu. lbs.
Clawson	s.	1	41 68
Fultz	s.	2	47 15
Gold Medal	d.	3	40 65
Washington Gloss	d.	4	36 30
Rice Wheat	d.	5	32 91
Heige's Prolific	p.d.	6	45 17
Finley's	s.	7	41 34
Red Mediterranean	s.	8	35 87
White Michigan	s.	9	33 99

In another field—having a better wheat soil than the above—the following varieties, which were sent by Prof. W. R. Lazenby from the Agricultural College of Ohio, were tried. The land was treated with a liberal amount of fer-

[1] In these tables, *d* indicates wheat down; *p. d.*, partly down; and *s*, stands up in good order at time of harvesting.

tilizers and put in the best possible condition, but the sowing was late—September 27.

Variety.		No. of plot.	Yield.
			bu. lbs.
Velvet Chaff	s.	1	38 31
Theiss	d.	2	35 49
Sandomunke	p d.	3	39 53
Hungarian White Chaff	p.d.	4	38 31
Zimmerman's Amber	p.d.	5	43 29
German Amber	p.d.	6	41 40
Champion	s.	7	45 77
Russian, No. 2	s.	8	41 78
York White Chaff	s.	9	47 99
Rickenbroda	s.	10	44 04
Silver Chaff	p.d.	11	40 73
Rivets, an English wheat		12	Failure.

In 1881 the yield of Clawson wheat exceeded that of Fultz by $2\frac{1}{6}$ bushels, while in 1882 the Fultz exceeded that of Clawson by $5\frac{7}{15}$ bushels.

Neither Clawson nor Gold Medal appears to respond to high manuring as well as the Fultz. This was suspected before, and the experiment appears to be confirmatory.

Gold Medal stood well the first year; but when the land had received another heavy dressing of fertilizers it fell down badly, and the yield was less in 1882 than in 1881 by forty-seven pounds, although the former year was more favorable for wheat than the latter.

The York White Chaff bids fair to be a valuable variety on fertile land, as does also Heige's Prolific, though the latter variety does not stand up as well as the former, or as the Fultz.

Wheat, different Fertilizers, 1880–1:

Treatment.	No. of Plot.	Yield.
		bu. lbs.
Crocker's superphosphate, 400 lbs.*	1	26 30
No fertilizers*	2	25 10
Swiftsure phosphate, 400 lbs.*	3	25 20
No fertilizers	4	14 40
Farm-yard manure, 10 loads or 5 cords	5	29 5
No fertilizers	6	17 20
Salt, 600 lbs	7	22 25
Crocker's superphosphate, 200 lbs., sul. ammonia, 100 lbs.	8	24 55
No fertilizers	9	23 40
Swiftsure phosphate, 200 lbs	10	23 20
Crocker's superphosphate, 200 lbs	11	24 40
No fertilizers	12	22 50
Pacific guano phosphate, 400 lbs	13	26 20
No fertilizer for 6 years, but under continuous wheat culture during that time	14	15 30

* A portion of these plots were flooded for a few days.

Wheat, different Fertilizers, 1881–2 :

The crops which preceded the wheat of these experiments were the same as in the following set of experiments, p. 104. The wheat was drilled September 13, with nine pecks of Clawson wheat per acre.

Treatment.	No. of plot.	Yield.	
		bu.	lbs.
No fertilizers	1	35	5
Phosphate 200 lbs. and sulphate of ammonia 100 lbs.	2	37	33
No fertilizers	3	35	
Farm manure, 7 cords or 14 loads	4	37	57
Phosphate, 200 lbs.	5	34	42
" " (seed badly shrunken)	6	29	28
" " (seed good)	7	34	43
No fertilizers	8	31	14
Gypsum (plaster), 200 lbs.	9	30	35
Salt, 200 lbs.	10	26	57

Comparison of all phosphated plots with adjoining plots on which no fertilizers were used:

	bu.	lbs.
Average of all phosphated plots, 1881	25	10
" " adjoining unfertilized plots, 1881	20	44
Average of all phosphated plots, 1882	35	39
" " adjoining unfertilized plots, 1882	33	43
Average of all phosphated plots for six years	25	45
" " adjoining unfertilized plots for six years	24	11
Gain of phosphated plots over unfertilized ones	1	34

The experiments with phosphates have been carried on long enough now to establish the fact that when drilled in with the wheat they fail to return (on the University farm) their first cost in the succeeding wheat crop. As the phosphates used are known by analysis to be of a high standard, the fault cannot be attributed to them. As has been said before, when the soil lacks moisture the phosphates seriously injure germination, and the subsequent benefit may be more than offset by the injury done to the seed. The soil appears to have a superabundance of lime, which without doubt combines with the phosphate and renders it to some extent insoluble. It has been noticeable in several instances that the phosphates appear to act the second year with more effect than the first; but this fact can only be established beyond a doubt by careful and long-continued experiments.

It would appear that if the phosphates were broadcasted some time before sowing the wheat, the benefits to the first crop might be greater.

Wheat and different Fertilizers, 1881–2 :

The following experiments to test the effect of various fertilizers were suggested by Prof. Atwater. At the time they were planned it was expected that they would be performed in several States. The plots contained $\frac{1}{20}$ of an acre each, were 66 rods long and three drill-marks wide; each plot was separated from the others by a vacant space of two feet. The crops preceding the wheat were as follows: Clover, 1876; corn, manured, 1877; oats, 1878; wheat, manured, 1879; corn, manured, 1880; oats, 1881. The wheat was drilled September 13, at the rate of two bushels per acre; the variety was Clawson. The growth was in good order, but too dry for seed to germinate rapidly. The fertilizers used had the following composition: nitrate of soda, 16 per cent. nitrogen; sulphate of ammonia, 21 per cent. nitrogen; dried blood, 11 per cent. nitrogen; superphosphate (dissolved bone black), 15 per cent. soluble and 16 per cent. total phosphoric acid; muriate of potash, 50 per cent. potash.

Kind and quantity of fertilizers used.	No. of plot.	Yield.
		bushels.
Nitrate of soda, 150 lbs.	1	28.
Superphosphate, 300 lbs.	2	24.66
Muriate of potash, 150 lbs.	3	29.5
Nitrate of soda, 150 lbs., superphosphate, 300 lbs.	4	26.66
No fertilizers	*N* 2	29.66
Nitrate of soda, 150 lbs., muriate of potash, 150 lbs.	5	32.66
Superphosphate, 300 lbs., muriate of potash, 150 lbs.	6	29.16
No fertilizers	*N* 3	28.66
Superphosphate, 300 lbs., muriate of potash, 150 lbs., nitrate of soda, 150 lbs.	7	32.33
Superphosphate, 300 lbs., muriate of potash, 150 lbs., nitrate of soda, 300 lbs.	8	29.86
Superphosphate, 300 lbs., muriate of potash, 150 lbs., nitrate of soda, 450 lbs.	9	29.16
Superphosphate, 300 lbs., muriate of potash, 150 lbs.	6 *a*	30.00
Superphosphate, 300 lbs., sulphate of ammonia, 112½ lbs., muriate of potash, 150 lbs.	10	29.83
Superphosphate, 300 lbs., sulphate of ammonia, 225 lbs., muriate of potash, 150 lbs.	11	29.82
Superphosphate, 300 lbs., sulphate of ammonia, 325 lbs., muriate of potash, 150 lbs.	12	27.16
Superphosphate, 300 lbs., muriate of potash, 150 lbs.	6 *b*	34.16
Superphosphate, 300 lbs., dried blood, 225 lbs., muriate of potash, 150 lbs.	13	32.66
Superphosphate, 300 lbs., dried blood, 450 lbs., muriate of potash, 150 lbs.	14	35.66
Superphosphate, 300 lbs., dried blood, 675 lbs., muriate of potash, 150 lbs.	15	38.66
Superphosphate, 300 lbs., muriate of potash, 150 lbs.	6 *c*	32.83
No fertilizers	*N* 4	34.00

About ten days after sowing the plots were examined, and it was evident that the phosphates had seriously injured the germination of the wheat, and that where they were used alone the damage was greater than where they were used in conjunction with nitrate of soda, potash, or dried blood. Experiments have frequently shown that in dry soils the damage done to the seed by phosphates, when used in liberal quantities, is very great; this fact has led us to the practice of mixing gypsum with phosphates in about equal proportions. The wheat is then drilled with one-half the quantity of seed and fertilizers desired, and then re-drilled crosswise; this distributes both seed and fertilizer most admirably, and gives with us a marked increase in yield over the old method. It will be observed that the plots are arranged in groups. From 1 to 6 inclusive is the preliminary group, from 7 to 9 inclusive the nitric acid group, from 10 to 12 inclusive the ammonia group, from 13 to 15 inclusive the organic nitrogen group; and N. 2, N. 3, N. 4 might be called the non-fertilized group. The average yield per acre of the various groups was as follows: Preliminary, 28.44 bushels; nitric acid, 30.45 bushels; ammonia, 28.93 bushels; organic-nitrogen, 35.66 bushels; non-fertilized, 30.77 bushels.

Two valuable lessons appear in these experiments: First, that concentrated fertilizers—under certain conditions of soil—when applied liberally and in direct contact with the seed, may do quite as much harm as good; second, that nitrogen, when applied in the form of dried blood, is far more effective than when applied in the form of nitrate of soda or sulphate of ammonia.

XV.

THE RELATIVE PROPORTION OF NUTRIENTS IN THE TOPS AND BUTTS OF CORN-STALKS.

By Prof. G. C. Caldwell.

This examination was made at the request of the Onondaga Farmers' Club. Under tops, the leaves and the upper half of the stalk are included; and under butts, the lower half of the stalk stripped of its leaves. The following averages are calculated from the table on page 107 :

	Butts.	Tops.
Moisture	15.35	14.05
Ash	7.00	5.91
Crude protein [1]	6.82	6.79
Fat	1.26	1.53
Non-nitrogenous extractive matters	31.33	40.5
Fiber	37.88	30.46

[1] Containing real albuminoids (Stutzer) 2.98 5.31

In the smaller proportion of ash and the larger proportion of real albuminoids and non-nitrogenous extractive matter or carbhydrates, the tops are shown to have a greater value than the butts ; if digestion experiments could be performed with the two parts of the stalk, a still greater advantage would doubtless appear in favor of the tops. The examination was suggested by the necessity of cutting the stalks and otherwise preparing them, in order to persuade the cattle to eat the whole ; and the query was propounded whether the nutriment in the butts would pay for such labor. Though poorer than the tops, yet they are richer than oat straw.

XVI.

MALT SPROUTS COMPARED WITH GRAIN, AND ENSILAGE COMPARED WITH DRY FEED FOR MILCH COWS.

By Prof. G. C. Caldwell.

Two sets of feeding experiments were tried for these purposes, one with a set of five cows, extending from December 1, 1881, to May 1, 1882, and the other with a set of three cows, extending from March 21 to May 1, 1882. All the animals were of native breeds. Each set was fed for at least a fortnight on the ration to be tested; the analysis of the milk included every milking during the last six days of each period. The ration in pounds per cow and day, the so-called digestible nutritive ratio of the ration, the average yield of milk in pounds per cow and day during the last six days of each period, and the per cent. of solids and fat in the mixed milk of all the cows of each set for the same period, are given below. The digestibility of the ensilage was taken to be the same as that of green fodder corn.

Set of five cows:

	Nut. ratio.	Yield of milk.	Solids	Fat.
First period.—Cornstalks, 9.5; clover hay, 9.5; bran, 3.5; corn meal, 3.5	1:7.4	19.7	13.3	4.02
Second period.—Cornstalks, 9.5; clover hay, 9.5; malt sprouts, 7	1:5	17.4	13.68	4.04
Third period.—Cornstalks, 8; ensilage, 46; malt sprouts, 4; corn meal, 3	1:8.5	16.7	13.34	
Fourth period.—Cornstalks, 8; clover hay, 4; oat straw, 4; malt sprouts, 3; corn meal, 2; wheat bran, 2	1:7.1	15.7	13.45	4.03
Fifth period.—Ensilage, 50; malt sprouts, 3; corn meal, 2; wheat bran, 2	1:9.5	16	13.24	3.71
Sixth period.—Cornstalks, 8; clover hay, 4; oat straw, 4; cotton-seed meal, 9	1:3.1	16.4	13.88	4.34

Set of three cows:

	Nut. ratio.	Yield of milk.	Solids	Fat.
First period.—Ensilage, 50; malt sprouts, 3; corn meal, 2; wheat bran, 2	1:9.5	15.9	12.89	3.83
Second period.—Cornstalks, 8; clover, 4; oat straw, 4; malt sprouts, 3; corn meal, 2; wheat bran, 2	1:7.1	16.6	12.95	3.95
Third period.—Ensilage, 50; malt sprouts, 3; corn meal, 2; wheat bran, 2	1:9.5	18.6	12.96	3.93

The rations of the first and second periods, with five cows, were continued for about a month. In the sixth period with the same set of cows such a large proportion of cotton-seed meal was substituted for the grain for the special purpose of noting the effect on the milk.

As to the effect of the ensilage on the yield and composition of milk, no marked results are exhibited ; in the case of the second set of cows there is a notable increase in yield in passing from the second to the third period, without any falling off or improvement in quality ; but no such result is given by the other set ; it may also be observed in favor of ensilage that the usual diminution in yield with the continuance of lactation is to some extent overcome. More than this, the most that appears to be safely established by these feeding trials, is that ensilage can be substituted for dry feed of good quality without danger of any notable change in respect to the milk.

The comparatively slight changes in the yield and character of the milk, with the wide changes in the nutritive ratio, or the proportion of albuminoids to other digestible matters in the ration, is a very noticeable result of these trials ; it appears to be indicated thereby either that this nutritive ratio is of less importance than it is commonly taken to be, or that the very commonly adopted period of two weeks on each ration in feeding trials is not long enough for the ration to produce its effect. This latter point will be made the subject of a special inquiry in some future experiments.

In December, 1881, Prof. Cook, of New Jersey,[1] set apart four cows from the herd of the college farm, for a test of the feeding qualities of ensilage for milk. Each ration was continued for twenty days, and the milk of the last five days of each period was analyzed. The rations in pounds per day, and 1,000 lbs. live weight, and yield of milk per cow per day, and composition of the milk are given below in the same manner as in the previous table.

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[1] Report of New Jersey Experiment Station for 1882.

Set 1, *two cows:*

	Nut. ratio.	Yield of milk.	Solids	Fat.
First period.—Dried fodder corn, 20; wheat bran, 3; brewer's grains, 30	1:5.1	29.1	13.55	4.27
Second period.—Same as first	1:5.1	28.8	13.55	4.49
Third period.—Ensilage, 50; wheat bran, 3; brewer's grains, 30.	1:5	27.0	13.87	4.58

Set 2, *two cows:*

	Nut. ratio.	Yield of milk.	Solids	Fat.
First period.—Dried fodder corn, 20; wheat bran, 3; brewer's grains, 30............	1:5.1	17.3	13.87	4.27
Second period.—Ensilage, 50; wheat bran, 3; brewer's grains, 30....................	1:5	18.5	14.01	4.42
Third period.—Same as in the first.................	1:5	17.3	14.51	4.53
Averages for the four cows fed on fodder corn, bran and brewer's grains, in the first period..		23.2	13.71	4.27
Averages for the four cows fed on ensilage, bran and grains, in the third period................		22.1	14.09	4.55

The effect of ensilage on either yield or quality of milk in these experiments also is not marked, whatever change there is being in the direction of the natural alteration that takes place with continuance of lactation.

CORNELL UNIVERSITY.

DEPARTMENT OF AGRICULTURE.

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President.

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STEPHEN HENRY CROSSMAN,
Experimental Assistant.

GEORGE W. TAILBY,
Foreman on the Farm.

ROBERT SHORE,
Head Gardener and Florist.

I.

MATERIAL EQUIPMENT.

The University Farm, including the campus, consists of 257 acres of land, the larger part of which is used for experimental purposes and the illustration of the principles of agriculture. Nearly all the domestic animals are kept to serve the same ends. Those portions of the farm and stock not used for experiments are managed with a view to their greatest productiveness. Statistics of both experiments and management are kept on such a system as to show at the close of each year the profit or loss not only of the whole farm but of each crop and group of animals.

The Barns are two in number. The south barn is devoted to the needs of the horticultural department, and also furnishes accommodations for the sheep and young cattle. The north barn is used for experimental purposes and the general needs of the farm. The large basement contains a covered yard and accommodations for the dairy cows, thirty in number, besides a cellar for the roots, and places for the cattle scales, the boiler and the engine. In the first story is a large floor into which wagons loaded with all kinds of farm produce may drive, and there be unloaded by horse power, the barn being provided with the most approved apparatus for this purpose. The floor also provides accommodations for a large number of farm wagons and carriages, hand tools, farm implements and threshed grain, besides containing the office and room for washing carriages. The second story contains the stationary thresher, chaffer, grain, straw and hay, and a sleeping room for workmen. In the wing attached to the main barn both common and box stalls are provided for twenty horses.

The Dairy House, not far from the main barn, is a two-story wooden building sufficiently capacious for all the purposes of making butter and cheese. The floor of the lower story is of small stones covered with cement. The outside walls of the building are of two thicknesses of boards and three of heavy paper, so arranged as to form four air spaces. The equipment of the building comprises a boiler, an engine, two creamers (a Cooley and a Ferguson), and other modern appliances for the manufacture of butter and cheese. The work done by students in dairy husbandry is under the direct supervision of Professor L. B. Arnold, and proceeds simultaneously with the yearly lectures given by him. The plant is used almost exclusively for purposes of investigation, and not for commercial purposes.

Museums, Reading Room, and Special Laboratory.—Seven large rooms in Morrill Hall are set apart for the exclusive use of the department of agriculture. The lecture-room is furnished with suitable maps, charts, drawings, etc., and a viscometer. The reading-room has on file all the leading agricultural journals, and the books bearing directly upon the subjects taught are here made more accessible than they would be in the general library. The large museum adjoining contains among other things the Rau models (the collection consisting of 187 models of plows made at the Royal Agricultural College of Würtemberg), 250 varieties of wheat, and a large number of models representing a great variety of agricultural implements. In the lower story one room is devoted to foreign and one to American implements. Another room is fitted up for a workshop and contains cases of all hand tools used in agriculture. During inclement weather students are here taught the use of the hammer, the saw, the plane, etc., by making gates, repairing implements and the like. Another room is furnished with power and contains the larger kinds of farm machinery. A self-binder is taken apart and put together twice yearly by the class, and each student is required to become familiar with the machines by using them and the engine which drives them.

The General Laboratories of the University in all departments related to agriculture are freely open to agricultural students. The laboratories in which special attention is paid to studies in agriculture are those of botany, chemistry, entomology, zoology, microscopy, anatomy, and geology. Each of these is fully equipped with the best appliances for modern scientific research, and each one is under the charge of an eminent specialist.

A Large Conservatory in connection with the department of botany is conducted with special reference to the needs of students, and furnishes an ample supply of botanical material throughout the year.

The Agricultural Library embraces some six thousand volumes on agricultural subjects, including veterinary science, and comprises the best works of both European and American writers.

As above mentioned, the works most frequently used are made constantly accessible by being placed in the agricultural reading room. The remainder are kept with the general library, which is at all times open to students.

II.

COURSES OF STUDY IN AGRICULTURE.

A.

The complete course in Agriculture, leading to the degree of Bachelor of Science in Agriculture.

Freshman Year.	1st Term.		2d Term.		3d Term.
Mathematics	5		5		5
French or German	5		5		5
English	2		2		2
Freehand drawing	3		3		3
	15		15		15
Military drill	2	Physical train'g	2	Military drill	2
Hygiene	6 lectures.				

Sophomore Year.	1st Term.		2d Term.		3d Term.
English	1		1		1
Physics	3		3		3
Invertebrate zool.	3	Vertebrate zool.	3	Botany	3
Physiology	3	Psychology	2	Logic	3
Microscopy	3		3		3
		Chemistry	3		3
	13		15		16
Military drill	2	Physical train'g	2	Military drill	2
Electives	2–5		3		

Junior Year.	1st Term.	2d Term.	3d Term.
Themes	2	2	2

The remaining work of the junior year, and all the work of the senior year, is elective, with the provision that at least twelve hours must be devoted continuously to studies specially relating to agriculture or horticulture, a list of which is given below (the studies being arranged somewhat in the general order in which they should be taken):

Agricultural chemistry: lectures; laboratory work in qualitative and quantitative analysis.

Botany: compositæ and gramineæ; arboriculture and landscape gardening; vegetable physiology, vegetable histology; fungi and algæ, and systematic and applied botany.

Geology, economic: lectures.

Entomology: lectures and laboratory practice.

Horticulture: lectures and field work.

Veterinary studies: anatomy and physiology, pathology, sanitary science, parasites, medicine and surgery.

Agriculture: lectures and field work.

Land surveying.

This course, it will be seen, is intended not only to give the student that practical knowledge of the science of agriculture which will fit him to become a successful farmer, but also to furnish such general scientific and literary culture, combined with technical training in agriculture, as will qualify the student to fill successfully any position as a teacher of agriculture, writer upon agricultural journals, or superintendent of large operations that he may be called upon to fill. A large number who have taken this complete course are now filling positions of this kind. Of Cornell graduates now exerting an influence for the advancement of agricultural knowledge in this country there may be mentioned, in illustration, Mr. Lazenby, Professor of Horticulture in the Ohio State University, and Director of the State Experiment Station; Mr. Holmes, Professor in the University of North Carolina; Mr. Wing, Professor of Agriculture in the Nebraska State University; Mr. Comstock, Professor of Entomology in Cornell University, formerly United States Entomologist; Mr. Henry, Professor of Agriculture in Wisconsin University; Mr. Trelease, of the Shaw School of Botany, author of many well-known works on the fertilization of flowers and upon parasitic fungi; Mr. Salmon, United States Veterinarian; Mr. Smith, assistant to the U. S. Veterinarian; Mr. Howard, first assistant to the U. S. Entomologist; Mr. Aubert, Professor in the Maine State Agricultural College; Mr. H. W. Smith, Professor in the Agricultural School at Truro, Halifax; and Mr. Atkinson, Professor in the University of North Carolina.

B.

Special course in Agriculture, not leading to a degree.

There are a large number of farmers' sons who would be glad to spend one or two years at the University pursuing studies in applied agriculture, of whom the four years' course demands too much in the way of preparation, as well as of time and expense. To accommodate this class a special course has been provided, the only requirements of which are that students must possess a fair knowledge of English, and must select at least three-fourths of their studies from the list of elective studies in agriculture, given above. This enables the student even in one year to attend the courses of lectures given by the Professor of Agriculture, the Professor of Veterinary Science, and the Professor of Agricultural Chemistry, and thus affords him a systematic and practical knowledge of those branches that will be of most service to him. Special students, during the time they are in the University, enjoy equal advantages in all respects with students studying for a degree.

III.

GENERAL CHARACTERISTICS OF THE COURSES—INFORMATION.

Students in the four years' course are presumed at the time of their admission to be fairly familiar with all of the rudimentary operations of the farm. If they are not, they can acquire this knowledge and practice either at the University farm or under the eye of some good farmer during their first summer vacation.

All students are required to work five hours each week for one year, under the direct supervision of the Professor of Agriculture, in the farm workshop, in the barns, or in the fields. Nearly as much more time is spent by them in the fields and barns, under the Professors of Veterinary Science, Botany and Horticulture, Geology and Entomology. Students receive no pay for this or any other educational work. The field-work supplements the lectures and recitations, in order that the application and value of the principles taught may be thoroughly understood and remembered by the student.

In applied agriculture, lectures and recitations are given daily throughout one year; a like amount of time is given to veterinary science and also to botany and horticulture. Three lectures each week for two terms, with laboratory practice, are given in entomology. Much time is devoted to agricultural chemistry and geology, and the teaching is with special reference to their application to agriculture.

Visits are made from time to time to the best farms and herds in New York and Canada, in order that the students may have opportunities for a wide range of study and comparison, and may come into direct contact and relations with the best class of farmers. These visits give the students the best of opportunities for studying the results of science and practice combined.

For the benefit of both teacher and student many experiments are entered into. The results of some of these investigations have been given to the public in published reports. Specific information in regard to all matters connected with the University is given in the Register, which will be sent free on application to Mr. E. L. Williams, Treasurer of the University.

IV.

REQUIREMENTS FOR ADMISSION.

For admission to the course leading to a degree, students must be at least sixteen years of age, and they are required to pass an examination in arithmetic, geography, grammar, elementary algebra, plane geometry and physiology. Regents' diplomas and pass cards, and certificates from approved high schools and academies, are accepted in place of these. For admission to the special course not leading to a degree students must be at least eighteen years of age, and must satisfy the Professor of Agriculture of their ability to carry on the work with profit.

Full instructions on this head will be found in the University Register.

V.

TUITION FEES.

To ALL students of agriculture tuition is GRATUITOUS.

CORNELL UNIVERSITY.

SPECIAL FEATURES.

Teaching. For those who desire to fit themselves for teaching, Cornell University offers special facilities. Professor S. G. Williams, Ph. D., Professor of the Science and the Art of Teaching, lectures throughout the year, treating of the Science of Education, School Instruction, the Organization and Management of Schools, Supervision, School Buildings and Appliances, Hygiene, School Economy, etc. A seminary for the discussion of questions presented by the lectures is also conducted throughout the year. A SPECIAL CERTIFICATE IN PEDAGOGY is given to graduates of the University who have completed these courses.

Medical Preparatory Course. To those who desire to become physicians, the Two Years' Course Preparatory to the Study of Medicine offers special advantages. Instruction is given in Chemistry, Physiology, Anatomy, Microscopy, Botany, Veterinary Science, Zoology, etc. A SPECIAL DIPLOMA is conferred on the completion of the course.

Law. A Law Department will be opened in September, 1887 The University possesses a Law Library numbering some 5,000 volumes. The course will be complete and thorough, the instruction of the best, and the expense moderate.

Summer Course. A SUMMER COURSE IN ENTOMOLOGY begins the Monday following Commencement, and extends over ten weeks. The chief object of the course is to give training in methods of natural history work.

Agriculture. Special students in Agriculture are received without examination, on condition that they are at least eighteen years of age, and satisfy the Professor of Agriculture of their ability to profit by the instruction afforded. TUITION IS FREE TO ALL SUCH STUDENTS.

Special Students. Special Students are received at any time, without examination, to prosecute such studies as they desire. Such students, excepting those in Agriculture, must be at least twenty-one years of age, and must be recommended to the Faculty by the head of the department in which they desire to work.

Graduate Study. Special facilities are afforded for college graduates desiring to pursue advanced studies. To all such students' tuition is FREE.

For further information, see second and third pages of the cover.

The University Register, containing a full description of the various courses, terms of admission, cost of residence, etc., is sent free on application to

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