REPORT OF THE CHIEF OF THE DIVISION OF VEGETABLE PATHOLOGY.

SIR: I have the honor to submit herewith my annual report for the year 1890. As heretofore, the report embodies only a brief summary of the work accomplished in this Division during the year, the details having been published in various bulletins and circulars already issued.

Respectfully,

B. T. GALLOWAY,
Chief of the Division of Vegetable Pathology.

Hon. J. M. RUSK,
Secretary.

WORK OF THE DIVISION.

GENERAL BUSINESS.

Under this heading may be mentioned care of correspondence, preparation of bulletins and circulars, work on the herbarium, indexing literature, and properly classifying and filing the same.

During the year nearly three thousand letters were received and answered, this work consuming fully one third of my own and assistants' time. The writing, indexing, filing, and general care of the letters requires nearly the whole time of two clerks.

Since my last report the Division has published, in addition to the regular annual report, one special bulletin and four numbers of THE JOURNAL OF MYCOLOGY. The special bulletin contained 120 pages and embodied the results of experiments made in 1889 in the treatment of plant diseases. The JOURNAL contains numerous papers, both scientific and practical, and as an important means of quickly and effectively disseminating information I can not conceive of anything more useful. During the year the edition was increased 500, but such has been the demand for it that every number but the last is now exhausted.

The general care of the herbarium requires the work of one assistant, while indexing, filing, and general supervision of the literature consumes a considerable part of the time of another.

The force practically remains the same as last year, the assistants being Miss E. A. Southworth and Mr. D. G. Fairchild. Erwin F. Smith is still in charge of the peach yellows investigation and Newton B. Pierce of the California vine disease. Pear blight and several other diseases have received attention at the hands of Mr. M. B. Waite.

LABORATORY WORK.

During the year the principal diseases under investigation in the laboratory were pear blight, a bacterial disease of oats, sweet potato diseases, anthracnose of the cotton and hollyhock, peach yellows, the California vine disease, pear scab, cherry leaf blight, grape diseases, and diseases of greenhouse plants, particularly of the carnation and violet.

A new disease of the grape appeared the latter part of September in several parts of New York State. The matter was investigated by Mr. Fairchild and found to be a malady which has been known for some time in certain parts of Europe. The disease manifests itself in the form of red or purplish spots on the leaves, the latter soon becoming brown and withered, and finally falling, leaving the fruit to shrivel or else mature imperfectly. In Mr. Fairchild's report, which was published in THE JOURNAL OF MYCOLOGY, Vol. VI, No. 3, the disease is fully described, its causes pointed out and suggestions made in regard to preventing it.

In connection with the laboratory work on pear blight Mr. Waite visited Georgia during the months of February, March, and April, making, while there, a series of field tests with fungicides, and also collecting such data as only field investigations render possible.

The work on peach yellows and the California vine disease is given more in detail under their respective headings.

FIELD EXPERIMENTS.

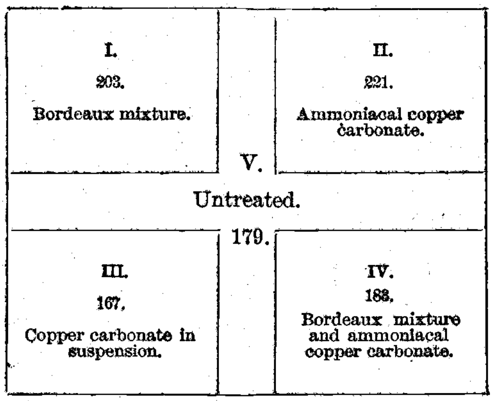
A special effort has been put forth during the year to make the field experiments as thoroughly practical as possible. With this end in view I have spent considerable time in the field myself and have also kept one or more of my assistants constantly engaged in work of this kind. I am more than satisfied with the results of the work, as we have been able to obtain facts which would not have been possible had we depended on field agents exclusively.

I believe that to obtain the best results in practical experiments, such as we are conducting, we must either do the work ourselves or place it in the hands of men having a thorough knowledge of plant diseases. Such men, with possibly here and there a rare exception, are as yet to be found only in some of our experiment stations; it is by coöperation with these that we are able to secure the very best results at comparatively little expense to the Department and practically none to the Stations. Our coöperative work this year with the Wisconsin Station has proved eminently satisfactory, both to us and the Station, and the expense to both has been less than half what we usually pay for field agents.

EXPERIMENTS NEAR WASHINGTON.

This work was conducted wholly by myself and assistant, Mr. D. G. Fairchild, the diseases under treatment being black rot of the grape, pear leaf-blight, and pear scab.

Treatment of black rot of the grape.—For this experiment a vineyard belonging to Capt. J. O. Berry, situated 12 miles southwest of Washington, was selected. The vineyard consisted of about one thousand Concord vines, sixteen years old, and trained to stakes 8 feet high. It had not borne a pound of fruit for several years on account of rot, thus furnishing the very best means of thoroughly testing the value of the fungicides.



The vineyard was divided into five plats, as shown in the accompanying diagram. The diagram also shows the number of vines in each plat and the treatment it received. The experiment was not made to discover a remedy for black rot, for this question had been settled already. The main object of the work was to determine, if possible, (1) the best means of applying the fungicides; (2) the relative value of the fungicides mentioned in the diagram, and (3) the amount of copper found at the close of the season on fruit treated with the Bordeaux mixture. Each plat was sprayed eight times, first on May 1, and afterwards at intervals of fifteen days, except the last treatment, which was made at the expiration of twenty days.

As regards vigor of vines there was considerable difference in the various plats, hence it was not expected that the yield for each division would be uniform, even if all were treated alike.

In applying the fungicides three spraying machines were used, namely: the Eureka, the Japy, and Nixon's Little Giant. The Eureka and Japy pumps are of the knapsack pattern, while the Nixon is a cart machine holding 40 gallons. It is drawn by hand and is provided with two hose connections, an agitator for keeping the liquid stirred up, and 16 feet of hose. After a thorough trial of all of the machines the Little Giant was selected as the one best suited to our wants. With it we were able to treat four rows at a time, doing the work as thoroughly and rapidly as we could spray two rows with the knapsack pumps.

There is no doubt that, in certain situations, such as on steep hillsides, where the vines are trellised, the knapsack pumps will be found to work to the best advantage. Also where a person has only a small vineyard, of say, not more than 3 or 4 acres, such a pump will be all that is required. For large vineyards horse-power machines should be used. Some of these pumps drawn by two horses and worked by two men and a boy will spray an acre of vines in thirty minutes.

In all cases we used the Improved Vermorel nozzle and lance and we can say without hesitation that for our work we have not been able to find anything better.

As to the relative value of the treatments, cost, etc., a full account is published in THE JOURNAL OF MYCOLOGY, Vol. VI, No. 3. I only give here some of the more important conclusions taken from this report. They are as follows:

(1) On Plat I, treated with Bordeaux mixture, there was saved $32.40 worth of fruit at an expenditure of $6.51, leaving a profit of $25.89, or 397 per cent. On Plat II, treated with ammoniacal copper carbonate solution, there was saved $25.92 worth of fruit at a cost of $4.32, leaving a profit of $21.60, or 500 per cent. On Plat III, treated with copper carbonate in suspension, the value of the fruit saved was $6.48, the cost of treatment $2.25, leaving a profit of $4.23, or 188 per cent. On Plat IV, treated with Bordeaux mixture and ammoniacal solution, the value of the fruit saved was $19.44, the expense of treatment $3.34, leaving a profit of $16.10, or 482 per cent.

(2) While the amount of fruit saved by the Bordeaux mixture was greater than that by the ammoniacal solution the latter preparation is after all the cheapest. In other words, there was more profit in using the ammoniacal solution than the Bordeaux mixture.

(3) A mixed treatment consisting of Bordeaux mixture and ammoniacal solution is more profitable than a treatment of Bordeaux mixture alone, but not as profitable as the ammoniacal solution alone.

(4) There is nothing whatever to be gained by treating with the carbonate of copper in suspension when the ammoniacal solution is at hand.

In regard to the amount of copper found on the grapes at the time of harvest it was shown that a person would have to eat from a ton to a ton and a half of fruit to obtain a poisonous dose of this salt.

Treatment of pear, cherry, and strawberry leaf-blight as affecting nursery stock.*—This work was conducted in the nurseries of Franklin Davis & Co., situated on the Pennsylvania Railroad about 25 miles northeast of Washington. The details of the experiment as well as those given under the next heading will be published in THE JOURNAL OF MYCOLOGY, copies of which will be sent on application.

The work so far as it relates to the experiments in the treatment of pear leaf-blight was in the main a repetition of that done last year. This season, however, a number of new fungicides were tried but none of them proved as satisfactory as the Bordeaux mixture. The discovery that this preparation, when properly applied, will prevent this most injurious disease, marks an era in successful nursery work. During the present season the nurseries of Mr. Davis were visited by tree-growers from all over the country and in every case they expressed the greatest satisfaction at the results of the treatment. Mr. Davis's abiding faith in the copper remedies, and especially in the Bordeaux mixture, is shown by the fact that this season he used over 2,500 gallons of the latter alone. Briefly stated, the most satisfactory method of treating the disease under consideration is to spray first with the Bordeaux mixture when the leaves are about two thirds grown, then follow with other applications of the same preparation at intervals of about twelve days until five or six sprayings in all have been made. The cost of such a treatment need not exceed 75 cents per thousand trees.

This year for the first time, as far as we are aware, a systematic endeavor was made to control a disease of the cherry which has come to be known among nurserymen as leaf-blight. This disease attacks the cherry leaves about the middle of June or the first of July, caus-

**Entomosporium maculatum*, Lév., *Cylindrosporium padi*, Karst., *Sphærella fragariæ*, Tul.

ing them to at first become spotted then turn yellow and fall. Frequently the trees will be completely defoliated before the middle of August, and as a result growth is checked and the plant is stunted.

In treating the disease the present season the best results were obtained from the use of the ammoniacal copper carbonate and the Bordeaux mixture. As far as the efficacy of the two fungicides is concerned there is little choice. The ease with which the ammoniacal solution is prepared and applied, however, makes it more desirable in the end. The treated trees retained their foliage until frost, and in many cases made a growth of nearly 2 feet more than the untreated. Six sprayings in all were made, beginning on May 1 and continuing at intervals of twelve days. The total cost of the treatment for trees three years old was approximately one fourth of a cent per tree.

As the experiments in the treatment of strawberry leaf-blight do not necessitate any elaborate details, we will give an account of the work in full.

On April 18 a plat of the Wilson strawberry containing five rows each 90 feet long and running north and south was staked off and prepared for treatment. The ground sloped gently towards the south and had evidently been somewhat neglected, as the plants were thickly matted and full of weeds. The rows were numbered 1, 2, 3, 4, and 5. On the 28th of April rows 1 to 3, inclusive, were sprayed, while the others were left unsprayed for comparison. At this time considerable leaf-blight had already appeared, but the plants were in nowise seriously injured by the disease. Of the three rows treated No. 1 was sprayed with ammoniacal copper carbonate solution; No. 2 with Bean's sulphur powder one half pound to 5 gallons of water; No. 3 with potassium sulphide solution, one half ounce to 5 gallons. The sprayings were repeated on May 13 and May 23.

The cost of the treatment, including labor in preparing and applying the remedies, chemicals, etc., was, for the plat treated with the ammoniacal copper carbonate solution, 13 cents; plat treated with Bean's powder, 8 cents; plat 3, treated with potassium sulphide solution, 3½ cents. Basing our estimates on these figures the cost of treating an acre with each of the foregoing preparations would be approximately as follows: For the ammoniacal solution, $21; Bean's powder, $12; potassium sulphide solution, $6. We feel safe in saying that in treating as much as an acre the cost would be lessened at least 25 per cent.

At the time of the second spraying it was an easy matter to distinguish the row treated with the ammoniacal solution on account of its brighter and more thrifty foliage, comparatively free from leaf-blight. The other rows at this date were all badly diseased, there being little if any difference between the treated and untreated. On May 23, when the last spraying was made, the difference between the row treated with ammoniacal copper carbonate and the others was even more striking than when noted ten days previous. What made the result of more interest and importance was the fact that a portion of this same row which extended beyond the experimental plat and which in consequence was not treated, was as badly diseased as the unsprayed rows of the plat.

Treatment of pear leaf-blight and scab in the orchard.—In addition to our nursery work in the treatment of pear leaf-blight it was thought best to make some attempt to prevent the injury to fruiting pear trees from the attacks of the leaf-blight and scab fungi.

This work was carried on in the orchard of Dr. W. S. Maxwell, near Still Pond, Maryland.

In the case of pear leaf-blight an attempt was made to throw some light upon the following questions: (1) The relative value of the Bordeaux mixture, the ammoniacal copper carbonate solution, a solution of copper acetate, copper carbonate in suspension, and mixture No. 5, as preventives of this disease; (2) the number of sprayings necessary to obtain the best results; (3) the proper time of applying the remedies; (4) the cost of the various treatments.

Summing up briefly the results it may be said that so far as effectiveness of the various preparations is concerned they stand in the order named:

Bordeaux mixture (Plate IV), ammoniacal solution (Plate V), copper acetate 3 ounces to 6 gallons of water, mixture No. 5, copper carbonate in suspension.

The difference between the effects of the Bordeaux mixture and of the ammoniacal solution was scarcely perceptible, so that taking the cost into consideration the latter would be preferable.

As regards the number of sprayings and the time of making the same it was found that three early treatments were just as effective as six made at intervals throughout the season. It was further made evident that one late spraying with either Bordeaux mixture or the ammoniacal solution would save a large percentage of the foliage, the former preparation proving much more effective in such a test.

The cost of the various treatments was as follows:

Treatment.	Cost of fungicide per tree.	Cost of application per tree.	Total per tree.
	Cents.	*Cents.*	*Cents.*
Bordeaux mixture, one spraying	1.7	1.1	2.8
Bordeaux mixture, three early sprayings	6.93	3.4	10.33
Bordeaux mixture, three late sprayings	7	4.8	11.8
Bordeaux mixture, six sprayings	15.1	8.7	23.8
Ammoniacal solution, one spraying	.61	.83	1.44
Ammoniacal solution, three early sprayings	3.32	5.6	8.92
Ammoniacal solution, five late sprayings	3.6	3.5	7.1
Ammoniacal solution, six sprayings	7.2	8.2	15.4
Mixture No. 5, six sprayings	8.6	9	17.6
Copper acetate, three sprayings	4.3	5	9.3
Copper acetate, six sprayings	12.4	9	21.4
Copper carbonate in suspension, five sprayings	6.8	6.5	13.3

In the treatment of pear scab the same fungicides used in the preceding experiments were employed, the cost per tree being practically the same. The conclusions drawn from the results of this work are:

(1) Early treatments, *i. e.*, before the fruit is half an inch in diameter, are absolutely necessary to prevent the scab.

(2) Spraying after the fruit is half grown is liable to injure the latter.

(3) The Bordeaux mixture and ammoniacal solution are the only preparations which give really satisfactory results.

COÖPERATIVE EXPERIMENTS.

Similar arrangements to those of last season were this year made with the director of the Wisconsin Experiment Station by means of which Prof. E. S. Goff, horticulturist of the Station, was enabled to carry on a series of experiments under our direction. The work was conducted on the fruit farm of Mr. A. L. Hatch, 3¼ miles southeast of the village of Ithaca, Richland County, Wisconsin, the diseases treated being apple-scab, blackberry and raspberry leaf-blight, and potato rot.*

Experiments in the treatment of apple scab.—These were planned with a view of obtaining some information upon the following questions:

(1) The comparative efficacy of the ammoniacal copper carbonate solution, Bean's sulphur powder, mixture No. 5, and copper carbonate suspended in water.

(2) The value of spraying previous to the opening of the flowers.

(3) The number of treatments necessary to secure the best results.

In this work many important facts were brought out, the most prominent of which may be summarized as follows:

(1) In seasons of excessive rains in early summer the scab on badly infested trees can not be wholly prevented by the treatments given in this experiment.

(2) That of the substances tested mixture No. 5 was the most efficient.

(3) Early treatments, especially previous to the opening of the flowers, are extremely important.

(4) Sprayings in midsummer are at best of doubtful value.

(5) On trees badly affected with scab the fruits that develop may be so far reduced in size by the fungus as to diminish the crop nearly 20 per cent. This, moreover, is doubtless a small part of the injury produced.

Raspberry leaf-blight—This was treated with the Bordeaux mixture and mixture No. 5. The disease, which is caused by a fungus known as *Septoria rubi*, makes its appearance on the leaves often as early as the middle of June in the form of whitish or faintly brownish spots. The spots frequently become so numerous as to completely cover the leaf, and as a result the latter dries up and of course becomes utterly useless to the plant. When fruiting canes are attacked in this way the fruit never matures or if it does it is small, dry, and tasteless. The varieties of raspberries selected for the experiment were Cuthbert for red and Tyler and Gregg for black; those of the blackberry were Stone's Hardy and Ancient Briton. All were growing in somewhat dense rows, and at the time of the first spraying, May 31, presented a thrifty appearance and gave promise of a good crop of berries. At this time the leaves were nearly full grown and the flower buds, though visible, had not yet opened. Forty feet of row of each variety selected for the experiment were treated at the different sprayings with each of the fungicides named. Treatments were given on May 31, June 5, 18, 28, July 7 and 14. In the treatment of June 28 the Tyler and Cuthbert raspberries were omitted, as there were unmistakable indications of injury to the foliage. In the treatment of July 7 and 14 all of the raspberries were omitted as the fruit was beginning to ripen.

It was shown by these experiments that—

(1) The foliage of the raspberry is delicate and can not endure applications of a corrosive nature.

(2) The foliage of the blackberry, though more resistant than that of the raspberry, is more susceptible to injury than that of the apple.

(3) None of the treatments given are to be recommended for the raspberry, and of the materials used only the copper carbonate solution can be pronounced beneficial in the case of the blackberry.

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* *Fusicladium dendriticum*, *Septoria rubi*, and *Phytophthora infestans*.

Experiments in the treatment of potato-rot.—The results of this work, which was carried on under my direction by Professor Goff, are eminently satisfactory. Without going into details, which will be published in a special bulletin, I will say that the Bordeaux mixture was applied six times, the result being an increase in the yield of the treated plats over the untreated of from 25 to 50 per cent with comparatively little expense.

WORK OF FIELD AGENTS.

The field agents this year were located in New Jersey, Virginia, South Carolina, and Missouri, their work for the most part being confined to experiments in the treatment of grape diseases. As the reports of these agents can not well be condensed I have reserved them for publication in a special bulletin.

SOME PRACTICAL RESULTS OF THE TREATMENT OF PLANT DISEASES.

The question has occasionally been asked what is the real value in dollars and cents of the treatment of plant diseases. Everyone who has carried on work of this kind knows how difficult it is to obtain exact reports, especially from farmers, fruit growers, and others who, as a rule, make no pretense to skill in bookkeeping. In a few cases, however, we have been able to collect reliable data which show what can be accomplished by proper care and attention to details. In the case of Mr. Berry's vineyard, already mentioned, 777 Concord vines were made to yield $84.24 worth of fruit at an expenditure of $17.42, a clear profit of $66.82. This result, it must be borne in mind, was obtained from an experimental vineyard where the object was not so much the production of a large yield of fruit as to test the relative value of a number of fungicides. It is safe to say that had we used the Bordeaux mixture on the entire vineyard the value of the yield would have been increased to at least $100, while the expense of treatment per vine would have been materially decreased.

Mr. D. M. Wyngate has a large vineyard near Marlborough, New York, and at my request has furnished a careful estimate of the profit derived the present season from treatments suggested by this Division. His vineyard contains 7,450 Concord and 1,000 Delaware vines. The vineyard last year was not treated and yielded 19,690 pounds of fruit, which sold for $625.87. This year the same vineyard was treated seven times, as follows:

(1) March 1, simple solution of copper applied to canes and posts.

(2) Just before blossoming with Bordeaux mixture B.

(3) Just after the grapes had formed with Bordeaux mixture same as 2.

(4) July, same as 2 and 3.

(5, 6, and 7) At regular intervals between July 10 and August 25, with eau céleste.

The total cost of the foregoing treatment, including a Eureka sprayer, was $112.52, divided as follows:

Eureka sprayer	$21.50
Material	38.52
Labor	52.50
Total	112.52

The yield of fruit this season was 53,430 pounds, which sold for $2,181.39. Thus it will be seen that the yield for 1890 (treated) exceeded that of 1889 (untreated) by 33,740 pounds, while there was a net increase in the profits of $1,555.52. It might be said that the season of 1890 was a better one for grapes than that of 1889, hence the increased yield: to obtain definite information on this point Mr. Wyngate left fifty of his vines untreated and they yielded only 40 pounds of fruit totally unfit for market. On this basis his entire vineyard, if not treated, would have yielded 6,760 pounds of inferior fruit worth perhaps $600. Mr. Wyngate, in concluding his report, places his profits for the season, as a result of the treatment, at $1,800 over all expenses.

Prof. L. D. Chester, of the Delaware Experiment Station, has for the past two years been making a series of trials in the treatment of black rot of the grape. Professor Chester has kept a careful record of the facts bearing upon the question under consideration, and his results may be briefly summed up as follows:

A vineyard of 1,088 vines which in 1888 yielded only 250 pounds of fruit was treated in 1889 with the Bordeaux mixture at a total cost of $36.10. As a result of the treatment the yield of grapes was increased to 2,953 pounds, which sold for $144.40, leaving a balance of $108.30. This year the same vineyard was again treated at an expense of $27.80. The yield was 7,451 pounds of fruit, which sold for $560.90, leaving a balance of $533.10. In two years Professor Chester has been able to increase the average yield of this vineyard from one fifth of a pound to 8.47 pounds per vine.

Turning now to another class of plant diseases we will give the results of a series of experiments personally conducted the past two seasons in the nurseries of Franklin Davis & Co., near Baltimore. In the spring of 1889 this firm set out a block of 50,000 pear seedlings with the expectation of budding them the following July. As a rule seedlings of this kind are attacked by leaf-blight* as soon as the foliage appears, and in consequence it is a rare thing that more than half of the buds take. In the hope of saving the foliage the Bordeaux mixture was applied seven times during the season at a total cost of $60, and as a result less than one tenth of 1 per cent of the buds failed to take. This year the same treatment was continued at an additional expense of $60. Many of the buds have made a growth of 10 feet during the season and as the block now stands it is worth fully $7,000. From control experiments and from the experience of previous years it is safe to say that this amount is fully double what the trees would have been worth had they been left untreated. These facts are sufficient to bring out clearly the point we wished to make, namely, that spraying for plant diseases can be done at a handsome profit. In the light of our present knowledge the work must be regarded as a legitimate part of one's business. In other words the farmers, gardeners, and fruit growers who neglect such work at the present day are as much to blame for short crops as those who fail to perfectly manure and cultivate the soil.

FUNGICIDES AND SPRAYING APPARATUS.

During the year a number of new fungicides have been prepared and tested by the Division; at the same time several marked improvements were made in apparatus for applying the same.

Entomosporium maculatum, Lév.

Of the new fungicides the most promising is the one sent out under the name of mixture No. 5. This consists of equal parts of ammoniated sulphate of copper and carbonate of ammonia, thoroughly mixed and put up in air-tight tin cans. It was prepared for us by Rosengarten & Sons, of Philadelphia, at a cost of 45 cents per pound. In most cases we used it at the rate of 12 ounces to 22 gallons of water, but for tender foliage, such as the cherry, blackberry, peach, and young grapes, this is too strong. Another season an endeavor will be made to determine if this amount can not be reduced without affecting the efficacy of the preparation. Mixture No. 5 gave excellent results in the treatment of apple scab; it also proved highly efficacious as a remedy against mildew and black rot of the grape. Much, however, remains to be done in the way of thoroughly testing the fungicide, especially in the matter of finding some means by which it may be prevented from injuring the foliage.

Some of the advantages the mixture possesses over other copper preparations are (1) cheapness, (2) ease with which it is prepared, and (3) the fact that it can be put up in small quantities, only requiring to be dissolved in water when it is ready for use. This last matter is one of considerable importance, as it will enable a great many people to use a fungicide who do not care to take the trouble of preparing the Bordeaux mixture and other similar preparations.

Copper acetate, which has already been used in France, was given a thorough trial in the treatment of a variety of plant diseases. It was used in various strengths varying from 3 to 6 ounces to 25 gallons of water, the usual method of preparing being to dissolve the copper in 5 or 6 gallons of water, allowing this to stand over night and then diluting the next day when ready for use. In no case did the preparation prove of any great value; in fact, in a number of instances, when it was used on young pears and cherries, it was positively injurious. We do not on this account wish to discourage further trials of it, but when it is used considerable caution should be exercised in applying it.

As stated in another part of this report, an endeavor was made to test the efficacy of the Bordeaux mixture when prepared in advance. The mixture was put up for us by a manufacturing chemist in Philadelphia in the following manner:

The copper and lime solutions were made in the usual way, and after mixing, the preparation was allowed to stand for a few hours or until the sediment had all gone to the bottom of the vessel. The clear liquid was then drawn off and thrown away while the pasty sediment, which is of a light-blue color, was slowly dried. This dried sediment was sent to us in the form of a coarse powder put up in 10-pound tin cans. It was used at the rate of 10 pounds to 25 gallons of water in the treatment of pear leaf-blight, downy mildew, and black rot of the grape. Without going into the details of the experiments made to test the efficacy of the preparation we will simply say that in no case did it prove as effectual as the Bordeaux mixture prepared in the usual way. We found it a difficult matter to keep the powder in suspension; moreover, the solution was washed from the leaves by the slightest rain. It is possible that some of the objections may be overcome, but I doubt very much if the mixture prepared as described will ever prove as satisfactory as that made in accordance with the old formula. For those who may wish to put the mixture on the market I would suggest that they put the copper and lime in separate cans, in this way simply furnishing the materials in convenient form and allowing the farmer or fruit grower to do his own mixing. At the present prices 4 pounds of copper and 5 of lime, which is sufficient for 22 gallons of the liquid, could be canned and labeled, in fact, fully prepared and sold for 10 cents a pound at a moderate profit.

In addition to the foregoing, experiments were made with a modified formula of the ammoniacal copper carbonate solution. This was prepared by mixing together 1½ pounds of pulverized ammonia carbonate and 3 ounces of copper carbonate. In using, the mixture was dissolved in half a pail of hot water and then diluted to 25 gallons. While this solution seemed to give as good results in the treatment of pear leaf-blight as the old formula it is not as satisfactory for several reasons. In the first place its preparation takes considerable time, as the ammonia carbonate must be pulverized. Again, it is a difficult matter, at least in inexperienced hands, to prevent the ammonia from losing its strength. Finally, it is a trifle more expensive than the ammoniacal solution prepared in the usual way, 25 gallons costing 35 cents and this for materials alone.

Professor Chester, of Delaware, who was, I believe, the first to suggest the use of this mixture, prepares it at an expense of but 25¼ cents for 100 gallons. He uses, however, but 2 pounds of ammonia carbonate and 6 ounces of copper carbonate for 100 gallons. Even of this strength the copper alone would cost about 40 cents if bought in the market. Professor Chester, however, manufactures his own copper carbonate at an actual expense for materials alone of but 14 cents per pound. His method of preparing it is as follows:

Dissolve in a barrel 25 pounds of copper sulphate in hot water. In another barrel dissolve 30 pounds of sal soda in hot water. Allow both solutions to cool, then slowly pour the solution of sal soda into the copper sulphate solution, stirring the same. Fill the barrel with water and allow the precipitate of copper carbonate to settle. Upon the following day siphon off the clear supernatant liquid which contains most of the injurious sodium sulphate in solution. Fill the barrel again with water, and stir the precipitate vigorously into suspension; again allow the precipitate to settle and again on the following day siphon off the clear liquid. This operation washes the carbonate free of most of the sodium sulphate which contaminates it. Make a filter of stout muslin by tacking the same to a square wooden frame which will just fit over the open top of the second barrel, letting the muslin hang down loosely so as to form a sack; through this filter the precipitate so as to drain off the excess of water, and as the filter fills remove the precipitate, and allow it to dry in the air, when it is ready for use. The operation is not troublesome, and can be carried on in connection with other work.

Professor Chester says that 2 pounds of commercial sulphate of copper, costing 5⅜ cents per pound, and 2.5 pounds of soda, costing ¼ cent per pound, will make 1 pound of carbonate of copper. Carbonate of copper prepared in this way can of course be used in the preparation of the usual ammoniacal solution, and the cost of 22 gallons of the same will be reduced from 34 to approximately 16 cents.

Experiments were made by several of our field agents and also by myself to test the efficacy of copper carbonate suspended in water. Three ounces to 25 gallons was the usual strength adopted, but the results obtained were far from satisfactory. This question as well as others pertaining to the subject will be fully described in a forthcoming bulletin containing the reports of field agents.

In the matter of spraying apparatus a new knapsack pump and several improvements in older machines have been designed by the Division during the year. The need of a cheap, durable, and effectual knapsack pump has long been felt in this country, where up to the present season there was only one similar instrument manufactured. The machine designed by us, including a copper reservoir, force pump, spraying nozzle, and lance, can be made for $12. A description, with working drawings of the apparatus, has been published in THE JOURNAL OF MYCOLOGY, Vol. VI, No. 2.

Owing to the expense of using copper for reservoirs an endeavor was made to substitute indurated fiber ware in its place. This ware, which is made from wood pulp, is light, durable, and cheap. Moreover it does not corrode even when our strongest chemicals are used. We have had several reservoirs made from it, and with the exception that it has been difficult to make tight connections where brass or copper are used they have given satisfaction. We are assured by the manufacturers that fittings of any kind can be permanently and tightly inserted in the reservoir if it is done when the latter is "green," *i. e.*, before it is indurated or cured. If this is the case, we see no reason why the fiber ware should not eventually come into use for work of this kind.

An effort is being made to induce manufacturers of spraying machines to adopt some uniformity in the matter of nozzle attachments. As it is, nearly every manufacturer has a size of his own, in consequence of which one is often forced to use a nozzle not wholly suited to the work or else go to the expense of having the proper fittings made. At the last meeting of the Association of Agricultural Experiment Stations Mr. Fairchild, my assistant; Mr. William B. Alwood, of the Virginia Station; and Mr. James Troop, of the Indiana Station, were appointed a committee to inquire into this matter and bring about, if possible, some change looking toward the object under consideration.

PEACH YELLOWS INVESTIGATION.

Laboratory work.—Beginning with November, 1889, about five months were given by Dr. Smith to bacteriological and histological study. This line of inquiry has not, however, been completed, and it would be out of place to draw conclusions from what has been done already. Much additional investigation will be necessary before we can speak decisively. This part of the investigation was crowded out in the spring of 1890 by field work, but will be resumed as soon as possible.

The work already done may be summarized as follows: Two suspected organisms have been isolated from the diseased tissues grown on and in various nutrient media, and studied as carefully as time permitted. Both are short rods (*Bacilli*). Both were found in nearly every diseased tree, but they appeared so rarely that grave doubts have arisen as to their disease-producing nature. If the disease is due to a microörganism it must be rather abundant, judging from the results of bud inoculations. To complicate matters, three yeasts were also isolated under conditions which render it almost certain that they came only from the inner bark. These also were rare. At that time no peach trees suitable for inoculation were at hand. These have since been grown from seed procured in three localities free from the disease, and are now ready for the inoculation.

Field investigation.—This work has been prosecuted continuously since early spring in Delaware, Maryland, Georgia, Michigan, and Kansas. Additional bud inoculations have been made and some further light has been obtained from both the new and old experiments. The results of this part of the investigation will be published as a separate bulletin. They may be summarized as follows: (1) The disease can be conveyed to healthy trees by the insertion of diseased buds. Additional proof of this has been obtained. (2) It may also be conveyed by the use of buds which appear to be perfectly healthy, but which have been taken from trees showing yellows on other branches. The difference in this case is that the disease does not manifest itself so quickly. (3) An additional experiment will be undertaken on a large scale to determine whether the disease may also be communicated by buds cut from trees which seem to be perfectly healthy in all parts but which stand in orchards where the disease prevails, *i. e.*, to determine whether the disease has a long period of incubation, as begins to seem probable.

The peaches budded on Mariana plum stock have been set in three orchards in the place of diseased trees. None have yet contracted the disease but it is too soon to speak definitely.

The experiments with fertilizers have been continued another season with the same personal attention to details. To avoid possible unsuspected sources of error, it is thought best to continue the treatments and include the observations of another year before making a definite report. It may now be said, however, that the other line of investigation (histological and bacteriological) seems to offer the most hope of a successful issue. Should the results of next year confirm those of 1889 and 1890 it may be set down as certain that genuine peach yellows can not be prevented or cured by the use of fertilizers.

In addition to the foregoing Dr. Smith has devoted considerable time to the study of a disease which has attracted considerable attention in various parts of the country. The disease is described in THE JOURNAL OF MYCOLOGY, Vol. VI, No. 4, under the name of the Peach Rosette.

THE CALIFORNIA VINE DISEASE.

The investigation into the nature of the vine disease which has destroyed the vineyards of some of the finest vine-growing regions of California is being steadily pursued.

Following the work indicated in my last report, during the rainy season when field work became impossible, Mr. Pierce, the special agent in charge of the investigations, undertook such laboratory work as could be followed with the facilities at hand. A brief examination into the pathological histology of the vine was made, and the search for parasitic fungi and microörganisms continued; the latter were often found, many times in a state of division. Material from the root system, obtained from various points in the affected district, was studied for the purpose of learning the constancy of such forms of fungi as are found in diseased roots at Santa Ana. One especially common form was figured.

During the early part of March, after having considered the necessity and advisability of widening the field of observation, Mr. Pierce was granted a leave of absence for five months without pay in order that he might visit certain parts of Europe and study there a number of vine diseases which, according to published accounts, somewhat resembled the California trouble.

The entire time was devoted to an active review of the workings of the vine diseases of the Mediterranean region. After passing from the northern to the southern portion of France, the leading vine regions of the southern departments were visited from below Bordeaux to the Italian line. A portion of this same region was again visited upon his return from Algeria. From France he entered Italy, and after first briefly visiting the vineyards and many of the leading scientists of northern and central Italy, Naples was chosen as a center of work for the South. The diseases of the province of Naples and adjoining provinces had his attention for upwards of seven weeks. From Naples he passed to Sicily, continuing the work at Messina, Catania, and Syracuse, and in the western portion of the island at Palermo, Marsala, and Trapani. Those regions where Mal Nero has done its worst work received most of his time.

From Marsala, in southwest Sicily, steamer was taken for Pantelleria and Tunis. Some 600 or 700 miles of travel were made through the regency of Tunis and departments of Constantine and Algiers. Several stops were made in the vine-growing sections.

His trip comprises over 15,000 miles of travel, and that portion bordering the Mediterranean was full of interest to the pathologist and fruit grower. Numerous diseases not yet known in America were encountered, and American affections were observed under new and very interesting conditions. Many facts of interest and value to the fruit grower have been collected, more especially to Californians, as the climate and flora of the two regions are quite similar. A report embodying the results of Mr. Pierce's investigations up to the present time is now being prepared, and it is hoped to have it in the hands of the printer within a few months.

In addition to Mr. Pierce's work an extended series of experiments were made by me in Washington with a view of determining the contagious or noncontagious nature of the disease. Healthy Muscat of Alexandria grapes were obtained from New York and inoculated in various ways with diseased material from California. The most common method of procedure in this work was to graft diseased Muscat wood upon healthy roots of the same variety. Other methods, such as inarching diseased and healthy canes, planting healthy vines in soil obtained in California from around dead and dying roots, etc., were tried, but in no case was any positive evidence of the transmissibility of the disease obtained. A peculiar fact noted in connection with these investigations was that nearly all of the diseased vines recovered as soon as they were placed in the open air. In the greenhouse, however, they never made a continuously healthy growth, but I attribute this largely to the fact that the roots being in pots were crowded, hence did not perform their functions normally. As further proof of this, healthy plants treated in the same way behaved exactly like those from California.

Along with the foregoing there was made a series of bacteriological investigations, something over three hundred cultures being made from various parts of diseased vines. While some evidence of a promising nature was obtained as a result of this work, the facts accumulated are not sufficient to warrant me in making any positive statements.

SPECIAL SUBJECTS.

Summaries are given below of three papers prepared by my assistant, Miss E. A. Southworth, to appear in full in THE JOURNAL OF MYCOLOGY. The subjects are of considerable economic importance, especially the anthracnose of cotton which threatens to be a troublesome disease.

HOLLYHOCK ANTHRACNOSE.

Colletotrichum malvarum (A. Br. & Casp.) South.

[Plate I.]

This is a disease which has been known to florists only five or six years. It is especially destructive to seedlings under glass, but attacks outdoor plants as well; and wherever it makes its appearance destroys a large part or all of the crop. It has quadrupled the price of hollyhocks in New York City in the last three years, and has nearly put an end to growing them for ornamental purposes in the Government grounds. The disease is caused by a parasitic fungus, which may live in any part of the plant. If it attacks the lower portion of the stem, as it is almost sure to do in time, it runs down to the root and kills the plant.

In order to gain all possible information as to the conditions which were favorable, or otherwise, to the life of the fungus causing the disease, a circular of inquiry was sent to some prominent florists. The answers revealed the following facts: (1) Greenhouse plants are more susceptible than others to the disease; (2) putting diseased plants out of doors *sometimes* checks the disease; (3) heat and moisture favor the development of the fungus.

An experiment in the use of Bordeaux mixture and ammoniacal copper carbonate as preventives of the disease was made in a large New York greenhouse. The results were only moderately satisfactory. Very little effect was observed from the ammoniacal solution, but the lot treated with Bordeaux mixture was much more vigorous and was much more free from the fungus than the unsprayed. The foreman of the greenhouses was so encouraged by the results that he decided to spray the plants out of doors as well.

ANTHRACNOSE OF COTTON.

Colletotrichum gossypii, South.

[Plate II.]

This disease was first brought to our notice in 1888; and since that time we have received many complaints and inquiries concerning it. It is especially destructive to the bolls, which it attacks before they are ready to open, stopping their growth, causing them to crack open, thus exposing the immature cotton fiber to the action of rain and dew and to the attacks of insects. Under these circumstances the cotton decays and the crop suffers accordingly. In this way our correspondents report that they lose from 10 to 25 per cent of their crops.

The effects described are found to be due to the action of a parasitic fungus very closely resembling the one causing the hollyhock disease. It has been found to possess great vitality, being able to live for weeks in the heated air of a laboratory. The spores produced by the fungus have also been shown to be capable of producing the disease in a healthy boll; both facts pointing to the necessity of removing diseased plants from the field, and of practicing rotation of crops. Plans are being made to test the value of fungicides for this disease during the next cotton-growing season. The mode of growing cotton renders it possible to apply fungicides rapidly and economically; and an intelligent cotton-grower, who has suffered some loss from the disease, has generously offered his assistance in field experiments having this object in view. It is therefore hoped that by another year we shall have something definite in the way of preventing the disease.

RIPE ROT OF GRAPES AND APPLES.

Glœosporium fructigenum, Berk.

[Plate III.]

The Annual Report for 1887 contained a full account of what was then called "bitter rot of apples." About two years ago a fungus very like the one causing this disease was found on the grape. The fungus was carefully studied and it was ascertained that spores from the grape would produce bitter rot on the apple, and *vice versa* that spores from the bitter rot of apples would produce the fungus and consequent decay in the grape. In the latter, however, the rotting grapes do not have the bitter taste characteristic in the apple.

These facts give rise to a confusion in regard to the name of the disease which is common to the grape and apple. "Bitter rot" will not apply to the disease of the grape. "Anthracnose" is preëmpted, otherwise this might be used, as the fungus belongs to the same type as the one causing the grape anthracnose. The term "ripe rot" may answer the purpose in spite of its lack of euphony, as the disease attacks neither apples nor grapes until they begin to ripen.

The fungus seems to be slowly gaining a foothold on the grape, and in some parts of the country causes the grapes to rot after they are carried to the packing houses. Experiments have shown that it is easily controlled by fungicides, but there is great danger in the fact that it is already widespread on the apple, and wherever it is present on this fruit the grape is not secure from it.

EXPLANATION OF PLATES.

PLATE I.—HOLLYHOCK ANTHRACNOSE.

FIGS. 1 and 2. Diseased plants.
FIG. 3. Fruit of fungus.
FIG. 4. Spores: *a*, *c*, normal; *b*, germinating.

PLATE II.—ANTHRACNOSE OF COTTON.

FIGS. 1 and 2. Diseased bolls.
FIG. 3. Fruit of fungus.
FIG. 4. Successive stages in formation of spores in artificial cultures.
FIG. 5. Spores.

PLATE III.—RIPE ROT OF GRAPES AND APPLES.

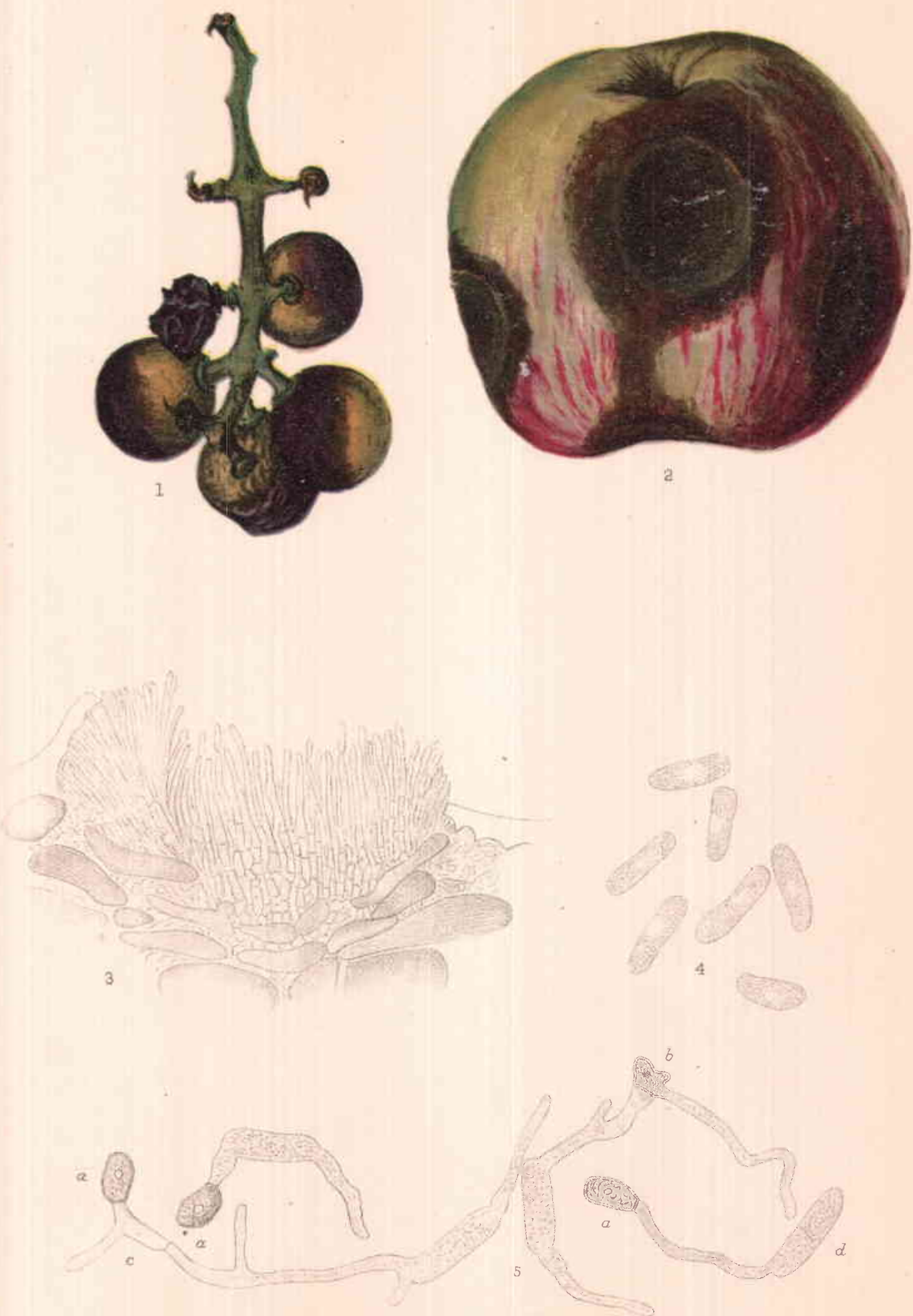
FIG. 1. Diseased grapes.
FIG. 2. Diseased apple.
FIG. 3. Fruit of fungus.
FIG. 4. Spores.
FIG. 5. Germinating spores, producing secondary spores at *a*, *t*, *c*; *b*, secondary spore germinating.

HOLLYHOCK ANTHRACNOSE

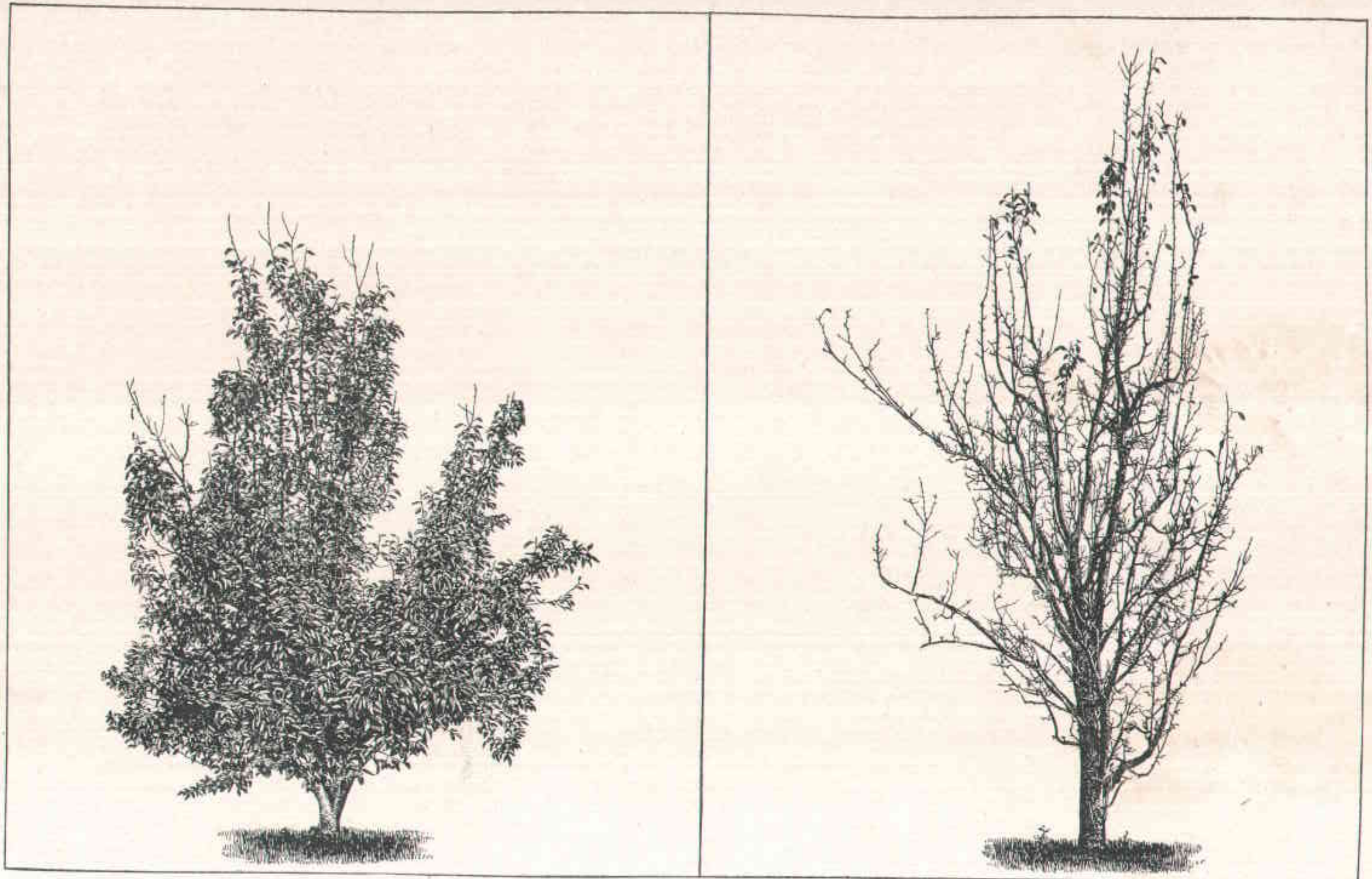
COLLETOTRICHUM ALTHAEAE SOUTHWORTH

ANTHRACNOSE OF COTTON BOLLS.

COLLETOTRICHUM GOSSYPII, N. S.



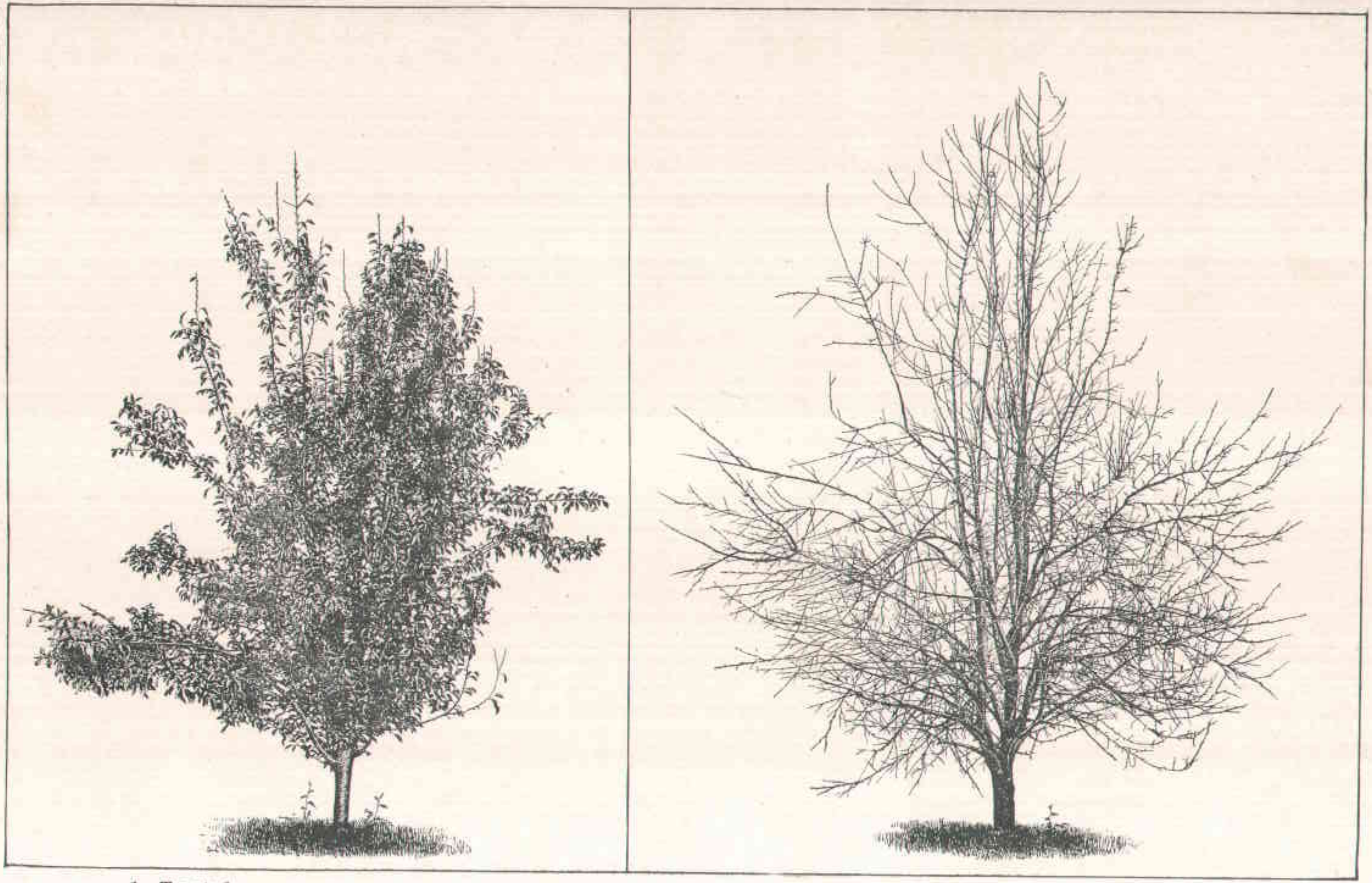
RIPE ROT OF GRAPES AND APPLES,
(GLŒOSPORIUM FRUCTIGENUM, BERK.)



1.—Treated.

TREATMENT OF PEAR LEAF-BLIGHT.—Bordeaux Mixture.

2.—Untreated.



1.—Treated. 2.—Untreated.

TREATMENT OF PEAR LEAF-BLIGHT.
(Am. Sol. Copper Carbonate.)

REPORT OF THE POMOLOGIST.

SIR: I have the honor to submit the following, which is my fifth annual report as Pomologist of this Department.

Very respectfully,

H. E. VAN DEMAN,
Pomologist.

Hon. J. M. RUSK,
Secretary.

THE FRUIT CROP

The year 1890 was in many respects quite unusual as regards the fruit crop of this country. The winter of 1889-'90 was very mild and the early fruit buds were unusually forward. Along the Atlantic coast as far north as Maryland, New Jersey, and especially the Peninsula east of Chesapeake Bay, and westward to Kentucky (except the mountain regions of the Appalachian range), thence to southern Missouri and Indian Territory, the peach trees were beginning to bloom when the temperature suddenly fell lower than at any other time during the winter. In Georgia and the Gulf States the peach, plum, and early pear trees had set their fruit, and a tender growth of leaves and wood was quite well advanced. In Florida the orange and other citrus fruit trees were either in full bloom or just past that stage. Strawberries were ripening in the extreme south and everything promised a very early spring. On the nights of March 3 and again on the 16th and 17th of the same month there were severe frosts in the South, and farther north snow and ice and frozen ground, which made sad havoc with all the above named fruits; and even the apple and other late blooming species were so damaged in the bud that they failed to hold their fruit after setting it. The peach crop was an almost entire failure except in California, where a good crop was gathered. It was from this source that the eastern markets were almost entirely supplied with fruit the past year. A few peaches were grown in southern Kansas, Missouri, New Mexico, Arizona, Connecticut, and northern Michigan, and these brought a big price. This was owing to the freedom from severe cold in the South and to the fact that the buds in the northern regions were not sufficiently advanced to be injured by the cold weather of the early spring.

The pear crop was light all over the Eastern and Central States, but in California there was an abundance. Oregon and Washington also produced a good crop of pears.

The supply of small fruits and grapes was reasonably good. It is thought that the orange crop of Florida alone will reach 2,500,000 boxes. California orange-growers report a good crop for the coming spring, roughly estimated at 1,400,000 boxes, and Louisiana will market about the usual amount.

TRIPS OF INVESTIGATION.

During the year, as Pomologist, I have had occasion to visit in connection with official business the States of Connecticut, Maine, New Hampshire, Vermont, and North Carolina, and a record of observations then made on fruit culture in these sections should properly find a place in this report.

In the early part of June a trip was made to Connecticut for the purpose of examining into the peach-growing business. Near Meriden a large orchard was observed, but the larger number of the orchards were found on the highlands along the Connecticut River between Hartford and Middletown. One very large, flourishing orchard was located in the level land not far from the river. The climate is rather cool and the summers short for the perfect development of the peach, and the trees were consequently small, but they were healthy and had on a light crop of fruit. Last year there was a heavy crop on these orchards, and Hale Brothers, who are the largest growers in the State, sold $25,000 worth of peaches. High culture is the secret of success, provided suitable soil and location have been selected, and this fact can be determined best by careful investigation on the ground and consultation with those who have succeeded. One of the chief points to be considered in connection with this industry is nearness to markets that afford a high price for peaches. A good crop of highly colored and delicious fruit marketed late in the season and free from bruises and decay will always bring good returns. All these things are possible in Connecticut.

In the latter part of July I attended a meeting of the State Horticultural Society of North Carolina, and a grape show at Mount Holly, which is in the southern central portion of the State. Owing to the damage by spring frosts there was little produced in the way of fruits in the central and eastern part of North Carolina, except grapes. Therefore the fruit exhibit was necessarily limited, and it was thought best to show only grapes. This exhibit was indeed very creditable, there being over fifty varieties of the very finest kinds commonly grown in the eastern United States. A large number of them were from the vicinity of Raleigh, and careful inquiry as well as close inspection of the samples proved that North Carolina is well adapted to the growth of this fruit. Since the vineyards of the central and eastern parts of the State ripen their fruit as early in the season as July, the growers are enabled to send them to market before the more northern States can possibly market theirs, and therefore the prices are high. The grape crop is generally considered remunerative by the practical vineyardists in North Carolina, where the growth of this fruit is being rapidly extended.

The principal purpose of my visit was to examine the condition of fruit culture in the mountain regions which comprise a large portion of the western part of the State. I saw but little of eastern Tennessee, which is practically the same in climate, soil, etc., as western North Carolina. Passing from Johnson City, Tennessee, which is in the great valley lying between the Blue Ridge on the east and the Cumberland Mountains on the west, to Cranberry, which is at the eastern terminus of the narrow-gauge railroad that runs into the mountains and just across the State line to North Carolina, I traveled thence by private conveyance, stopping wherever anything of interest could be found, to Lenoir, which is about

50 miles eastward and on the edge of the level lands which stretch to the Atlantic Ocean. I then traveled south and westward by rail to Waynesville, in Buncombe County, which has an altitude of about 3,000 feet. Here I visited the most comprehensive experimental orchards in western North Carolina, so far as I could learn of their existence, and found in a flourishing condition almost every species of fruit commonly grown in the eastern United States. The apple is the leading fruit of this mountain region, and I have seen no place in the United States where soil and climate are better adapted to the production of winter apples. Summer rains are usually abundant and drouths very rare. The soil is a mixture of shale, decomposed granite, mica-schist, and an abundance of decayed vegetation. The temperature is very much cooler than might be supposed for that latitude. The conformation of the land is very rough and the soil is incumbered with rocks, but there are narrow valleys and mountain slopes, commonly called "coves," which can be cultivated with ordinary ease. The experience of those who have been growing the apple in that region for twenty years and more goes to prove that the most successful apple region there lies between an elevation of 1,500 and 3,500 feet above the sea level. Where experiments have been attempted at higher altitudes the climate has proved to be too cool for the proper development of the apple. Although the trees grow reasonably well, the fruit is rather small and inferior in flavor. It might be proper to state in this connection that the native growth in these high altitudes is in some respects similar to that of northern New England, the yellow and black birch being quite common, and also black spruce and balsam fir on the highest peaks.

The peach is cultivated in North Carolina very successfully until an altitude of about 2,000 feet is reached, where the climate becomes too cool. The pear also succeeds very well in the eastern and central parts of the State as well as in the mountain region of the western part, where the apple flourishes so remarkably. I have never seen thriftier pear trees than in the vicinity of Asheville and Waynesville, where numerous experiments have been tried. The fruit produced is of the finest quality and fully equal to that grown in the Northern States. The quince seems especially adapted to the cool, moist climate and rich soils of the mountains, and no more profitable fruit can be planted there. The varieties of both native and foreign plums are successful, and although the ravages of the curculio were evident, yet there appeared no reason why with proper care the cultivation of this fruit should not prove profitable. In the mountain regions the commonly cultivated varieties of the grape flourish, but the fruit is very much later in season than that grown 50 or even 25 miles to the eastward. In fact the Catawba does not ripen earlier than the same variety in western New York.

Small fruits of all kinds seem to grow in greatest luxuriance. Nearly all the choice varieties of the blackberry and also many of the raspberries, both red and black, grow in abundance. The strawberry seems peculiarly adapted to the moist climate of the mountain, and although the fruit was out of season at the time of my visit the plants seen gave evidence that this fruit when cultivated yields abundantly. The currant and the gooseberry, which usually fail in the South, succeed in the higher altitudes of the mountains. After spending several days in the vicinity of Waynesville and Asheville I traveled through the country by private conveyance north and eastward to Linville, in Mitchell County, and thence to the railroad at Cranberry. I examined fruits of all kinds, as far as they had been tested, in every altitude, and found soil and climate well adapted to the growth of most species. Means of transportation is one of the great questions in that country, but railroads are being projected and in several places are being built across the mountains, and the time is not far distant when there will be ready means of shipment. The home market will be good, as there are already many summer resorts established in this locality and it is certain that more will follow.

In the early part of September I went to Lewiston, Maine, where the State Pomological Society held an exhibition of fruits in connection with the fair at that place. Although the season was a very unfavorable one for the growth of fruit, being cool and rainy, yet I found a very creditable exhibition of apples, pears, grapes, and plums, and a few quinces and peaches. The varieties represented were such as are grown in the apple-growing regions of the country, but of course they were not so far advanced in maturity as would be found in the Southern States. The fruit was usually very highly-colored and attractive in appearance, and in quality fully equal to that tested in other places. It is evident that Maine is well adapted to the growth of many kinds of our popular fruits. The apples are of such a character that they will keep very late in the spring and even into the next summer. The nearness of the State to markets, both domestic and foreign, gives abundant opportunities to the grower to sell at advantageous prices. Specimens were examined at this exhibition from nearly every county in the State. It was quite surprising to see the great display from Aroostook County, which is in the northeast, where it might be expected that apple and pear trees would scarcely be able to endure the winters. The plum seems quite well adapted to this State, especially to the southern part, and although the curculio makes considerable ravages upon it, still there is no great difficulty in producing a reasonable crop even of the choicer varieties of *Prunus domestica*.

From Maine I passed westward through New Hampshire to Newport, Vermont, which is within 5 miles of the Canada line and at the southern end of Lake Memphremagog. At this place is located the fruit farm of Dr. T. H. Hoskins, who is one of the most careful experimenters in fruit growing in all New England. He has tried almost every kind of fruit that would be at all likely to produce successfully so far north, and an examination of his orchards was exceedingly interesting. It is a notable fact that this year, when nearly all of the orchard fruits, especially the apple, have failed to produce even a small crop in a large part of the country, as has already been stated in this report, that the apple orchard of Dr. Hoskins was found loaded with fruit. A number of trees of Yellow Transparent, which is one of the best of the Russian apples, had been fairly loaded, as the trees gave evidence and as Dr. Hoskins stated to me, but, being out of season, the fruit had all been gathered before the time of my visit. The Wealthy, which is a seedling originated by Peter M. Gideon, of Minnesota, is among the varieties which seem to be most profitable. The trees were loaded with all they could hold of very handsome apples of fair size and quality. Scott's Winter, a native seedling of New England, although rather small in size, was abundantly loaded. This is a variety which keeps well through the winter, and the tree is as hardy as any other variety, either native or foreign, yet tested. McMahon's White, a seedling of Wisconsin origin, was one of the most promising varieties in his orchard. Although the trees were quite young and only just beginning to bear, they were well loaded with fruit of large size and of very delicate flavor and attractive appearance. Switzer, which is one of the Russian varieties elsewhere described in this report, is of much value. The trees were loaded and the fruit was of good size and appearance.

The trees of Prolific Sweeting were heavily loaded with fruit of fair size and of a delicate, pale yellow color. Its quality is quite good, and when baked it is an excellent substitute for Tallman Sweet, which is well known as one of the best for this purpose. It is, however, only a fall apple, being past its prime at the time of my visit.

Zuzoff's Winter appeared well in the orchard, and the fruit is not only of rather large size but its bright red color makes it very attractive. It may be a popular market apple for the extreme North. How long it will keep is unknown, but I thought it of about the season of Wealthy.

Trees of Oldenberg were well loaded. and a more attractive orchard view could rarely be found than these trees in full fruiting. Dr. Hoskins was preparing for shipment 50 barrels of this variety, for which he received a good price, and there were plenty more left in the orchard. Besides these varieties there were many more just beginning to bear which gave promise of good success.

As to other fruits I saw many which seemed well suited to that climate. The strawberry grows luxuriantly and the same is true of the currant and gooseberry.

Of all varieties of the currant Fay seems to be the best for that locality and it yields a very large profit.

Of the cherries there were found in healthy condition a number of the lately introduced Russian kinds, but the trees were not old enough to bear. From what I know of these elsewhere I am led to believe that there is much to expect from them for the extreme North and it may be for the whole country.

Some of the Russian plums were quite promising and certainly the trees are quite hardy even in that cold climate. Several of our native varieties seemed equally hardy. It was a surprise to me to find so many kinds of our cultivated grapes bearing and ripening so well so far north. However, those ripening early seemed to be the best suited to the short summer season. All in all there is no doubt that fruit growing in northern New England is far from a failure.

DISTRIBUTION OF SEEDS, PLANTS, AND SCIONS OF FRUITS.

Through the continued courtesy of the Department of State, and the intelligent efforts of the United States consular officers in foreign countries, I have been enabled to secure a few rare and valuable varieties of fruit. A number of our correspondents have also kindly donated seeds, plants, and scions of choice fruits of native origin, all of which have been distributed for testing where they seemed most likely to succeed. The most important are as follows:

AVACADO PEAR (*Persea gratissima*).—The "Aguacate" of Mexico, Central America, and the Spanish West Indies. A pear-shaped. tropical fruit, with a large solitary seed. Flesh very rich, of the consistency of butter, and resembling beef marrow in flavor. Excellent as a salad base, or with pepper and salt upon bread. From Lake Worth, Florida.

SUGAR APPLE OR SWEET SOP (*Anona squamosa*).—Seeds received from several points in southern Florida.

SOUR SOP (*Anona muricata*).—One of the most tender and beautiful of the anonas. Its acid flesh is quite a luxury in tropical countries. Seeds obtained from Palm Beach and Lake Worth, Florida.

SAPODILLA (*Achras sapota*).—Illustrated and described in my last annual report. Seeds from south Florida.

MEXICAN GUAVA (*Psidium lucidum*).—Grown in Florida as "Yellow Cattley."

DOWNY MYRTLE (*Myrtus tomentosus*).—Highly ornamental semitropical shrub, bearing a pleasant flavored berry-like fruit.

OREGON ELDER (*Sambucus glauca*).—An excellent and very prolific elderberry from the mountains of Oregon and northern California. Possibly valuable to hybridize.

APPLE.—A limited number of scions of the following varieties have been distributed to various experimenters for trial: Arkansas Black, Benton, Hatley, Shiawasse, and Shirk.

PLUM (*Burbank*).—A few trees and scions were sent out for testing through the courtesy of the originator, Luther Burbank, of Santa Rosa, California.

CAPRI FIG.—With a view to settling the vexed question of the caprification of the fig of commerce, cuttings of the genuine wild capri fig were imported from Smyrna and distributed to a number of correspondents interested in the subject. All arrived in excellent condition, a few even retaining and maturing fruit which had set before shipment. These immature fruits all contained the insect *Blastophaga peenes* encysted, but the lack of a proper host plant caused their loss when the fruit ripened. However, the Entomologist purposes to import this insect when these plants have become well established in order to further investigate the subject. While this experiment may prove the fallacy of the theory of caprification (fertilization of fig blossoms supposed to be effected by pollen carried by insects) as affecting the flavor of the fruit, its success may also prove of incalculable value to the fig industry of the Pacific Slope and the Southwest.

PERSIAN PEACH PITS.—As suggested in my last annual report, efforts have been made to secure seeds of the peaches of Persia, Turkestan, and Bokhara, in the hope of introducing a valuable new strain. Early in the season a few pits were received from Minister E. Spencer Pratt, at Teheran, and immediately distributed. At the end of the coming season a much larger quantity of fresh seed is expected.

GOOSEBERRY.—A very few plants of an excellent seedling originated by Philip Strubler, of Naperville, Illinois, were distributed.

MANGO.—A number of plants of the celebrated No. 11 mango of Jamaica, and a quantity of fresh seed, were secured through the Royal Botanic Gardens at Kingston, Jamaica, and placed in the hands of reliable persons for propagation. Rear-Admiral Ammen, U. S. Navy, also presented to this Department three seedlings of a choice variety.

FIG.—Through the courtesy of Mr. William Saunders, Superintendent of Gardens and Grounds, of this Department, I have been able to distribute cuttings of the following varieties of the fig, obtained through commercial channels: Bianco Precoce, Prolifero, Natalino, Dattato. A Fruitti Nero, Di Napoli tivano, Lordaialo, Trojano, Sanvito, White Brogiotto, Black Brogiotto, Rubado, San Piero, Brianzola, Guigliona, Dalmatino, Smyrna (?), Black Dattato.

CITRON.—During the year, two hundred and seventy-five citron trees, embracing eleven varieties, were procured through the Department of State and placed in the hands of reliable experimenters in Florida and California. It is believed that these shipments include the choicest varieties of the citron cultivated in Italy and Sicily. They are as follows: From Naples, Sorrento, Calabria, Amalphi; from Palermo, Pomo d'Adamo, Macrocarpa, Icompio, Pereltone, Citrus Medica; from Catania, Cedro Vero, Testi di Turco, Pereltone, Limonziana. No descriptions were sent, but there is every reason to believe that in due time there will be produced within the United States the entire amount of prepared citron now imported.

PERSIAN GRAPEVINES.—In my last annual report mention was made of an effort to procure cuttings of the choice named Persian grapes, and I now take pleasure in stating that two hundred and thirty-two plants, embracing eleven varieties, were propagated by this Department from imported cuttings and distributed to points in California, Arizona, New Mexico, Texas, and Florida, where they are now doing well. The thanks of this Department are due Hon. E. Spencer Pratt, United States minister at Teheran, for the lively interest and great care he has displayed in this matter. The renown of the Persian grapes is so great that the value of this importation is beyond question. The varieties are as follows: Alhakhee, red, keeps to middle of March; Askaree, good for raisins; White Shahanee, good winter grape; Black Shahanee, especially for wine; Chavooshee, green, rare; Hutab, large sweet; Dizmar, very sweet, yellow; Khallillee, early, first ripe; Paykanee, good winter; Rish Baba and Shiraz, both of very finest quality.

THE DATE.—As a result of the steps taken last year looking toward the introduction into the United States of the choice cultivated varieties of the date grown in Egypt and Algeria, I now take pleasure in reporting that eleven named varieties, three from Algeria and eight from Egypt, have arrived in excellent condition, and after careful disinfection by the Entomologist, are now growing well at several points in California, Arizona, and New Mexico. The interest which this importation has occasioned may be taken as a fair index to the importance of the subject. This office has been besieged with applications for rooted suckers, although not a single plant was kept here. Information regarding date culture, the prospect of success, value of the crop, etc., was eagerly sought after by the public press and widely copied in the southwest; and the Southern Pacific Railroad Company kindly granted free transportation over its lines for the carload of plants. As usual with the plants we have imported, this Department retains control of the progeny as long as any necessity for free distribution remains, the recipient of the original tree merely acting as trustee. By this method any attempt on the part of a nurseryman to create a "corner" in any variety of our introduction is prevented, and to this Department is secured the credit of introduction and the privilege of free distribution as long as is necessary to assure success or thorough trial. In the case of these date trees, however, it must be a number of years before sufficient suckers are grown to warrant a general distribution, and applications for plants will not be considered until the original trees bear and their fruit has been tested. Only the choicest varieties will then be propagated extensively. To Las Cruces, New Mexico; Yuma, Arizona; and Tulare, California, the following varieties were sent: Amhat, Nakleh-el-Pasha, Seewah, Hazaneh, Zeb-el-Aled, Sultaneh, Amreeyeh, Rasheedeh, Deglet Nour, Rars, M'Kentichi-Degla; and to Phoenix (Arizona) National City and Pomona (California) the following: Amhat, Nakleh-el-Pasha, Seewah, Hazaneh, Yeb-el-Aled, Sultaneh, Amreeyeh, and Rasheedeh. A male tree was sent with each lot. Among the plants sent to National City, California, the Amreeyeh, Hazaneh, Seewah, Rasheedeh, and male were double, and in order to still more widely distribute these varieties, one plant of each was separated and turned over to the Southern Pacific Railroad Company for planting at Indio, in the valley of the Colorado.

NUT CULTURE.

During this year a circular on this subject has been addressed to a large number of correspondents calling for a statement of their experience and observation with both wild and cultivated nuts of all kinds. It has been responded to very generally, and a special report is now being prepared which will contain the information thus gained, together with that which is already known by the Division on the subject. In advance of this report I may say that there is a large part of our country suitable to the culture of several kinds of nuts; and already the chestnut, pecan, Madeira nut, and almond are being planted. The industry is only now well started. We annually import large quantities of almonds, Madeira nuts, and filberts; and there are no climatic reasons why all that our markets need may not be grown at home. The two former are grown in California for the market to some extent. One grower has about 1,000 acres planted to the almond alone. The filbert is not grown here, except an occasional plant; but there is good reason to believe that it will flourish, especially in the Puget Sound region, and I am taking steps to have the trial made.

THE PECAN.

The *Hickoria pecan* is one of the best of all nuts, and is found wild only in North America. It abounds in the rich river and creek bottom lands of the Mississippi Valley, especially in Texas, Louisiana, Mississippi, Indian Territory, Arkansas, and Missouri. Even as far north as southeastern Iowa it grows wild; but the region of profitable culture does not probably extend so far north as the other species of the hickory family. In the Gulf States is found the best climate for this nut, and already there are considerable orchards of it planted there. It is needless to expect success in poor soil, for like all nut trees the pecan grows to the greatest perfection in rich, moist alluvium. Many of the lands subject to periodical floods along the Mississippi River and tributary streams might be planted to the pecan with great profit. Once well established these orchards in rich bottoms would yield large quantities of the very best nuts, and would not be injured by the floods, which usually occur long before the time of gathering the crop. There is great variation in the nuts as to size, shape, thickness of shell, and quality of the kernel.

The illustration, Plate I, Fig. 1, shows the character of the ordinary wild nut; and Fig. 2, the large, choice, wild nuts sent to market. Fig. 3 is a very choice variety named Stuart, in honor of the originator, Col. W. R. Stuart, Ocean Springs, Mississippi. This is one of the largest and best in quality and thinnest shelled of any that I have yet examined. Fig. 4 represents another variety by the same originator, named Van Deman by him, as a compliment to myself. It is also very large, and thin shelled. Either of these varieties can be crushed in the hand.

Fig. 5 is a cut of a choice variety received from Louis Biediger, of Idlewild, Texas, and named Idlewild by me, as I thought it well worthy of propagation under a distinct name. A very choice variety is also shown in Fig. 6, which was obtained from E. E. Risien, of San Saba, Texas. Distinct differences will be noticed in the shape of the varieties, and these are only a few of a large number of choice kinds which have been sent to this office.

It is only just to mention that in addition to the above the following persons have large and delicious pecans, which it will pay any one who contemplates growing this nut to procure: T. V. Munson, Denison, Texas; O. D. Faust, Bamburg, South Carolina; B. M. Young, Morgan City, Louisiana; Arthur Brown, Bagdad, Florida. The illustration on Plate II is of a tree thirteen years old, on the farm of Col. W. R. Stuart, of Ocean Springs, Mississippi, and shows the typical size and shape of a pecan tree grown in the open field. It has been bearing for three years past.

THE CHESTNUT.

In my report last year I mentioned this nut and gave an illustration of Paragon, a chestnut which was brought to notice by H. M. Engle, of Marietta, Pennsylvania. I then thought it might be partly of foreign stock, and now am sure that it is nearly or entirely so. It is better in quality than the other varieties I have tested of either European or Asiatic parentage, but it is now quite well established that W. L. Shaffer, of Philadelphia, planted a European nut, from which the original tree of this variety came. The same may be said of a variety mentioned in my report of last year under the name Dupont, which is a Delaware seedling from a foreign nut. Recent investigations prove that its true name is Ridgley and that Dupont is only a synonym. There are a number of very large varieties of foreign chestnuts in the hands of Samuel C. Moon, of Morrisville, Pennsylvania, and William Parry, of Parry, New Jersey, who both sent me samples this year. It is, however, my belief that we should

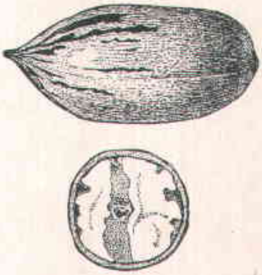


Fig. 1. COMMON WILD PECAN.

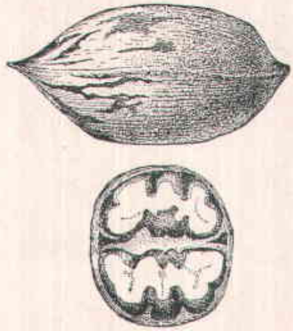


Fig. 2. LARGE WILD PECAN.

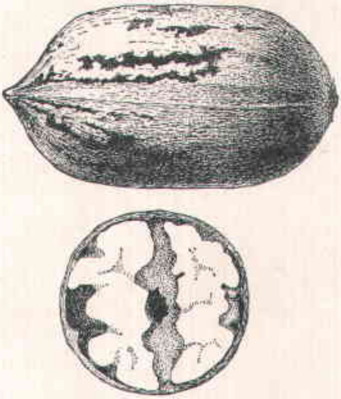


Fig. 3. STUART.

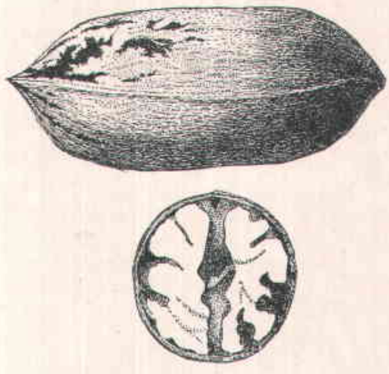


Fig. 4. VAN DEMAN.

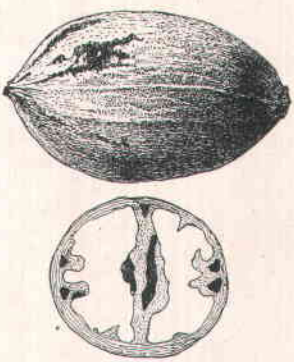


Fig. 5. IDLEWILD.

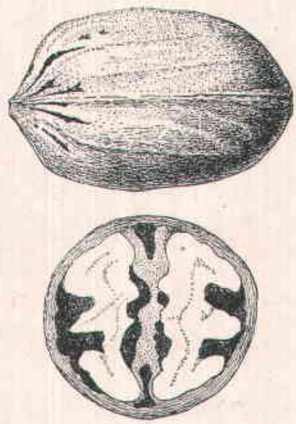


Fig. 6. RISIEN.

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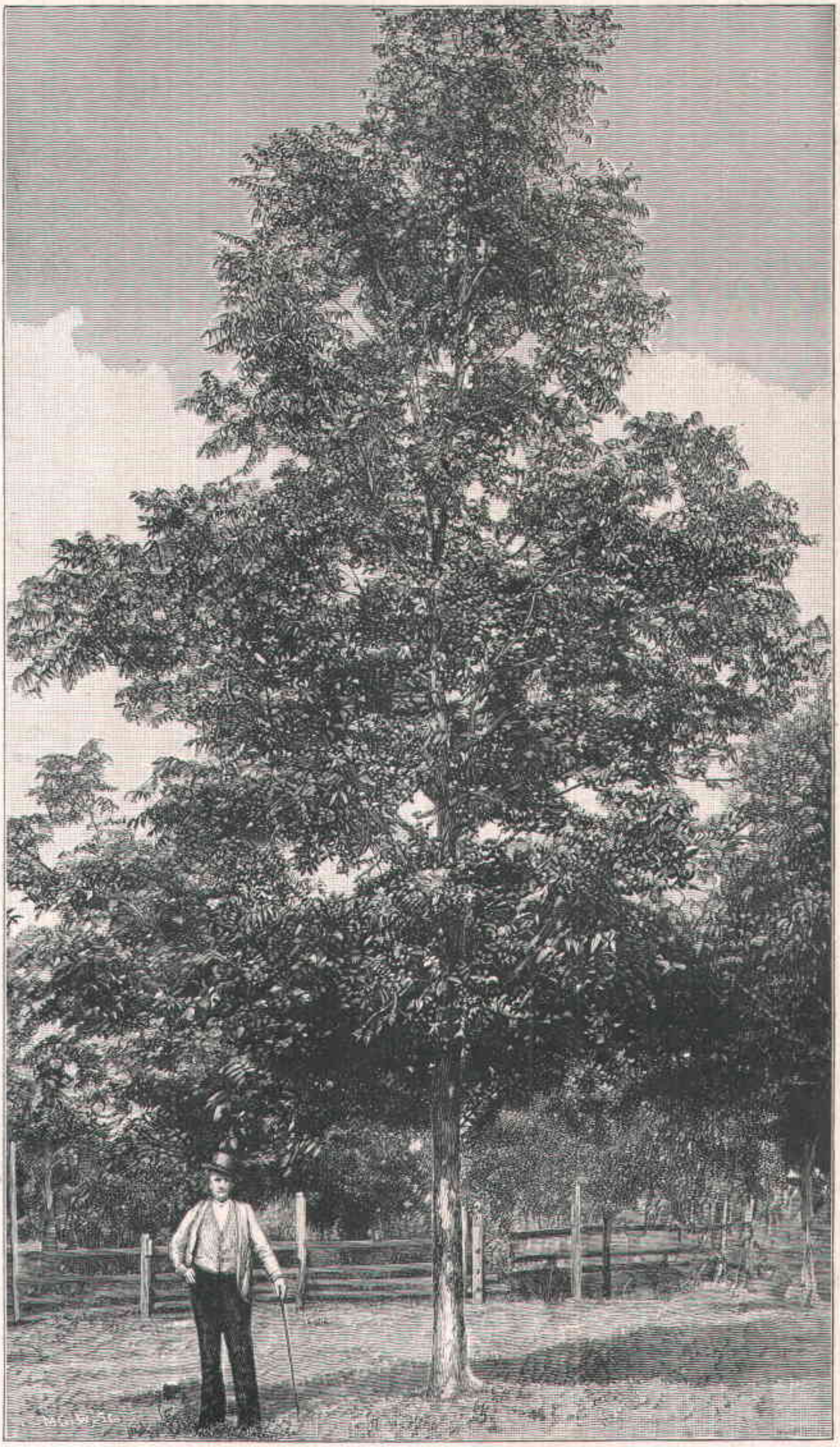
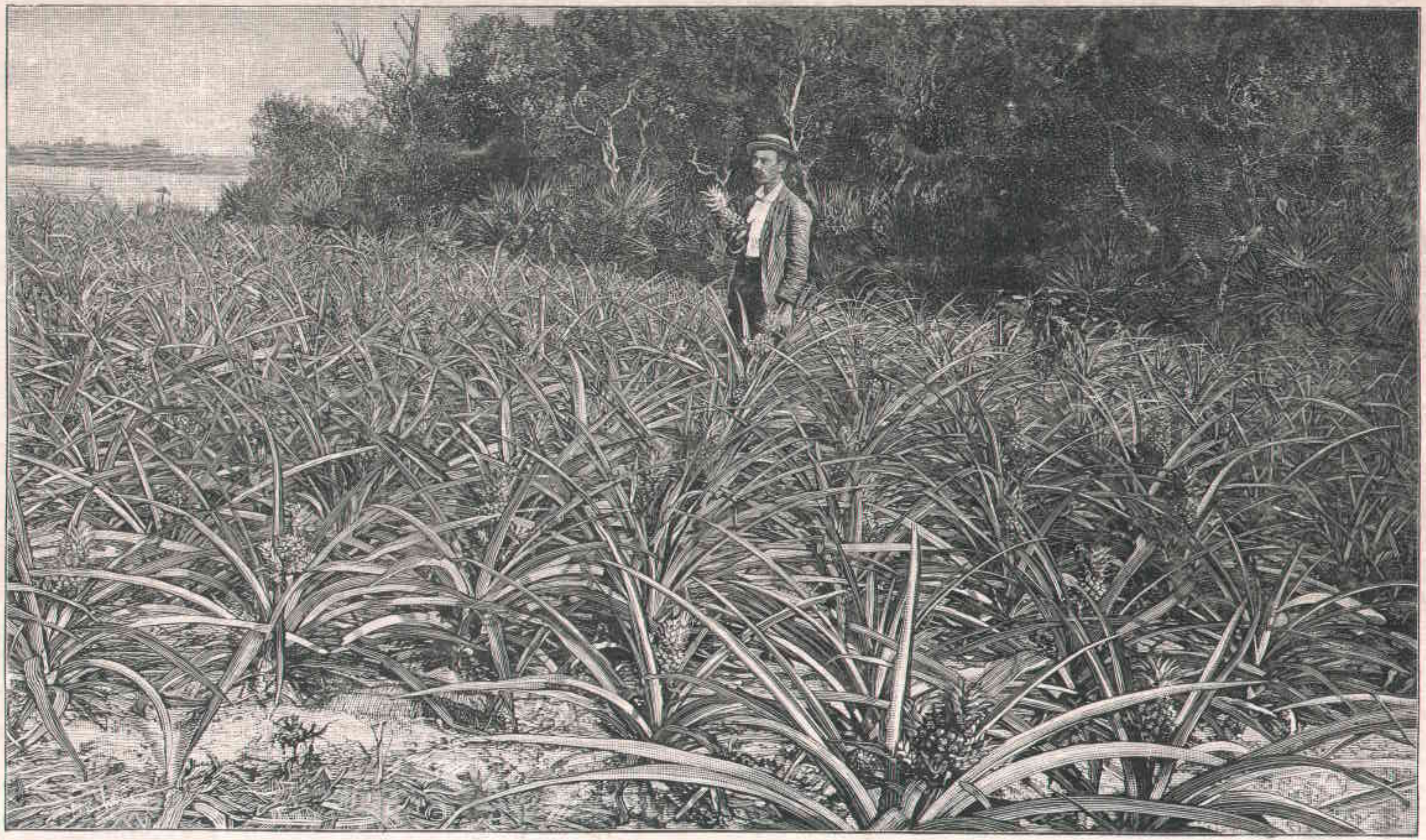
WILD AND CULTIVATED PECANS.



PECAN TREE, IN ORCHARD AT OCEAN SPRINGS, MISSISSIPPI.
Fourteen years from seed.



PINEAPPLE FIELD AT LAKE WORTH, FLORIDA.
Second year after planting.

fruit. It ships with greatest safety, as it may be gathered when quite hard, and ripens gradually for several weeks afterward. There is no fruit better adapted to street selling, as it is attractive in color and ripens so gradually that very little need be lost by decay. The Japanese esteem it as their most popular fruit, and do not always wait until it fully ripens before eating it. When dried it resembles the fig, and thus prepared and afterwards cooked it is quite palatable. Eaten fresh with cream and a little sugar it is delicious. Investigations are being continued in order to obtain, if possible, from the northern parts of Japan and Corea varieties which may prove hardy in our central States. As yet, however, I only have information indicating that we may get such kinds, and promises that trees will be sent.

The severe cold last spring killed nearly all the blossoms of this fruit in Florida and in the other Southern States, and in many cases the trees were seriously damaged, consequently there has been almost no fruit this year, and no progress has been made since my report of last year in disentangling the confused nomenclature of the varieties. However, past experience will fully warrant the publication of the descriptions and illustrations of the two following varieties:

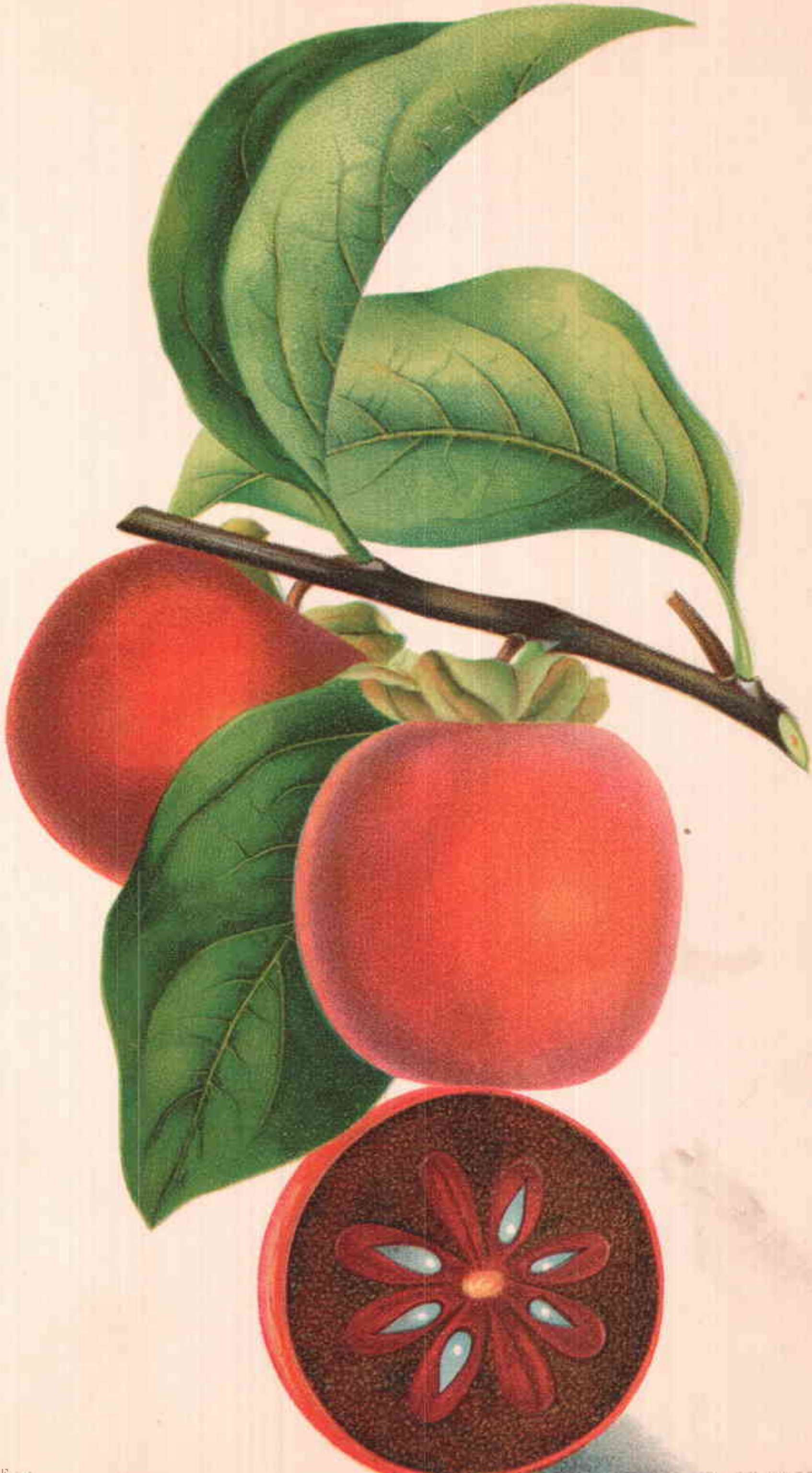
Zengi (pronounced Zen-gy).—This is one of the smallest varieties, averaging about 2¼ inches transverse diameter, although often not more than 1½. Occasional specimens reach 3 inches. In shape it varies from distinctly oblong to globular, sometimes having a slight depression at the apex. Skin dull red with a yellowish cast, not as brilliant as the larger varieties, generally marked with black cracks about the point when well matured on the tree. Flesh rather stringy, dark, showing black dots and white fibers when cut transversely, and light colored fibers with broad splashes of brown when cut vertically. Usually quite seedy; flavor very good, seldom astringent even when hard. Very early and prolific. Plate VII was made from fruit sent by Mr. J. S. Wade, Homeland, Florida.

Tsuru.—Very long and slender (2 by 3½ inches) as its name (*Tsuru*, a crane) indicates. Rather bright orange red, skin smooth with very little tendency to crack at point. Flesh orange colored, rather dry; seeds few, with correspondingly slight tendency to show brown markings; very astringent when unripe. Mainly valuable as a late keeper. Specimens ripened on the tree are rather broader at the base than when ripened off the tree. The illustration, Plate VIII, was taken from a specimen obtained from Mr. G. L. Taber, Glen St. Mary, Florida.

THE GOUMI.

The Goumi (pronounced goo-my), *Elæagnus pungens*, from Japan, is a pretty red, gold-flecked berry, fairly pleasant for eating, and is likely to prove an addition to our gardens as an ornamental shrub as well as a fruit. Its hardiness has been partially tested, and the probabilities are that it will not prove sufficiently hardy for the Central States. The buffalo berry of the West is a member of the same genus. The fruit is eaten raw in Japan, or either pickled or preserved, and either way it is quite palatable. It is also valuable for jelly, resembling currant jelly to some extent. The fruit appears like an elongated pie-cherry, and averages one half to five eighths of an inch in size. Color bright red, surface appearing as if covered with small golden brown dots; stem long, one and one eighth inches;

slender, brown. Fruit slightly depressed at each end; acid and somewhat astringent until fully ripe, when it acquires a pleasant aromatic flavor. It ripens in midsummer. Wood bright brown, slender; buds small, brown, conical; leaves alternate, oval, acute, pointed, thin, light green above, silvery with brown dots below, both surfaces covered with stellate hairs. Grows freely on tolerably dry soil; reproduces closely from seed; a shrub about 6 feet high. The illustration on Plate IX was made from a specimen grown and sent to this office July, 1890, by Prof. T. V. Munson, Denison, Texas. It has also fruited with H. H. Berger & Co., of San Francisco, California.



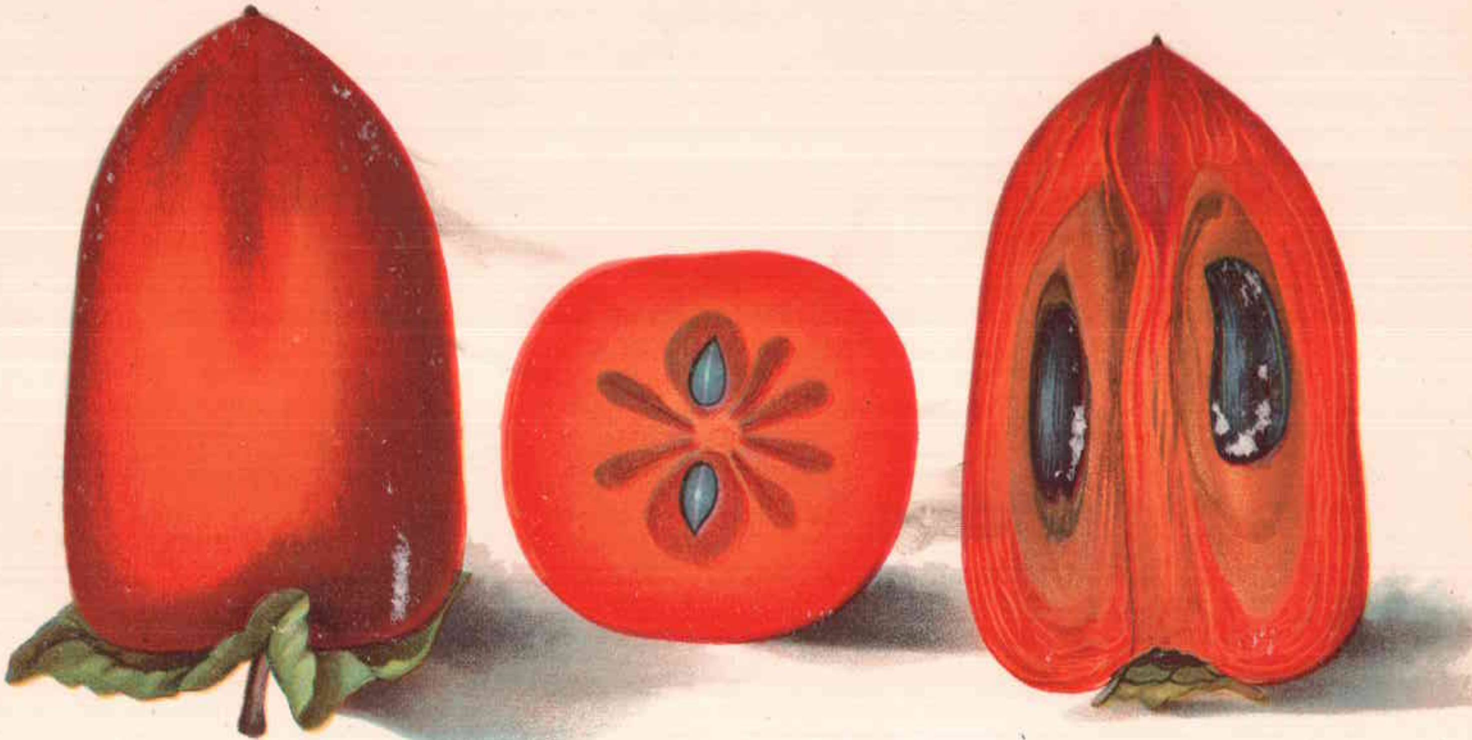
Prestele Fecit

Geo. S. Harris & Sons Lith. Phila.

ZENGI

Plate VIII.

Report of Pomologist U.S. Dept. of Agriculture 1890



TSURU.

W^m H Prestele Fecit.

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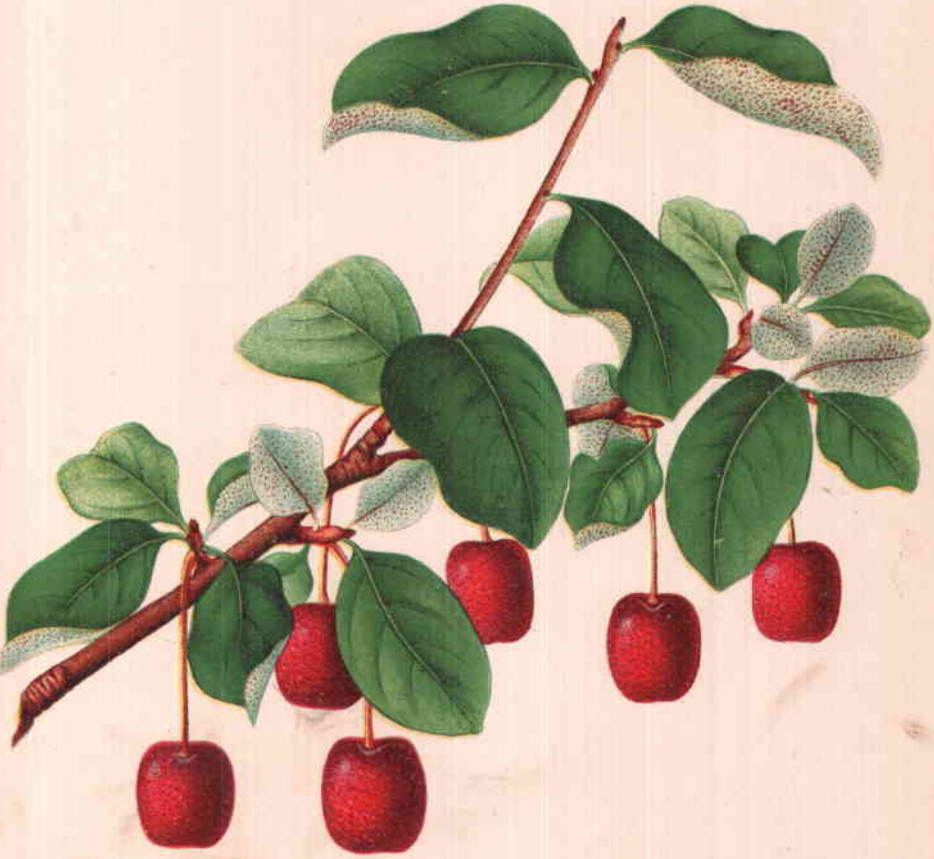


GOUMI. (Goo-my.)
(ELAEAGNUS PUNGENS.)

Wm. H. Prestele, Fecit. Geo. S. Harris & Sons Lith. Phila.

REPORT OF THE CHIEF OF THE SEED DIVISION.

SIR: I have the honor to submit to you my report of the operations of this Division for the past year. This report consists mainly of the tables showing the distribution of seeds as to quantity, kind, and method of distribution, and also the quantity and kinds distributed to foreign countries, and of the condensed reports from correspondents.

A comparison between the table showing the quantity of seeds distributed and the reports from correspondents illustrates strikingly the force of the comment made in last year's report for this Division on the difficulty of making the average recipient of this bounty from the National Government comprehend that in return he is bound to report the results of the trial given to seeds sent him. The seeds sent abroad are usually sent in response to requests received through the representatives of these countries, or our own consuls resident therein, and are so sent most frequently in return for similar courtesies extended to this Department through the same channels.

A comparison of the distribution of seeds with that of the previous year will show an increase in the past year over the former by nearly a million of packages. The amount distributed also is far in excess of any previous years. It should be remembered, in considering this fact, that the appropriations for the year covered by the present report were just the same as for previous years, and that the larger amount of seed made available therefor was due entirely to a better system adopted in the purchase thereof. The plan adopted by your direction—the employment of a special agent who should personally visit various sections of the country and inspect the places where the seeds were produced, as well as the seeds themselves—is to be credited with this great economy which has effected so great a saving in the aggregate cost of the seeds as to insure the purchase of this largely increased quantity without any increased expenditure. Moreover, this system of personal inspection has resulted in securing an improved quality of seed. Altogether, the outcome of last year's work in this direction is most gratifying, and fully confirms the most sanguine anticipations as to the results of this new departure.

It will be observed by reference to the first table that the aggregate distribution to State and county statistical agents and correspondents, and agricultural experiment stations, colleges, and associations, amounted to nearly half a million packages. As regards the statistical agents and correspondents, this distribution is in the nature of an acknowledgment of the valuable services rendered by these gentlemen gratuitously to the Statistical Division of this Department. As regards the distribution to the agricultural stations, colleges, and associations, it is obvious that as long as the present system of distribution continues, and the difficulties of obtaining reliable and prompt reports of results from the average recipient remain, we must rely mainly upon these institutions and associations for such careful trial of the seeds sent out, and such trustworthy reports as to results as will enable us to compile records of value to this Department in regard to the comparative value of different seeds and the special adaptability of certain varieties to particular localities. I shall endeavor during the coming year, with your approval, to enlarge this channel of distribution and to establish it upon a still more systematic basis.

I regret to have to emphasize in the present report the remarks made by my predecessor last year with reference to the inadequacy of the accommodations in the present building, both for the efficient performance of the duties involved by the distribution and for the proper handling and storage of the seeds as they are received and held for distribution. Even though there are no possibilities of remedying this state of affairs under the present conditions of the Department's building facilities, the results of our inadequate accommodations are so grave that I feel I should be remiss in the performance of my duty, were I not to call attention once more to the inconveniences from which this Division is suffering.

Respectfully submitted.

J. B. PECK,
Chief of the Seed Division.

Hon. J. M. RUSK,
Secretary.

CONDENSED REPORTS FROM CORRESPONDENTS.

ALABAMA.

Cotton.—The Champion Cluster is an excellent variety; it is long limbed, but has large bolls and a fine staple; it yielded 38 pounds of lint to 100 pounds of seed cotton. The Wimberly made from twenty to thirty bolls to the stock, had very superior lint, and seems well adapted to this section. Shine's Prolific matured early, and yielded about 300 pounds of seed cotton.

Sorghum.—The Red Liberian made a fine yield of very superior sirup.

Wheat.—Currell's Prolific grew rapidly and made a good crop, was not affected by rust, the kernel not being quite as large as the sample.

Vegetables.—The seeds received from the Department were all planted with gratifying results, the Early Surehead cabbage, the Early Puritan and the Trophy tomatoes are worthy of special commendation. The large Wethersfield onions were a success in all respects.

ARKANSAS.

Buckwheat.—The Japanese made a large yield, the flour being of very fine quality, and it is well adapted to this locality.

Cotton.—Wimberly's Improved is an excellent variety, with long lint and strong fiber, and is highly recommended for future planting.

Tobacco.—The Caboni is reported as an excellent variety for the northwestern section of this State.

Wheat.—The new Genesee made an excellent growth, the grain was entirely free from rust, and yielded better than the common kinds. The Rudy (bearded) is reported as making excellent flour, the grains and heads much larger than other varieties, and perfectly free from rust. The Velvet Chaff had very plump grains; one quart of seed yielded one half bushel of wheat.

Vegetables.—The Alaska pea is reported as being ten days earlier than other varieties and superior in all respects. The Edinburgh Beauty pea was very prolific, and very sweet. The Black Wax beans proved to be all that was claimed for them. Ely's King of the Earliest tomatoes were very early and prolific.

CALIFORNIA.

Sorghum.—The Honduras cane yielded nearly double the amount of sirup that the other varieties did.

Vegetables.—Carter's Stratagem peas grew well, were very early, and very prolific. Edmund's Imperial turnip beet was very sweet and succulent.

COLORADO.

Wheat.—The New Mediterranean has been very successfully raised in the southeastern part of the State.

Vegetables.—The Eclipse beet did well, some specimens weighing 10 pounds and measuring 26 inches in circumference. The Yellow Danvers onions were uniform in size, and one of the best varieties for this climate. The Orange Cream pumpkins were excellent.

CONNECTICUT.

Buckwheat.—The Japanese did very well, yielding a third larger crop than the old varieties and was highly satisfactory.

Wheat.—The Velvet Chaff did exceedingly well. It came up nicely, stooled out well, and made a strong growth, reaching the height of 4½ feet. One quart of seed yielded one half bushel, weighing 31¾ pounds. It can be profitably grown in this section.

Vegetables.—The Pee & Kay corn was very early; the ears were large and very sweet. The Kidney Wax beans were of superior quality. Lane's Imperial beet made a large growth of fine vegetables, and they were very smooth and solid.

FLORIDA.

Clover.—The Japan germinated well, but was injured by protracted drought. The Luzerne also proved to be a fine variety.

Teosinte.—Grows rapidly, and was cut every twenty or twenty-five days during the season, and was more generally sought after by stock than the millet; but the seasons are too short to mature seed.

Vegetables.—The Citron melons were very fine; every seed germinated; each seed produced from five to ten good-sized melons. The Livingston tomatoes grew to perfection. The Osage muskmelons were very delicious, of good size, and delicate in flavor. The Miller Cream muskmelons were very fine in size and rich in flavor.

GEORGIA.

Cotton.—The Ellsworth proved to be a most remarkable and valuable variety, several stalks yielding as high as two hundred full-grown and well-developed bolls. The Wimberly is a long-limbed variety, the limbs coming out all around, having what is technically termed a well-balanced stalk; the lint was very good, and the seed seemed pure.

Clover.—The Japan and Sanfoin were both well adapted to this soil and climate; the Japan is a fine fattening plant for all kinds of stock.

Grasses.—The Texas Blue and the Rescue are both finely adapted to this section.

Vegetables.—The Dark Icing watermelon had a thin rind, crimson flesh, and was of excellent flavor, and was a decided success. The Black Wax beans can not be excelled for sweetness and tenderness.

ILLINOIS.

Corn.—The Piasa King was of vigorous growth and produced 40 bushels to the acre.

Oats.—The Improved American grew to the height of 4 feet and yielded nice, plump oats. The White Wonder stood the dry weather very well, the straw being about 2½ feet high, and the grain was sound and good.

Clover.—The Alfalfa stood the drought much better than other varieties grown under the same circumstances.

Wheat.—The reports upon the success of Velvet Chaff in this section are highly satisfactory; it was very early and yielded 22 bushels to the acre, 25 per cent better than other varieties which stood near it. It is ironclad in regard to standing hard winters. The Fulcaster is considered by some farmers as the best for this section, the yield of the Velvet Chaff and the Fulcaster being about the same. Eight pounds of the seed of the Improved Rice sown yielded 90 pounds.

Vegetables.—Barr's Mammoth asparagus came up rapidly and made strong and vigorous plants. Lane's Improved sugar beet was very fine, the flavor being unsurpassed. Perry's Hybrid sweet corn had large ears and the grains were of good flavor.

INDIANA.

Oats.—The White Bonanza yielded well and was of good quality.

Teosinte.—This forage plant did well, and it will doubtless be largely planted next year.

Wheat.—The Velvet Chaff has proved to be one week earlier than other varieties, and makes a saving of 20 per cent of seed sown, the grain being somewhat small, but very plump and perfect, and weighing 61 pounds to the bushel. The Improved Rice gave perfect satisfaction. It grew strong and had an excellent berry, and its yield was 25 bushels to the acre, and it was pronounced by competent judges a superior wheat for milling. The Fulcaster was somewhat damaged by the cold weather of March, but yielded good, plump kernels.

Vegetables.—The Early Winningstadt cabbage, the Kidney Wax beans, the Long Green cucumbers, and the Yellow Danvers onions all germinated well, grew vigorously, and made satisfactory crops.

IOWA.

Corn.—The Minnesota King ripened early; the ears were well filled and sound; it is recommended to those wishing an early corn.

Tobacco.—The White Burley made a fine growth and formed good-sized leaves.

Sorghum.—The Kansas Orange sorghum was planted in rows 3½ feet apart one way and 1 foot the other; it averaged 11 feet in height, with large stalks, and made from it 97 gallons of light, clear molasses of excellent flavor and very thick.

Wheat.—The Velvet Chaff proved very productive, notwithstanding many discouraging circumstances; it stood the winter well and yielded more wheat and of better quality than any other winter wheat in this vicinity. Eight pounds of Hard Red Fyfe seed yielded at the rate of 15 bushels to the acre, the average yield of wheat in this section this year being only 11 to 12 bushels per acre. One quart of Martin's Amber was sown in 1887, which produced 76 pounds. It was sowed in 1888, and again in 1889, and it has done much better than any other variety tested, the miller pronouncing it a very superior milling wheat.

Vegetables.—The Alaska peas were hardy, made a good yield of excellent quality. The Red Crosby sweet corn produced abundantly and the ears were very sweet. The Improved Flageolet beans were an excellent variety and very prolific. The Pale Dun beans were very early, very prolific, and quite hardy. The Pee & Kay sweet corn was two weeks in advance of other varieties.

KANSAS.

Corn.—The Leaming produced at the rate of 45 bushels to the acre. The Prairie Queen made an immense growth, and was by far the best of eight varieties planted under the same circumstances. It yielded at the rate of 60 bushels per acre, and is a valuable corn for this latitude. The Piasa grew rapidly, with large stalks, was medium early, and the yield from 16 square rods was 11 bushels of shelled corn.

Oats.—The White Wonder proved to be an extra fine variety. One quart of seed yielded 1½ bushels of grain. The White Bonanza made a strong growth of large straw, and in a favorable season would no doubt be very productive.

Clover.—The Alfalfa made a good stand, does not freeze out through the winter, and will be a very profitable crop to grow.

Sorgum.—The Early Amber thrived finely, grew tall, with a smooth stalk, and made good sirup. The Early Orange made a good yield of sirup of excellent quality.

Wheat.—The Velvet Chaff stood the winter well; the berry was plump, round, and of good quality; 4 quarts of seed yielded 68 pounds of wheat. The Fulcaster was very fine in quality, and was considered a success. The New Genesee also was a success in northern Kansas.

Vegetables.—The Chiswick Red tomatoes did well. The Golden Perfection watermelons were a success. The Black Seeded Satisfaction lettuce was unsurpassed. The Kidney Wax bean was prolific and well adapted to this soil and climate.

Vegetables.—The St. Louis Market lettuce is spoken of very highly. The Prize Head lettuce proved to be a good variety. The Acme tomato, Philadelphia Butter lettuce, and the Early Cory corn all grew well and matured fine crops of excellent quality. The King of the Garden Lima bean was excellent.

NORTH CAROLINA.

Cotton.—Three fourths of an acre planted in the Ellsworth yielded 1,400 pounds of seed cotton, which ginned over one third. This is considered a good yield, and good judges pronounced it a very superior bolled cotton.

Clover.—The Japan came up very quickly and made an excellent grass.

Grasses.—The Timothy did well.

Sorghum.—The Red Liberian did well and yielded upward of 50 gallons of molasses, pronounced by judges to be a first-class article. Had a good mill been used doubtless the yield would have been 200 gallons.

Wheat.—Currell's Prolific was early and made a good yield. The New Genesee stood the winter well and yielded as fine wheat as any grown here.

Vegetables.—The Early Green Cluster cucumber germinated quickly and grew well. The New Jersey tomato is a rapid grower, very early, and produces fine fruit. The Eclipse beet is very prolific.

NORTH DAKOTA.

Oats.—Hargett's White germinated well and were not injured by several days of frost; the straw being very strong and stiff it stools wonderfully, producing as many as seven stalks from one kernel of seed.

Wheat.—The Red Fyfe yielded well, and produced first-class wheat in quality, hardiness, and color. It was very satisfactory.

Vegetables.—The Early Winningstadt cabbage was very superior, making large solid heads. The Philadelphia Butter lettuce and the Premium Flat Dutch cabbage both did well.

OHIO.

Corn.—The Pride of the North proved to be vigorous in growth, early, and productive.

Clover.—The Alfalfa and Japan clover were both very satisfactory and were not injured by the wet weather.

Forage.—The Vetch (Vicia Villosa) did not do well at first, and when other grasses were cut the last of June they were just beginning to blossom; but after that time they made a wonderful growth, and branched out near the ground, and the vines spread in every direction, until the whole was a complete mat of tangled vines; owing to the wet weather, the pods under the vines rotted, and did not ripen seeds. From its rank growth, it promises to be unequaled as a soiling plant.

Grasses.—The Johnson made a wonderful growth, and there is no doubt but that three crops could be cut in a season. The Orchard makes the finest appearance of all our grasses. It has a compact sod, and the blades are of a bright, green color, about 20 inches long; it held its own without assistance against weeds and wild grasses. The same is true of the Meadow Fescue and the Rye grass.

Wheat.—The New Genesee was sown at the rate of 6 pecks per acre. The habit of growth was superior to three other varieties in the same field, and it sent out more healthy and stronger shoots, and had covered the ground in advance of the others. The Rudy (bearded) yielded 68 pounds from one twenty-seventh of an acre; the grain was very large and plump. Four quarts of Velvet Chaff produced 70 quarts of fair quality of wheat, and it weighed 60 pounds to the bushel.

Vegetables.—The Roman Carmine turnip radish was very early, crisp, and neither wormy nor pithy, and retained its flavor much longer than other varieties. The Perpetual lettuce proved to be excellent. The Volunteer tomatoes were very early and productive, and of excellent quality.

PENNSYLVANIA.

Buckwheat.—The Japanese made a large yield, of a very fine quality of flour, and it is well adapted to this locality.

Oats.—The White Bonanza gave good results, the straw being heavy and stiff, and the heads were large and well filled, with large, plump kernels.

Wheat.—Three and one half pounds of Fulcaster were sown broadcast on one sixteenth of an acre, and yielded 90 pounds of good wheat. The Improved Rice came up well, stood the winter, and 1½ quarts of seed yielded 14¼ pounds of very pretty plump grain.

Vegetables.—The Peach tomato produced handsome fruit, but of inferior quality. Moore's Concord sweet corn grew finely and was pronounced excellent in quality. The Flat Purple Top turnip is acknowledged by all as superior to other varieties.

SOUTH CAROLINA.

Cotton.—Shine's Early Prolific was a success and is considered a fine variety.

Forage.—The Unknown pea was very prolific.

Grasses.—The Texas Blue flourished well.

Vegetables.—The Bridgeport Late cabbage was early and made fine, solid heads. The Large Red Wethersfield onions did well. The Yellow Crook Neck squash bore abundantly.

SOUTH DAKOTA.

Oats.—One half bushel of White Wonder, sowed on three eighths of an acre, yielded 12 bushels of oats.

Wheat.—The Red Fyfe made a much better yield than other varieties tested. Two and a half pounds of seed yielded one half bushel of very good plump wheat.

Vegetables.—The Chicago Market sweet corn is very early, of good quality, and suitable for a northern climate. Dewing's Early Improved turnip beet is small, but very early and tender. The Everbearing pea did extremely well.

TENNESSEE.

Corn.—The Piasa King did remarkably well and was pronounced superior to other kinds.

Oats.—The White Wonder grew about 3½ feet high and matured very fine, plump grain, and made a much larger yield than other varieties sown under the same circumstances.

Wheat.—The Fulcaster has proved beyond question to be the wheat for this section of Tennessee. It harvested 380 per cent increase on the amount sown, and the straw was extraordinarily bright and strong.

Vegetables.—Henderson's Early Summer cabbage was a perfect success, as every seed germinated and made large compact heads. The Paris pickling onion was small, but exceedingly nice for pickling. The Fulton Market tomato was the best of twenty varieties.

TEXAS.

Corn.—The Piasa King did well, and yielded at the rate of 35 bushels to the acre. It is considered a superior variety.

Cotton.—The Jones's Improved is a very superior kind, and it yielded more to the acre and stood the vicissitudes of the weather better than other varieties. It has a fine staple, and large bolls. Truitt's Improved was very prolific, and excellent in yield and quality; it was early and very hardy.

Sorghum.—The Red Liberian proved a success in every variety of soil, in the mountain, valley, and river bottom districts, the joints being short, sweet, and the yield exceedingly good.

Vegetables.—The Cardinal tomato withstood an excess of rain, not cracking or rotting as other varieties. The Vandergrau cabbage was very early and excellent. The Rosy Gem radish was early and tender.

VIRGINIA.

Oats.—The White Wonder was very satisfactory.

Wheat.—The Improved Rice yielded 5 quarts to 1 sown. The Fulcaster was very healthy and vigorous, yielding 15 quarts to each 1 sown, of perfect, beautiful grain. It is a valuable wheat for this climate. The Velvet Chaff stooled well, made a very stiff straw, and the yield was 9 bushels per acre; the quality of the grain very good. The Rudy (bearded) is a fine variety, and, planted at the right time, will make an extraordinary yield.

Vegetables.—Vick's Early watermelon proved to be very fine; they were early and very prolific, some weighing from 15 to 20 pounds. The Alaska peas were early, prolific, and very satisfactory. The Champion of England peas were very productive and had large, well-filled pods. The Maud S peas are a superior variety.

WASHINGTON.

Wheat.—The Rudy (bearded) proved to be a good variety. The Improved Rice yielded 60 bushels to the acre, the grain being large and plump.

Vegetables.—Walker's Improved peas are all that can be desired in size, flavor, and productiveness. The Westerfield Chicago pickling cucumber yielded well; the fruit was of fine shape and size.

WEST VIRGINIA.

Sorghum.—The Early Orange made very fine sirup; three fourths of an acre sown yielded 91 gallons.

Wheat.—One quart of Fulcaster sown harvested 28 pounds of very fine grain, the other varieties only making half a crop.

Vegetables.—The First and Best peas were very early. The Chicago pickling cucumber and the Jersey tomato were both very good. The Deacon lettuce was very fine indeed.

WISCONSIN.

Buckwheat.—Eighteen pounds of seed of the Japanese made 808 pounds of nice, clean buckwheat, superior to any seed in this section. This is the testimony of a farmer of thirty-five years' experience.

Sorghum.—One quart of seed of the Red Amber Sugar Cane was sown on 1⅗ acres and produced 54 gallons of extra fine sirup, pronounced by the manufacturer to be the best he had ever made.

Wheat.—The Velvet Chaff did well, withstood the winter, and is adapted to this locality. Seven pounds of seed planted produced 143 pounds of very plump grain of excellent quality.

Vegetables.—The New Peach tomato was very satisfactory. The Red Japan squash was of fair quality. The White Belgian carrot gave perfect satisfaction, also the Golden Dwarf celery. The Early Winningstadt cabbage had small, firm heads.

Kinds and quantities of seed issued from the Seed Division of the Department of Agriculture, under the general appropriation act of Congress, from July 1, 1889, *to June* 30, 1890.

Description of seeds.	Varieties.	Senators, Representatives, and Delegates in Congress.	County statistical correspondents.	State statistical agents.	Miscellaneous applicants.	Experiment stations and agricultural colleges and societies.	Total.
		Packages.	*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*
Vegetable	208	3,972,232	109,680	39,080	480,592	118,107	4,719,691
Flower	204	349,219	141,600	225	140,965	900	632,909
Honey plant	2				149		149
Sunflower	1				372		372
Tobacco	10	60,930			4,033	57	65,020
Tree	8				160		160
FIELD SEEDS.							
Wheat	14	21,954	3,216		4,455	231	29,856
Oats	2	14,544	246		1,073	11,059	26,922
Corn	8	9,928	317	57	1,715	5	12,022
Barley	1	12			39		51
Buckwheat	1	267	482	57	2,688	8,370	11,864
Sorghum	14	830	239		1,134	29	2,232
Kaffir corn	1				70	5	75
Turnip	9	517	43,640	8,395	3,206	147	55,905
Sugar beet	5	1,739	223		2,865	1,094	5,921
Mangel-wurzel	1	53	126		315	20	514
Potatoes	1	4,834			251	2,380	7,465
Grass	17	12,774	407		3,608	309	17,098
Clover	4	331	212		1,183	7	1,733
Millet	1	14		57	206	5	282
Teosinte	1	48	174		290	20	532
TEXTILE.							
Cotton	6	9,552	449		4,217	225	14,443
Ramie	1				30		30
Grand total		4,459,778	301,011	47,871	653,616	142,970	5,605,246

Packages of seeds sent to foreign countries during the fiscal year 1889-'90.

Names of countries.	Vegetable.	Flower.	Corn.	Wheat.	Oats.	Buckwheat.	Millet.	Sugar beet.	Honey plant.	Forage plants.	Grass.	Clover.	Tobacco.	Potato eyes.	Sorghum.	Kaffir corn.	Broom corn.	Cotton.	Osage Orange.
Canada	115	130		1										1					
Mexico	390	30							2	10		2							
West Indies	43														15				
Guatemala	15																		
Honduras	480	35	25	25	25	25	25	25	40	28	105	75	25			1	25	25	
Venezuela	100	100																	
United States of Colombia	800		4	4	4	4	4												
Ecuador	145		10	20	10		10		5	5		35	15				5	5	
Chili	50	25	2		2													2	
Argentine Republic													16						
England	10	15											5						
France	20																		
Belgium			100		70										25				
Denmark	5	5																	
Sweden	10	10																	
Switzerland	50																		
Italy	20	20									2				13				48
Turkey	34		1		2	1		1			2								
Algeria															6				
Egypt			6												12				
Liberia	6																		
South Africa	14																		
India				4											36				
Java															15				
China										10		1							
Corea	185	10																	
Japan	23																		
Australia															18				
Fiji Islands	40	10											10						
	2,555	390	148	54	113	30	39	26	47	53	109	113	71	1	139	1	30	32	48

REPORT OF THE CHIEF OF THE DIVISION OF ILLUSTRATIONS.

SIR: I have the honor to submit my first report covering the few months that have elapsed since this Division was established under the appropriation act for the current fiscal year, July 14, 1890.

It will be interesting, I think, to accompany this first report with a brief review of the development of the work of illustration in this Department, which has culminated under your administration in the organization of a Division of Illustrations under my charge.

As long ago as 1878 the method which left the work of illustration to persons employed outside the Department was found to be extremely defective, and I was engaged to prepare the illustrations for the annual report, and to be available for such incidental work as might occasionally be required in connection with the several Divisions of the Department. These at that time not being numerous, one competent person sufficed to do all the work needed in the line of illustration, and for nearly two years I was the sole draftsman permanently employed in the Department. As the work increased beyond the capacity of any single person, however competent, it became necessary to engage other artists, but these being paid from the funds of the various Divisions needing their services were assigned to the forces of such Divisions. This arrangement, however, was found to have many defects and it was impossible under these conditions to systematize the work. There were times when some of these artists were overworked, while others had time to spare. Again, it was impossible to so divide the work as to enable each to work to the best advantage, some being assigned to work which others could have performed more efficiently than they, and *vice versa*, while, and this was the chief objection, there was no one responsible head charged with the duty of superintending all the work and held responsible for its faithful execution. These difficulties were apparent to you from the very beginning of your administration, and hence the organization by your direction of a Division of Illustrations which you were good enough to place under my charge.

As thus organized, the Division consists of one chief, eight assistant draftsmen (one such place being at this writing vacant), and three wood engravers. The work of the Division is scientific, requiring great skill and experience; and being from nature, and often from specimens in a dried or injured condition, frequently calls for the greatest ingenuity on the part of the artists. Moreover, many of the specimens are so minute as to require the magnifying glasses or the microscope in elucidating the details, and our draftsmen, therefore, must be familiar with the handling of these instruments. The work of the Division consists in drawing illustrations on wood for engraving by the xylographers, or on paper with pen and ink, or painting them in water colors, the illustrations made by the two latter methods being reproduced outside of the Department by lithography, or photoengraving, or by "process work." Many drawings, paintings, and sketches have to be prepared in the Division which are not intended for publication, but for the purpose of fixing graphically some interesting phase in the development or life history of objects from the plant or animal kingdom.

I have ventured to thus present to your consideration in detail the exacting character of the work required of this Division in order that the necessity for assistants of the highest order in this department of the work might be thoroughly understood, and in view of the manner in which the work is now being performed by the force actually at my disposal I beg to respectfully suggest that their efforts be recognized if possible by the application of a more liberal scale of remuneration.

The following is a record of the work performed under my charge for a period of something less than six months, showing the several Divisions for which the work has been executed:

Entomology, 32 plates, aggregating 160 figures, pen and ink; Botany, 12 plates, partly on wood, partly pen and ink work; Chemistry, 13 plates, illustrating new chemical apparatus, pen and ink; Forestry, 6 plates, on wood, double size, with two maps; Microscopy, 57 plates, mostly water colors; Ornithology, 17 plates, pen and ink; Animal Industry, 50 plates, containing more than 200 figures, mostly microscopical; Vegetable Pathology, 40 plates of over 150 figures, in pen and ink, and in color. Of engravings by the xylographers of the Division: Botany, 7 plates; Chemistry, 1 plate; Forestry, 6 plates, double size; Entomology, 1 plate; Irrigation Inquiry, 1 plate.

A considerable amount of other work has been begun and partly completed. As most of the plates contain from five to ten figures, and as the period in question covers that during which the annual leaves of absence of the force of this Division occurred the, amount of work must be regarded as highly creditable to the force engaged.

In this connection I consider it my duty to submit to your consideration the fact that the only rooms which it was found possible to assign to this Division, located in the attic of the main building directly under the roof, are in many respects unsuited to the work required of us, while their very high temperature during the summer months (on several days 102° to 104° Fahr.) renders the work of this Division extremely onerous.

In conclusion, allow me to say that many of the illustrations of this Department have gained an enviable reputation even in European scientific circles in return for our efforts to send out only such work as will be a credit to this Department. It has not unfrequently happened, however, that while the original drawings or paintings had been made with the utmost care and accuracy and were in every respect creditable, the reproduction done outside the Department by some of the methods indicated above has been quite unsatisfactory and inferior.

I would suggest that if some way could be devised by which the supervision of the chief of the Division could be extended to the work of illustration up to and including the actual printing of the plates such a course would, I am convinced, secure the reproduction of our work in the best manner and as economically as at present.

Respectfully submitted.

GEORGE MARX,
Chief of the Division of Illustrations.

Hon. J. M. RUSK,
Secretary.

REPORT OF THE CHIEF OF THE DIVISION OF RECORDS AND EDITING.

SIR: I have the honor to present herewith a report upon the work of this Division during its first half year, together with certain recommendations which aim to extend the usefulness of the publications of this Department

Very respectfully,

GEO. WM. HILL,
Chief of the Division of Records and Editing.

Hon. J. M. RUSK,
Secretary.

WORK OF THE DIVISION.

The Division of Records and Editing was practically called into existence by my appointment on the staff of the Statistician in July, 1889, and the work which I then undertook did not differ materially from that now carried on by the Division as at present organized under the act of appropriation of July 14, 1890, except in being restricted necessarily before that date by the want of sufficient clerical force from undertaking all that was contemplated as the work of the new Division. The organization of the Division was undertaken immediately upon the passage of the act of appropriation, and the positions provided thereby were duly filled by your appointments in compliance with the law regulating the Civil Service.

The work of this Division should, so far as its responsible head is concerned, supply the place of the "reader" of a publishing house, to whom all work for publication is submitted, and whose report to the chief is made the basis of the latter's conclusion as to publication. This is rendered necessary, not only to enable the chief to assume due responsibility of what is published by his authority, but to enable him to fairly and judiciously assign the printing fund between the several Divisions of the Department. It must also afford to the Division chiefs who supply the matter all the facilities of a publishing house, supervising the work from the moment it leaves the hands of the author until the work appears in complete form ready for distribution.

By fulfilling adequately these two lines of duty it will certainly not only relieve the Secretary and the Division chiefs of a large amount of work, but, in the hands of competent persons of the right practical experience in the work of publication and printing, it will necessarily accomplish the work better and much more economically. The amount of the printing fund of the Department, though inadequate to the publication work required, is yet so large a sum as to make it a matter of economy to place its administration in practical hands.

It is safe to say that in no private business would it be deemed wise to allow the expenditure of $40,000 annually on any line of work without placing it under some responsible and experienced head.

The character of a bulletin must determine the extent of circulation, and hence the number of copies required. The occasional reproduction in another form of a portion of some bulletin can sometimes be economically and advantageously substituted for an increased edition of the original publication; the complete preparation of a work in proper form, ready for the printer's hand, is a saving of time and money, and in a variety of ways this Division, if managed as it ought to be, can and should aid in securing to the publication work of this Department—work that grows in importance every day—a full measure of efficiency and economy.

There could be no better evidence of the possible efficiency of the new Division than that afforded by the subjoined list, which represents the publication work of the Department for the past twelve months.

THE PUBLICATIONS OF THE DEPARTMENT

The editing of all the bulletins issued by the Department from its several divisions, and the conferences entailed in the course of my duties with the chiefs of the several divisions, have resulted in some conclusions as to the publications of the Department, which I have now the honor to lay before you. The first element entitled to our consideration in the preparation of the Department publications must be the constituents whom the Department is specially designed to serve. The value of the Department must necessarily be measured in a large degree by the amount of valuable practical information which it is enabled to impart to farmers in regard to their business, and in the aid which it can thus afford them in solving the problems with which they find themselves confronted. At the same time there is an obvious necessity for the preservation in printed form of a record of all scientific work done in the various divisions of the Department, whether its immediate results have or have not any direct interest for the practical farmer. The Department owes something to the student and the scientist, as well as to the farmers, and it owes this much at least to its own workers and to those who are to succeed them, namely, to place in their hands a complete detailed record of all the technical and scientific work carried on in the several divisions, whatever the results thereof may have been.

It is obvious, then, that we are confronted at the outset with the necessity for at least two classes of publications—one consisting simply of records of scientific work; the other presenting results of practical value to the farmers themselves. The first being of value chiefly to agricultural students, scientific men, and the workers in the Department and in the agricultural colleges and experiment stations of the country, can be issued in comparatively limited editions; the others according to their character in larger editions.

The great increase in the number of divisions preparing matter for publication, and the dual character of most of them—combining administrative duties with scientific research—have resulted in the necessity for important modifications in the character and scope of the Annual Report of the Department. Your own declaration approving "the frequent issue of special bulletins from the various divisions relating to the work undertaken by them instead of awaiting the issue of the Annual Report, already too bulky for the purpose for which I conceive it to be designed," suggests in the main the character of the modifications to which I refer; and the necessity for such modifications was amply confirmed when, after consultation with the various chiefs of divisions in anticipation of the publication of the Annual Report of the Department for 1889, it was found that space was desired which would have resulted in a bulky volume of not far from 1,500 pages, whereas the Report as actually published consisted of less than 600 pages. It is evident that the time has come when the Annual Report of the Department must offer to each chief of Division merely an opportunity for a business report to his chief of the work actually performed in the Division which he superintends, for a general review of the field of economic agriculture assigned to his division, and for presenting suggestions and plans for increasing the efficiency and extending the benefits of his work. At the same time a great extension is called for in the line of publications in the form of special bulletins. It should not be forgotten in this connection that notwithstanding the increase in the number of divisions, the great extension of the general scope of work assigned to the Department, no increase has been made in the last few years in the amount of the printing fund, while on the other hand a considerable reduction has been made in the number of copies of the Annual Report remaining at the disposal of the Department. In anticipation of a considerable increase in the number of bulletins, and a considerable increase in many cases of the number of copies issued, as, for instance, in the case of the monthly crop report, which, being practically a monthly review of the condition of agriculture throughout the world, should be far more extensively distributed than it is; and in view also of the necessity for increasing the number of the bulletins referred to as "Farmers' Bulletins," it seems quite impossible that even with all the discrimination exercised in the distribution, the Department can accomplish the least that is expected of it in the line of publication with an appropriation of less than $60,000.

In the meantime, in view of the large number of divisions engaged in preparing matter for publication, and the desirability of an equitable apportionment of the printing fund, it would seem as though some method might be devised which will give to every Division a fair share of the publication fund during the year in proportion to the relative importance of the matter which each has to present. To effect this, it would be necessary that each divisional chief should submit at the beginning of the fiscal year a table of matter on hand already prepared for publication, and also a list of proposed publications, the preparation of which could be completed in time to bring the publication within the current fiscal year. In this way the relative value of the proposed publications could be properly estimated; a suitable allotment of the printing fund arranged for by which justice should be done to every Division; and when the fund was found insufficient for all the publication work contemplated, that which seemed to promise the greatest general benefit could be selected. At present, it not unfrequently happens that a considerable amount of work is done in the preparation of a bulletin for publication, only to find out when the work is done, naturally to the great disappointment of the chief of the Division under whom it has been prepared, that there is no fund available to print it.

The limited amount of the printing fund available for the publications of the Department outside of the Annual Report has necessitated great economy in the work of publication, sometimes limiting the number and editions, so that valuable bulletins are soon out of print, and at other times compelling the undue postponement of bulletins containing information which should promptly be made available, and in a few cases entailing the abandonment of a publication after a considerable amount of work had already been done in its preparation. Considerable economy has been and must continue to be exercised in the method of distribution, and the prevalent idea existing in the country that the bulletins of the Department are published in unlimited numbers, and that the easiest way to get any special one is to simply request that *all* the bulletins issued by the Department be sent regularly, permitting the two or three of practical use to the writer to be selected and the rest to be consigned to the garret, must be done away with. In fact, at present the varied character of the work carried on in the Department and the tendency of the farmers themselves to specialize, makes it well-nigh impossible for any one individual to be profited by all the bulletins issued.

In the effort, therefore, to husband our resources, one of the first things to be done is to carefully discriminate in the distribution of the various bulletins of the Department, and simple requests that the writer may receive all the bulletins issued by the Department, without any explanation, should be entirely ignored. Another movement in the line of economy must be the frequent substitution for more expensive bulletins, of short treatises or tracts on some particular subject of special interest to the farmers generally, or to the farmers in some particular locality. Such were the special bulletins on "The Horn Fly," on "Potato Rot" and "Peach Blight," "Inoculation for Hog Cholera," "The Beef Supply," "The Hollyhock Disease," "The What and Why of the Experiment Stations," and "The Work of the Experiment Stations," the last two having aggregated a circulation of 200,000, and having been given the suggestive title of "Farmers' Bulletins." The necessity for bulletins of this kind arises from time to time in all the divisions of the Department, and seems for many practical as well as economical reasons to be worthy of the greatest encouragement, and I would venture to suggest that all the bulletins of this character hereafter be issued, each as one of a Department series, to be known as "Farmers' Bulletins," and to be numbered consecutively, and not as a special series of the Division from which it emanates.

In some cases it has been deemed desirable to issue bulletins of a periodical character in monthly or quarterly parts. While no doubt much may be said in favor of such a method, it is in my opinion open to certain grave objections, likely to grow stronger as the work progresses, and sufficient to overcome all the arguments offered in its favor. In the first place, the Department is not a publishing house, and it is essential that the occasion of a publication should be not the recurrence of any particular date or the lapse of any particular period, but the possession of facts or information worth making public. Indeed, in pursuance of this idea, the regular periodicity of these serial publications in the Department must be and in some cases has been practically abandoned. There is a tendency, however, with all such serials to approach some hard and fast rule as to number of pages, etc., which ought to have no part whatever in regard to the publications of the Department. Whether a bulletin is to be ten pages or fifty should depend not upon looks or upon the relative number of pages in the preceding number, but whether the valuable information ready to be given out can best be presented in ten pages or more. Furthermore, from what has been said already in regard to the varied character and the several classes of bulletins which seem to be necessary to meet all requirements, it is obvious that serial publications containing a little of each sort entail a large waste of matter in distribution, for it would be wellnigh impossible for any Division to issue a satisfactory periodical bulletin consisting exclusively of matter appropriate to one or the other of the three classes of bulletins indicated.

The arguments which have seemed sufficient to establish the necessity for the publication in some special form of the detailed scientific work of the several divisions of the Department have so far been mostly advanced in favor of the issue of periodicals by the several divisions. While the arguments themselves are well founded, I think, for reasons stated above, that the conclusions are not satisfactory. Taking, however, the arguments as to the necessity of a complete record of the scientific work done in the Department, and the objections that unquestionably obtain against the adoption of separate serial publications by the various scientific divisions, it would be possible, perhaps, to satisfy the first and to meet the second by adopting the serial form for a Department publication of a technical character, to which all the divisions would have access, and which should be practically a record or review of the scientific work of the several divisions of the Department, which would serve as a suitable book of reference for such work, not only for those who will carry it on in the future, but to the students and others engaged in the work of agricultural science. Such a publication, under certain limitations, ought, it seems to me, to answer a very useful purpose and satisfy the requirements of the various scientific divisions as well as the natural demands of those engaged in analogous work.

A glance at the subjoined list of publications, and the fact that since 1885 no general index has been kept of the publications of the Department, point very strongly to the necessity of beginning such important work before it becomes an overwhelmingly tedious and irksome task. Indeed, in view of the vast importance of much of the work undertaken in the several divisions, and inasmuch as some of the most important bulletins have, as has already been stated, gone out of print, it seems to me worth while to consider whether work akin to that carried on in the office of Experiment Stations with reference to the publications of such Stations, in accordance with the law indicating the relation between the Stations and the Department, should not be undertaken with reference to the publications of the Department itself.

For fear of causing misapprehension in reference to the suggestions contained herein as to increasing the number of special bulletins and the different classes of bulletins contemplated, it may be well that I should here emphasize my perfect understanding that the publication work of this Department must be carried out in full compliance with the general policy which demands that the work of a Government institution be directed to aid and supplement the efforts of, and not to compete with, private enterprise.

I beg leave to direct your special attention to the subjoined list of the publications of the Department for the year. It presents, I think, a very striking exhibit of the activity of work in every Division of the Department under your charge, though inadequate in its testimony, inasmuch as several publications practically ready have had to be withheld, owing to the insufficiency of the printing fund.

PUBLICATIONS OF THE YEAR.

In the list subjoined the summary of publications contained in your last Annual Report is continued and brought down to the close of the current year. To supply a need repeatedly suggested by the correspondence of the Department, the character of each bulletin is briefly indicated in cases where this is not accomplished by the title alone. Circulars are not mentioned below, unless they have served to distribute information. Such as have been used to facilitate inquiry, though occasionally given a document number, may be classed more properly as correspondence, being, for the most part, blanks which are mailed to correspondents to be filled out and returned. The fact that during the year upwards of 400,000 have been mailed from the Division of Statistics alone will indicate the extent to which their use is found necessary. The size of bulletins mentioned below is uniformly octavo unless otherwise specified; the date assigned to each is intended to represent the date of its actual receipt for distribution from this Department.

At this writing all bulletins of the year are available for distribution to public libraries, and copies of nearly all can be furnished to individual applicants. Owing to the wide demand for the Report of 1889, however, the supply allotted by law to this Department is now exhausted, and persons applying for the publication will necessarily have to be referred hereafter to their Representatives in Congress. (See page 2.) The annual reports of the Bureau of Animal Industry, also, are largely retained by Congress.

OFFICE OF THE SECRETARY.

Report of the Secretary of Agriculture for 1889. With plates, wood cuts, and index. June, 1890, pp. 560	400,000
Report of the Secretary of Agriculture for 1890. (Preliminary.) November, 1890, pp. 52	5,000

BUREAU OF ANIMAL INDUSTRY.

Fourth and Fifth Annual Reports of the Bureau of Animal Industry for the years 1887 and 1888, with plates. March, 1890, pp. 510	50,000
Report on the Beef Supply of the United States, and the Export Trade in Animals and Meat Products, by Dr. D. E. Salmon. (Advance sheets from Report of the Secretary of Agriculture for 1889.) March, 1890, pp. 15	10,000
Report on Inoculation as a Preventive of Swine Diseases. (Advance sheets from Annual Report of the Secretary of Agriculture for 1889.) March, 1890, pp. 10	10,000
Proceedings of an Interstate Convention of Cattlemen, held at Fort Worth, Texas, March 11, 12, and 13, 1890. May, 1890, pp. 102	5,000
The Animal Parasites of Sheep, by Cooper Curtice, D. V. S., M. D., with plates. July, 1890, pp. 222	15,000
Report of the Chief of the Bureau of Animal Industry for the year 1889. Author's edition. (From the Report of the Secretary of Agriculture for 1889.) August, 1890, pp. 49–110	500
Special Report on Diseases of the Horse. (In press.)	20,000

DIVISION OF BOTANY.

The Agricultural Grasses and Forage Plants of the United States and such Foreign Kinds as have been introduced. By Dr. George Vasey, Botanist. With an appendix on the chemical composition of grasses, and a glossary of terms used in describing grasses. New, revised, and enlarged edition, with 114 plates. January, 1890, pp. 148	10,000
Grasses of the Southwest. Plates and Descriptions of the Grasses of the Desert Region of Western Texas, New Mexico, Arizona, and Southern California. Part 1. By Dr. George Vasey, Botanist, Department of of Agriculture. October, 1890, pp. 108 (7½ by 11½ inches)	5,000
Contributions from the U. S. National Herbarium, No. 1. (Lists of plants collected in Southern California, and at Lagoon Head, Cedros Island, San Benito Island, Guadaloupe Island, and the head of the Gulf of California.) June, 1890, pp. 28	2,000
Contributions from the U. S. National Herbarium. No. 2. (A collection of plants made in Texas, in the region of the Rio Grande.) July, 1890, pp. 29-62	2,000
Contributions from the U. S. National Herbarium, No. 3. (A list of plants collected in Lower California and Western Mexico.) With plate. November, 1890, pp. 63-90	2,000
Report of the Botanist for the year 1889. Author's edition, with plates. (From the Report of the Secretary of Agriculture for 1889.) August, 1890, pp. 377-396	1,000

DIVISION OF CHEMISTRY.

Chemical Bulletin No. 24. Proceedings of the Sixth Annual Convention of the Association of Official Agricultural Chemists, held at the U. S. Department of Agriculture, September 10, 11, and 12, 1889. Methods of Analysis of Commercial Fertilizers, Cattle Foods, Dairy Products, and Fermented Liquors. Edited by Harvey W. Wiley, Secretary of the Association. March, 1890, pp. 235	2,500
Chemical Bulletin No. 25. A Popular Treatise on the Extent and Character of Food Adulterations. By Alexander J. Wedderburn, Special Agent. February, 1890, pp. 61	10,000
Chemical Bulletin No. 26. Record of Experiments in the Production of Sugar from Sorghum in 1889 at Cedar Falls, Iowa; Rio Grande, New Jersey; Morrisville, Virginia; Kenner, Louisiana; College Station, Maryland; and Conway Springs, Attica, Medicine Lodge, Ness City, Liberal, Arkalon, Meade, Minneola, and Sterling, Kansas. By H. W. Wiley, Chemist. April, 1890, pp. 112	10,000
Chemical Bulletin No. 27. The Sugar Beet Industry, Culture of the Sugar Beet and Manufacture of Beet Sugar. By H. W. Wiley, Chemist. With plates, wood cuts, and map. September, 1890, pp. 262	10,000
Chemical Bulletin No. 28. Proceedings of the Seventh Annual Convention of the Association of Official Agricultural Chemists, etc. (In press.)	2,500
Report of the Chemist for the year 1889. (From the Report of the Secretary of Agriculture for 1889.) August, 1890, pp. 135-190	500

DIVISION OF ENTOMOLOGY.

The Horn Fly (*Hæmatobia serrata*), being an account of its Life History and the Means to be used against it. By C. V. Riley and L. O. Howard. (Reprinted from Insect Life, Vol. 2, No. 4.) December, 1889, pp. 93-103	2,000
Entomological Bulletin No. 20. The Root-Knot Disease of the Peach, Orange, and other Plants in Florida, due to the Work of Anguillula. By J. C. Neal, Ph. D., under the direction of the Entomologist. With plates. October, 1889, pp. 31	5,000
Entomological Bulletin, No. 21. Report of a Trip to Australia to Investigate the Natural Enemies of the Fluted Scale, by Albert Koebele, under the direction of the Entomologist. With illustrations. March, 1890, pp. 32	3,000
Entomological Bulletin, No. 22. Reports of Observations and Experiments in the Practical Work of the Division, made under the direction of the Entomologist. With illustrations. June, 1890, pp. 110	3,000

Insect Life. (Devoted to the economy and life habits of insects, especially in their relations to agriculture, and edited by the Entomologist and his assistants. With illustrations.)

Vol. 2, No. 5. December, 1889, pp. 125-162	5,000
Vol. 2, No. 6. January, 1890, pp. 163-197	5,000
Vol. 2, Nos. 7 and 8. February, 1890, pp. 198-262	5,000
Vol. 2, No. 9. March, 1890, pp. 263-292	5,000
Vol. 2, No. 10. May, 1890, pp. 293-334	5,000
Vol. 2, Nos. 11 and 12. July, 1890, pp. 335-390	5,000
Vol. 3, No. 1. August, 1890, pp. 42. With table of contents and index for Vol. 2	5,000
Vol. 3, No. 2. October, 1890, pp. 43-88	5,000
Vol. 3, No. 3. November, 1890, pp. 89-130	5,000
Vol. 3, No. 4. December, 1890, pp. 131-178	5,000
Report of the Entomologist for the year 1889. Author's edition. (From the Report of the Secretary of Agriculture for 1889.) August, 1890, pp. 331-361. With index	1,000
Insecticides and Means of Applying them to Shade and Forest Trees. By C. V. Riley. Author's edition. (Reprinted from the Fifth Report of the U. S. Entomological Commission.) February, 1890, pp. 31-47	200
Insects affecting the Hackberry (various species of Celtis), by C. V. Riley. Author's edition. (Reprinted from the Fifth Report of the U. S. Entomological Commission.) October, 1890, pp. 601-622	200

OFFICE OF EXPERIMENT STATIONS.

Experiment Station Record. (A condensed record of the contents of the bulletins issued by the Agricultural Experiment Stations of the United States.)

Vol. 1, No. 1. November, 1889, pp. 56	5,000
Vol. 1, No. 2. March, 1890, pp. 57-116	5,000
Vol. 1, No. 3. May, 1890, pp. 117-174	5,000
Vol. 1, No. 4. May, 1890, pp. 175-244	5,000
Vol. 1, No. 5. June, 1890, pp. 245-308	5,000
Vol. 1, No. 6. August, 1890, pp. 309-358. With index	5,000
Vol. 2, No. 1. August, 1890, pp. 40	5,000
Vol. 2, No. 2. September, 1890, pp. 41-88	5,000
Vol. 2, No. 3. October, 1890, pp. 89-138	5,000
Vol. 2, No. 4. November, 1890, pp. 139-184	5,000
Vol. 2, No. 5. December, 1890, pp. 185-264	5,000
Experiment Station Bulletin, No. 4. List of Horticulturists of the Agricultural Experiment Stations in the United States, with an outline of the work in horticulture at the several Stations. By W. B. Alwood. January, 1890, pp. 27	5,000
Experiment Station Bulletin, No. 5. Lists of the Agricultural Experiment Stations and Agricultural Schools and Colleges in the United States. May, 1890, pp. 67	5,000
Experiment Station Bulletin, No. 6. List of Botanists of the Agricultural Experiment Stations in the United States, with an outline of the work in botany at the several Stations. June, 1890, pp. 23	5,000
Miscellaneous Bulletin, No. 2. Proceedings of the Third Annual Convention of the Association of American Agricultural Colleges and Experiment Stations, held at Washington, D. C., November 12, 13, 14, and 15, 1889. July, 1890, pp. 142	4,000
Farmers' Bulletin, No. 2. The Work of the Agricultural Experiment Stations. (Better cows; fibrin in milk; bacteria in milk; silos and silage; alfalfa; field experiments with fertilizers.) June, 1890, pp. 16	150,000
Report of the Director of the Office of Experiment Stations for the year 1889. Author's edition. (From the Report of the Secretary of Agriculture for 1889.) August, 1890, pp. 485-544. With index	1,000

DIVISION OF FORESTRY.

Forestry Bulletin, No. 4. Report on the Substitution of Metal for Wood in Railroad Ties. By E. E. Russell Tratman, C. E. Together with a Discussion on Practicable Economies in the Use of Wood for Railway Purposes. By B. E. Fernow, Chief of the Division of Forestry. With plates and index. August, 1890, pp. 363	5,000

Report of the Chief of the Forestry Division for the year 1889. Author's edition. (From the Annual Report of the Secretary of Agriculture.) August, 1890, pp. 273–330	1,000

DIVISION OF MICROSCOPY.

Report of the Microscopist for the year 1889. Author's edition. (From the Report of the Secretary of Agriculture for 1889.) With plates. August, 1890, pp. 191–200	500

DIVISION OF ORNITHOLOGY AND MAMMALOGY.

North American Fauna. (A record of such results of the work of this Division as are of use mainly to those engaged in scientific research.) No. 1. Revision of the North American Pocket Mice. With plates. October, 1889, pp. 36	5,000
North American Fauna, No. 2. Description of fourteen new species and one new genus of North American Mammals. With plates and index. October, 1889. pp. 52	5,000
North American Fauna, No. 3. Results of a Biological Survey of the San Francisco Mountain Region and Desert of the Little Colorado, Arizona. With plates, maps, and index. September, 1890, pp. 136	5,000
North American Fauna, No. 4. Descriptions of twenty-six new species of North American Mammals. With plates and index. October, 1890, pp. 60	5,000
Annotated List of Reptiles and Batrachians collected by Dr. C. Hart Merriam and Vernon Bailey on the San Francisco Mountain Plateau and Desert of the Little Colorado, Arizona, with descriptions of new species. By Leonhard Stejneger. Author's edition. (Reprinted from North American Fauna, No. 3.) October, 1890, pp. 103–123	100
Report of the Ornithologist and Mammalogist for the year 1889. Author's edition. (From the Report of the Secretary of Agriculture for 1889.) With plates. August, 1890, pp. 363–376	1,000

DIVISION OF POMOLOG

Pomological Bulletin, No. 3. Classification and Generic Synopsis of the Wild Grapes of North America. By T. V. Munson. October, 1890, pp. 14	6,000
Report of the Pomologist for the year 1889. Author's edition. (From the Report of the Secretary of Agriculture for 1889.) With plates. August, 1890, pp. 433–452	500

DIVISION OF STATISTICS.

Statistical Report, No. 68. Report on Yield of Crops per Acre and on Freight Rates of Transportation Companies. (Estimated yields of corn, potatoes, buckwheat, sorghum, tobacco, and hay.) November, 1889, pp. 439–484	19,000
Statistical Report, No. 69. Report on the Crops of the Year and on Freight Rates of Transportation Companies. (Prices of farm products, area and condition of fall sowing of wheat and rye, etc.) January, 1890, pp. 485–548	19 000
Statistical Report, No. 70. Report upon the Numbers and Values of Farm Animals and on Freight Rates of Transportation Companies. (Including cotton returns, our foreign trade in dairy products, and European Crop Report.) February, 1890, pp. 64	19,000
Statistical Report, No. 71. Report on Distribution and Consumption of Corn and Wheat and on Freight Rates of Transportation Companies. March, 1890, pp. 65–116	19,000
Statistical Report, No. 72. Report of the Condition of Winter Grain, the Condition of Farm Animals, and on Freight Rates of Transportation Companies. (Including European crop report for April.) April, 1890, pp. 117–174	18,000
Statistical Report, No. 73. Report of the Condition of Winter Grain, the Progress of Cotton Planting, and Wages of Farm Labor; also on the Freight Rates of Transportation Companies. (Including report on farm wages, sugar production in Europe, European Crop Report, and United States Consular Reports.) May, 1890, pp. 175–230	18,000

Statistical Report, No. 74. Report on the Acreage of Wheat and Cotton and Condition of Cereal Crops and on Freight Rates of Transportation Companies. (Including report on cotton production and trade of the world, domestic and foreign wools, course of agricultural prices, farmers' milling companies, and European Crop Reports.) June, 1890, pp. 231–310 ... 18,000

Statistical Report, No. 75. Report on the Area of Corn, Potatoes, and Tobacco and Condition of Growing Crops and on Freight Rates of Transportation Companies. (Including report on Statistics of Mexico, European crop prospects, and notes on foreign agriculture.) July, 1890, pp. 311–374 ... 18,000

Statistical Report, No. 76. Report on the Condition of Growing Crops and on Freight Rates of Transportation Companies. (Reports on Statistics of Canada, Argentine Statistics, European crops, and the Indian wheat crop.) August, 1890, pp. 375–430 ... 18,000

Statistical Report, No. 77. Report on Condition of Crops in America and Europe and on Freight Rates of Transportation Companies. (Including a report on tariffs of South America and a statistical review of Venezuela.) September, 1890, pp. 431–494 ... 18,000

Statistical Report, No. 78. Report on Condition of Crops, Yield of Grain per acre, and on Freight Rates of Transportation Companies. (Including reports on the crop year in California and Colorado, and prices of wheat in 1890.) October, 1890, pp. 495–542 ... 18,000

Statistical Report, No. 79. Report on Yield of Crops per Acre and on Freight Rates of Transportation Companies. (Including reports on a decade of wheat exports, statistics of Colombia, small holdings and allotments in Great Britain, and the French agricultural syndicates.) November, 1890, pp. 543–590 ... 18,000

Statistical Report, No. 80. Report on the Crops of the Year and on Freight Rates of Transportation Companies. (Including reports on New York Dairymen's Association meeting, financial condition of California farmers, peanut production, European Crop Report for December, and Belgian crops, 1889 and 1890.) January, 1891, pp. 591–652 ... 18,000

Miscellaneous Report, No. 1. (New Series.) A Report on Flax, Hemp, Ramie, and Jute, with considerations upon flax and hemp culture in Europe, a report on the ramie machine trials of 1889 in Paris, and present status of fiber industries in the United States. By Charles Richards Dodge, Special Agent. With illustrations and index. April, 1890, pp. 104 ... 10,000

Synopsis of the monthly reports of the Statistician (a brief recapitulation of the returns of statistical correspondents, intended for prompt and wide circulation in advance of the regular Monthly Crop Report from which it is condensed):

- March Report. March, 1890, pp. 4 ... 20,000
- April Report. April, 1890, pp. 4 ... 80,000
- May Report. May, 1890, pp. 4 ... 80,000
- June Report. June, 1890, pp. 4 ... 78,000
- July Report. July, 1890, pp. 4 ... 78,000
- August Report. August, 1890, pp. 4 ... 78,000
- September Report. September, 1890, pp. 4 ... 78,000
- October Report. October, 1890, pp. 4 ... 78,000
- November Report. November, 1890, pp. 4 ... 78,000
- December Report. December, 1890, pp. 4 ... 78,000

Report of the Statistician for the year 1889. Author's Edition. (From Report of the Secretary of Agriculture for 1889.) August, 1890, pp. 201–272 ... 1,000

SILK SECTION.

Silk Bulletin, No. 1. How to Raise Silk-Worms. A brief Manual of Instructions, abridged from Bulletin No. 9 of the Division of Entomology. By Philip Walker, Chief of the Silk Section. February, 1890, pp. 16. With illustrations ... 5,000

Report of the Chief of the Silk Section for the year 1889. Author's Edition. (From the Report of the Secretary of Agriculture for the year 1889.) August, 1889, pp. 453–476 ... 300

DIVISION OF GARDENS AND GROUNDS.

Reports of the Superintendent of Gardens and Grounds for the year 1889. Author's Edition. (From the Report of the Secretary of Agriculture for 1889.) August, 1890, pp. 111–134 ... 500

DIVISION OF VEGETABLE PATHOLOGY.

Journal of Mycology. (Devoted to the study of Fungi, especially in their relation to plant diseases.)	
Vol. 5, No. 3. With plates. November, 1889, pp. 113–180	1,500
Vol. 5, No. 4. With plates. November, 1889, pp. 181–249, with index	1,500
Vol. 6, No. 1. With plates. May, 1890, pp. 44	2,000
Vol. 6, No. 2. With plate and cuts. September, 1890, pp. 45–88	4,000
Vol. 6, No. 3. With plates and cuts. January, 1891, pp. 89–136	2,500
Botanical Bulletin, No. 11. (Section of Vegetable Pathology.) Report on the Experiments made in 1889 in the Treatment of the Fungous Diseases of Plants. By B. T. Galloway. With plates and index. May, 1890, pp. 119	5,000
An Experiment in Preventing the Injuries of Potato Rot. By Clarence M. Weed. (Reprinted from Journal of Mycology, Vol. 5, No. 3.) November, 1889, pp. 158–160	1,000
Peach Rot and Peach Blight. By Erwin F. Smith. (Reprinted from Journal of Mycology, Vol. 5, No. 3.) November, 1889, pp. 123–134	1,000
Treatment of Plant Diseases. (A series of articles reprinted from Journal of Mycology, Vol. 6, No. 1.) May, 1890, pp. 23	5,000
A New Hollyhock Disease. By Miss E. A. Southworth. (Reprinted from Journal of Mycology, Vol. 6, No. 2.) With plate. November, 1890, pp. 45–50	3,000
Report of the Chief of the Section of Vegetable Pathology for 1889. Author's Edition. (From the Report of the Secretary of Agriculture for 1889.) With plates. August, 1890, pp. 397–432	500

REPORT OF THE SUPERINTENDENT OF THE DOCUMENT AND FOLDING ROOM.

SIR: I have the honor to submit herewith my report of the work of the Document and Folding Room during the past year.

Upon this Division devolves the important work of preparing and keeping in order the mailing lists of the Department and of distributing the reports and bulletins emanating from its several Divisions. In addition to this work there must be written a large number of franks and envelopes for the dispatch of circulars and other documents for the press prepared in the Division of Records and Editing, besides the mailing of envelopes and paper to correspondents, return envelopes, etc., aggregating a great many thousands. In last year's report I pointed out in some detail the large increase of work which had devolved upon this Division and which I was compelled to perform with little or no increase in the clerical force. I gratefully acknowledge an increase in the force during the present year by the addition of two folding clerks and one laborer; at the same time I may be permitted to point out that the increase of the work this year by comparison with the last has been quite out of proportion to the increased force assigned to me. It can be readily understood that as the work of the Department develops and new divisions are created additional work is immediately and unavoidably imposed upon this Division. This is so obvious that I shall not attempt to elucidate this matter in detail, but will merely call your attention to the fact that whereas the total publications of the Department for the previous twelve months aggregated 566,000 copies, the total number of copies of the publications for the twelve months just expired aggregated 1,133,000, a trifle more than twice as many copies, the care and distribution of which devolved upon this Division.

It will be unnecessary for me in this report to include a detailed statement of these publications, as an extended list of the same will, I have reason to believe, be included in the report of the Division of Records and Editing. It has only been, then, by unremitting efforts, in which I wish to say I have been cordially aided by my assistants, that I have been able to dispose of the enormous amount of work involved by this great increase both in the number of publications and the number of copies.

In this connection I desire to suggest that the method of keeping the lists calls for some modification looking to improvement in two respects, first, promptness, and secondly, economy in distribution. Some of the Divisions at present write their own franks. As these are occasionally delayed on account of press of other work, corresponding delay in the distribution is inevitable. The force of this Division should in my opinion be so enlarged as to permit of the keeping of all lists and the writing of all franks under my own supervision. This would enable us furthermore to adopt a system by which any possibility of duplication in the distribution of bulletins or reports would be certainly avoided.

I beg leave to call your attention here to the gratifying evidence, of which the work of this Division affords the most ample testimony, of a rapidly increasing demand for the publications of this Department. It is but a few years ago that little if any interest seemed to be manifested by a majority of the farmers of the country in the publications of the Department even on subjects of vital interest to themselves. All this has now changed, and the mere appearance of a notice of a forthcoming bulletin brings us hundreds and thousands of applications, which continue to be received after the bulletin or report has appeared, until to-day I am constantly obliged to call attention to the rapidly diminishing supply of the several bulletins on hand.

This leads me to suggest the propriety of enlarging the editions if possible, while at the same time it might doubtless be possible to be a little more conservative in our methods of distribution. In many cases, as I have said, thousands of applications are received under the present system even before the bulletin itself has been received from the Public Printer, and as the appearance of the bulletin in print is apt to stimulate the demand, we find ourselves constantly threatened with an exhaustion of the supply on hand. I regret to say that this is the case with the first report of the Secretary of Agriculture, of which only 25,000 copies were assigned to this Department, and of which, in my opinion, judging by the repeated calls, 50,000 copies would not have been an excessive number for our use.

Inasmuch as the work of this Division represents one of the channels through which all the work done in the various Divisions of the Department must pass before reaching the public, and inasmuch, furthermore, as all the work done by us brings the Department in direct contact with that portion of the public for whose benefit it is especially designed, I think the importance of its efficient equipment with a staff of capable clerks, adequately remunerated, the thorough systematizing of its work, and sufficient and suitable accommodation for its prompt and efficient performance can not be overestimated.

Respectfully,

A. T. LONGLEY,
Superintendent of Document and Folding Room.

HON. J. M. RUSK,
Secretary.

REPORT OF THE SPECIAL AGENT IN CHARGE OF FIBER INVESTIGATIONS.

SIR: I have the honor to present herewith a report upon the investigations of the Department, during the past year, into fiber cultivation in the United States. As the culture of flax and hemp are important recognized industries in which the greatest interest exists at the present time, while the production of ramie, sisal hemp, etc., can hardly claim recognition as established industries, I have devoted the principal part of the report to the consideration of the first-named fibers, confining myself chiefly to matters of culture, or those which directly interest the American farmer.

Upon my return from Europe in November, 1889, where, in pursuance with your instructions a study was made of the flax, hemp, and ramie interests, a line of investigation into American fiber industries was at once entered upon. This has been persistently pushed and the progress of the year, as far as practical results are concerned, has been especially marked in regard to the flax and hemp industries and, in a partial degree, as to those of ramie and sisal hemp. Early in the season the outlook was very promising for success with two or three new forms of fiber material that might be used as jute substitutes in cotton bagging, such as okra and the bast of the ordinary cotton stalk, but no practical results have been secured so far as the Department has been able to learn, and in two or three instances the experiment has been marked with positive failure. I should state that the manufacture of bagging from the fiber derived from pine straw or pine needles is not included in this category, as the present year's operations, with this material, have been quite large.

FLAX.

In considering the fiber interests of our country flax should undoubtedly be given the first place. At the outset of these investigations it was ascertained that flax was grown by our farmers almost wholly for seed, the straw, of inferior quality, when used at all, going to the tow mills or the paper mills, and selling for from $1 to $8 a ton, the average in the different sections being not more than $2.50 to $4, while by far the larger quantity, that which is wasted or burned, represented no money value whatever. While in the older States the area under cultivation was found to be small and steadily decreasing, in the newer States, or States where agriculture is being pushed steadily westward from year to year, the area under cultivation seemed to be fairly holding its own, and can be stated in round numbers at about one million acres.

As to the method of culture it was learned that in the newer States it is the general practice to grow on "first breaking," or land plowed from the prairie sod, manures being rarely used. On cultivated land it is the custom to grow after corn, grain, or clover, and it is almost the rule to follow with a grain crop of some sort, wheat and oats being most commonly cultivated. Corn is also grown, and sometimes grasses and clover or potatoes. In such cases the ground is prepared as for a wheat crop, barnyard manures being applied; in some rare instances bone or other fertilizer is spread after seeding, and the soil is brought to a fine state of tilth by harrowing. It seems to be generally understood that a fine mellow soil is necessary for the success of the crop, even when grown only for seed, and one or more, sometimes three, plowings are given and the earth pulverized as thoroughly as possible. The seed is obtained at the oil mills, at the local stores, or is imported, some Russian seed being sown in the new States. It is either drilled or sown broadcast, the latter being the almost universal custom. Little or no cultivation is given the crop while growing, and when the seed is ripe the straw is cut with the reaper, the knives set high, and the "self-raker" employed. The straw is run through an ordinary thrashing machine, which leaves it a broken and tangled mass, the coarse fiber it contains being rendered valueless for almost any purpose save upholstery tow. When it is not used for fiber, and not burned or otherwise wasted, it is sometimes employed for thatching, as bedding for stock, or packing for ice, and sometimes as a fertilizer. By many it is fed to sheep and cattle, though its use for this purpose, despite the wide advocacy of the practice by some agricultural writers, can not be condemned too strongly on account of the danger to the animal from eating the fiber in quantity.

At present the area for seed production seems to be increasing, and with the agitation of the present year looking toward the reëstablishment of the flax industry has come the inquiry, oft repeated, whether it will be possible to grow for seed and save the fiber also. To what extent our farmers may grow both for seed and fiber in the same plant is a problem in the solution of which Western agricultural experiment stations can do important work. Or, stated differently, careful experiment can only determine the precise value of a fiber produced without sacrificing the quality of the seed. Many old writers affirm that good seed and salable fiber can not be produced from the same plant, and the statement has been reiterated time and again during the past season. There are two sides to this question, though in the limits of the present report it will be impossible to properly discuss them. Undoubtedly when the flax fiber industry is fairly established in the United States there will be three distinct forms of flax culture. First, the culture for seed only, by present careless methods; secondly, a more careful culture with a view to getting a full crop of seed, while producing a tolerable fiber that will be marketable for certain kinds of manufacture, and lastly, a careful, skillful culture for the production of fine fiber, the seed product being a secondary consideration. We have nothing to do with the first form of culture, so but two forms are to be considered.

The finest flax produced in Europe is grown in Belgium, where the seed not only is saved but is used in some cases to produce the next year's crop of flax.* In a letter recently received from Mr. John Orr Wallace, a Belfast authority, occurs this statement:

About the fiber being coarse if the seed is saved, this will not be the case if the flax straw is pulled before being too ripe and hard. In France and Belgium our spinners get the finest fiber, and the growers there save the seed.

Here is an extract from a recent number of the Irish Textile Journal, furnishing added proof that fiber and seed can be secured in the same plant. The italics are mine:

The crop must be grown with a view towards getting from the land the highest yield of straw that will produce the *finest quality* of fiber. *The seed, which ought to be a large factor in profit, should be saved*, etc.

In an article in the same journal, relating to experiments in flax culture in the south of Ireland, this statement occurs:

The measured acre of green flax, one week pulled, weighed 5 tons 9 cwt., and yielded 22 bushels of prime seed.

From a careful sifting of evidence it would seem that it is easier to produce salable fiber and salable seed for the oil mill than to grow fine fiber, and at the same time secure seed that will produce equally fine fiber the second year. As there is a certain degree of seed deterioration, necessitating renewal by importation each season, the oil mill becomes an important factor in the enterprise, whatever form of fiber is grown.

Mr. Henry Stewart has stated in the Country Gentleman that "it is futile to expect that fiber and seed can be produced from the same crop." Mr. Eugene Bosse, formerly a Belgian flax grower, but now a citizen of the United States, produced in 1889 a crop of flax pronounced by one of our manufacturers fit for fine linen. His fiber was sold at a good price in Boston, and the same crop yielded at the rate of 10 bushels of seed per acre, for which he received $1 per bushel. Mr. Bosse has produced a large crop of fine flax the present year, in Minnesota, though detailed statements regarding it have not yet been received. According to Mr. Stewart, not only seed and fiber, but *fine flax* can not be grown in America.† Can it be possible that this writer does not know that just over the border, dividing Michigan from Canada, large areas of flax are annually grown, and that almost a score of flourishing mills have been in operation for years? Does he not know that the Canadians are seriously considering the growing of flax for export into Great Britain? What can be done in this section of Canada can be done in Michigan, Minnesota, and other States. Mr. Stewart is correct in his statement, however, that if the plant is left long on the ground the fiber loses its strength and firmness and becomes harsh, brittle, and

* The usual practice in Belgium, as I learned from Government experts while abroad last season, is to import the seed annually, though I found that in some localities a different custom prevailed, as in the Brabant. Imported seed is planted the first year, Dutch or Russian, and the seed product of this crop planted the second year, giving, it is claimed, a better quality of flax than the first year; but for the next year's sowing new seed is again secured.

† My first effort was made in Michigan thirty years ago, after returning from a lengthened visit from Europe, during which I spent a few weeks in the north of Ireland, in the center of the flax-growing district, and later in Pennsylvania. In Ireland I witnessed the latter stages of the culture of this crop, and the preparation of this fiber for sale to the linen factories, several of which I visited. On my return I prepared a piece of land, and had it sown with flax by a man who came from this same district, and who seemed to be as sanguine as I was that we could grow flax in America. But every effort to grow fine fiber failed. A coarse fiber, fit for making grain bags, can be easily grown.

coarse. The plant should not be left "long" on the ground, but as Mr. Wallace suggests, should be pulled before it has become hard and overripe.

Having shown that it is possible to save the seed when flax is grown for fiber, I do not wish to be understood as saying that culture for seed production and culture for fiber production are one and the same thing. When flax is grown for seed, and without regard to fiber, it is sown thin, at the rate of 2 to 3 pecks of seed per acre, in order that the plants shall branch and produce as large a crop as possible. And a large seed is also desirable. When the production of fine fiber is the object, a thicker sowing is necessary, that is, from 1½ to 2 bushels (or even more) per acre are required. This prevents branching, the plants are shaded, and a crop of clean, slender, straight straw is the result. Referring to the original question: Can our farmers cultivate for seed, and also secure a fiber that can be made a marketable product?

In the course of my investigations during the past year, valuable affirmative testimony has been secured from which the following deductions are made. It will be possible to grow flax for seed, *i. e.*, for sale to the linseed oil manufacturer, and also to secure a fiber which will be applicable to many of the coarser uses for which flax is employed, though with some modification of the present (common) method of flax culture in this country. There must be a little better preparation of the seed-bed, making it smoother, so that the farmer will be enabled to run the reaper knives as near the roots as possible and get the full length of straw, and it may be better to sow a little more seed to the acre. He must discard the ruinous practice of tearing the straw into fragments in taking off the seed. Let him keep the straw straight, water-ret it if he will take the trouble, or carefully dew-ret it if he thinks the water-retting will not pay. Regarding the matter of scutching or cleaning the straw, when the better quality of straw is produced, there will be scutch mills if they are needed. In this connection it may be stated that the Department has in its collection some beautiful samples of well-cleaned Western flax, from straw grown for seed but kept straight, that were hackled direct from the breaker, without scutching.*

* A few extracts from the letter of Mr. John Ross, of Boston, which accompanied these samples, will be interesting in this connection. The long experience of Mr. Ross in handling flax fiber, as well as knowledge of the requirements of the industry from the manufacturer's standpoint, enables him to speak authoritatively. He makes statements as follows:

"To obtain the best results as to quantity and quality from the Western straw, as at present sown and cultivated for the seed, I believe that the straw should be cut, or better, pulled and kept straight, and the seed removed by rippling or some similar process which will not tangle the straw. The straw must then be steeped in water in streams, or in pits or ditches, and thoroughly water-retted, the process being carried as far as is possible without positively endangering the strength of the fiber. Then the retted straw must be thoroughly dried, and, if possible, exposed to some artificial heat immediately before being broken. In Holland the straw is dried by exposing to the heat produced by the combustion of the shives and dust from the brakes, and this drying process is attended by a boy. The dry straw should then be passed through a brake provided with several sets of fluted rollers, so that the straw, rendered brittle by the drying process, will be thoroughly broken up, and the greater part of it will fall, and that which remains on the fiber will be loose and will be easily detached by the subsequent processes of hackling, carding, and spinning, thus yielding a clean yarn.

"It will be noticed that this method of treatment omits the process of scutching. This is always the most expensive process in the preparation of the flax fibre, and when applied to so short and weak a fiber as is produced in the West under the

I am informed that these samples were produced from water-retted flax grown near Cedar Falls, Iowa, for seed purposes. They well illustrate the possibilities of this fiber when properly handled and grown as at present without additional expense or trouble to the farmer, except the keeping of the straw straight and the rippling of the seed.

Mr. A. R. Turner, jr., president of the Flax and Hemp Spinners and Growers' Association, in an important and lengthy communication to the Department, last February, made the following statements bearing directly upon this question:

At present we have a home demand for good flax fiber for yarns, thread, etc., but many farmers who have shown samples have offered inferior flax, raised from poor seed, and the fiber has not been properly cleaned. While the making of threads requires a strong flax, many grades of flax not fitted for threads are suited for weaving, and it is a thoroughly practical matter to make coarse linens from ordinary grades of Western flax when sufficient protection is given the manufacturer in the producing of goods. * * * Some plan should be devised to save all the fiber that is now being wasted, and to me it seems a safe statement to make that it is possible to preserve all the fiber from flax even though it may be sown primarily for seed.

Here is positive testimony from the manufacturer's standpoint, though Mr. Turner does not stop here, but urges the necessity for experiments in "the raising of long and strong flax from the best seed, the aim being to produce the best possible quality of fiber."

This brings us to the subject of fine flax culture, or that form of cultivation where good management and a certain amount of skill are essential to success and where seed is a secondary consideration.

In view of all that has been published during the past year regarding fine flax culture, it would seem unnecessary to give any space in this report to the question, "Can we produce fine flax in the United States." There has been such opposition to the revival of this industry, however, chiefly from the American representatives of foreign interests, and so much has been published with the direct object to discourage all attempts toward flax production,* that a few

present system of cultivation, it would cause a large product of scutching tow, and would raise the cost of the fiber beyond its market value.

"I send, in the accompanying box, samples of the hackled line and tow produced from Western straw, which has been kept straight and retted in water and passed through a brake without scutching. The samples of coarse line and tow represent a product of 50 per cent line, and about 40 per cent tow, and 10 per cent waste, and are suitable for spinning into medium and coarse twine, and for the warp and weft yarns in coarse crashes, etc. The samples of the fine line and tow show what can be produced from this flax when thoroughly hackled, and from this line can be spun a 50-lea weaving yarn suitable for many of the finer and even some of the finest of the linens on which the Flax and Hemp Spinners and Growers' Association asks an additional duty that they may be made at home instead of imported from abroad. The fine tow is suited for fine weft yarns for weaving purposes."

* I regret to state that not only have prominent commercial journals used their influence in this direction, but not a few of our leading agricultural papers have endeavored to teach farmers this false doctrine, editorially, even with the facts before them, or readily available, that would refute their misstatements. An extract from an editorial published in a leading newspaper of St. Paul, Minnesota, during the summer, comments upon this matter most pointedly: "Either from ignorance or design there has been a general and persistent attempt to discourage the cultivation of flax in this country with a view to utilizing the fiber. Our farmers were taught that a flax crop might be made to pay well if raised for seed alone; but they were given a whole host of reasons why the industry could not stand on the broader ground of a profit from both seed and fiber. This has been so generally the impression that even the ablest of the trade journals have fallen into line, and the public has assumed as a fixed fact that the manufacture of twine or textiles from flax grown in the United States is an imaginary industry."

statements showing the results of the Department's investigations upon this subject will serve a good purpose at this time.

It has been asserted over and over again that neither the soil nor climate of the United States was adapted to fine flax culture.

A perusal of the reports of the Department of Agriculture for a period of forty years, and in connection with the Census volumes, gives abundant evidence that flax cultivation for fiber has been a recognized American industry in the past. In the first half of the present century the flax wheel was as common in the household as is the sewing machine in our generation, while there is hardly a country boy of that early period, still living, who does not remember perfectly every operation related to culture, as well as the subsequent ones connected with the preparation of the fiber. The flax of New York and New England of sixty to seventy years ago is described as strong and flexible, though not always as clean as it should have been, and sometimes uneven in quality; and good flax was grown in New Jersey. The history of the flax culture from that time down to within a score of years of the present time is a history of flax fiber production in varying quantities, the most of it being good staple flax.

The decline of the industry is due, first, to the change from household manufacture to that of the central spinning mill, to the increasing use of cotton, to the war period, to the tariff revisions of 1872 when the flax industry had begun to revive, and latterly, as stated by Mr. Turner, to the fact that encouragement has not been given to the raising of flax because the supply of linens is principally imported and we have lost our position as manufacturers in the linen trade.

Were linen factories scattered over our country, and especially through the Northwestern States, a demand would be made for flax by the manufacturer which the American farmer, if he produces good fiber, can supply. The increase of duty on the dressed line flax from 2 to 3 cents per pound should certainly aid the farmer in his effort to fill this demand. It is urged, however, that farmers not only will never pull flax, but that when it comes to the retting (in pools, of course) no American farmer will ever take the trouble to learn the business. These are very broad statements, which hardly merit a reply. It may be said, however, that a common practice abroad is for the farmer to sell the crop standing in the field and frequently before it has completed its growth. As the purchaser attends to the pulling, retting, and scutching, the farmer's responsibility really ends when the weeding has been accomplished. Indications already point to the adoption of this course in America, for in those localities where the industry is beginning to revive the linen factory, scutch mills, and flax farms are component parts of a comt mon interest, and are but wheels in a single machine. Under present conditions and with a reduced foreign supply the American manufacturer will be able to pay a better price for his dressed flax, no matter who dresses it, and so, in connection with this encouragement, insure the paying of better prices to all who handle the product, right down to the farmer, whether he rets his crop himself or sells it standing.

To return to the question whether we have the proper soil and climate for flax culture, and can grow flax, I will say that good flax was grown last year in several States, samples of which were sent to the Department, one of them even coming from Texas, produced by a former Irish flax grower.

A study of meteorological data obtained from the Weather Bureau in Washington reveals some interesting facts. In the discussion upon flax culture a great deal has been said about the hot, dry climate of the United States in comparison with the cool, moist climate of Ireland; but if the truth must be stated the best flax is not grown in Ireland, nor is the best flax spun by the Belfast manufacturer produced by Irish farmers, but by the growers of Belgium.

The best American flax I have seen was grown at Green Bay, Wisconsin, where the average temperature for the three growing months is 54° F., and with abundant rainfall. The average temperature of Belfast, Ireland, for the same period is 52.2° F., and for Brussels, Belgium, 55.9° F. The temperature for St. Paul, Minnesota, near which station superb flax was produced this season, is only a fraction of one degree higher.

Studying the figures for humidity we are enabled to make further interesting comparisons: For Brussels, Belgium, the average for the three growing months is 77.4 and the average annual 83. For Green Bay, Wisconsin, average for three months 72 and for the year 77.9. For Cologne, Germany, the average for April, May, and June is but 67.1 and the annual but 74 (contrast with Green Bay), while for St. Paul, Minnesota, the averages are, respectively, 65.6 and 71. An effort was made to ascertain the humidity for Belfast, but persistent search through the records of the Weather Bureau, as well as all available publications running back forty years, was unsuccessful. On the authority of an expert linen weaver, formerly of Belfast, the average humidity for that station is stated to be 70 to 72.

For better comparison the following table is presented:

From records of the Weather Bureau.

	Temperature.		Humidity.	
	Average* 3 months.	Average annual.	Average 3 months.	Average annual.
Foreign stations—	°	°		
Belfast, Ireland	52.2	48.8	....	....
Brussels, Belgium	55.9	....	77.4	83.4
Prague, Bohemia	54.6	48.1	66.0	74.0
Cologne, Germany	55.7	50.6	67.1	74.0
American stations—				
Albany, New York	57.7	....	64.5	70.5
Green Bay, Wisconsin	54.0	....	72.0	77.9
St. Paul, Minnesota	56.7	....	65.6	71.0
Portland, Oregon	56.9	....	66.7	83.0

*April, May, and June.

By this table it is shown that the temperature of the leading flax-growing sections of this country and Europe is practically the same, the average for the four European stations being 54.3°, and for the four in the United States 56.3°, or a difference of but 2°. The humidity for the foreign stations given is slightly higher than for those of this country, though stations indicating greater humidity in the States named and near which fine flax can undoubtedly be produced, could have been used. The humidity of Washington, as indicated by the data from Spokane Falls, Olympia, etc., will be found almost as great as of any foreign stations reported, and there is no doubt but that good flax can be grown in this new State.

Though the process of bleaching or "grassing" belongs to the manufacturing branch of the industry and does not interest the farmers it may be stated that the process has been accomplished in this country with quite as good success as in Europe. Some fine samples of linen thread from a large New Jersey manufacturing firm may be seen in the collection of the Department, which were bleached out of doors in less time than it takes in Belfast when the same process is followed. As we have in many localities the right temperature, rainfall, and humidity to grow flax, the proper conditions for bleaching it, and as spinning flax was produced on nearly every farm in the country fifty or sixty years ago, and good flax was grown in several localities the present year, it is nonsense to protest that flax culture is not adapted to the United States.

Another point urged by the friends of the foreign producer is that it is doubtful whether flax culture will pay in this country. We are told that the American farmer can never compete with the foreign grower who pays 50 cents a day for his labor. Neither could he, were the conditions equal; but a careful study of the situation on both sides of the Atlantic reveals the fact that the conditions are so unequal that in many things the American farmer has a positive advantage, which, with a few years of experience and aided by the persistence of American inventive genius, will make him master of the situation.

In the first place the foreign flax farmer is obliged to use an enormous amount of fertilizers, because the lands, worked for centuries, will not produce paying crops without. Stable manure is freely applied in the fall. Then in the spring, before sowing time, the soil is again heavily treated, but this time with chemical fertilizers, often at the rate of 500 to 750 pounds per acre. In addition to this many farmers go over the ground with night soil in solution, and a great deal of this material is brought from the towns and kept in large closed reservoirs until time to use it. I have no figures at hand showing what the rent of land amounts to, but it is so far in excess of land rentals in this country that it is no wonder flax culture is being abandoned in many localities because the grower can not get enough out of it to meet his expenses. It is true he gets his labor at exceedingly low wages, but the foreign farm laborer is slow and plodding. Much of the flax is grown by small farmers upon limited areas, and the small farmer does not use labor-saving machinery.

An American farmer would never think of spading over a 10-acre field, when with horse implements he could do the work better in a quarter of the time. And what American farmer, wishing to roll his ground, would strap boards to his feet and level it by tiresome tramping up and down, when with a horse roller the work could be finished in a few hours, and enable him to ride while accomplishing it. Yet these are some of the "foreign methods" of flax culture that are practiced at the present time. I was told by hemp farmers in Brittany that a French laborer who breaks out 65 to 75 pounds of fiber (on a hand brake) has performed a good day's work, yet a Kentucky negro, using a similar hand implement, will make 150 pounds. From my observations last year in the foreign flax countries visited, I have no hesitancy in saying that one average farmer or farm laborer in this country will accomplish as much as two abroad. And with the application of labor-saving machinery to all the operations in flax culture, the difference in the prices of farm labor alone will be more than compensated, and the cheapness of land and the natural fertility of the soil in this country will give a clear advantage on the side of the American flax grower. The soil will be plowed, harrowed, crushed, and rolled with improved machinery. A mechanical flax-puller has already been invented, and there are several improved machines for taking out the seed without injury to the fiber. We lead the world in the invention and manufacture of agricultural implements, and when the demand is made by flax farmers for improved implements for special purposes in this branch of agriculture they will be produced. And when our farmers have had a few years' experience, and this "American practice" of accomplishing hand labor by means of iron and wood and horseflesh, instead of human sinew and muscle, is adapted to flax culture, we shall be in position to outsell the European grower in his own market.

Cultivation.—As I have stated, the growing flax for fiber and growing for seed and saving the fiber, such as it is, are two distinct kinds of flax culture. For the benefit of those who may wish to try the experiment of growing flax for fiber, the following brief instructions have been prepared. A great deal depends upon the selection of the soil, a moist, deep, strong loam upon upland giving the best results. Barley lands in the Middle States and new prairie lands or old turf in the Western States are frequently chosen. Some former New York flax growers inclined to a heavy clay loam for the production of fiber and seed, though the choice of a wet soil will be fatal to success. In Russia flax culture is carried on upon the vast plains in the interior subject to annual overflow from the rivers. In Belgium, as I was informed, flax succeeds best in a deep and well-cultivated soil that is not too heavy, experience proving that in a dry, calcareous soil the stalk remains short, while in heavy clayey soil it grows very long, although its fiber is not so fine.

A soil full of the seeds of weeds is to be avoided above all things, and the American farmer who is not overnice in regard to clean land had better let flax culture alone. Not only does a weed-ridden soil add greatly to the labor of making the crop, but the fiber itself will be injured. Clean land, then, is one of the first requisites to success. In Europe the ground is plowed either in the fall or spring—plowed or spaded, for a great deal of the flax land is turned with the spade. The work may begin in November, sometimes a little earlier, or it may be put off until February, or the first days of March. I was told that both methods had their advocates and opponents, and that either season may be advantageous or disadvantageous, according to the kind of winter which follows or precedes. In our own country fall plowing is desirable with a second plowing in the spring as early as possible. Then harrow, reduce to fine tilth, and roll the ground well before putting in the seed. Mr. S. Edwards Todd, in a prize essay on flax culture published several years ago, laid great stress on the matter of reducing the soil to fine tilth and rolling well, the object being to have the surface of the ground as smooth and uniform as it can be made, so that the flax may get an even start, grow more uniformly, and the surface of the ground be better to work over when the flax is pulled. All stones should be removed or pressed into the earth, and lumps are to be equally avoided.

Reference has already been made to the thoroughness of the foreign grower in keeping up the fertility of the soil. The American farmer, and especially on the newer lands of the Western States, doubtless will not need to manure as heavily as is done on the other side of the water, though present practices, followed in many localities of the West, of taking everything from the soil but the roots of the plant and returning little or nothing, will have to be abandoned. Phosphates, plaster, ashes, and salt are considered the best manures. Dr. Ure recommends a mixture of 30 pounds of potash, 28 of common salt, 34 of burnt gypsum, 54 of bone dust, and 56 of magnesia, which he claims will replace the constituents of an average acre of flax. Well rotted barnyard manure should be used in preference to coarse barnyard manures, which are apt to make too rank a growth to produce good fiber. As before stated, Belgian farmers use liquid night soil or other liquid manure collected from the cow-house and stables, fermented in cisterns, and sometimes mixed with oil cake.

The American farmer must not depend upon careful soil preparation and fertilizing alone to put his flax land in proper condition. A systematic rotation of crops is absolutely essential in order to secure the best results. A former New York grower used to begin the preparation of the soil for a crop of flax three years before. The rotation followed was Indian corn, barley, oats, winter and spring wheat, and red clover, the corn being planted on land plowed from clover sod. The cleaning process, to rid the soil from weeds, began with the first crop which followed the clover sod. Rotation in Europe is reduced to such system that oftentimes the entire farm is laid off in plots and the order of planting for the different crops planned for several years in advance. The Belgian farmers are particularly careful in this matter. Regarding the precise order of rotation and even the length of time between two growths of flax on the same land in Belgium, there is the greatest difference of practice in the several districts and even in different towns of the same district, so no one absolute course of cropping can be laid down. In the Courtrai region the occupancy of the land with flax varies from five to ten years, the average being about eight. In eastern Flanders it is five to nine, and in the Brabant five to eight. In some other sections a much longer time elapses between two crops of flax, and several generations back fifteen and even eighteen years were sometimes allowed to intervene. One informant stated to me that flax was most generally sown after leafy plants, such as potatoes or turnips, wheat and especially oat-stubble being highly approved. A common rotation is clover, oats, rye, wheat, and in some cases hemp. Crops of rape, tobacco, beans, and vegetables (these latter crops on farms contiguous to towns), or even onions and salsify, are grown, as in middle Belgium. Clover is considered one of the best crops to precede a crop of flax, as its numerous roots go deep into the soil and from their decomposition not only furnish nutriment to the growing flax roots, but enable them more easily to push down into the soil.

After a thorough preparation of the ground, which must be almost as fine as garden soil and of absolutely even surface, the seed may be sown; and again, at this point, great care should be exercised, for upon a careful selection of the seed much depends. It must be pure, free from the seeds of weeds, and from all odors which would indicate mustiness and bad condition, that would affect its germinating power. The foreign grower in purchasing his seed is subjected to a dozen forms of fraud, and the only safe plan pursued is to buy of reputable dealers exclusively.

In all cases the heaviest, brightest, and plumpest seed should be preferred. Get only the best. Mr. J. R. Proctor, of Kentucky, writing upon this subject ten or twelve years ago, advocated the white blossom Dutch as the best seed for American flax growers. Mr. Eugene Bosse, a practical flax grower, writing to the Department under recent date, states that his preference, based upon several years' experience, is for (1) "Riga seed, once sown in Belgium"—that is to say, imported seed grown on Belgian soil from seed procured in Riga. Next to this he places (2) seed imported direct from Riga, but states that it must be Riga and not Finland seed. Third in the list he places (3) Dutch (Rotterdam) seed, and lastly (4) American seed, which is "as good as Nos. 2 and 3 when well cultivated, though it will not stand the drought as well." He also states that No. 1 will produce about 8 bushels of seed to the acre,* No. 2 10 bushels, and No. 3 between 8 and 10 bushels. Note that he calculates for the rate of seed production, even when stating the relative value of the different kinds for the production of fine fiber.

As to quantity, 2 bushels per acre is the smallest that should be sown when good results are desired. When sowing for the production of seed alone, 2 pecks to a bushel will suffice. The larger the quantity of seed, therefore, the finer the straw, and likewise the fiber. The amount of seed sown in Belgium varies ordinarily from $2\frac{1}{2}$ to 3 bushels per acre, though in one district (Hainault) it is claimed that the quantity sown is sometimes double this amount. Probably 3 bushels per acre comes nearer the general practice. Some growers hold that more should be used when the sowing is late than when it is early; at any rate, when planted too thickly, as is sometimes the case, it is afterwards thinned, though such a practice adds just so much to the cost of production. Finer fiber is obtained from early sown flax than from later sown.

As to the proper time to sow in this country a former grower in New York State says: "Sow when the soil has settled and is warmed by the influence of the sun and weeds and grass have begun to spring up and the leaves of trees begin to unfold."

Mr. A van Hemert, writing to the Department from Grand Meadow, Minnesota, says:

> No definite rule can be laid down as to which time in the spring is the best to sow flax, atmospherical conditions governing the growth to a great extent. I consider for myself the first part of May is the best time for seeding it.

Too early sowing may result in injury to the growing plants. The work must be done with great regularity; in fact, in foreign countries many farmers employ for this purpose special workmen who make it their business at this season of the year. A practice followed by some farmers, especially where the soil is at all weedy, is to allow the land to lie, after it is put in condition, until the weeds appear, then, just before sowing, give the surface a light harrowing, when the majority will be killed. The weeding, when necessary, is performed when the plants are less than 5 inches high. Mr. Todd's practice for the removal of the coarser noxious weeds like thistles, dock, etc., is to send a man into the field shod with three or four pairs of woolen stockings, to avoid injury to the young flax by treading it into the soil. This is done when the plants are about 8 inches high. In the operation of weeding some attention should be

* In Mr. Bosse's detailed account of his flax crop of 1889 he states that $1\frac{1}{2}$ bushels of seed were sown to the acre. He obtained about 620 pounds of fiber and 10 bushels of seed to the acre, the flax selling for 11 cents a pound and the seed at $1 per bushel. He reckons the expense side of the account, including freight on the product, at $42, and his profits at $38.17 per acre.

paid to the condition of the soil, as it must be neither too wet nor too dry. On clean soil one weeding will suffice, but sometimes two or three are necessary. As to the proper time to harvest the crop no general rules can be laid down. Those who heretofore have grown only for seed will be inclined to allow the heads to ripen well, to the injury of the fiber. This matter has been fully discussed on another page, however, and experience doubtless will prove the surest guide. As to the manner of harvesting, the common practice in the West is to use the reaper. If the land surface is made smooth so that the knives can be set low, this may answer for general purposes, though several inches of the best portion of the stem is lost. In fine fiber production there is no question that the crop should be pulled; that is, the plants drawn out of the ground by the hand and the dirt knocked off against the boot, which is the usual manner of procedure. The straw is then laid in handfuls crossing each other so as to be readily made into bundles or "beets."

Subsequent operations.—Securing the seed is the next operation after the crop is harvested, and this is called "rippling." There are special machines to accomplish this, besides improved thrashers, although the work can be done, in a way, in an ordinary thrashing machine by opening the "concave," so that the teeth will just come together; then, with one man to open and pass the bundles, another takes them by the butt ends and spreading them in fan shape, presents the seed end to the machine. The straw is not released, the operator withdrawing it again as soon as the seed has been torn off. With a whip the loose seed is shaken out and the flax rebundled. Some, however, perform the operation without breaking the bundles. The best method of separating the seeds is to pass the heads through plain rollers, free at one end, which avoids injury to the fiber, and there are powerful machines for this purpose to be obtained in Great Britain. Whipping out the seed against a sharp stone set up at an angle of 45 degrees is a New York method. Two or three smart blows, the bundle being held in both hands, will accomplish the result.

Now comes the important operation of retting. In this country the fiber is separated from the stalk by dew-retting almost wholly. The best results are accomplished by the foreign method of water-retting, which necessitates the building of "steep-pools" especially for the purpose. A moist meadow is the proper place for dew-retting, the fiber being spread over the ground in straight rows at the rate of a ton to an acre. If laid about the 1st of October and weather is good, a couple of weeks will suffice for the proper separation of the fiber and woody matter. When the retting is progressing unevenly the rows are opened with a fork or turned with a long pole.

For water-retting, the softest water gives the best results, and where access can not be had to lakes or sluggish or slow-running streams, "steep-pools" will have to be built.* A pool, 30 feet long, 10 feet wide, and 4 feet deep, will suffice for an acre of flax. Spring water should be avoided or, if used, the pool should be filled some weeks before the flax is ready for it, in order to soften the water. It should be kept free from all mineral or vegetable impurities. The sheaves are packed loosely in the pool, sloping so as to rest lightly on their butt ends, if at all, for it is considered best to keep

* There is always objection to retting flax in quantity in the running streams, for sanitary reasons as well as danger of killing the fish.

the sheaves entirely under water without allowing them to come in contact with the bottom. Irish growers cover with long wheat straw or sods, grass side down, the whole kept under water by means of stones or other weights. Fermentation is shown by the turbidity of the water and by bubbles of gas, and as this goes on more weights are required, for the flax swells and rises. If possible, the thick scum which now forms on the surface should be removed by allowing a slight stream of water to flow over the pool. The fiber sinks when decomposition has been carried to the proper point, though this is not always a sure indication that it is just right to take out. In Holland the plan is to take a number of stalks of average fineness, which are broken in two places a few inches apart. If the woody portion or core pulls out easily, leaving the fiber intact, it is ready to come out. The operation usually requires five to ten days. In Courtrai a second retting is sometimes given.

When the retting has been accomplished the bundles should be taken out by hand—for the use of pitchforks may injure the fiber—and set up on end that the water may drain off gradually; twenty-four hours is a sufficient time. Then the bundles are opened and spread evenly over a newly mown grass field, to cleanse the fiber and improve its color, being turned occasionally by poles that it may color evenly. Three or four days will suffice for the grassing, and then, if thoroughly dry, the flax is ready to lift, tie in sheaves, and be put under cover, ready for scutching. As the farm operations end at this point it will not be necessary, in the limits of the present report, to go into details regarding the cleaning of the fiber.

Enough has been stated to prove that fine flax *can* be grown in the United States, and it only remains for our farmers to make the trial. I can but reiterate the statement made in a former report that there will be obstacles to overcome at the outset, of course. But the American farmer is progressive; he has brains and ambition, and inventive genius will aid him in surmounting many difficulties if he will work intelligently and stick to it—not one year or three, but year after year—growing each season a little flax, growing it well, and striving, with the acquirement of skill and experience, each year to produce the best results, and in the end he will be enabled to successfully compete with the foreigner and drive his product out of the market.

HEMP.

One of the results of the excitement caused by the high prices of binding twine, a year or so ago, has been to bring into greater prominence the cultivation of the common, or American hemp. Until recently the great bulk of this fiber produced at home was grown in Kentucky. Of late years, however, its cultivation has been extending in States north of the Ohio River, and during the past two seasons it has been grown to a considerable extent in New York, Illinois, and Missouri, while Minnesota and a few other States have contributed small areas.

As the aim has been, chiefly, to produce a grade of fiber that could be sold at a low price, for such coarse uses as binding twine and the cheaper wrapping twines, much of the labor attending the culture has been accomplished by machinery, and with the agricultural implements found on almost every farm in the West. The plan in vogue in Illinois, as reported to the Department by Mr. John

Heaney, of Buckley, is to sow the seed as early as possible after the ground is in condition, March 25 being named for the season of 1889. The land is plowed in the fall if possible, and in spring the large disk harrow is used, followed by the smoothing harrow. The seed is put in with a broadcast seeder and afterwards carefully harrowed. When the crop is ready to harvest it is cut with mowers, and spread evenly that the retting may be accomplished without the labor of turning over. If rainy, however, the Bullard hay-tedder is used to change the position of the straw or stalks, and to expose to the air the inside of any bunches that might be left to the action of the rains.

When retted the stalks are raked up with the horserake and loaded upon the wagons to transport to the breaker. Mr. Heaney says that 8 to 10 tons of straw per day can be taken care of. The fiber is not kept in a straight form, as the twine-makers break it up on the cards, and this form of fiber suits them better. Here are some of Mr. Heaney's facts, furnished the Department early in 1890:

> I can furnish the clean fiber at 4 cents per pound at a profit. I have 800 acres of hemp this year betwixt this place and Peotone, Illinois. I have shipped already 60 tons of fiber to the spinning mill this fall and winter, from Buckley. I have one field of 140 acres from which I am expecting to get 1,500 pounds of fiber to the acre. It usually costs $15 per acre for rent and labor—on the product of an acre delivered on board cars. If the people would but take 3,000,000 acres of land out of the corn, and oats, and wheat culture, and grow hemp, we could then consume all our grain at home and save the millions we annually pay out for fibers. It would relieve the present agricultural depression wonderfully. All this fine country can raise good hemp wherever it can raise a good crop of anything else.

Notwithstanding that the aim is to produce a cheap fiber it must be admitted that this is a careless kind of cultivation which may not always give satisfactory results. In a communication from another source the danger of overretting is referred to, and the statement made that in practice a difference of 50 per cent is found to exist between well saved and badly saved hemp on the same ground.

In New York State, where for two years past hemp has been grown in the neighborhood of Troy and Schaghticoke for the Cable Flax Mills, a considerable amount of good fiber was produced. I am informed by Mr. Hartshorn, of the Cable Mills, that the crop of the present season did not turn out well, although in 1889 the farmers engaged in the enterprise made money from hemp culture.

Referring to the figures of production, the best record of income from the sale of a crop, net proceeds per acre, cost of seed deducted, was $76.48. The second best was $58.38, and the best five crops averaged $49.71 per acre, exclusive of the cost of seed. The total average of twenty crops—that is, the crops on twenty farms, including one complete failure and another crop which was almost a total failure from the drowning out of the plants when they were 18 inches high—was $18.22 per acre. Sandy or loamy soils are considered most favorable, the hemp succeeding both on the "uplands" and in the "bottoms." The soil is plowed very deeply and made very mellow by the use of the harrow. Barn-yard manures or standard fertilizers are used, as the soil must be put in good fertility to produce a successful crop. The seed is sown from April 20 to May 10, and the crop is usually harvested between the 1st and 21st of September. When the stalks do not exceed 8 feet in height, the cutting is done with an ordinary sweep rake harvesting machine by cutting two thirds the ordinary width of the swath, while a larger growth must be cut with a sickle, corn hook, or short scythe. It is claimed that a light frost will not injure the crop and that there need be no haste in cutting it, the plant continuing to grow until the stalks have turned a pale yellow. However this may be the opinion in New York State, where the fiber is employed in the coarser manufactures, a different idea prevails abroad; namely, that after the proper time for cutting has arrived the fiber deteriorates, and for fine manufactures there would be considerable loss in value.

Mr. W. B. Hawkins, of Lexington, Kentucky, details the general practice of growers in his State, at the present time, as follows:

The usual procedure in the cultivation and handling of hemp is about this: Our best land produces the best hemp. Virgin soil sown to hemp can be followed by hemp for fifteen to twenty years successively; sown then to small grain and clover; can be sown to hemp every third year (no fertilizer required) almost indefinitely. Given bluegrass sod: Plow not over 4 inches deep in the fall or early spring; sow about the time to plant corn; sow broadcast 33 pounds of seed per acre, having first prepared the seed-bed thoroughly, and cover by dragging with the harrow, as for any of the small grains, wheat, oats, etc. No cultivation can be done, of course, as it is broadcast.

About one hundred days are required for the crop to mature ready for the knife, or when the first ripe seed can be found in the heads. The hemp is then cut and spread thinly, covering the ground it grows upon; it must be kept from tangling. Let it lie for one or two weeks to cure; rain will not injure it in this time. Now rake into bundles and tie (be careful to keep straight), about 10 inches in diameter, and stack dry, about 2 acres in the stack. About December 1 we spread on the ground, as before, and when retted sufficiently set upon end in shocks about the ordinary size of corn shocks, and the hands can carry their brakes from one shock to another in the field to brake it out. Much depends upon the retting, and must be determined by testing when it is ready to take up. The approximate cost of an acre of hemp in Kentucky, counting man and team worth $3.50 per day, is as follows:

Plowing	$2.00
Harrowing	1.00
Seed, at $3	2.50
Cutting	3.00
Taking up and shaking	3.00
Spreading	2.00
When retted, shocking	1.00
Braking, $1 per 100 pounds (the usual crop being 1,000 pounds)	10.00
Total	24.50

The fact that American hemp can be grown in Northern States at a cost of 4 cents per pound, or less, should open the eyes of our Western farmers who have been compelled to pay such enormous prices for binding twine made from imported fiber. In the manufacture of this twine manila hemp, from the Philippine Islands, and Mexican sisal hemp are largely used. About the time that these investigations were begun the market price for sisal hemp was 8½ cents per pound, while manila was nearly 12 cents. And the prices at the beginning of the year previous were several cents higher than these figures. Yet American hemp, or even flax, could have been employed at this time for the raw material of binding twine, at a cost of one third to one half the price of sisal grass, or one quarter to one third that of manila, with the additional advantage that the Western farmers could have produced the hemp. It is not my purpose to discuss here the causes of the high prices of these fibers last year. Enough to say that there was a combination or "understanding" among cordage manufacturers who were thus enabled to control the supply of raw material, and make it impossible for outside parties to buy fiber. It furnishes a beautiful illustration of the folly of relying upon a distant market for a product for which there is a constant and regular demand, and emphasizes the point that monopoly always cuts the throat of competition. Were the grain growers of the West to demand American hemp twine and use no other, raising the raw product on Western farms, it would be next thing to impossible for any combination to bring about such high prices as were charged for binder twine a year or more ago.

There is no reason why hemp culture should not be extended over a dozen States and the product used in manufactures which now employ thousands of tons of imported fibers. In the manufacture of binder twine alone there is an outlet for upwards of 50,000 tons of hemp annually. Manila is no better than hemp, and sisal quite inferior. American hemp twine is said to run 100 feet more to the pound than sisal, 5 pounds of this twine, at the same price per pound as sisal, going as far as 6 of sisal, an advantage of about 17 per cent in favor of American hemp. (See letter of D. M. Osborne & Co., on another page.)

When the market for binder twine was first created American hemp filled the demand, the more carefully prepared article, straight or dressed hemp, being employed. About ten years ago the demand increased to a point beyond the supply of native hemp, and to meet the exigency of the case other fibers were employed. Manila and sisal came into use, and as the consumption of binder twine grew to its present enormous proportions, these fibers held their position, and hemp was relegated to the background.

The grain growers should be the hemp producers, and in point of fact only take from their own pockets in buying twine what they would get for their raw hemp, with the simple cost of manufacture and dealers' profits added. As a relief from the unwarranted high prices of binder twine during the last two seasons a demand was made to Congress to remove the duty on all so-called hemp substitutes. This meant a reduction of 1 cent per pound average for the different fibers. In my opinion a surer and a more permanent relief for the consumers of binding twine would be the distributing among them of the \$4,000,000 or \$5,000,000 which the production of this fiber would mean, with an additional saving in the difference in price between the twines made from the native and the imported fibers. It is estimated that not over 5,000 tons of American hemp twine were used the present year. Last spring this twine was quoted in carload lots at 12½ cents against 16 for manila. If only one half of the binder twine output of last year had been made of hemp, at these prices, there would have been a clear saving of \$1,750,000 to the consumers in a single year from difference in prices alone. From all that I have been able to learn there is no question but that the machine binders will work with hemp twine quite as readily as with the stiffer twines from sisal and manilla, when a well-made twine is used.

A great deal has been said on this subject, the principal objections coming from those who are especially interested in manila and sisal, but the fact is, and it can be proved by abundant evidence, that the "prejudice" against hemp twine has no substantial foundation. I have taken pains to investigate this matter thoroughly, and have had no trouble in securing testimonials in favor of the use of American hemp twine both from farmers and manufacturers, one of which I take pleasure in publishing entire. It is as follows:

[D. M. Osborne & Co., manufacturers of harvesting machinery.]

AUBURN, N. Y., *March* 29, 1890.

DEAR SIR: We have your esteemed favor of the 26th instant, making inquiry as to our judgment of the value of American hemp twine, commonly known and called as "Kentucky hemp binding twine" for harvesting machinery.

We have sold several thousand tons of this twine, and without exception it has given the best of satisfaction to the farmers using it on their self-binding harvesters. The standards for binding twine are, pure sisal, 500 feet long; half manilla and half sisal, 550 feet long, and pure manilla 600 feet. American hemp when spun 525 feet long is the equal of sisal, half each sisal and manilla, or pure manilla, of the lengths given above.

There is no fiber in the world better suited to this use than American hemp. It is our judgment, based upon nearly ten years' experience with large quantities of binder twine each year, that the entire supply of this twine should be made from American hemp. It has been demonstrated that this hemp can be grown in the States of Kentucky, Missouri, Kansas, Southern Iowa, Southern Illinois, Indiana, Ohio, and New York, and probably several other States that are adapted to raising winter wheat. There are 50,000 tons of this binding twine used annually, every pound of which could and should be made from this home product.

Your Department can do no greater service to the farming community than by widely disseminating the information as to the extent of the use of this twine for binding purposes, and the fact that American hemp is not a difficult crop to raise, and that the usual average yield upon good soil is from 1,000 to 1,500 pounds of hemp per acre.

Very truly yours,

D. M. OSBORNE & CO.
By G. W. ALLEN, *Treasurer.*

CHAS. RICHARDS DODGE, Esq.,
Special Agent Fiber Investigations.

If the Western farmer objects to paying high prices for binding twine he has at least a partial remedy in his own hands. He will find it to his advantage to grow American hemp, and use the twine made from American hemp. If necessary, I would even advocate farmers' interesting capital in the erection of twine mills at home. They would then have a direct interest in the question of the supply of raw material, upon which price must more or less depend.

SISAL CULTIVATION IN FLORIDA.

I have referred to the use of sisal hemp in the manufacture of binding twine. Only a portion of the sisal imported is used, however, in this form of manufacture, but it is largely utilized for making cordage. Recently there has been considerable interest in the subject of producing our own sisal, and of late so many inquiries have been made regarding the industry that a special bulletin is now under preparation, giving the results of my investigations.

The question of growing sisal hemp (*Agave rigida* var. *sisalana*) in the United States was first agitated about 1834, when Dr. Henry Perrine, United States consul at Campeachy, introduced into Southern Florida a few plants from Yucatan. In the fifty or sixty years which have intervened between that time and the present these plants have been so multiplied, from different causes, that the Agave is now found abundantly in many localities. In recent years the attention of the Bahaman Government has been called to the value of the sisal industry, and considerable areas have been covered largely from plants secured in Florida. The success of the enterprise is assured, and samples of fiber sent to London were pronounced better than the Mexican, and quoted at a much higher price per ton. Judging from the samples of Florida sisal received by the Department during the past year, I am satisfied that as far as the mere question of ability to grow the plant is concerned, sisal may be cultivated as successfully in Florida as in the Bahamas, and as good a fiber can be produced. As to the cost of production, not as much can be said at present, for the attempt has not yet been made to produce fiber in marketable quantity. The removal of the duty of $15 per ton will now make it harder to compete with the foreign fiber, though the nearness to market, and the use of improved machines in preparing the fiber may help the matter a little. When the new industry has made further progress, it might be well to consider the expediency of affording to it encouragement in the form of a bounty, for a term of two or three years. I should state that the Bahaman Government has placed a bounty on the production in the British West Indies.

Several companies and individuals are actively interested in the new enterprise and plantations are being established. One near Jupiter, of about 60 acres, has been established for two or three years, and is doing well, leaves large enough for fiber having already been produced. There are several machines of American invention for cleaning the fiber which give promise of success, and altogether the outlook seems hopeful. In the limits of the present report it will be impossible to go into detail regarding the results of my investigations, which are not fully completed, and the information collected must await later publication.

RAMIE.

Regarding the agricultural phases of the ramie industry there is little in the way of progress to report at the present time, although there seems to be a widespread interest in the subject. Practically the culture is at a standstill, both here and in Europe, the knotty problem of economical decortication of the stalks when grown not having received satisfactory solution. In my special report on ramie, published in the spring, the machine question, as far as European investigations are concerned, was fully discussed. Regarding American machines or processes there is nothing to be said at the present time, as the Department has been unable to make any tests showing capacity for a day's work. Without considering the question of the amount of fiber that may be produced in a given time, there are several American machines which effect the decortication successfully and leave the fiber straight. Whether they will come up to the record of foreign machines, or do better or not so well, when the trials are finally made, remains for the future to determine. What was stated in the ramie bulletin published in the early part of the year must be reiterated at the present time:

> To those who know nothing of the story it may be briefly stated that the invention of machinery and processes for the extraction and cleaning (degumming) of ramie fiber in the last thirty years in the various countries where experiments are going on might foot up a hundred or more could the entire catalogue be enumerated. In spite of the vast inventive effort, ramie, up to the present time, has not been grown in any country (excepting China and Japan) save in a limited way, because no machine or process for decortication thus far has been presented that has filled all the requirements demanded of a thoroughly practical decorticator.

It should be stated that while little of importance has been done in the past year which would give evidence of progress in culture, there are indications that some considerable areas will be planted the coming season. The interest is greatest in the States of Louisiana, Texas, and California. Should a practical decorticator be presented during the coming season, or should any of those now under experiment fulfill the requirements of the economically successful machine, ramie culture is in favorable condition, I think, for early establishment of the industry.

In the field of manufacture considerable progress has been made, especially in New England, and while the industry at this time has hardly more than passed the stage of experiment, from what I have seen in the course of my official investigations, and from examination of samples of yarn and fabrics produced, the first named by the ton, I have good reason to believe that American ramie manufactures will soon be on the market. The Department has been able to secure the beautiful exhibit of Mr. Charles Toppan, illustrating the progress of this manufacture in New England from Chinese fiber cleaned by his process, and which was displayed at the recent Mechanics Fair held in Boston. In this collection are shown fine and coarse yarns, dress goods, piece goods, blankets, carpets, upholstery fringes, duck or sail cloth, hammocks, fish nets, etc., in addition to a series of samples exhibiting every stage of manufacture. Some beautiful samples of fine spun yarns, produced on silk machinery, have also been received from Mr. S. S. Boyce, of New York, also from Chinese fiber, which illustrate the possibilities of manufacture in this direction. With a practical machine for cleaning the fiber from the stalks, the success of the industry will be assured.

OTHER FIBERS.

I regret that the results of my investigations regarding the use of okra fiber and the fiber of the cotton stalk as substitutes for jute in the manufacture of cotton bagging have been unsatisfactory and disappointing. The okra plant was cultivated for fiber in several localities this season, one field of 100 acres having been reported in Texas. As to results, I have nothing practical to report in the utilization of this fiber in manufacture, and up to the end of the year was not able to secure specimens even of the fiber, save in two instances, and from small experimental lots. Dr. C. F. Panknin, of Charleston, South Carolina, who planted a small area in okra, gives the results of his carefully conducted experiments as follows: A half acre of stalks was produced, one half of which when decorticated by his process, yielded at the rate of 180 pounds of fiber to the acre, the expense being in the neighborhood of $75. Regarding the cotton-stalk fiber industry, the Department has been unable to learn anything definite, further than the fact that small quantities of the fiber were prepared experimentally, last spring, from which about half a dozen yards of bagging were made, at a jute bagging factory in New Jersey. Considering the expense attending the harvesting of so branching and bulky a crop as both okra and cotton, where the stalks are coarse and woody, I do not see how the fiber can be obtained at a price to compete with fibers in present use, and therefore have serious doubts as to the success of either enterprise. The attempt to utilize the bast of the cotton stalk is no new thing, as experiments were made with the fiber years ago, and without success.

Out of the score of other bast fibers indigenous to, or that can be grown in the United States, there are several which may be regarded as promising jute substitutes, though careful experiments will be necessary to demonstrate the point of practical utility. These will also be treated in a special bulletin.

Several fine specimens of leaf fibers from tropical plants, including banana, have been received, and a few seeds of the manila hemp of commerce were imported during the summer and distributed in Florida and Southern California. In the latter State New Zealand flax is already growing, from which a good sample of fiber has been prepared.

During the year there has been a large correspondence in relation to fibers and fiber industries, and over five hundred samples of fibers have been received, these having been sent by farmers for identification and for information in regard to utility as well as by manufacturers or those interested in special processes or machinery.

On the whole the interest in fibers seems to be increasing, and it is hoped that much good will result from the work of the Department in this direction.

Respectfully submitted.

CHAS. RICHARDS DODGE,
Special Agent in Charge of Fiber Investigations.

HON. J. M. RUSK,
Secretary.

REPORT OF THE SPECIAL AGENT IN CHARGE OF THE ARTESIAN AND UNDERFLOW INVESTIGATIONS AND OF THE IRRIGATION INQUIRY.

SIR: I have the honor to present herewith a report of the operations of the office conducted by me, under your appointment and direction, since the 15th of last April, when the artesian wells investigation first began, in accordance with the terms of a provision of an urgent deficiency act passed and approved April 4, 1890. On the 30th of September succeeding, by a provision of the general deficiency bill, the continuance to completion of that investigation was provided for, and to it was added also an examination of the sources and location of underflow waters found or to be located between the foothills of the Rocky Mountains and the ninety-seventh meridian of west longitude. The location and character of the artesian basins and wells were limited by the same boundaries. An inquiry into the cultivation of the soil by means of irrigation was by the act of September 30 also ordered and authorized.

WORK OF THE INVESTIGATION.

The necessity of completing these three extended investigations within seven months has kept the special agent, the engineer, and the geologist selected by the Secretary to carry out the same, with their small corps of field and office experts, exceedingly busy. One valuable series of reports, accompanied by maps, diagrams, and illustrations, is now ready for distribution. This is the report of the artesian wells investigation begun on the 16th of April and terminated as to its field work on the 1st of July, and as to the preparation of the reports thereof about six weeks later. The mere physical labor required to complete this arduous amount of work can hardly be realized. But although the limited time allowed by Congress for its accomplishment was insufficient for the attainment of entirely satisfactory results, it was utilized to the utmost extent by every one engaged. Over 70,000 miles in all were traveled during a period of ten weeks by the fifteen persons who formed the field staff. In the office organized by the Department 10,000 circulars and about 3,000 letters were written, mailed, and forwarded, answers being received to the extent of at least 50 per cent. Maps and diagrams were prepared, the work being in a field of observation almost unknown to the professional men engaged or to the scientific world itself. In the main, also, the staff required had, with the exception of the chief engineer and chief geologist, the field geologists and two or three of the field agents, to be educated into the special requirements of the work performed. They have all done well and are deserving of commendation.

The two other inquiries ordered by Congress and which are now in progress have had the opportunity, so far as field work is concerned, since the 30th of September, of less than six weeks of weather in which out-of-door observations, engineering and geological, could be performed. It is impossible at this date to anticipate the reports on progress work which are to be made through you to Congress, but so much is known as to warrant the statement that these recent field labors will in their results prove to be of as great value as those of the midsummer investigations.

Two other reports, one a progress report on irrigation, the other a special series of papers on underflow and subterranean water, called for in June last by the United States Senate, are now in course of rapid preparation.

EXPERT AND FIELD STAFF.

The staff of the Artesian Wells Investigation was arranged into the statistical, engineering, and geological divisions. Besides the special agent in charge and his immediate force, it consisted in the field of the following gentlemen: Supervising Engineer Edwin S. Nettleton, of Colorado; Prof. Robert Hay, of Kansas, whose division geologists were the following: Prof. Garry E. Culver, State University, Vermillion, North Dakota; Prof. G. E. Bailey, State School of Mines, Rapid City, South Dakota; Prof. Lewis E. Hicks, State University, Lincoln, Nebraska; Prof. P. H. Van Diest, C. E., Denver, Colorado; and State Geologist E. T. Dumble, of Texas. The field agents were J. W. Gregory, Garden City, Kansas, who is known as the earliest advocate of the underflow theory as a source of irrigation supply; T. S. Underhill, North Dakota; Prof. S. G. Updyke, State Agricultural College, South Dakota; State Engineer F. F. B. Coffin, of the same State; Prof. Lewis G. Carpenter, who fills the chair of irrigation engineering in the Colorado State Agricultural College, had charge of eastern Colorado and New Mexico; and Frank E. Roesler, western Texas, with Mr. Horace Beach, special expert, comprised the field staff.

THE REGION EAST OF THE FOOTHILLS.

The area covered by the artesian wells investigation of the past summer and by the one now in progress embraces nearly 700,000 square miles of territory, of which 658,000 are found east of the one-hundredth meridian. This, in the central portion of the plains, passes along the foothills to the point where the Rio Grande enters Texas. From the northeast corner of Wyoming the foothills of the Rockies make a sweeping trend to the northwest, leaving east thereof nearly or quite two fifths of Montana. This area covers the States of North and South Dakota, over one half of Nebraska, Kansas, and Texas, all of Oklahoma, with the Public Land Strip, and about one third, east of the mountains, of Wyoming, Colorado, and New Mexico. The population of this region is now estimated at about 1,250,000 persons. The amount and value of the chief grain crops produced may be stated fairly as follows: In corn 185,000,000, in wheat 125,000,000, and in oats about 75,000,000 bushels. The average cash value of all farm products grown within this area during the past year can be moderately estimated at $275,000,000. This does not include valuable fruit and wine crops raised in some portions of the arid region. The stock interests of the same area are of great importance and value. A fair estimate will give a total of 34,000,000 head of horses, cattle, sheep, and hogs, having a valuation of $366,000,000. These bald figures are sufficient to indicate the agricultural and pastoral possibilities of the region.

In this region the average or normal rainfall from the western Gulf section to that of the extreme northwest will range from 23.11 to 14.35 inches. On the western limit it will fall at El Paso, in Texas, and Fort Buford, in North Dakota, to an annual average of 10 inches, while at the ninety-seventh meridian the average will be from north to south about 21 inches. Within these long lines and parallels the dominant topographic and other conditions very seriously affect the degree of local—even of neighborhood—rainfall. This almost entirely treeless region is always liable during the most important weeks of summer to a dangerous deficiency of the precipitation needed to insure a good harvest. The soil is almost uniformly fertile, the sunshine is seldom wanting, and the normal temperature presents a fair mean, but the earth is desiccated by frequent droughts and the growing grain is devastated by the too frequent hot winds. Still, a careful analysis of the records shows that in this Great Plains and foothills section the annual precipitation is so distributed that at least one half, often more than that, falls within the growing and ripening months of May, June, July, and August. Following the lines of topography from north to south, as well as east and west, it will be seen that there is a wide difference in this respect between the semiarid or plains region and that of the arid domain proper—the intra-basin and Sierra Plateau table and valley sections beyond the Rocky Mountains—wherein it will be found that the rainfall is greatest during the fall and winter months.

Another and a most striking series of facts consists of those which relate to the formation of the Great Plains region, in connection with the distribution of the waters thereof, whether by surface channels or underground drainage. Their breadth from east to west is almost uniform, or about 500 miles. Northwest of 105° of west longitude the areas embraced within the artesian and underflow inquiries include broken table-lands or mesa formations, the wild irregular areas known as the "Bad Lands," and a large proportion of rugged foothills. The plains themselves have quite a uniform grade of from 3 to 20 feet per mile, ranging from east to west. The whole formation has a small "dip" from northwest to southeast. In considering the drainage of this great region, in both its present and future relations to the cultivation of the soil, this general "dip" and grade must be borne in mind. Unlike the narrow Allegheny plane along the Atlantic coast, this one of the transmissouri region is traversed only by a few shallow streams, whether these be narrow or broad in valley areas. They are all tributary to the Mississippi system; a majority are direct branches of the Missouri; but the Arkansas and its tributaries flow into the Father of Waters itself. This river system from northwest to southeast, forms the important western feeders of the Mississippi River. Along the southwestern border of the plains region the Rio Grande, having a wide and open valleyway for less than 400 of its whole course of 1,200 miles, passes from the Saguache and San Juan ranges in southern Colorado, through mountain cañons, open parks, broad valleyways in Colorado and New Mexico, until receiving the Texas tributaries in the midst of a wild cañon region, it finally reaches the open alluvium bottoms and is lost in the Gulf of Mexico a few miles below Brownsville.

The infrequency of river courses in the region we are investigating is a momentous fact which must always be borne in mind. The State engineer of Wyoming, Mr. Elwood Mead, estimates that there falls annually upon the great mountain range of that State, a precipitation of snow equal to 60,000,000 acre feet—that is, 60,000,000 acres covered 1 foot deep with snow. Allowing one third for evaporation and one third for drainage, there remains in Wyoming 20,000,000 feet of such snow precipitation, or that number of acres covered 4 inches deep by water. Evaporation is generally considered to be equal to one third of the total amount of fall. It may well be questioned, however, whether such be the case within the temperate regions and at such high altitudes. Sufficient rain falls also during the year to make the annual average not less than 15 inches of water. To estimate this vast amount of moisture in the ordinary language of our eastern agriculturalists, by gallons or barrels, will present an array of figures almost impossible for the human mind to grasp. Allowing for evaporation upon the mountain summits and slopes to the extent of 25 per cent, it will be fair upon entering upon the open plains region to allow for a loss of 30 per cent from the same cause. It will thus be seen that there remains unaccounted for at least 45 per cent of the total annual precipitation. It does not need a special training to perceive that this great loss from the surface water disappears into the earth itself. Of the evaporation into the atmosphere, the major portion of the moisture taken up must at some place and period, return to the surface of the earth. But this is not the case with that which torrentially or otherwise disappears below that surface.

Here, then, is the problem which the investigations of last summer and autumn are endeavoring to solve. Taking into consideration the topographic and hydrographic features of the whole region, knowing something of the climatic conditions that affect the distribution of waters therein, observers, engineers, and geologists must naturally be disposed to consider the restoration of the underflow, artesian, or phreatic waters, a project of the most serious importance, but one which is not met at the outset by any stupendous outlay or vast difficulties in the way of engineering work. It is not necessary to deny the need of storage works at some not distant day; it is only desirable to consider the means by which security to agriculture may *now* be obtained and how the development of this region already so well begun can be made of a permanent and prosperous character. The labors of the past seven months have brought together such a mass of facts and testimony as to show:

(1) That over a major portion of the region designated by law to be investigated, the rainfall, if it could be distributed when most needed, is almost if not quite sufficient for ordinary agriculture.

(2) That the period of serious deficiency during the year is confined as a rule to within a few weeks of the summer time.

(3) That the conditions affecting the phreatic or drainage waters of the region, are even now sufficiently known to warrant the statement that these waters may readily be recovered, and in connection with the storage, distribution, and use of surface streams, afford a reasonably sufficient supply for at least two thirds of the area under consideration. It must also be borne in mind that such earth-waters

are replenished every season. The experience of southern California establishes this, as so excellent an authority as Prof. E. W. Hilgard virtually maintains.

The map accompanying this report shows the location of 1,300 artesian wells now bored and flowing from north to south, between the ninety-seventh and one hundred and fifth meridians. Speaking broadly, it may be asserted that the artesian basins, which these several wells have penetrated, present, when the facts are collated, a striking similarity of conditions. The depth, taking elevation into consideration, will be found almost uniform. The pressure, volume, and temperature, of their waters all bear a striking resemblance. The geological formations are intimately related to each other, and in the northern half of the region are entirely similar. The chief variance from this statement will be found in the Denver artesian basin, which is probably fed by secondary rather than by primary or deep drainage; also in the tertiary basins of western Kansas. No area in the world presents so large a present and possible supply of artesian water, and none yet known to us covers so wide a range and embraces such a large territory.

The report of the Artesian Wells Investigation, as well as the supplemental report, called for by the Senate in June last, will show other sources of supply from earth waters which are sure to prove of great importance to the farmer and cover an area even more important than that which can be supplied by artesian wells proper. Mr. J. W. Gregory, field agent for the central division of this investigation, deserves the credit of being the earliest to present systematically the existence of a large water supply at very moderate depths below the surface within the valley regions that traverse the Great Plains. Living at Garden City, Kansas, in the Valley of the Upper Arkansas, this gentleman, affected by the climatic conditions which threatened the ruin of so promising a community as that in which he resides, begun several years ago to take notice of the facility with which water was obtained throughout that broad valley within from 5 to 40 feet of the surface. As settlement progressed in western and southwestern Kansas, varying in progress with the wet or dry seasons, Mr. Gregory's observations became extended to the prairie lands beyond the valley. Taking the general grade of the country, its rise toward the Rocky Mountains, the great amount of precipitation known to fall upon the higher summits thereof, and, relating these observations to the volume of water at various periods found in the channel of the Arkansas, Mr. Gregory became convinced of the existence at moderate depths below the surface and according to the elevations thereof of an almost continuous drainage supply, which he has termed the under-sheet or under-flow water.

At the same period a series of close observations had been made under the direction of State Engineer Nettleton, of Colorado, now the Department's chief field engineer, into the seepage or percolation of irrigation ditches and as to what became of the water thus disappearing in the earth. The observations of Colonel Nettleton and his assistants, as well as of other experienced persons in Colorado, soon established beyond dispute the fact that the waters thus disappearing in the canals and ditches that irrigate large areas in northern and central Colorado reappeared in the channels below at such distances as proved that the gravel strata just below the alluvium forms an admirable water bearer and conveys this ditch seepage to the point at which the grade admits of its reappearance on the surface. There are numerous facts not yet properly collated which go to prove that the cultivation of the soil through irrigation must by means of the capillary attraction attached to the plant roots necessarily bring to the surface a large supply of the minor phreatic waters. Springs are known to break out where before none existed within such irrigated areas. The humidity of the night condenses itself under the fall of temperature into what is called "dew" for want of a better definition. Before cultivation and human habitation no such phenomena were there observable. This humidity is doubtless due more to increased moisture in the earth than to any additional supply in the atmosphere. It is claimed also, and with considerable force in Colorado and Wyoming, that these facts and many others not yet fully examined point conclusively to the truth of the declaration that irrigation means no final loss of the water supply to the farming communities lower down the stream. They point, however, even more forcibly to the necessity of a thorough examination of the western part of the Great Plains region from north to south, with a view to a reasonable ascertainment of the character, quantity, and availability of the upper drainage waters, which are constantly being fed from high-altitude mountain sources, and which by reason of the topographical formation may, it is believed, be made easily accessible to the use of farmer, horticulturist, and cattle-grower.

CONCLUSIONS OF THE SUPERVISING ENGINEER.

The supervising engineer, Edwin S. Nettleton, upon taking the field in April last, decided to begin work in North Dakota and proceed southward. A topographical survey was found unnecessary, railway elevations being found numerous enough for accurate levels. In the series of questions framed for the obtaining of geological data, the one relating to the depth and the geological strata passed through was almost wholly unanswered. This important failure has been one of the real difficulties of the investigation, the total depth being in general the only record kept of the well. The agents and officers of the Department obtained the pressure of many wells by the aid of gauges furnished them. This pressure was generally given as so much per square inch when the flow was shut off. The larger wells were measured by passing the water over a weir. Within the James River Valley basin the supervising engineer found about 150 wells, scattered over a territory more than 400 miles in length from north to south and from 40 to 50 miles in width. A number of failures to find flowing water in rock-bored wells has occurred along the eastern line of this valley. West of this land all borings have been successful when made deep enough to penetrate the Dakota sandstone. This sand rock, composed of a soft, porous, light-grayish stratum of unknown thickness, has been penetrated 80 feet without reaching its lower bed. In many places the drill goes down by its own weight. The "dip," as shown by the records of this water-bearing stratum, is toward the north. On a line from Yankton to Devil's Lake the "dip" is 830 feet, being about 2.3 per mile, while the surface trend towards the south and east is on an average of eight tenths foot per mile. At the top of the wells the pressure ranges from 20 to 167 pounds to the square inch. The area of greatest pressure so far as now determined from existing wells lies in the central portion of South Dakota. The greatest pressure in water-bearing stratum is near Jamestown. All surface indications and out-croppings point westward for the source of supply.

The wells now in use have in a majority of cases been active for the last 5 years without diminution of pressure. Engineer Nettleton regards the Dakota basin as the largest and strongest artesian supply yet discovered in the world. The wells maintain a flow quite near to that which is due to the hydrostatic pressure minus the loss of force by friction in passing through the pipe. Nearly all of the Dakota wells throw out large quantities of sand. This is a fact which is taken by some of the drillers to prove that the water-bearing stratum is simply loose sand. Observations of pressure and reliability of flow show that the water must have a free and considerable movement through the stratum so that the pressure reaches its maximum almost the instant the wells are shut off. The engineer regards the indications seen at Waco, Texas, and its vicinity as proofs of another important basin, which the want of time made it impossible to fully examine. A very notable fact about this basin is that the water-bearing stratum lies over 1,800 feet below the earth's surface, and at least 1,200 feet below the level of the Gulf. The pressure at the Waco well indicates that its supply must also come from a loose and porous rock. A third important basin now in process of development, but just west of the foothills line, is found in the San Luis Valley, Colorado, where many hundred wells of comparatively little depth have been bored or drilled during the last twenty months. Several thousand acres were irrigated by the water of these wells during the season of 1890. The supervising engineer sums up the following as presenting the more important results of his investigation:

(1) The existence of a large artesian basin in the Dakotas, which is indicated by the number of flowing wells scattered over an area of about 12,000 square miles.

(2) The presence of an abundant supply of water in a loose sand stratum of great thickness and subjected to great pressure, which is fully maintained after being pierced by numerous wells flowing their full capacity for years.

(3) The probability of an extension of this basin to westward or a considerable distance from the James River Valley developments and having similar characteristics.

(4) The probable existence of an artesian basin in Texas similar to that in the Dakotas and of unknown area, but lying at a greater depth from the surface.

(5) The existence of several artesian basins in other parts of the country examined, which have similar flows, from which water is obtained in sufficient quantities for domestic use, and, in some instances, for the irrigation of small areas.

(6) The existence of two artesian basins lying in the drift, where flowing water for domestic use and for irrigation is obtained at a very low cost.

(7) The necessity of irrigation to prevent total loss of crops at times and for their full development nearly every year.

(8) The existence of large supplies of subterranean waters underlying quite generally the whole territory examined.

(9) The lack of knowledge of the majority of the people of the methods for utilizing the artesian well and underground waters for irrigation purposes.

(10) The need of a closer and more extended geological examination to designate, as near as possible, where it is probable that water may or may not be obtained.

(11) The necessity of verifying by test experimental work some of the conclusions of the geologists.

(12) The necessity of investigating the subject of utilizing the subterranean waters and the extent of country which can be reclaimed by them, and to report on methods for bringing such waters to the surface and the cost therefor.

THE GEOLOGICAL RECONNOISSANCE AND RESULTS.

Prof. Robert Hay, F. G. S. A., chief geologist of the Department, who was in charge of that branch of the field work during the summer past, presents the following as the problems to which he sought to obtain intelligent solutions:

(1) In the region under examination are there any artesian wells now used for irrigation?
(2) If so, are the wells so used in groups or isolated?
(3) Are any of the wells available for irrigation to a larger extent than at present?
(4) Can the areas in which existing wells are found be defined and their geologic conditions determined?
(5) Are there other areas whose conditions are similar where artesian water may probably or possibly be found?
(6) May the areas already known be expected to yield more water with further exploration?
(7) In what way are the phenomena of springs and the subflow of river valleys related to the conditions of artesian wells, and are the springs and subflows available for irrigation?

As a result of the inquiries made in the direction indicated, Professor Hay relates, geographically and otherwise, the artesian basins examined in whole or part, as follows:

(1) The wells of the Red River Valley in northeastern North Dakota.
(2) The wells of the James River Valley in the two Dakotas (North and South).
(3) The wells of the Yellowstone Valley at Miles City, Montana.
(4) The shallow wells in the drift formation on the eastern side of the two Dakotas.
(5) The wells of northern Nebraska.
(6) Four groups of wells in southwestern Kansas.
(7) The wells of the La Pondre, Denver, and Pueblo basins in Colorado.
(8) The Fort Worth and Waco groups in Texas.
(9) The wells of New Mexico.
(10) The wells of Wyoming.

The group numbered 9 represents attempts rather than wells. Since the preparation of his report, however, a successful artesian well has been bored at a point 6 miles south by east of Springer, in northern New Mexico, the water from which is now flowing. In the first three groups named Professor Hay claims that a considerable portion of the flowing waters from their successful artesian wells can easily be made available for irrigation, and that, too, at no great cost. The remaining five groups consist of flowing wells under greater or lesser pressure. The geologist places the total number at 1,400, of which about 350, mostly in Texas and Colorado, now require pumping to bring the water to the surface. This cessation of flow is due according to Professor Hay to the boring of too large a number of such wells within a too limited area. The fact, in his opinion, points to the necessity of local legislation in order to prevent too great a continuity of wells, especially where the waters of the same are likely to be used for irrigation purposes. It may be stated here that this necessity has been found imperative in San Bernardino and Los Angeles counties, California, where several thousand wells are in use for domestic, stock, garden, and orchard usage and irrigation. Local ordinances require the capping of all wells when not strictly in use for beneficial purposes. They also compel the shutting off of the water, at certain periods, of groups of wells, so that the supply for others may be equalized. All these point, it is claimed, to the conclusive necessity of considering all subterranean waters from which the artesian wells are supplied as part of the natural supply to be utilized under regulation for the common benefit. In all arid regions natural waters above or below the ground are commonly regarded as public property, subject to regulation and control. The means of reaching, storing, and distributing, may or may not be of the same character, according to the will of the communities in which they are found.

The chief geologist does not consider that the James River Valley is connected with the artesian supply of the Dakotas in the direct way of cause, nor does he believe that it "limits the area of the real artesian trough, which is a deeply seated synclinal fold, whose axis is approximately north and south, and whose eastern edge is hidden in eastern Dakota by later accumulations of the drift period, while the western rim is upturned on the eastern flanks of the Black Hills and the more distant mountains of the Upper Missouri." Professor Culver, who served as the Dakota field geologist, believes from the records of the wells which he has studied that the impervious beds that overlap the pervious sandstone to the east seal in the waters on the low edge in that section of the artesian basin and thus prevent their escape. On the southeast boundary of the Dakotas, however, this overlap does not take place, and the waters escape in springs along the Iowa border, so that the pressure from the wells of that section of South Dakota is much less than further north in the James River Valley. From the geological indications Professor Hay considers that artesian water should be had from the same sandstone very much further to the west and northwest than has yet been tested. It is pointed out, however, that on the great Sioux Reservation the valleys thereof are so deeply eroded as to make it probable that the water-bearing sandstone may be reached at much less depth than is the case in the northern parts of the James River Valley. It is notable also that in Wyoming, on the western side of the Black Hills, the same sandstone formation yields flowing wells of salt water, bearing also oil and gas in considerable quantities. Professor Bailey makes note of sixty of these wells. The extent of this wonderful geological formation may be realized when it is remembered that in southwestern Kansas and southeastern Colorado, just over the line and below the Arkansas Valley, there is found a group of artesian wells which derive their waters from the Dakota sandstone. The same formation outcrops in eastern Nebraska and central Kansas, giving further evidence of its large water-bearing capacity. Professor Hay does not believe, however, that the supply in these States is derived directly from the drainage of the foothills of the Rockies. A geological change occurs in the sandstone corresponding in latitude with southern Nebraska and northwestern Kansas by which, according to the professor, there is a metamorphic change into quartzite, through which the Dakota stratum loses thereby much of its permeable quality.

In the eastern part of the Dakotas, as well as elsewhere to the south throughout the Great Plains, Professor Hay calls attention to a number of wells of much less depth, pressure, and flow than those which derive their supply from the Dakota sandstone. They obtain their water from gravel and sand belonging to the glacial drift, a sheet of which from 15 to 200 feet thick was found beneath the alluvium at moderate depths. When this glacial drift is covered with clay the water is sufficiently confined to make an artesian flow of at least the negative quality. It is less mineralized and cooler, says Professor Hay, than the artesian water. The artesian basin in and around Denver, Colorado, presents geologic conditions which deserve close study. Their supplies are received from formations much newer than the sandstone. The probability of finding similar waters in Eastern New Mexico is also favorably considered. Since the summer investigation a large amount of data has been obtained in relation to the possibility of obtaining water in this region by means of bored and drilled wells and through the utilization of an enormous area of natural waters which flow with artesian force to the surface in the form of springs. No attention has heretofore been given except in the way of noting the same on the maps of the public-land surveys, to the extended area, abundance and great volume of springs which are found from very near Arkansas River southward and beyond the center of Texas turning eastwards, and to indicating the pressure of waters flowing from subterranean sources as it breaks out along the southern flanks of the superimposed Staked Plains region.

A very interesting portion of Professor Hay's observations and reports relates to the water-bearing capacity of what he terms the tertiary grit, a formation largely underlying the plains region of western Kansas, and conspicuous also over a large area in eastern Colorado and New Mexico, and in a large portion of western Nebraska and Texas. It is from this tertiary grit that the numerous springs referred to are taken. Many of them may be tapped, says Professor Hay, above their present outlet, and be made available also for irrigation. The geologist regards the observations made as showing that in the subarid region investigated there are at least five water-bearing formations of different geologic ages. "In descending order they are: The Glacial drift; the Tertiary; Laramie; Dakota sandstone; and the Triassic red beds." Professor Hay's chief conclusions are as follows:

> It is highly probable that known artesian areas will be greatly extended by further exploitation.
>
> It is certain that some of the areas as already defined may have many more wells than now exist without reducing the supply of water.
>
> The diminished supply, or rather the loss of force to the extent of wells ceasing to flow, at Fort Worth, in Texas, and at Denver, Colorado, is a warning that should operate to prevent the clustering of wells too closely together, even where there is an ample supply of water.

He adds that—

> The phenomena of springs which may be defined as natural artesian wells form a necessary part of the things to be examined, as they suggest limits within which artificial artesian wells can scarcely be expected, besides the fact that such examination of springs may lead to their utilization in irrigation.
>
> The sandy nature of formations which in a large part of the plains region are noted for their water-bearing capacity is the main cause of the conditions which allow some of the river valleys to have a subflow of water equal to or perhaps greater than that of the visible streams. The conditions of hydrostatic pressure under which the subflows exist suggest that their phenomena are directly related to those of artesian wells and springs, and may properly be investigated with them.

THE DAKOTA ARTESIAN BASIN.

The vast extent of the Dakota artesian basin has been testified to by the inquiries and deductions of the engineers and geologists. Even a slight acquaintance with the chief features of the physical geography of the Dakotas strongly points to the probable permanency of the water supply. The western mountain drainage flow penetrates below the superincumbent stratum to the body of friable rock known as the Dakota sandstone. It is evident that the drill has nowhere penetrated more than a few inches of this water-bearing and conserving stratum. The altitude, the general trend of the land, and the formation and character of the great hydrological or river area which intersects it, give weight to the deductions that are made as to extent and permanency. There are found within it over one hundred and fifty high-pressure artesian wells, including, with those in the Dakotas, the few bored in the Yellowstone Valley of Montana. There are also found in South Dakota several hundred flowing wells, whose supply is evidently from sources not identified with the greater artesian basin. In northeast Dakota, in the hydrological basin of the Red River, claimed by geologists to be the seat of an ancient lake, there are nearly a thousand small flowing wells, whose waters are used largely for farming and stock purposes, as also in garden and other small irrigations. No diminution of pressure is anywhere reported. The source of their supply is from the upper beds of glacial drift. The people who have settled in the Dakotas belonged originally to States wherein the practice of irrigation is unknown. Active settlement began in these two new commonwealths during years that were blessed with considerable rainfall. A few years more, however, have proven conclusively that the element of insecurity as to rainfall is really a permanent one. It would be folly to deduce from such a short period of years as that in which observations have been taken any theoretical dictum claiming authority for its statement; but it is evident, not simply from climatic observations in the Dakotas, but from those taken throughout the Great Plains region, and extending over a much longer period, that there is something like a periodicity of abundance and drought, covering, so far as can now be deduced from observation, cycles of from seven to nine years in duration. Another, and perhaps even a more important feature for the establishment of agricultural security in the Dakotas as well as elsewhere on the Great Plains, is involved in the possibility of realizing a more equitable distribution of the rainfall, and it may reasonably therefore be assumed that over a large portion of the area under consideration the annual rainfall is almost or quite sufficient, if it could be evenly distributed as to area or controlled in its fall as to time. The fact remains that there is no equality in the distribution either in area or time.

Evidence tends to show that human industry applied to the land has already greatly modified the phenomena of distribution. Naturally enough those who have observed such features have hastened to the conclusion that these modifications tend also to a permanent change of climate. It may, however, safely be assumed that so much of this conclusion is correct as warrants a belief in the modifying and ameliorative effects, locally speaking, of human industry upon our semiarid soils and region. What the farmers of the Northwest desire and what they need is development of the water supply which lies beneath their feet, and which they may find immediately at their gates. Over the eastern half of the twin Dakotas they are not absolutely dependent upon irrigation. For industrial security, however, they need the power to draw upon supplies stored in wells or reservoirs. The harsher and larger climatic conditions at their period of need prove too often destructive of all their labor and its results. Such a supply as will meet this want, not large, but imperative in character, seems to be at their command in the wonderful artesian basins that unquestionably lie within the borders of the two great States, and which will probably be found to also serve a considerable area of northern and eastern Montana.

The people who had settled within this new northwestern section, and who have recently brought to the Union five great and important commonwealths, have paid into the Treasury of the United States for the public lands they have reclaimed and made fertile from $35,000,000 to $40,000,000. In the Dakotas alone the total of land payments exceeds $25,000,000. By adding the great sums paid by settlers to land-grant corporations we shall have, in all probability, a total of $35,000,000 for the Dakotas alone. A great net-work of railroads has already been constructed, and prosperous towns and villages have already been founded by the hundred. The Dakotas are famous in the markets of the world for the production of wheat. The commerce of the nation has been greatly increased by the growth and shipment of this its particular and valuable grain.

The popular feeling in the Dakotas, especially south of Devil's Lake and west of the Red River Basin, has settled during the progress of the investigations into a public opinion, which asks of the General Government a full and comprehensive investigation of the limits east and west, north and south, of their remarkable artesian basin. It is urged that this investigation does not involve the necessity of a protracted topographical survey; that the altitude and other physical features of the country are all well established and known; that the work of the geologist and engineer can necessarily be confined to a reconnoissance of the country in which the outcropping and the altitude both afford proof sufficient to warrant the belief that therein will be found the western limit of the water-bearing basin. The people interested are unanimous in asserting that the one important help they now require is the sinking and boring by the General Government of a range of experimental wells westward from the James River Valley, such as will show to the settler and private capital the possibilities involved and the practicability of obtaining at moderate cost the artesian waters known to exist. With such help these communities assert their ability to obtain capital by which to enable the counties and towns of each State to purchase machinery to sink wells and to construct storage reservoirs, sufficient in number to make secure their present great agricultural possibilities and enable them to maintain the homes which as pioneers they have won from the wilderness. The reports of Engineer Nettleton and Geologist Hay, as well as a thousand confirmatory facts and observations, all tend to strengthen the views so generally expressed by the people of the Dakotas.

During the past year, and largely since the action of Congress in appropriating $20,000 for the first investigation, great activity and interest have been manifested in this matter of water supply. In South Dakota a considerable number of wells have been sunk or are now in process of being drilled. Inspiration to such investment and effort has arisen largely from the presence of the Department agents in that region, and through the great discussion in progress over the questions of artesian and underflow supply. Under a law passed by the first State legislature of South Dakota, as an amendment to one passed by the territorial legislature, the counties are permitted to issue bonds for the raising of money wherewith to pay for the sinking of wells. In some of the more populous counties already large preparations are being made for the purpose—one, the county of Brulé, proposing to spend in all about $1,500,000 for this purpose, During the past summer, under the encouragement afforded by the practical teaching and experience of Engineer Nettleton, as well as by the current discussion, several efforts were made to irrigate small areas of land by water from artesian wells. About 500 acres have been so irrigated. In several instances the reports made to the Department, through the office of irrigation inquiry, show results of most encouraging character. The yield on the land irrigated has been from ten to fifteen times as great as on unirrigated portions of the same field or farm. Within the States of North and South Dakota, by water from negative artesian wells (in the Red River Basin in Miner and Sanborn counties), there are now about 3,000 acres under irrigation. This excludes the southwestern portion of South Dakota, known as the Black Hills, in which irrigation by ditches and from surface streams is already quite extensive, embracing about 15,000 acres. Evidence comes from this region as to the practicability of reënforcing the surface supply by extensive drainage deposits.

THE DAKOTA TOWN WELLS.

As an illustration of the extent to which the artesian and underflow waters are utilized in the Dakotas, the following tabulation of water works completed for town purposes within the States of North and South Dakota up to the beginning of 1890 is herewith annexed. During the past year ten or twelve additional town systems have been put in operation.

NORTH DAKOTA.

Town.	County.	Source of supply.	Diameter of well.	Depth of well.	Flow.	Pumping machinery, daily capacity.
			Inches.	*Feet.*	*Gallons.*	*Gallons.*
Ellendale	Dickey	1 artesian well	6	1,087		
Oakes	do	1 artesian well (flowing)		853		
Devil's Lake	Ramsey	1 artesian well		1,520	35,000	
Fort Totten	do	Spring				48,000
Jamestown	Stutsman	1 artesian well (flowing)		1,500		
Grafton	Walsh	1 artesian well		912		1,500,000

SOUTH DAKOTA.

Town.	County.	Source of supply.	Diameter of well.	Depth of well.	Flow.	Pumping machinery, daily capacity.
Plankinton	Aurora	1 artesian well (flowing)		545	(*)	
Huron	Beadle	do		863	1,500,000	
Scotland	Bon Homme	1 artesian well				
Tyndall	do	do	4¼	735		
Aberdeen	Brown	2 artesian wells (flowing)	{ 5¼ (†)	906 1,000	3,000,000	
Columbia	do	1 artesian well (flowing)				
Andover	Day	1 artesian well				
Mitchell	Davison	2 artesian wells (flowing)				1,000,000
Faulkton	Faulk	1 artesian well (flowing)		1,210		
Miller	Hand	do	6		3,900,000	
Highmore	Hyde	do				
Spearfish	Lawrence	Springs			(‡)	
Salem	McCook	Well		225		60,000
Rapid City	Pennington	Spring §				
Woonsocket	Sanborn	1 artesian well (flowing)	6		(‖)	
Doland	Spink	Dug well	4¼ feet	937.5	850,000	
Mellette	do	1 artesian well (flowing)				
Redfield	do	do				

* Two gallons per minute.
† Six and one half inches at top and 4¼ inches at bottom. Used for water works, sewage pump, and for fire purposes. Two other town wells being bored.
‡ Average daily flow 209,455 gallons.
§ Reservoir capacity 400,000 gallons.
‖ Daily yield 3,000 to 6,000 gallons.

THE CENTRAL PLAINS AND THE UNDERFLOW REGION.

One of the most remarkable of the series of facts which the investigation has so far brought together relates to the existence of great deposits of drainage water at a moderate depth below the alluvium, the existence of which supply has so far been quite well established at different points within the central division of the Great Plains, embracing a large portion of western Nebraska and eastern Wyoming, as well as the greater portion of western Kansas and eastern Colorado, with a considerable area in the Indian Territory and the adjacent section of New Mexico. It is also demonstrated, through the actual finding of water at moderate depths, to be underlying the moderately elevated plateau or table-land known in Texas as the "Staked Plains." Without doubt investigation will establish the same condition in the Panhandle region of that State. This phreatic supply differs in degree and perhaps in volume from that which is found underlying the surface in the wide regional river valleys, such as the Platte, the Arkansas, and Cimarron. The substratum, permeated by the percolating flow of the rivers, is largely composed of sand, the movement through which, although continuous, must be much slower than that through the looser gravel stratum. The continued rise westward at a steady grade per mile has induced the engineers and canal owners within the upper Arkansas Valley to construct works for the utilization of this great body of undersheet water. Such works are already in partial but successful operation at Dodge and Garden Cities in western Kansas. The owners of the Eureka Canal are fully expecting to supply that large irrigation ditch with water from the subcanals and reservoirs that have been constructed at and near Dodge City. Similar works are now in process of construction in the valley of the North Platte, Nebraska. A number of submerged dams have also been successfully constructed and operated at points in Colorado, by means of which the flow of streams otherwise diffused and lost below the surface has been successfully stored and utilized for irrigation and other domestic purposes. Civil Engineer Van Diest, of Denver, who was in charge of the geological examination of eastern Colorado and New Mexico, in closing his valuable report has the following to say in regard to both artesian and underflow waters and their relations to irrigation uses:

The artesian flows are means for transfer of water from high humid regions to more arid tracts.

The advantages of such process over transfer of water in irrigating ditches are that it costs nothing, that there is no loss by evaporation and seepage, and that the supply is uniform and practically independent of a dry season.

The hydrostatic pressure forces the supply to a point where the water is needed, provided a communication is made between the underground flow and surface. If the depth of water supply is not too great the cost of boring will in many cases be less than the cost of bringing the water by long ditches to the land.

The limit of depth to which boring for water can advantageously be undertaken is largely dependent on the amount of supply that can be obtained and on the kind of crop that can be raised on the land to be irrigated.

It will pay to bore to a considerable depth for the irrigation of fruit trees and garden truck when the flow is small, while for raising wheat it may not pay to bore at a moderate depth, even when the flow is large.

The utilization of artesian flows has a great disadvantage in the many requisites of a flowing artesian well. Only at a few places in eastern Colorado and New Mexico are these several conditions so happily combined that artesian wells are cheaper means of irrigation than by lateral distributing from surface ditches. Another drawback is that artesian wells must necessarily be bored at lower levels than the collecting area, and consequently are not beneficial at points located higher than can be reached by ditches. On these grounds the artesian well can never become a very important factor in irrigation in Colorado and New Mexico, but it may be in many places a great benefit when the water supply from other sources is small.

In eastern Colorado, where the climatic conditions and the soil limit agriculture to cereals, an artesian well does not give a sufficient supply for so large a tract as such a culture requires to become profitable. It is, however, an excellent auxiliary to the efficacy of the ditch. The farmer who has an artesian well in addition to his ditch lateral has an advantage over his neighbor similar to the advantage in the time before the opening of the Suez Canal of the Indian merchantman with auxiliary steam-power over the sailing vessel for weeks becalmed within the tropics.

The utilization of underground flows without hydrostatic pressure is not so limited as the utilization of the true artesian flow. The collecting area of this kind of subterranean flow is in eastern Colorado and New Mexico vastly greater than of artesian flows; they occur at less depth, and although they have but feeble or no pressure and must be raised artificially to the surface they can be forced in great volumes to points higher than ditches from neighboring streams could reach. The possibilities of bringing productiveness to a large area of arid land by the utilization of these underground flows are great. They may become in the future very important factors in the work of irrigation, and deserve a closer and more detailed investigation than the very limited time of the present investigation allowed to devote to this problem.

Mr. Van Diest has paid great attention to the science of hydrology and has had a remarkable experience in the construction and direction of hydraulic work related thereto, having served as engineer in Holland (his native country), France, England, Java, India, Japan, and in the United States, of which he is a citizen.

Observations made by Professor Hilgard, of the University of California, strongly confirm the practical experience which has shown already in Colorado and elsewhere the extent and feasibility of this great underflow supply. As great an authority as Prof. T. Sterry Hunt declares that 1 square mile of sandstone 100 feet thick will contain, when thoroughly saturated, water enough to flow continuously 1 cubic foot per minute for a period of thirteen years. Pure sand when saturated contains from 30 to 40 per cent of its bulk in water, while the more porous gravel will hold 25 per cent, with certainly a freer space for the element to move in. In sandy soils, which are always porous, the water will rise or fall with the temperature and the changes of climate. A fall of 6 feet to the mile, and that of the rivers on the central plains is much greater, may give from saturated sand and gravel a steady discharge of from 40,000,000 to 50,000,000 cubic feet per square mile.

A cubic foot of fine sand it is estimated will contain 2 gallons of water, of coarse sand 2½ gallons, of sand and fine gravel 3 gallons, while a cubic foot of coarse gravel and small stones will contain about 3¼ gallons. The porosity of sand is equal to abont one third its cubical volume. To 1 square yard of quartzoid sand 33 per cent of water can be added; to marl can be added at least 15 per cent of water. Clay, when dry, will absorb about 12 per cent; loose gravel, sand, and small stones will take up from 15 to 20 per cent of their space in water. Given these conditions and keeping in view the contours of the earth and the vast topographical features of the great region under consideration, it may be readily perceived that there is a great deal more than hypothesis or conjecture in the underflow proposition. Indeed the array of data and of facts already collated presents such an amount of proof as to justify the conviction that everywhere throughout the arid and semiarid regions it will be found over very large areas to be a prospective source of water supply of great industrial importance. Already large and prosperous manufactories of pumping and lifting machinery have been established, and among the papers that will be embodied in the supplementary report on underflow will be found a report from the manager of one of the most important of these new enterprises.

THE ECONOMIC IMPORTANCE OF THE INVESTIGATIONS.

It is probable that no one has seriously considered what is meant by an outcry against encouragement to irrigation and the investigation by the General Government and by this Department of the sources of supply of water in the arid region. Antagonism has been unquestionably expressed and from unexpected sources. It has been assumed that the growth of irrigation will rapidly tend to increase a disastrous agricultural competition in the markets of the continent and the world. In the progress of the investigations ordered by Congress this line of discussion has been met at nearly every turn. As it is founded on misapprehension it may be well to show what are the real forces at work to justify further inquiry and a continued examination into the general results of irrigation.

In the first place, no outcry is likely to prevent the movement westward on the unoccupied territory of our people. Whether such movement be wise or not it continues to go on. Ten years since it was declared on high authority that not over 11,000,000 acres of arable land remained east of the one hundredth meridian, and that west thereof a very small proportion of the whole area could be brought under cultivation. Yet since the publication of this statement more than 50,000,000 acres have been taken up for farming purposes, and a considerable proportion of this area has raised heavy crops of large and small grains, vegetables, and other products. At the present moment about 9,000,000 acres of land, considered worthless in 1880, are cultivated by means of irrigation. The forthcoming reports, preparing under your direction, will include some striking tables of land values, showing an increase of from 100 to 500 per cent in the market price of arid lands made fertile by the artificial distribution of water. But the great economic fact which replies to all the fears of competition is to be found in the rapid growth of industries other than that of agriculture that inevitably follow the reclamation of considerable areas of our arid lands. The railroad construction proceeds and accompanies such reclamation. The capital invested therein brings other capital to aid in the development of the country; markets grow about the railroad centers; mines are opened and manufactories established; towns are built; while the production created by means of irrigation must largely prove to be not of a competitive character, so far as our continental markets are concerned. It is virtually, under almost all circumstances, the creation of new products and industries. The development of our mineral wealth with the progress of arid reclamation will be conducted on a scale and with a certainty heretofore unknown. The intramountain valleys and basins, generally limited in extent, in which water can be obtained for agricultural uses will become the neighbor of the mine and the supporter of the prospector and miner. The average food products so raised will be consumed at home. But it is not in the direction of average products that the wealth-making benefits of irrigation, applied to the soil for the purposes of cultivation, will usually be found. It is not necessary to consider here the character of soil and climate within our arid domain. The facts, known of all men, are such as to prove not only where irrigation is practiced that ordinary crops can be produced with greater certainty, but that, in a much larger degree, the land so cultivated will be devoted to the raising of special crops that, in the main, will supplement and not compete with the Eastern farmer, bringing high prices to the producer and adding new wealth to the nation.

The experience of California and Colorado clearly demonstrates the truth of this presentation. Seventeen years ago the San Joaquin Valley, in California, was a desolate waste, given over to the jack rabbit, the horned toad, and the broad-horned steer, whose subsistence required from 15 to 25 acres of wild land per head. Very little wheat, hardy cereal as it is, could be grown in Merced, Fresno, or Kern counties; that of Tulare is better adapted to wheat raising. In 1874 the first colony life began in Fresno County, an area larger than some States and containing 5,600,000 acres. At the date named some 500 poor settlers located in and around what is now Fresno City. Now 20 different canal systems are in existence. Sixteen hundred vineyards make it the largest center of raisin-grape culture in the world. There are now over 30,000 people in and about that city, whose settlement began in 1874 with less than 500 colonists, while the county has over 100,000 population. The area devoted to the cultivation of grapes is 49,086 acres, of which 27,188 are in full bearing and 22,280 are devoted to the raisin or Muscal grape. The increase during the past year has been quite one fourth of the total area given. The value of this new industry, manufactured by sunshine and water out of the desert soil, is to Fresno County alone not less than $4,000,000 a year, while nearly as much more is created elsewhere in the State of California. Besides the vineyards there are 20,000 acres in orchards, mostly devoted to semitropical fruit. Of this area 300,000 acres are also devoted to the cultivation of wheat and alfalfa. The lifting of the water plane below from 50 to within 10 of the surface is the result of irrigation and cultivation. It has made the growing of grain a success. Mining, lumbering, and other regional industries have grown rapidly with the development of the new agriculture. A little tabulation of land values and the rapid increase caused by irrigation will prove of interest. The names and figures are taken almost at random from a large number in the possession of the Irrigation Inquiry Office:

Land values in Fresno County.

Name.	Length of years.	Acres owned.	Original cost.	Present value.
W. Mackersie	20	20	$700	$10,000
J. C. Duelle	1	20	4,000	6,000
J. Rowell	15	20	750	6,000
H. Lindstrom	10	10	500	3,000
T. C. White	13	120	6,000	50,000
Richard Williams	13	40	2,025	18,000
E. R. Cabot	7	20	1,000	5,000
R. M. Wilson	8	20	1,300	9,000
Holmes Hakes	6	20	3,500	8,000
Thomas Cross	9	20	1,400	7,000
Hartley Bros	2	40	9,000	16,000
A. E. D. Scott	14	40	5,000	8,000
M. J. White	8	20	1,200	8,000
Ellen Jacobsen	2	20	1,000	5,000
John Connor	10	20	700	10,000
F. Douglas	12	20	750	10,000
Walter Witney	11	20	700	10,000

THE YEAR'S PROGRESS IN IRRIGATION.

Besides the activity already seen to exist in the artesian wells and underflow areas, the investigations made by the Irrigation Inquiry Office show a rapid increase of interest in the whole subject of irrigation and of the cultivation of the soil thereby, whether the needed supply may be obtained from the surface or subterranean sources. The total area "under ditch" was shown at the close of 1889 to be 13,661,000 acres. That actually cultivated thereby was stated at 7,578,000. The increase in the cultivated area is believed to have been during the past year not less than 500,000 acres, while the area to be served by works now in process of construction will at an early day increase the area served by at least 3,000,000, and possibly 5,000,000 acres. Outside of the artesian wells investigation region a great many discoveries have been made of artesian and underflow water within areas of considerable extent and agricultural importance. In Utah there were reported at the beginning of 1890 not less than 1,794 small flowing wells. According to the officials of the Mormon Church these wells irrigated 1,993 acres. According to the reports made to the Senate committee the area of irrigation was not less than 5,000 acres. Some considerable increase of this area has occurred during the past year. As already stated, Colorado has greatly developed its underflow and artesian area. A remarkable struggle is now going on there between the working farmers and the large ditch corporations. The farmer organizations are a unit in demanding the public control of all irrigation waterways and works. This agitation will probably culminate during the ensuing winter in a vigorous discussion within the State legislature, owing to the fact that a code of irrigation laws has been prepared and will be reported by the State commission. The drift of public opinion in Colorado on the part of water users seems to be toward the establishment of irrigation districts similar to those of the system now under way in California, which, it is claimed, has solved all serious difficulties arising over water title and prior appropriation disputes.

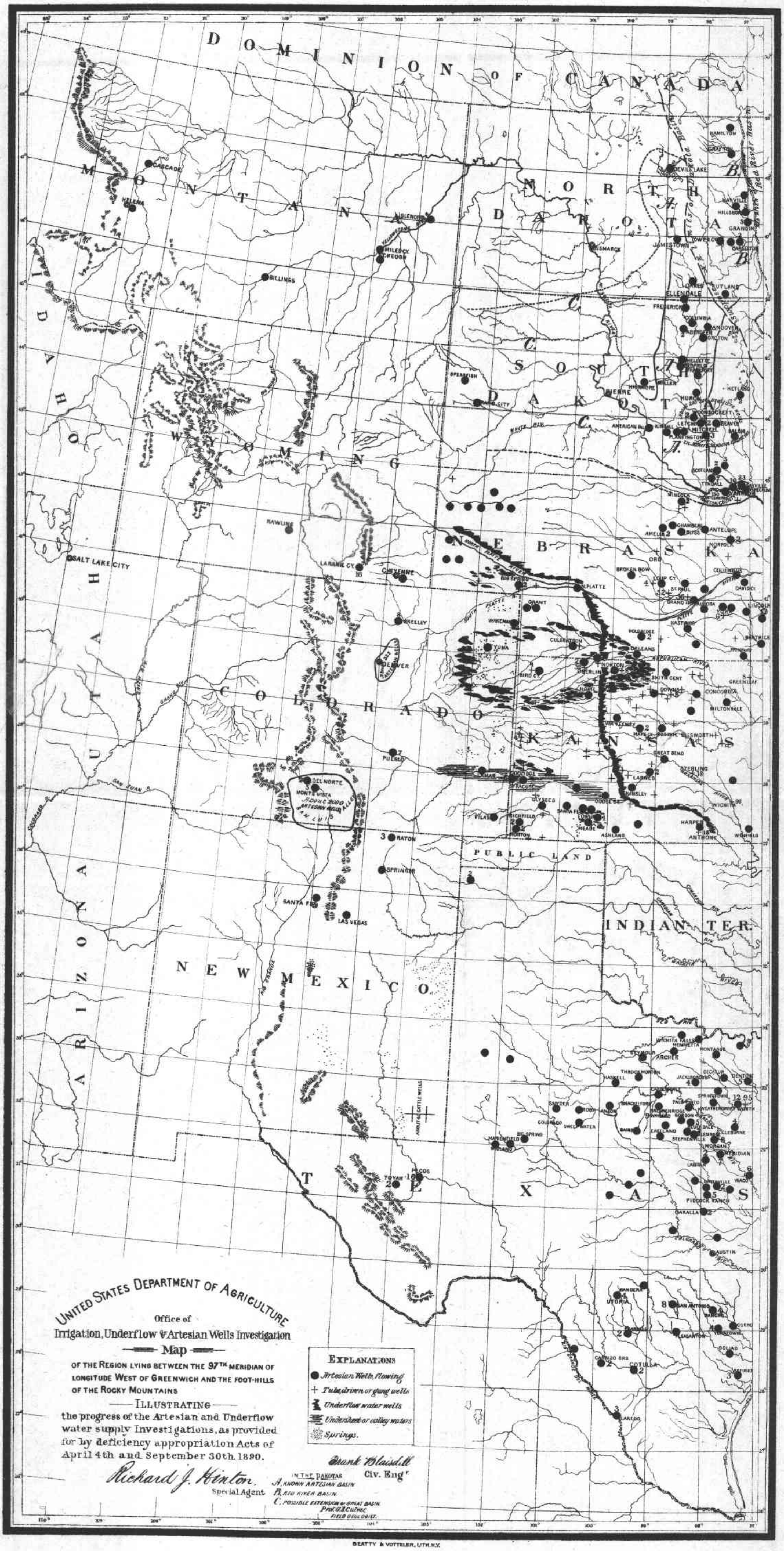
In the north and southwest the area of projected irrigation works has considerably increased, and large systems of reservoirs and canals are being promoted largely by the capital of mortgage land companies in the center and by railroad land-grant owners in the northwest. In California irrigation enormously increases the prosperity of that State. More and more the utilization of the subterranean waters becomes a matter of larger public and individual interest. Sixty thousand acres are irrigated by wells, artesian and bored, driven and gang, 3,000 of which are reported as in operation within California, one tenth of these being used for irrigation. The coming session of the Nevada legislature will be of importance, owing to the fact that reclamation projects under consideration there, are to be debated and decided upon.

In conclusion it may safely be asserted, considering the limitations of time, means, and other conditions, that no more practical investigation has been carried on at less outlay or with promise of larger results to the nation at large and the communities affected than that upon which I have now the honor, in accordance with your directions, to submit a first report.

Respectfully submitted.

RICHARD J. HINTON,
Special Agent in Charge.

Hon. J. M. RUSK,
Secretary.



BEATTY & VOTTELER, LITH. N.Y.

REPORT OF THE DIRECTOR OF THE OFFICE OF EXPERIMENT STATIONS.

SIR: I have the honor to present herewith the report of the Office of Experiment Stations for the year 1890. Although the limits of this report permit only an outline of the operations of this Office and of the stations, I trust the statements here made will suffice to show the value of the work now being done by the stations and the promise of its increasing usefulness. This Office was established in October, 1888, and has therefore been in operation but a little more than two years. Necessarily much of this period has been occupied in learning the needs of the stations, and in devising ways and means for carrying on the work for which the Office was organized. As the stations develop and the scope of their work is enlarged the Office is constantly confronted with new problems. Some of these, together with the need of increased means for discharging the duties imposed on the Office by Congress, are set forth in this report.

Respectfully,

W. O. ATWATER,
Director.

Hon. J. M. RUSK,
Secretary.

INTRODUCTION.

The report of the Office of Experiment Stations for 1890 is for convenience arranged in three general sections, relating to (1) the operations of the Office; (2) the work of the agricultural experiment stations, and (3) the agricultural colleges with which the stations are intimately connected, and the Association of American Agricultural Colleges and Experiment Stations, which is an efficient instrumentality in promoting the interests of both the colleges and the stations.

The work of the Office, described in the first division of this report, has included a very large and varied correspondence; visiting stations; attendance on farmers' meetings and conventions of college and station officers; the collection, cataloguing, and indexing of station and other literature; the collection of statistics and historical and other data regarding the stations and colleges; the indication of lines of inquiry for the stations; and the promotion of co-operation among the stations. Besides these things a very large share of the time and energy of the Office has been devoted to the preparation and publication of a record of the current publications of the stations and this Department, with a full index; the proceedings of the convention of the Association of American Agricultural Colleges and Experiment Stations; bulletins for farmers and botanists; organization lists of the colleges and stations; and circulars and letters of inquiry on topics relating to station work. The preparation of plans for exhibits of station work at the Chicago Exposition has also engaged the attention of the Office. This part of the report also contains an outline of the proposed work of the Office in 1891, a statement of its needs, and suggestions regarding special lines of inquiry which may be profitably undertaken or carried on more extensively by the stations in the immediate future.

The second division of the report, which relates to the operations of the stations, comprises some general statistics illustrating the extent of the station work; facts regarding the stations recently established; illustrations of the practical outcome of station investigations in a number of the States, as reported in 1890; and some conclusions respecting the status, needs, and prospects of the station enterprise. Statistics regarding the names and locations of the stations, the number of station officers of different classes, the lines of station work, the finances of the stations, etc., are given in tables.

In the third division of the report are presented statements with reference to the relations of the stations and colleges, the recent legislation by Congress for the benefit of the colleges, facts regarding colleges recently organized, and an account of the convention of the Association of American Agricultural Colleges and Experiment Stations at Champaign, Illinois. There is also a list of the schools and colleges in the United States having courses of agriculture, with locations and names of chief officers.

Those who desire to investigate the work of the stations in special lines will note that the bulletins and annual reports of the stations are sent, as far as practicable, on application to the respective stations. Communications regarding the work of the stations in any particular line may also be addressed to this Office, where they will either be answered directly or be referred to the proper station. Numerous references to the station publications will be found in this report, either in the text or in foot-notes, and a list of the stations, with the names of directors and addresses, is given on pages 548, 549. The publications of this Office intended for general distribution are sent to those who apply for them. A list and description of these publications may be found on page 548. As the editions are limited, the Office can not undertake to supply full sets of its publications, except in special cases.

OPERATIONS OF THE OFFICE OF EXPERIMENT STATIONS.

WORK OF THE YEAR.

Correspondence.—The correspondence of the Office is large and rapidly growing. The number of letters received and written during the year ending November, 1890, is, in round numbers, 10,000. The rapidity with which this portion of the work of the Office has increased is shown by the fact that the number of letters reported as written and received in 1889 was but 4,800. This correspondence, which reaches all parts of the world, includes requests for publications and for information which may be given by sending publications; inquiries regarding the organization and work of the experiment stations in this and other countries; inquiries for general and special information on a wide range of topics in scientific and practical agriculture; and communications with the experiment stations or their officers regarding the scientific, administrative, and general interests of the stations. Much of the correspondence involves considerable study and labor in the preparation of answers, as well as consultations with State or station officers. It is to be expected that this part of the correspondence will grow in magnitude as the usefulness of the stations becomes greater and their work better known throughout the country and the world. It is believed that the Office, possessing as it does published and manuscript reports of the work of all the stations, will be able to do more and more useful work as a bureau of information.

The visiting of stations, conventions, and farmers' meetings.—Since the last annual report was presented representatives of the Office have visited sixteen stations, have attended the meetings of the Association of American Agricultural Colleges and Experiment Stations at Champaign, Illinois, and the Association of Official Agricultural Chemists, Washington, District of Columbia, and have addressed meetings of farmers in various parts of the country. In order that the Office may be brought into such intimate relations with the stations as are obviously desirable it is important that its work in this direction should be materially increased.

Collection and cataloguing of publications and a mailing list.—The current publications of the stations have been received by this Office with greater regularity the past year than hitherto. Important additions of the earlier and rarer publications of the stations have also been made to the library of the Office. The card catalogue of station literature referred to in previous reports is constantly kept up to date; numerous additions to and corrections in the mailing list of the Office have been made.

Publications of the Office of Experiment Stations.—The principal work of the Office thus far has been that involved in the collecting and preparing of material for publication. The publications issued or in course of preparation are divided into six classes:

(1) The Experiment Station Record, issued in parts and containing brief abstracts of the current publications of the stations together with matters of kindred interest.

(2) Experiment Station Bulletins, intended for station workers and others specially interested in agricultural science.

(3) Farmers' Bulletins, containing accounts of experiment station work and cognate information, in brief, popular form. These are intended for general distribution to farmers and others.

(4) Miscellaneous Bulletins, treating of a variety of subjects more or less intimately related to the stations and agricultural colleges.

(5) Monographs on special topics in agricultural science.

(6) Circulars, containing matters of transient or restricted importance, and usually intended for limited circulation.

A list of the publications for general distribution thus far issued by the Office, with their titles, may be found on page 546. The following seem to require special notice:

Farmers' Bulletin No. 2.—Illustrations of the work of the stations.—This contains brief articles on Better Cows for the Dairy; Fibrin in Milk; Bacteria in Milk, Cream, and Butter; Silos and Silage; Alfalfa; and Field Experiments with Fertilizers. An edition of 150,000 copies was printed and has been distributed, partly through members of Congress. Although no special attempt has been made to advertise this bulletin, it has been in great popular demand and has been very widely quoted. Experiment stations have requested it for distribution to citizens of their respective States. At the time of this writing there have been received requests from twenty-five stations, aggregating 201,775 copies. The publication of the results of experiment station work in this country for the especial benefit of experiment station workers is provided for in other publications of this Office, but the selection and wide publication of such portions of the station work as are of immediate and practical use to the farmers has been considered from the outset as an important part of the work of this Office. It is to be regretted that lack of funds for printing has made it impracticable to issue these publications as frequently and in as large numbers as the demand for them would warrant.

The Experiment Station Record.—This is intended to be a current record of the work of the stations and of this Department. It contains abstracts of their publications of sufficient length to show the object and plan of the investigations reported, the main facts necessary to an understanding of the way in which the research was carried on, and concise statements of the results. Statistics and other information regarding experiment stations in different parts of the world, suggestions of lines and methods of inquiry for our stations, brief reports of important meetings of station workers, and notes on other matters deemed of general interest to the stations are given in editorial notes. Facts regarding the operations of the stations, changes in their working corps, additions to their equipment, new legislation affecting their work, etc., are concisely stated in experiment station notes. Abstracts of the publications of the Canadian stations have also been included in the present volume, and it is purposed to begin at once to make such brief mention of the work of the experiment stations and kindred institutions in Europe as the limited means at the disposal of the Office for editorial work will allow. A full index of authors and subjects is to be published for each volume.

The difficulty in determining what should be the character and size of this publication, and the interference caused by other work of the Office and inevitable delays in passage through the press, prevented the publication of the earlier numbers of the Record at regular intervals. The first volume consisted of six numbers and contained abstracts of the station bulletins for the calendar year 1889. This volume was finished in July, 1890, at which time the abstracts prepared by the Office were six months behind the station publications.

During the past year the number of station publications has considerably increased, both because new stations have been established and because the other stations issue bulletins more frequently. Moreover these publications are now of greater average length, and contain more scientific material. This is due to the fact that the stations are becoming better established and more of their experiments are reaching completion. The editorial labors of the Office have in consequence been materially enlarged. In view of the number of station publications and the desirability of furnishing summaries of current experiments to the station workers and the public as promptly as possible, the Record is to be issued for the present fiscal year in monthly instead of bimonthly parts. Since the first of July the Office has made a special effort to bring the abstracting of the station publications as nearly up to date as practicable, and has so far succeeded that under present arrangements these publications are, with rare exceptions, abstracted within a few days of their receipt in the Office. Six numbers of the second volume of the Record, containing abstracts of 160 publications, have been prepared for publication during the past five months. At least a month, and sometimes more, is required to get a number of the Record through the press. Moreover, the abstracts of many station publications are delayed by causes over which this Office has no control. It has not yet been possible to secure the prompt and orderly receipt of all publications. Some come to us long after their issue; others come out of regular order. Station bulletins and reports often bear upon their pages a publication date very much earlier than the actual one. Errors or obscurities of statement in the original publications often involve correspondence, which consumes considerable time and labor. Inasmuch as the Record is and should be an authoritative exposition of the current work of the stations and the Department, great pains should be taken to have it accurate not only in a general way but in every detail. To secure this involves a very large amount of the most painstaking labor both in the preparation of the abstracts and in the reading of the proofs. Errors have undoubtedly crept in already, and we can not hope to keep entirely free from them in the future. But it is the intention of the Office to perform this part of its task with a due regard to the magnitude and importance of the enterprise which it represents.

Owing to the fact that the appropriation for this Office has not been increased during the present fiscal year the digest of experiment station reports, bulletins on swine feeding and the monographs on the nutrition and feeding of domestic animals, the preparation of which was announced in the last Annual Report, have not progressed as rapidly as was expected. It is hoped, however, that means will be speedily provided for their publication.

SPECIAL FEATURES OF THE WORK OF THE COMING YEAR.

Indexes of experiment station publications and kindred literature.—The mass of literature containing reports of investigations on agricultural science in this country and Europe has grown to be so large that it is very important that general indexes should be prepared and kept up to date. It is very appropriate that an office like this, having a permanent organization, should undertake this work, which would be too expensive for private enterprise, and which when once begun, should be conducted on a consistent plan from year to year without interruption. The necessity for such an index has been appreciated by the Office from the outset of its work. There are, however, many difficulties in the way of its realization. Questions as to the proper system for the classification of topics, and the amount and kind of material to be included in such an index have required a large amount of preliminary study. The collection and cataloguing of the publications to be indexed have so far occupied a good deal of the attention of the Office.

Progress has, however, been made during the year in the formulating of definite plans for a general index of station literature. These plans were presented at the recent convention of the Association of American Agricultural Colleges and Experiment Stations at Champaign, Illinois, where they elicited much interest and the Office was earnestly urged to prosecute the work. It is hoped, therefore, that some portion of such an index will be published during the coming year. The plan of work proposed is in general terms as follows: The system of classification and the amount of matter to be contained in the index will be finally decided upon after conference with station workers and others interested, and the Office will prepare a card index by subjects of the current publications of the American stations. Portions of this will be printed from time to time for distribution. Whenever the means at the disposal of the Office are sufficiently enlarged the indexing of the past publications of our stations, as well as the publications of the kindred institutions elsewhere, will be taken up. In this connection it is worth noting that the index of Vol. I of the Experiment Station Record, which is at the same time an index of the station bulletins of the year 1889, fills 30 pages, closely printed, in small type and in double columns.

Compilation of results of European research.—In the previous reports of this Office reference has been made to the pressing needs of our experiment stations that the fruits of European research should be made available to them. Despite the limited facilities of this Office the need of this work is so urgent that a beginning has been made. In connection with the monograph on swine feeding the results of European experimenting on that subject are being collated. A similar attempt is being made to collate the results of later inquiries regarding the effects of fodder upon milk production by cows. A number of the more important European journals and other publications have been selected, and brief abstracts of inquiries reported in them are in course of preparation for the Experiment Station Record.

THE INDICATION OF LINES OF INQUIRY TO BE PURSUED BY THE STATIONS.

Specific suggestions and directions for field experiments with fertilizers were made after a conference with representatives of stations, and published in Circular No. 7 of the Office, as elsewhere stated. Plans for co-operative experiments on the effects of fodder upon milk production by cows are being prepared in accordance with a conference with a committee appointed for the purpose at the recent convention of the Association of American Agricultural Colleges and Experiment Stations in response to suggestions by the Director of this Office.

Investigations of feeding stuffs.—The need of improvement in the methods of analysis of feeding stuffs and foods, and for estimating their nutritive values has been repeatedly insisted upon by this Office. At the instance of the Director it has been made an especial theme for consideration by the Association of Official Agricultural Chemists. The report of the committee upon the subject presented at the meeting of the association in Washington, August 28–30, 1890, will be published in full in the forthcoming report of the proceedings of the association by the Division of Chemistry of this Department. In the Experiment Station Record, Vol. II, No. 5, the need of investigations on this subject is insisted upon, and plans, ways, and means for them are discussed.

It is safe to say that all of the work we have done in the past and are doing to-day in the analysis of feeding stuffs and the feeding trials based upon them will have to be revised and much of it discarded. In other words, a large amount of work is being done which is not bringing the needed results, can not in the nature of the case be of the highest and most enduring value, and much of which may have to be done over again when correct methods shall have been devised.

The first step toward reform must be research in analytical, organic, physical, and physiological chemistry. The needed improvements of our methods will evidently come only as fast as does the chemical and physiological knowledge which must serve as a basis for changes. This means that the most abstract and profound study is necessary. Fortunately such study is more and more engaging the attention of chemists and vegetable physiologists.

Investigations in these lines have been already undertaken by the Division of Chemistry of the United States Department of Agriculture, by several of the experiment stations, and by other institutions of research. The work of the Association of Official Agricultural Chemists in developing and improving the methods of analysis has been of the greatest value. For the collating of the results of previous inquiries, and for the prosecution of the necessary investigations, co-operation of large numbers of specialists will, of course, be requisite. We may confidently expect that experiment stations will be able to devote more and more labor to these higher inquiries. The increased resources of our agricultural colleges will enable them to encourage such researches. The scientific value of this work is such that chemists in other colleges and universities ought to be led to join in it. And is it too much to suggest that international co-operation might be secured? The expense of this research may be best met by the wise expenditure of relatively small sums of money judiciously distributed, so as to stimulate investigations and bring them to completion. In what the Smithsonian Institution has done in times past in promoting research by small amounts of money, we have an illustration of what might be accomplished here. The result would be useful in several ways. It would encourage research, develop talent, and improve the intellectual tone of the institutions where such work was being done. Its influence upon the development of science in this country would be excellent and the practical value of the outcome would many times exceed the cost.

Investigation of soils.—In the report of this Office for 1889 attention was called to the importance of more thorough investigation of the soils of the different parts of the country for the purpose of securing more extended knowledge and better development of their agricultural capabilities. Such investigations form a part of the duty of the stations, as defined by act of Congress. The subject was discussed by the Association of American Agricultural Colleges and Experiment Stations in its convention at Washington in November, 1889, and a resolution was passed requesting the aid of the Department in collating and publishing the results of soil investigation at home and abroad. A number of the stations are already prosecuting investigations in this line. The present purpose of illustrating the importance of these inquiries and indicating what is needful for their best success will be served by specific illustrations. Two are therefore selected, one from South Carolina and one from California, thus exemplifying the advantage of such inquiries in the older regions of the East and the newer ones of the West. In the one case the improvement of soils more or less exhausted by culture is particularly indicated; in the other the advantage of pioneer investigation in behalf of the settlers of new territory is most plainly shown.

Soil investigations by the South Carolina Station.—The South Carolina Station has undertaken a systematic study of the soils of its experimental farms in Spartanburgh, Columbia, and Darlington and of other typical soils of the State. These inquiries include observations on the meteorology, topography, and geology of the regions where the soils are located; the natural growth upon the soils, especially of the trees; and the methods of tillage and manuring practiced and the crops produced. With these have been made field experiments on the effects of different fertilizers on the growth of cotton, corn, wheat, and other crops on the different soils; mechanical and chemical analyses of the soils and special studies of their physical properties as related to plant growth and crop production. Taken in connection with the other work of the station on varieties of crops best adapted to the different regions and conditions and their proper utilization, the plan begun would, if logically carried out, embrace such meteorological, topographical, physical, chemical, botanical, and agricultural studies as would lead to a thorough understanding of the climate and soils of the State, the crops best adapted to different regions, and the proper methods of tillage and manuring. It would in fact constitute an agricultural survey of South Carolina.

In a report to the director of the station Professor Whitney thus tersely states some of the reasons for prosecuting these inquiries:

The various parts of this State are naturally arranged according to certain marked and well-defined classes of soil and climatic conditions. Certain products are peculiar to certain sections and are excluded from others, or their cultivation or character must be materially modified. This is notably the case with cotton and rice. We have within the State regions where the conditions favor their most productive growth and others where they can not be grown. The causes favoring the production of sea island cotton on the coast and its failure to mature on the uplands is in itself a subject worthy our most careful study and investigation. The reason will be found in the physical conditions of the soil, methods of cultivation, and climatic conditions. As the maturity of cotton has been materially hastened on the sea islands through methods of cultivation, that is, by changing the physical conditions under which it grows, there seems every reason to believe a systematic study of these soils and conditions of growth would have immediate practical benefit to our farmers and the advancement of agricultural science. Further than this, the small yield of our grain crop at the South, the lateness of our bottom-lands, the rusting and other diseases of cotton, the washing of our red lands in the up country all depend to a large extent upon the physical character of the soil, as well as in a lesser degree upon meteorological conditions, and certainly if these matters were better understood we would speak more intelligently of remedies to be applied. Further than this and intimately connected with the subject in hand, is the physical action of manures and fertilizers, which has never been understood, but which we have worked out in part within the past year.

Corn, wheat, oats, and such staple crops of the North and Europe will grow almost anywhere from the intensely hot countries to frozen Siberia, and the experimenters at the North and in Europe have been almost unable to obtain conditions unfavorable for these crops. The soils at the North are also more mixed than they are with us, owing to the changes of the glacial period, so they have not the typical soils that we have, and the limited areas of uniform soil are materially modified by generations of manuring and intensive cultivation. Cotton and rice are more sensitive to their surroundings, and consequently are better adapted to the study of the soils than the staple crops just mentioned.

It is only by comparison of conditions existing in different characteristic soils that the relation of these physical properties of soil to plant growth and crop production will be made apparent.

Mechanical and chemical analyses of soils of the three experimental farms of the station and of sea island cotton and rice land soils of the coast of South Carolina have been made by Prof. R. H. Loughridge.

Investigations on the physical properties of soils, as related to plant growth and crop production, have been conducted by Prof. Milton Whitney. These included laboratory experiments on the soils of the station farms, sea island upland cotton soils, and upland cotton soils of different geological formations, supplemented by observations in the field and by meteorological studies. The scope of the work may be inferred from the following summary:

Soil particles.—(1) Interpretation of the result of mechanical analysis. (*a*) Number of particles in unit weight or volume of soil; (*b*) diameter of average-sized particle of soil and the mean arrangement of the particles; (*c*) surface area of particles (this shows the need of still further perfecting the method of mechanical analysis). (2) On a movement of soil particles due to changing water content and changing temperature, as related to the growth of roots, and the physical action of manure, with the effect of barometric changes and vapor pressure on the same.

Soil moisture.—(3) Method for the determination of the moisture in the soil by electrical resistance. (4) On the movement of soil moisture. (*a*) The cause and laws of the movement; (*b*) the effect of temperature; (*c*) the effect of manure; (*d*) the effect of rain; (*e*) the effect of cropping and cultivation. (5) Calculation of the relative movement of soil moisture in different soils from the mechanical analysis. (6) Calculation of the relative rate of evaporation and underdrainage from different soils from the mechanical analysis. (7) On the capillary value of different soils from the mechanical analysis. (8) Effect of fineness and compactness on the water-holding power. (9) On the action of underdrains in the soil and of how they act. (10) On the flocculation and subsidence of clay particles. (11) On the swelling of clay when wet. (12) On the compacting of soils by rain. (13) On the physical action of manures and fertilizers.

Soil temperature.—(14) New form of soil thermometer, which registers the maximum and minimum temperature of a definite layer of soil. (15) The relation of the soil to heat as observed in the field in typical soils or under different conditions of cultivation and fertilization. (16) Calculations of the relation of different soils to heat from the mechanical analyses, with the effect of the water content, cultivation, and cropping. (17) The actual temperature of different soils, with range, etc. (18) Study of the loss of heat from different soils. (*a*) As calculated from the mechanical analysis; (*b*) as determined with the radiation thermometer. (19) Specific heat of typical soils.

Meteorology.—(20) Temperature of the air and soils, and amount of moisture in same most favorable for plant growth. (*a*) Distribution throughout the growing season; (*b*) the relative effect on the growth of plants and crop production; (*c*) how modified by manure and cultivation. (21) The estimation of the actual amount of moisture in the soils from time to time. (22) Influence of meteorological conditions. (*a*) On grain production, as explaining low average yield of grain at the South; (*b*) on the distribution of crops throughout the State; (*c*) on the growth and ripening of crops. (23) Amount and intensity of sunshine available for the crop. (24) Effect of wind movement on plant growth, especially as to the amount of ammonia supplied to crops.

The practical applications of the principles involved in researches of the character indicated are interesting. The culture of cotton gives manifold illustrations. The cotton plant requires in the earlier period of growth plenty of warmth and moisture to develop "weed" (stem and foliage), while in the later period of growth less moisture is desirable so far as to favor full and early development of seed including the lint. The meteorological conditions of South Carolina are favorable for this, but right cultivation of the soil is necessary. In other words, success in cotton growing depends upon keeping the soil in the right physical condition. The improvement of late years in the regulation of the moisture by the management of the soil in cotton culture are noteworthy.

The sea island cotton is now famous for its quality and brings a high price. Yet some years ago it was thought the culture of sea island cotton would have to be abandoned even on the sea islands, and, indeed, the ordinary upland cotton was substituted to a large extent for the long staple because it was less liable to injury from the caterpillar, and because the season of growth of the long staple was so long as to render it liable to be caught by frost, making the crop very uncertain. The systematic use of Paris green and London purple, under the very watchful and intelligent care of the planters, makes the crop secure from the ravages of insects, and the improved method of culture at present employed materially hastens the maturity of the plant, bringing it well within the length of the season, increasing the yield and improving the quality of the lint.

In brief, here is a case in which threatened failure has been followed by assured and remarkable success, and the agriculture of a region most notably benefited by management which has fitted the physical character of the soil to the needs of the plants.

Professor Whitney thinks that similar improvement is feasible in other parts of the State. He cites specific localities where this may probably be done, and explains the conditions of soil and climate upon which his judgment is based. The improvement may and doubtless would come in the course of years or generations through practical experience, without the aid of scientific inquiry, but here as in many other cases, that inquiry would help to the speedy solution of the problems, bridge over costly experience, and repay its expense many fold.

Soil investigations by Professor Hilgard, Director of the California Station.—Volumes V and VI of the United States Census of 1880 contained detailed reports upon investigations of the soils of Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Louisiana, Texas, Indian Territory, Arkansas, Missouri, Mississippi, Tennessee, Kentucky, and California, by Prof. E. W. Hilgard and associates. In connection with the Northern Transcontinental Survey, Professor Hilgard was for some time engaged in investigations of the soils of the northwestern regions of the United States, the results of which have not yet been published in detail. As a part of the work of the California Station carried out under his direction, over two thousand two hundred samples of representative soils of that State have been collected, and when desirable, subjected to chemical analysis and physical investigation. The data thus used have served as a basis for a classification of the soils of the State. Parallel with these studies of soils, numerous analyses of waters have been made to learn their values for irrigation and other purposes.

In communications to this Office, and more especially in a report of the California Experiment Station,* Professor Hilgard has summarized the results of a large amount of experience in the study of soils, of which his own for thirty-five years forms a prominent part. He urges the value of chemical as well as physical analyses of soils and explains their interpretation; insists upon the especial importance of investigations of the soils of the newer States and Territories, where the question is not how to restore or maintain the fertility of the soil, but rather "Which soils are most likely to afford the settler a comfortable living, and what cultures are best adapted to the prevailing conditions of soil, climate, and market;" cites instances in which individual settlers and colonies have suffered disastrously from mistakes in the selection of place for settlement because they did not understand the nature of the soil, as well as instances in which soil investigations have been of the utmost value in preventing such mistakes and in finding remedies; and argues strongly in behalf of an agricultural survey of the United States. The following statements are from a communication by Professor Hilgard:

A full and accurate knowledge of the agricultural features and other industrial resources of the State is of the most direct and obvious importance to every one concerned in industrial pursuits. It is wanted by the immigrant or the settler seeking a new home suitable to his tastes and resources, as well as by the large farmer and capitalist desiring to locate and invest to the best possible advantage.

Most of the older States have long ago partially satisfied this demand in some form; mostly in connection with the public surveys usually named from their fundamental feature, geological surveys, but commonly charged as well with the full investigation of the other industrial features of the State. It is but fair to state, however, that in but few cases have these surveys gone into the agricultural work wholehearted. * * * This has occurred largely for the reason that no agricultural experts have been employed who could have made observations sufficiently broad to cover the requirements of agricultural practice and presented them in language intelligible to the farmer. * * * Outside of the cotton States, where such work was to a certain extent carried on in connection with the Tenth Census as well as by a few State surveys, it is now practically impossible for most of those interested to obtain full, authentic, and impartial information concerning any particular region of the United States without the trouble and expense of a personal visit. The demand for this kind of information is shown by the publication of numerous pamphlets and newspaper articles, describing more or less fully and correctly certain regions recommended for immigration or settlement. But the fact that these publications emanate largely from interested parties and are compiled by persons unused to accurate observation of natural phenomena and not possessed of the means for thorough investigation, greatly reduces the usefulness even of the correct information thus conveyed.

Moreover, the possession of an accurate description of the agricultural features and peculiarities of a State is an indispensable prerequisite to the giving of truly practical instruction to the youth of the States in the courses at the agricultural colleges. Nothing can be more obvious than that they should be taught not only what they should have to do in certain hypothetical cases, but also what are the circumstances and difficulties with which, in actual fact and practice, they will have to deal in their own State.

The experiment stations now established in each State are designed and constantly called upon to furnish information and advice regarding the best agricultural practice within their respective spheres of action, and to solve existing difficulties and questions by experimentation. But as a matter of fact they do not possess and have not the means or even definite prospects of getting possession of the actual facts of the cases with which they will have to deal. They are placed in the position of a physician who is expected to prescribe for a patient of whose condition and ailments he knows nothing except what public rumor or the statements of some person ignorant of medical science may have led him to conjecture.

In order that these institutions may properly fulfill the functions imposed upon them, they should not be obliged to await the tardy and irregular action of appli-

* Reports of the Agricultural Experiment Station of the University of California for 1888 and 1889.

cants for information or to rest content with the fragmentary and unreliable observations that may accompany such requests. They themselves should be in possession of the actual facts, as collected and co-ordinated by competent observers and as published on a uniform plan by one central bureau, and thus be able to foresee and investigate the difficulties and problems that will beset the individual settler or farmer in advance of the time when irrational culture may have rendered such solutions more difficult of practical application. In other words, they should have as a basis for effectual work the operations and results of *an agricultural survey of the whole country.*

The information desired by the intending settler or land purchaser will usually include the following points:

What is the character of the climate? The face of the country, wooded or treeless? What is the quantity and quality of the water supply, and how far is it down to bottom water?

Is the land capable of yielding profitable crops without fertilization or other costly improvements; and, if so,

How long is it likely to hold out under ordinary (exhaustive) culture before it will require fertilization?

When it does give out, what fertilizer will it require first, or what other mode of restoring productiveness can be employed?

To what crops is the land, from its (physical and chemical) nature, best adapted?

In the great majority of cases these questions, so vitally important to the welfare of the settler, can be quite fully answered by properly qualified observers, while wild guesses are all that the average farmer will be able to make regarding some of the most essential points in the premises. These require a knowledge—from actual observation—of the physical and chemical characters of the soil; and in the study of these the expert must be aided by all the natural characteristics that would guide the judgment of the "old farmer," as well as by the discussion of the experience that may already have been had in cultivation. The mere identification of soils, their mapping so as to show how far the experience acquired at any one point may serve to forecast the value and proper treatment of larger areas, would be sufficient to justify a considerable expenditure in field surveys.

But in the present state of science much more than this can be done, and the agricultural interest is entitled to the very best that can be accomplished.

It has been said * * * that a good farmer could tell all about a soil so soon as he saw it and that such investigations are uncalled for. This is simply and grossly untrue outside of the immediate range of the experience of nine tenths of the farming population; but granting it true of the *good* farmer, then just such persons, but properly qualified to give the reasons for the faith that is in them—in other words, qualified agricultural experts—should be made to do this work for the other nine tenths, who now go ahead blindly, experimenting at random in new climates and soils and each learning by bitter experience what might have been foreseen and prevented. It is difficult to see why what is done by geological surveys for the miner should not be equally, at least, done for the farmer by properly conducted agricultural surveys. The agricultural expert should have all the knowledge possessed by the good "old farmer," but a great deal more in addition by using all the lights that modern science can throw upon the subject.

The reports of the California Station above referred to give numerous examples of forecasts which were made upon the basis of such information and have been verified by actual experience. They have to do with such subjects as irrigation of arid lands; remedies for "alkali," and reclamation of alkali soils; the evil of impervious subsoils and the remedies for it; and the occurrence and lack of lime, potash, and phosphoric acid in soils. Their full import, however, can hardly be realized by those not familiar with the regions and the details. Areas in California as large as Eastern States, once arid and waste have been reclaimed by irrigation and tillage; direful loss has been threatened, but means of prevention have been discovered, largely through the aid of the station. Such, for instance, has been the case in portions of the "Great Valley" of California which is traversed by the Kern, San Joaquin, and Sacramento Rivers. The fundamental facts, broadly stated, are these: The regions referred to were waste, not from lack of plant food, for this was often present in abundance, but from lack of water. Irrigation and tillage have supplied the water. In numerous cases, however, excess of salts consisting chiefly of sodium chloride, sulphate, and carbonate, and popularly known as alkali, has accumulated at or near the surface of the soil, sometimes before irrigation was introduced and sometimes as the result of it. The effect of this alkali has been to injure or destroy the fruit, grain, or other crops. It is brought to the surface of the soil by water which rises from below and evaporates from the surface. The remedies are tillage to prevent evaporation. drainage to wash the salts out, and amendments, especially gypsum, to counteract their effect.

Results of chemical and physical investigations of soils.—Among the important general conclusions derived by Professor Hilgard from studies of soils in California and other States are the following: The soils of California, studied in nearly all cases, are *calcareous*, *i. e.* contain enough of carbonate of lime to impart to them the distinctive character of such soils, and to render a further addition of that substance as a fertilizer superfluous and ineffective. The great majority contain amounts of *potash* largely in excess of those found in the soils of the region east of the Mississippi, very often exceeding 1 per cent. Potash salts are often found circulating in the soil water; the conclusion being that the use of potash as a fertilizer will likewise be uncalled for for a long time to come. On the other hand, it has been found that *phosphoric acid* exists in the soils of California in relatively small supply as compared with those of the East, and of Oregon, Washington, and Montana.

Actual trial both at the California Station and by farmers has corroborated these conclusions.

These investigations have called attention to the broad fact, heretofore overlooked, that *the accumulation of lime in the soil of arid regions* is as necessary a consequence of the climatic conditions as is that of the alkali salts; and that such countries must under ordinary conditions be expected to have calcareous soils. This generalization is amply verified by numerous soil analyses from the States and Territories west of the one hundredth meridian, made in connection with the Northern Transcontinental Survey, but thus far unpublished.

In the States of Alabama, Mississippi, and part of Louisiana the agricultural survey, while classifying the lands so that the experience had in one part of a soil region would be known to be applicable to the rest, has been specially useful in the discovery and examination of the beds of calcareous and greensand marls, which are admirably adapted to the restoration of the productiveness of the lands exhausted by long cropping with cotton.

In the same States certain soil regions that had been highly extolled by land speculators on the basis of their pleasant appearance were proved to be absolutely incapable of profitable cultivation without improvements too costly to be undertaken until land values shall be considerably higher than is the case at present. The best mode of improvement has been pointed out and in several cases successfully carried out on a small scale.

In California the planting of colonies on lands of good appearance, but which ultimately proved unfit for permanent cultivation, has in several instances been carried out, in others attempted. The existence of official reports on such lands would have prevented large losses of money, and even much suffering.

Interpretation of analytical results for practical purposes.—In forming a judgment regarding the practical import of the data resulting from a soil analysis the simple question must be, "What does the comparison of such data with actual agricultural practice teach us?"

The first broad statement that may be made is that *in no case has any natural virgin soil showing high plant food percentages been found otherwise than highly productive under favorable physical conditions.* This being true, the practical value of soil analysis is thus far established, that it can teach the settler, *a priori*, that certain soils, new to him and to everyone, are a safe investment.

But the reverse is not true, viz, that low plant food percentages necessarily indicate low productiveness.

That it *can not* be true is evident from the simple fact that heavy clay soils rich in plant food may advantageously be diluted with arid sand, several times over, thereby increasing instead of diminishing their productiveness, *because of improved physical conditions.* This fact is abundantly exemplified in the daily experience and practice of gardeners. In nature it is emphasized by the effects of the washing down of the poor, sandy soils of pine and "black-jack" ridges upon the heavy, black prairie soils of the Southwestern States, where the "mahogany" soils so formed are in the highest repute for both productiveness, "safeness," and durability, and are invariably preferred to the black, heavy prairie soils.

A material limiting cause in the premises is the nearness to the surface of either the water-table, or of hardpan difficult or impossible to penetrate by the roots. It has repeatedly occurred in California that sandy soils of low plant-food percentages that yielded heavy crops while the water was at the depth of 10 or 12 feet, ceased to produce so soon as, by increase of irrigation in the neighborhood, the water rose within 5 feet or less of the surface. Examination showed that the active root system has thus been confined to less than half of the bulk of soil previously occupied by it in these pervious soils. In clay soils 5 feet would have been more than sufficient depth for the same crops, as their roots would not go deeper in any case. In the same region, calcareous hardpan lying at the same depth has, like the water, caused production to languish after a few years, but when it was broken through, after the lapse of a year, vigor was restored.

It is then absolutely indispensable that both the physical character—as to penetrability, absorptive power, etc.—*of a soil should be known as well as its depths above bed-rock, hardpan, or water, before a judgment of its quality, productiveness, and durability can be formed from its chemical composition.* But it is equally obvious that *without* a knowledge of the chemical composition, it is not possible to form such a judgment with "*connaissance de cause.*" Definite information on *both* classes of properties must be before the agricultural expert; and it will be his own fault if from such data he can not beat the old farmer in judging of soils. * * * A *properly qualified* agricultural chemist can render the most direct and important services to the farmer, settler, and immigrant, by forecasting both the best adaptation of the lands occupied, the mode of culture, and the improvements and fertilizers that will be first needed when (as now invariably happens) the soil "gives out" under exhaustive culture. This, and not mere glittering generalities, is what an agricultural survey deserving of the name should supply. In most of the country lying between the Alleghanies and the Pacific Ocean, the history of each field is generally still in the memory of persons living; and thus the most valuable direct evidence of the effects of cultivation on natural soils, and of the extent to which soil examination can be useful to practice, is within the easy reach of our experiment stations. It will be their most grevious fault if these advantages, scarcely to be found in any other country in the world, are not utilized by them for the advancement of the science as well as the practice of agriculture.

To the foregoing illustrations of what the stations are doing in this line others of very considerable interest and value might be added. The purpose here, however, is to urge that what is being done be done right and in such a way as to bring the best results from the work as it goes on, and to lead to the most effective organization and carrying out of investigations in the future.

This idea was urged in Circular No. 7 of this Office, in which it was said that "we must understand the topography, geology, and the meteorology of the different regions, the boundaries of the faunal and floral areas, and the chemistry and physics of the soils themselves before we can know what we need to know about the agricultural capabilities of the wonderfully diverse soils of the country and the most advantageous ways to cultivate them."

It is fortunate for the prosecution of these inquiries that the agencies are already in operation and all that is required is their natural growth and extension. In fulfillment of the duties imposed upon them by Congress, the stations are instituting the investigations in the different parts of the country where they can best observe the characters of our soils and the demands of agriculture. The topographical and geological inquiries needed as part of the foundation of their work are or can be provided for in connection with organizations already established. What is now wanted is to collate the known facts and devise wise and economical methods of inquiry and push that inquiry as the wants of localities demand and science and experience advise. The collating of the fruits of experience, both American and foreign, the elaboration of methods, and the arranging of co-operative investigation can be most economically and effectively done through the Office of Experiment Stations in connection with the stations, colleges, and other institutions of research. As the methods are worked out they can be used by the stations in their several localities as circumstances demand and opportunities permit, and thus the enterprise will have its normal growth and the work be most advantageously done.

REPRESENTATION OF THE EXPERIMENT STATIONS AT THE WORLD'S COLUMBIAN EXPOSITION IN 1893.

In consideration of the importance of an exhibit by the experiment stations at the coming Exposition in Chicago, plans were drawn up by this Office and presented at the convention of the Association of American Agricultural Colleges and Experiment Stations at Champaign, Illinois, in November, 1890, by Mr. A. W. Harris, assistant director of this Office. They were very cordially received, and a committee was appointed to represent the association in conferring with this Department and making arrangements for such an exhibit. The committee are Director Armsby of Pennsylvania, Professor Morrow of Illinois, Directors Thorne of Ohio, Tracy of Mississippi, and Henry of Wisconsin.

The plan includes (1) an experiment station in operation, to be manned by station workers, containing an office, library, chemical, botanical, and entomological laboratories, greenhouse, stable, and dairy. (2) An exhibit of the work of the stations, to be made up of two parts, the first containing exhibits of the individual stations, showing location, climatic relations, plans of buildings, history, resources, principal lines of work, etc.; and the second consisting of topical exhibits of the work of the stations, illustrating methods, apparatus, and results pertaining to special subjects or classes of subjects.

Small pamphlets, primers, or leaflets explaining the exhibit are contemplated, and it is proposed that members of station staffs, students of the agricultural colleges, or others be detailed as demonstrators to explain to visitors the meaning of the exhibit.

STATISTICS OF THE STATIONS.

Agricultural experiment stations are now in operation under the act of Congress approved March 2, 1887, in all the States and Territories except Montana, Washington, Idaho, Wyoming, and Oklahoma. In several States the United States grant is divided so that forty-six stations in forty-three States and Territories are receiving money from the United States Treasury. In each of the States of Connecticut, Massachusetts, New Jersey, and New York a separate station is maintained entirely or in part by State funds, and in Louisiana a station for sugar experiments is maintained mainly by funds contributed by sugar planters. In several States branch or substations have been established. If these be excluded the number of stations in the United States is fifty-two. During the past year six new stations have been established, viz, in Northern and Southeastern Alabama, Arizona, New Mexico, North Dakota, and Utah. The stations with this Office received during 1890 $988,146, of which $652,500 was appropriated from the National Treasury, the rest coming from State governments, private individuals, fees for analyses of fertilizers, sales of farm products, and other sources. The stations employ four hundred and twenty-nine persons in the work of administration and inquiry. The number of officers engaged in the different lines of work is as follows: directors 66, chemists 101, agriculturists 63, horticulturists 47, botanists 42, entomologists 33, veterinarians 19, meteorologists 11, biologists 4, viticulturists 2, physicists 3, geologists 1, mycologists 2, microscopists 4, irrigation engineer 1, in charge of substations 16, secretaries and treasurers 21, librarians 5, clerks 18. There are also forty-two persons classified under the head of miscellaneous, including superintendents of gardens, grounds, and buildings, foremen of farms and gardens, apiarists, herdsmen, etc.

During 1890 the stations have published 36 annual reports and 225 bulletins. The mailing list of the stations now aggregates about 340,000 names. At a low estimate a total of 35 millions of pages, containing information on agricultural topics, have been disseminated among the people during the past year; furthermore the results and processes of experiments are described in thousands of newspapers and other periodicals. The mailing lists of the stations have largely increased during the year. The calls upon station officers to make public addresses are numerous and increasing. The number of such addresses reported to this Office as delivered during the past years is about 750. The station correspondence with farmers is now very large and touches nearly every topic connected with farm theory and practice. A number of stations have made exhibits of the processes or results of their investigations at the State and county fairs. There have been many evidences of public approval of the stations and their work as indicated by acts of the State legislatures in their behalf and gifts of money by local communities, agricultural associations, and private individuals, and by commendations of their work in the agricultural journals as well as by farmers. The relatively large space given to reports of work of the stations in the agricultural press is also an indication of the increasing favor in which the work of the stations is held.

By an act of the legislature passed in December, 1889, to take effect November 1, 1890, the connection of the South Carolina Experiment Station with the University of South Carolina has been severed and the station has been removed from Columbia to Pendleton, where it is now in operation as a department of the newly established Clemson Agricultural College.

The post-office address of the Georgia Station has been changed from Griffin to Experiment, and that of the Maryland Station from Agricultural College to College Park.

STATIONS RECENTLY ORGANIZED.

The North and Southeast Alabama Branch Agricultural Experiment Stations were established by an act of the State legislature approved February 28, 1889, and are connected with agricultural schools organized under the same act. They are under the management of boards of control, consisting of the State commissioner of agriculture, the director of the experiment station of the Agricultural and Mechanical College of Alabama, and of five farmers residing in the vicinity of the respective stations, appointed by the governor of the State. The North Alabama Station is located at Athens, and its director is C. L. Newman, B. S. The Southeast Alabama Station is located at Abbeville, and its director is T. M. Watlington, B. S.

In accordance with a resolution of the board of regents of the University of Arizona, adopted July 1, 1889, the college of agriculture and an experiment station have been organized in connection with the university. Selim M. Franklin, Ph. B., was at that time elected professor of agriculture and director of the station, but he has since been succeeded in both offices by F. A. Gulley, M. S., formerly director of the Texas Station. The station is located at Tucson, Arizona. The other members of the station staff are C. B. Collingwood, B. S., chemist, and Ferdinand Brandt, horticulturist. M. P. Freeman, president of the university, is *ex officio* president of the governing board of the station.

A substation for Southern California was established in July, 1890, at Pomona, Los Angeles County, in conformity with the result of explorations made last season with the view of finding a locality reasonably representative of a region which includes both the coast from Santa Barbara to San Diego and the more or less arid lands of the interior. On the ground that the station should be situated within the great valley of that portion of the State (which reaches from Los Angeles to San Bernardino Mountain, and which is the largest and earliest settled tract of agricultural land south of the San Joaquin Valley), a compromise location within that valley seemed to be best realized on or near the water divide between the two river systems that now drain it diagonally, viz, the San Gabriel and Santa Ana Rivers. As in former cases, the land for the station has been donated. The soil of the main tract of 30 acres is the reddish loam, which is considered especially favorable to the success of citrus fruits. The 10-acre tract is a fair sample of the black loam that constitutes most lands of this as well as of the coast region, is especially adapted to field crops of all kinds, and needs no irrigation. The two tracts lie about 2 miles apart. On the larger one the station buildings will be erected with the aid of about $3,000 subscribed by the citizens of Pomona. At a late meeting of the regents of the University of California, Mr. Richard Gird, who gave the land for the station, was appointed "patron" of the South California Station. Buildings are being erected and it is hoped that the station will be fully stocked for the coming season's work. Offers of land and of funds for buildings were also received from the citizens of Riverside; but the fact that the coast climate was entirely unrepresented in the work of the station prevented the location of the new substation at this place, where it would have been essentially representative only of citrus culture in the interior. In addition to the three grape culture stations connected with the California Station a fourth has recently been established at Glen Ellen for investigation on the phylloxera and the reconstitution of vineyards.

The North Dakota Agricultural College and Experiment Station was organized in accordance with an act of the State legislature approved March 8, 1890, and is located at Fargo, North Dakota. The station as well as the college is under the control of a board of five directors appointed by the governor with the advice and consent of the State senate. The first director of the station was S. T. Satterthwaite, but he has been recently succeeded by H. E. Stockbridge, Ph. D., formerly director of the Indiana Station. The other members of the station staff are E. B. Waldron, botanist; James Holes, superintendent of farm experiments; Jacob Lowell, general superintendent; E. F. Ladd, chemist. The station has begun experiments with grasses for hay and pasture, varieties of wheat under different methods of cultivation, silage, and sugar-beets. An effort is also being made to collect and classify the injurious grasses and noxious weeds of the State.

The Agricultural College and Experiment Station of New Mexico was established by an act of the legislature of the Territory, passed during the session of 1888-89. The college and the station are located at Las Cruces, and Hiram Hadley, M. A., is president of the college and director of the station. The other members of the station staff are Ainsworth E. Blount, M. A., horticulturist and agriculturist; Elmer O. Wooten, B. S., chemist and botanist. The citizens of Mesilla Valley have donated a farm of 120 acres to the station. Part of the farm was in common crops, cultivated with primitive methods; the rest was virgin soil. Irrigation was necessary. One section of the farm is "mesa" land, above irrigation level, and covered with native mesquite and tornillo. It receives only the scanty rain-fall of that arid region. This has been cleared and reveals a soil of apparently great fertility. The farm has been fenced, irrigating ditches constructed, leveling done, and buildings begun. The land is being planted with common crops to bring it into subjection.

The Agricultural Experiment Station of Utah was founded as a department of the Agricultural College of Utah by an act of the Territorial legislature, approved March 8, 1888. It was not organized until near the end of 1889, and J. W. Sanborn, B. S., was appointed director. The other members of the station staff are W. P. Cutter, B. S., chemist; E. S. Richman, B. S., horticulturist. Five buildings for the use of the station are being erected, a laboratory, bank barn (surrounded by a silo, root cellar, hoghouse, engine-house, and wagon shed), farm and dairy-house, and two cottages. The station is also well equipped with chemical apparatus and farm and horticultural implements. The legislature of the Territory has supplemented the national grants of money by liberal appropriations for buildings, farm tools, and stock. Eighty-five acres are now covered with crops; 40 acres are serving the combined purposes of inquiry and economic farming. The field experiments now in progress include tests of grasses, clovers, and other forage plants, oats, wheat, corn, barley, sorghum, and sugar-beets; the cultivation of corn, potatoes, and wheat; rotation of crops; tests of fertilizers; and the relative ability of different crops to obtain nitrogen from the air. Box experiments are also being made with reference to soils, evaporation of water, and the growth of various crops. Feeding experiments, meteorological observations, and tests with the dynamometer are also planned. In horticulture, tests of varieties of apples, pears, plums, peaches, cherries, strawberries, raspberries, apricots, and various other fruits, and of vegetables and economic fruit-trees not grown in the Territory have been commenced. Systems of tillage and irrigation will also be tested by the horticultural department.

LINES OF WORK PURSUED BY THE STATIONS.

A classification of the lines of work pursued by the several stations has been attempted in the table on pages 552, 553. The following explanatory statements may serve to help to a clearer understanding of what the stations are doing in the various branches of investigation.

Meteorology and climatology.—Some 25 of the stations are working on these subjects. Some of them simply make observations on the barometric pressure, temperature, humidity, rain-fall, direction and velocity of the wind, etc., and publish the records in bulletins and reports. At others there is an organized weather service, in some instances co-operating with the United States Signal Service. In such cases more complete observations are made and recorded and weather bulletins are sent out. The Alabama Station has recently published a bulletin entitled the climatology of Alabama, in which are contained records extending back more than a century.

Soil.—The investigations of the soil made by the stations are conveniently grouped under three heads: (1) geology, physics, and chemistry; (2) tillage, drainage, and irrigation; (3) action of manures and soil tests.

(1) *Geology.*—Inasmuch as soils vary with the character of the rocks from which they are formed it is desirable to know the history, *i. e.* the geology of the soils of districts in which investigations are being carried on. In so far as the needed information is not supplied by the geological surveys it becomes necessary for the stations to make studies in this line. Thus far, however, but little has been done by the stations. The work is confined to particular localities or to details not included in more general geological surveys. As a rule the experiment station worker will take up his investigation of the soil where the geologist leaves it.

Soil physics.—The fertility of a given soil is decided very largely by its texture, moisture, and temperature. Upon the texture of a soil depend the ease with which it is tilled and the readiness with which air and water and the roots of plants can penetrate it. The principal factors are the fineness of its particles and their character, whether sand, clay, humus, etc. The moisture depends upon not only the rain-fall but also the texture of the surface soil and the Strata below. Temperature and moisture are closely connected. several stations are investigating the texture of soils by mechanical analyses and other means. A number are making regular observations of the temperature of soils at different depths, from an inch to 8 feet, with a view to learning the variations in different seasons and years and under different conditions of rain-fall, drainage, etc., and thus learning more of the relations of soil temperature to plant growth.

Soil chemistry.—Although mere chemical analysis of a soil is not a sufficient basis for judging what kind of fertilizer will be best for it or what crops may be most successfully grown upon it, yet when taken in connection with the physical properties of the soil, chemical analysis is an efficient aid. This is especially true of wide areas of the virgin soils of this country. Investigations in this line are being made by a number of stations, especially by that in California, as stated on pages 498–503.

(2) *Tillage, drainage, and irrigation.*—The effects of different methods of tillage, as harrowing and cultivating, on the mechanical condition of the soil, on its power to absorb and retain moisture and heat and to prevent evaporation, the movements of water in the soil, the rates of outflow from tile drains, the methods for distributing drainage waters with reference to the needs of different soils and crops, and the relations between rain-fall and drainage are among the special problems on which work is being done by the stations. Problems relating to irrigation are being investigated in the States of the West containing large areas of arid lands. The work there undertaken includes not only studies on methods of irrigation but also investigations on special topics, such as the kinds of water suitable or unsuitable for irrigation, or the effects of irrigation and drainage on the alkaline deposits at the surface of the soil, which are in some places disastrous.

(3) *Soil tests with fertilizers.*—It has been found by experience that the most practicable method for finding what fertilizers are best for worn-out soils is to put the question to the soil with different fertilizing materials and get the answer in the crops produced. As it is obviously desirable that such work should be carried on systematically in accordance with well-matured plans, a considerable number of the stations have adopted plans formulated and published by this Office and have enlisted the co-operation of intelligent farmers in different sections of their respective States. These men, working on their own farms under the direction of the stations, have been enabled in many cases to find the needs of their soils and profitable ways to supply them; they have developed capacity for accurate and valuable experimenting, and the educating influence of their work in their communities has been great. An important result of the work in the different regions has been to bring out more clearly than ever before the wide differences in soils and show how they should be studied in order to learn what kinds of tillage, manures, and crops are most advantageous. Of course many of the experiments fail, but the success on the whole has been very considerable. Illustrations are found in the reports of a number of the stations as in those of Connecticut, New Jersey, and Kentucky.

Fertilizers: Analysis, inspection, control.—Throughout the older regions of the country, including the Atlantic and Gulf States and portions of those in the Ohio Valley and some others, phosphates, potash salts, and other commercial fertilizers have become a necessity. The value of these depends mostly upon the fertilizing ingredents, nitrogen, phosphoric acid, and potash, as shown by chemical analysis. So extensive is the use of these articles and so important the testing of their composition that a number of States have on their statute books laws requiring the official inspection of commercial fertilizers. The inspection and analysis are made in some cases by the stations, and in others by State officers appointed for the purpose. In some cases the stations simply make the analyses called for by the law or the necessities of the farmers, while in others the stations collect the samples of fertilizers, make the analyses, publish the results, and if necessary, prosecute parties who violate the laws by either selling fertilizers without statement of composition or selling articles which do not come up to the composition stated. The official inspection, publication of analyses, and prosecutions where called for are included in what is commonly called fertilizer control.

Field experiments with fertilizers.—Besides the experiments for soil tests above referred to, the stations conduct field trials to test the effects of fertilizers upon staple crops, vegetables, fruit-trees, or special crops in particular localities. The proper methods for applying fertilizers also receive attention.

Crops: Composition, manuring and cultivation, varieties, rotation.—Under these heads are included studies of the more important crops, such as corn, oats, wheat, potatoes, tobacco. Analyses are made to determine the composition of the plants and of their different parts, as grasses, hays, and the kernels and stalks of corn. By such means light is obtained regarding not only the character of the product but also the best time and methods of growing and of harvesting. Different methods of manuring and cultivating are also being tested, and at some stations systems of rotation of crops are being tried with a special view of introducing greater diversity in the agriculture of some localities. An important part of the stations' work with crops is the testing of the merits of different varieties of grains, vegetables, fruits, etc. The tendency to improper naming of varieties and the selling of old varieties under new names has led the stations to take steps toward the adoption of systematic rules for nomenclature.

Feeding stuffs: Composition, digestibility.—The stations are making many analyses of the feeding stuffs used in their respective localities as a means of judging of their nutritive values and the best ways to use them. To a similar end the materials are used in feeding experiments with different kinds of animals. The digestibility of the feeding stuffs is studied both by laboratory experiments and by feeding them to animals.

Silos and silage.—Many stations are studying such questions as the location and construction of silos, the kinds of crops suitable for silage, and at what stage of growth they should be harvested, methods of storing the silage, the changes in silage brought about by the fermentation arising from the action of bacteria and other causes, the effects of silage on the growth of animals and on the quantity and quality of milk and butter.

Feeding of animals.—Thirty-one stations are conducting feeding experiments for milk, beef, mutton, or pork, or are studying methods of experimenting. Among the questions considered are the effects of different feeding stuffs and rations upon the quantity and quality of milk yielded by cows, upon the flesh, muscle, and bone of beef, and upon the lean and fat of pork, etc. The manurial value of different feeding stuffs is also taken into account. Not only are different breeds of animals compared, but of late more and more attention is being paid to individual differences in animals of the same breed. It is already clear that individual peculiarities are often of more consequence than breed distinctions, and that the farmer should not only be careful to choose animals according to the purpose he has in view in keeping them, but should also keep a close watch on each animal and get rid of the unprofitable ones.

Feeding experiments are comparatively expensive and require the able management of experts for satisfactory results. Plans are now under consideration by which it is hoped, through the co-operation of the stations, to secure better methods of investigation and to study special problems by experiments with large numbers of animals. Much help in this line of work has been received, and more is expected, from individual and associated breeders and dairymen in different parts of the country.

Dairying.—Not only is the feeding of dairy animals above referred to an important part of station work, but many special investigations are in progress on the composition of milk, the influence of minute organisms (bacteria) on the souring and creaming of milk, the devising or testing of different methods for the raising of cream and the making of butter and cheese. In several States special attention has been devoted to creameries. Much has been done by the stations to promote paying for the milk delivered to creameries according to its quality as well as its quantity. As an aid in this direction much ingenuity has been exercised in devising simple, inexpensive, and accurate methods of testing the proportion of butter fat in milk. Several such methods have already been devised and are more or less widely used. They promise to be very serviceable to dairymen in testing the quality of the milk of individual cows and getting rid of the unprofitable ones. A brief account of these "milk tests" is given on pages 527–536 of this report.

Chemistry.—As already indicated, a very large amount of chemical work is done by the stations in the analysis of soils, fertilizers, feeding stuffs, and foods. Besides this they are called upon to make many analyses of other things, as waters and minerals.

Not content to work in routine ways the chemists are continually devising new and better apparatus, improving the methods of analysis, and pushing their researches into the higher fields of inquiry. Through the Association of Official Agricultural Chemists systematic co-operation in this work is secured.

Botany.—While most of the work of the stations which relates to plants might be included under this head, it is convenient for our present purposes to make this term embrace only studies on the general classification of plants, vegetable physiology, plant diseases (mycology), seeds, and weeds. In our newer and some of our older States much remains to be done in the systematic collection and study of species of grasses, and other plants which may be useful in agriculture. The problems relating to vegetable physiology, *i. e.* to the ways in which plants live, are nourished, and grow, have as yet received comparatively little attention in this country. In both these lines the stations are making a beginning of useful investigations. There is now considerable activity in the study of the diseases of plants, especially those due to the action of fungi. New species of fungi have been discovered, and the life history of many formerly known has been traced out. Attention is also given to the devising and applications of remedies, especially fungicides. Much useful work in this line has been done by the stations during the past year.

The testing of seeds as regards their purity and vitality has been a part of the work of 25 stations. These tests are made in appropriate apparatus, in the greenhouse, and also in the garden and field.

The study of species of weeds as to their prevalence, ability to rob the soil, seed-producing capacity, the dissemination and vitality of the seed, propagation by roots or stems, poisonous or other obnoxious qualities, methods for their eradication, etc., has been undertaken to a limited extent.

Horticulture.—The work of the stations in horticulture has thus far consisted very largely in the testing of new varieties of vegetables and large and small fruits, or of old varieties with reference to their introduction in localities where they have not been grown hitherto. To facilitate this work and make its results of general use the stations have co-operated with this Office in establishing uniform conditions and methods for such tests and in bringing their work to the attention of originators of new varieties in order that as far as practicable such varieties may be carefully tested by the stations before they are offered to the public. One important feature of this horticultural work has been the detecting of identical varieties which are innocently or fraudulently distributed under different names. While much still remains to be done to systematize variety testing and to bring order out of the present confusion, the horticulturists of the stations are rightly unwilling to confine their operations to this line alone and are doing a considerable amount of work with reference to the improvement of varieties by selection of seeds and plants and by cross-fertilization.

Forestry.—Twenty stations have begun operations in forestry. The work thus far done has been mainly the planting of different varieties of forest-trees to test their adaptability to the climate and needs of particular sections. A similar line of work has been undertaken with trees suitable for wind-breaks.

Entomology.—Thirty-one stations investigate injurious insects with a view to their restriction or destruction. A portion of the work includes the tracing of the life history of insects, the kind of plants they injure, and the ways in which this injury is done. A great deal of attention has recently been paid to the use of insecticides, such as Paris green, London purple, and white arsenic, with the aid of spraying apparatus or otherwise for the destruction of injurious insects. The experiments have included the tests of various substances with reference to their effects not only upon insects but also upon the foliage of different kinds of plants.

Apiculture and aviculture.—Problems relating to the raising, housing, and general care of bees and poultry are being studied by several of the stations.

Veterinary science and practice.—The investigations in this line have reference to the causes, symptoms, and treatment of animal diseases. Such diseases as hog cholera, Texas fever, and tuberculosis have received the most attention. Experiments have also been made with reference to the effects of such operations as dehorning and spaying and the methods of performing the operations.

Technology.—Under this head are included experiments in the making of sugar from cane, beets, or sorghum, wine making, etc. The Louisiana Sugar Experiment Station has been the most active in experiments on the production of sugar from cane, and the California Station in investigations on wine making. The cultivation of sorghum and sugar-beets, and the production of sugar from them is now occupying the attention of several stations.

While collectively the work of the stations covers a very wide range, individual stations for the most part limit their work to a comparatively small number of topics. The experience of our stations is already teaching the lesson which the European stations learned long ago, that a few subjects well studied are preferable to many with less thorough work. Some stations have, therefore, recently given up lines of work in which they found by experience they could not profitably engage. On the other hand, increase in resources has enabled some stations to establish new departments of investigation.

ILLUSTRATIONS OF STATION WORK.

The following statements, compiled from reports of the work of the stations received by this Office in 1890, may serve to indicate the nature and value of their experimental inquiries as illustrated by their practical outcome. Of course no attempt has been made to cover all the points of interest or value presented by the current record of a year's work of the stations. The object is simply to indicate some of the ways in which the stations are endeavoring to aid the farmer. For a more complete showing of the scientific character and practical utility of such work resort must be had to the bulletins and reports of the stations and to those publications of this Office in which the station publications are summarized, especially the Digest of Annual Reports and the Experiment Station Record. In the references to station publications given in this report in foot-notes, each station is designated by the name of the State in which it is located, *e. g.*, New York (Cornell) Station Bulletin No. 5 means Bulletin No. 5 of the Cornell University Agricultural Experiment Station at Ithaca, New York. A full list of the stations, with addresses is, given on pages 548 and 549.

CORN.

Experiments with corn at the Illinois Station* have led to the following among other conclusions:

Not to exclude other meritorious varieties, the following medium-maturing dent varieties may be safely recommended for general culture in Central Illinois: Yellow—Leaming, Clark's Iroquois, Legal Tender, Riley's Favorite, Fisk. White—Champion White Pearl or Burr's White, Gourd-Seed, Clark's Premium 110-Day. The following, which are desirable early-maturing varieties in this latitude, may be recommended for general culture in Northern Illinois: Yellow—Murdock, Edmonds or Kane County Pride, Grange Favorite, King of the Earliest (for very early). White—Wisconsin White Dent, Champion of the North.

The following, which are almost too late for this latitude, would probably be desirable farther south: Yellow—Improved Orange Pride, Steward's Improved Yellow, Swengel. White—Helm's Improved, Parrish.

There are many good varieties of Indian corn for this latitude. No one variety tested was noticeably superior to all others.

Such phrases as "ninety-day" or one-hundred-day" corn are misleading, if meant to teach that ordinary field corn will fully mature in average seasons in this latitude in the number of days named. The early-maturing varieties required one hundred and twenty-five days or more to mature fully.

The medium-maturing varieties, or those maturing about September 25, gave larger yields of well-dried corn than either earlier or later varieties.

Thoroughly air-dried corn contains about 11 per cent of water in the shelled grain. The loss in weight after husking is greater than is generally recognized. It may be from 10 to 20 per cent. Eighty pounds of ear corn, as husked, of the medium-maturing varieties, would not make more than a bushel of air-dry corn.

Barrenness of the stalk seems to depend much more on the conditions under which the crop is grown, as thickness of planting and the season, than on the variety.

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*Illinois Station, Bulletin No. 8, G. E. Morrow.

The date of planting within the limits ordinarily fixed for corn planting in this latitude had little influence on the yield of a medium-maturing variety.

Depth of planting did not materially affect the yield either in 1888 or 1889. In the latter year the roots which supported the plant during the most of its growth usually started within 2 inches of the surface, whatever the depth of planting. Unless the soil near the surface has not sufficient moisture, there seems to be no good reason for planting corn in this region more than about 3 inches deep. Drill planting was not found materially better than hill planting either for the production of corn or fodder. The quantity of seed planted controlled the yield, rather than planting one or four kernels in a place. For corn alone, planting at the rate of one kernel every 9 or 12 inches gave better results than thicker or thinner planting. For fodder, planting at the rate of one kernel every 6 inches gave better results than planting twice as many kernels.

Stirring or cultivating the soil while the crop is growing was not essential in either 1888 or 1889. Good yields of corn were obtained where there was no cultivation after planting, except to remove the weeds by scraping the surface.

Preventing the growth of weeds was more important than stirring the soil.

Root pruning injured the crop. Stirring the soil to a depth of 4 inches or more will injure many roots of the corn. Comparatively few roots will be affected if the soil is not stirred more than 2 inches deep.

Shallow-working cultivators gave better results than deep-working ones, but required more care and skill in their use. The deep-working shovel cultivators killed the weeds more thoroughly than the shallow-working ones, but the latter injured the roots less. Usually, frequent cultivation did not repay the extra cost.

Commercial fertilizers failed to increase materially the yield of either corn or fodder in any one of nine trials. The soil apparently had a sufficient supply of the plant food that these fertilizers furnish.

Stable manures increased the yield of corn and fodder in most cases, but not always enough in one year to repay certainly the cost. Fair crops were produced on land which had been in corn for fourteen years without manure of any kind. For like soils in Illinois, the estimates often made of the value of either commercial or barn-yard fertilizers, based on the price at which the elements of plant food contained by them can be bought, are misleading.

The yield of most varieties, and the average yields of all, in 1888 and 1889, were above the average reached by good farmers in field culture. Probably the chief reasons for this result were that the varieties were better than the average; that more than usual care was taken to secure a good seed bed and to plant well, thus securing a good and uniform stand; and that the cultivation was more careful than in average field culture.

Experiments with corn have been carried on for a number of years at the Ohio Station,* from which the following conclusions, especially applicable in that State, have been drawn:

(1) Considering the several varieties of corn, according to our present classification, the large yellow dent varieties, as a class, are most productive. Large white dents take second place, followed by medium yellow dents, mixed dents, and medium white dents in the order named.

(2) In the flint varieties the large white flints take the lead, followed by mixed flints, and these by yellow flints.

(3) Taken as a whole or as individual varieties, the flint varieties are not a profitable class for Ohio land, unless it should be in some of the northern sections. The following are noted as failures at the station: Smut Nose, Top-Over, Hudson Bay, Angel of Midnight, Chadwick, Tuscarora, and King Philip.

(4) The soft or flour corns have failed to mature in the tests of the last two years. To grow them for stock-feeding purposes would not be profitable, and if they are valuable for house use their failure to mature prevents their general adoption in this latitude.

(5) Any of the large yellow dent varieties will give fair yields, but the ones more certain of maturing are the Leaming, Murdock's Improved, and Woodworth's. The Chester County Mammoth, Cloud's Early Dent, and Golden Beauty are quite uncertain, but when they mature they are fine varieties and good producers.

(6) Among the medium yellow dents the Clarage and Farmer's Favorite are recommended. Either of these is ten days earlier than any of the large yellow dents, and is probably better adapted to the more northern parts of the State.

* Ohio Station, Bulletin Vol. III, No. 3, J. F. Hickman.

(7) Of the large white dents Hess's White is a good variety for gravelly loam soils or other soils of a gravelly nature. The Champion Early Pearl has done fairly well this year and promises to be a good variety.

(8) In seven years' experiments with deep and shallow planting the average results show an advantage in favor of planting 1 inch rather than 2 inches deep, but indicate that in dry seasons it may be better to plant 2 inches deep.

(9) The greatest amount of marketable corn has been produced where the stalks averaged 12 inches apart; the variations in yield were slight, whether planted one grain every 12 inches, two every 24, three every 36, or four every 48 inches.

(10) Three years' trial has not indicated any marked differences in the reproductive qualities of corn from the butts, middles, or tips of the ears. If there is any variation it is in favor of middles and tips and against the butts.

(11) The experiments of 1888 and 1889 indicate that corn should be cultivated more frequently in a dry season than in a wet or ordinary one.

(12) The average results of two years' experiments favor deep cultivation rather than shallow. The implements used were the harrow and cultivator for shallow tillage and the double shovel for deep.

Experiments were conducted at the Pennsylvania Station* in 1888 and 1889 to study the adaptability of some varieties of field corn to this section, and also to make observations upon the yield of the corn plant at different stages of its growth.

The Self-Husking variety was the earliest of the flints. The Queen of the North, Wisconsin Earliest White Dent, Minnesota King, Leaming, Queen of the Prairie, and Cleaver were the dents which matured. They are named in the order in which they matured. The Golden Beauty, Golden Dent, Hickory King, and Champion White Pearl can not be recommended for cultivation for grain in our section. In the southern part of the State and in many of the river valleys they may be grown. They are named in order of earliness, although there is but slight difference between them. They would be much earlier than the larger varieties, Chester County Mammoth, Mammoth White Surprise, and White Giant Normandy, grown here in 1888.

[As regards the distribution of dry matter (actual food matter) in different parts of the plants, the results obtained from the field-cured samples show that] fully half of the valuable dry matter is in the ears, and of this nearly one fifth is in the cob. The leaves and husks contain from one fourth to one third of the total, and there are four to five times as much of the remainder in the butts or harder and tougher parts as in the tops. Thus, when fodder is fed whole, there is more or less waste of the butts by the animal. From our results it would seem that this loss would be from 7 to 22 pounds in every 100 pounds of dry matter. Practical experience proves that much of this may be saved by cutting up the cured fodder or putting it in the silo.

The experiments at this and the Kansas Station and elsewhere have shown that much of the dry matter of the corn crop is lost by harvesting before the corn is mature; for example, the average of the dent varieties grown at the Pennsylvania Station during two seasons shows a gain of nearly one fifth of the total amount of dry matter by allowing plants to mature.

WHEAT.

Experiments in wheat seeding.†—During nine years in which rates of seeding, ranging from 2 to 10 pecks per acre, have been tried at the Ohio Station the 7-peck rate has given the highest average yield, but is closely followed by the 5 and 6-peck rates. With a single slight exception the highest yields have been produced for seven years from seeding during the last week in September and the first week in October. In experiments covering five seasons better yields have been obtained from seeding 1½ to 2 inches deep than from shallower or deeper planting.

* Pennsylvania Station, Bulletin No. 11, W. H. Caldwell.

† Ohio Station, Bulletin Vol. III, No. 6, J. F. Hickman.

Varieties of wheat.—Among the varieties grown at the Ohio Station for six years the following are especially commended:

The Valley, Nigger, Penquite's Velvet Chaff, and Diehl Mediterranean among the red-bearded wheats; of the smooth red wheats, the Red Fultz, Poole, and Finley; of white wheats, Silver Chaff (smooth), Royal Australian (Clawson), Martin's Amber, and Democrat.

The director of the station makes the following statements regarding certain varieties of wheat which have received different names:

Sibley's New Golden and Tasmanian Red appear to be the old Mediterranean under new names. Reliable, Valley, and Egyptian closely resemble each other in the field, but show slight differences in the grain. We have not been able to distinguish Red Fultz and German Emperor from Michigan Amber. Poole resembles these closely, but is distinct. Witter was classed with them last year, but is distinct and inferior. The only point of distinction we have yet found between Hungarian and Geneva is the excessive smuttiness of the former. Diehl Mediterranean, Golden Cross, Missouri Blue Stem, and Seneca Chief are one and the same variety. Royal Australian is the old Clawson under a new and high-sounding name. Finley and Fultz are not distinguishable, whether in the field or granary. Silver Chaff, Martin's Amber, and Landreth resemble each other so closely that we can not yet describe their points of difference, if they have any. Martin's Amber may prove to be slightly different after further comparison. Of other varieties we are yet in doubt. It is not always possible to decide positively whether two differently named lots of wheat are identical or otherwise from a single season's observations, especially if the seed has been obtained from different localities.

Bearded vs. smooth and red vs. white wheat.—During the past ten years ninety-five trials of white wheats and three hundred and thirteen of red wheats have been made at the Ohio Station.

The average yield per acre for the white wheats has been 30.8 bushels per acre, while the greater number of red wheats have averaged 31.5 bushels per acre for this series of ten years. During the ten years one hundred and sixty-two trials of bearded wheats have been made, giving an average of 31.7 bushels per acre, while two hundred and thirty-four trials of smooth wheats have given an average of 31.1 bushels.

The differences in the yields of these different classes of wheat in so many trials, covering such a long period, are so slight as to indicate that under the conditions prevailing at this station one kind is about as reliable as another.

Frosted and rusted wheat.—The Minnesota Station* has been studying the effect of frost, rust, and other injurious agencies upon the value of wheat for milling and for sowing. The smoother the hull of wheat the more easily and economically can it be milled, and if for any reason the hull has been seriously injured the value of the wheat for making "patent" flour is decreased. Injuries to the hull may not affect the germ or the interior of the grain, so that wheat which grades low for milling may be of good quality for seed. In 1888 much of the wheat failed to grade high for milling, and was, therefore, indiscriminately classed as "poor wheat." When this poor wheat was used for seed it sometimes yielded good crops and sometimes failed to produce any crop. In many cases this difference in results was thought to be purely accidental, or in case differences in the seed used were observed, poor returns were attributed to a lack of vitality in the injured grain or to the slow growth of grain from "frozen" seed. But the fact generally lost sight of was that the causes which produce "poor wheat" are different in different cases, so that really there are more or less distinct classes of such wheat, which, if used for seed, will give diverse results. Dr. Har-

* Minnesota Station, Bulletins Nos. 5, 6, 7, and 11, E. D. Porter and D. N. Harper.

per, chemist of the Minnesota Station, has attempted a classification of the varieties of "poor wheat," according to the cause of the injury to the grain, into bleached, rusted, blistered, and frozen wheat.

Bleached wheat is defined as wheat which, after harvest, has been exposed to rains and the heat of the sun until the outer envelope of the grain is opaque and brittle. Ordinarily this does not affect the usefulness of the wheat for seed.

Rusted or blighted wheat is more or less shrunken in appearance, and is usually of a deeper amber color than is normal. "It is a poor wheat for milling because of the bad condition of the hull," but if not too much injured may be used for seed, as is indicated by the results of experiments.

Blistered wheat retains its normal amber color, but has a brittle hull, and in many cases contains more gluten and protein and less starch than sound wheat. "As blisters may be caused by other means than frost, and even after the wheat is cut, it is not correct to call all such wheat frosted." Except in extreme cases it may be safely used for seed if well cleaned. Cured wheat is not affected by the lowest temperature which occurs in Minnesota, but a temperature only a few degrees below freezing affects immature and uncured wheat. "Wheat well into the 'dough' stage, if subjected to a temperature below freezing, may be blistered (frosted), but when 'in the milk' the same temperature produces frozen wheat."

Frozen wheat "is badly shrunken, has lost the normal translucent amber color, is of an opaque, bronzed appearance, and has had the composition of its chemical constituents changed, as well as the internal structure of its cells destroyed." The grain contains less gluten, and the quality of the gluten is seemingly injured. In other words it appears that the material in the wheat which gives tenacity to the flour is so altered that the quality of the flour made from frozen wheat is poor. Such wheat deteriorates greatly after being harvested. When used for seed the crop is unfit for milling. Fermentation may set in later on and the chemical constituents be further changed, as was the case in Minnesota during the winter of 1888–89, so that the frozen wheat when planted in the spring was in a much worse condition than when harvested the previous fall. In the majority of cases, however, the frozen seed germinated and produced wheat having the characteristics of the seed from which it sprung. It was also observed that the difference between the crop from sound seed and that from frozen seed was not marked until after the wheat was harvested.

The desirability of cleaning the "poor wheat" to be used for seed has been shown in the experience of numerous farmers. "Indeed, in many cases seed from very poor wheat when cleaned has yielded better than wheat originally good but uncleaned. The density of wheat must largely determine its value for seed."

As the outcome of his investigations and his observations of the results of experiments by farmers Dr. Harper draws the following conclusions:

(1) A vast difference as to their seed value exists between the various kinds of "poor wheat."

(2) Rusted or blistered (frosted) wheat, if well cleaned, is safe to use for seed.

(3) Frozen wheat, which is utterly worthless for milling, is likewise of no value for seed. It can not produce a good crop.

(4) The more thoroughly wheat is cleaned the better the seed resulting and the better the crop, particularly in yield; and by cleaning I mean, besides separating the dirt, also casting out the weaker grains of wheat. Thus poor milling wheat may

be made vastly better for seed than wheat of high milling value if the latter is uncleaned.

(5) Wheat should invariably be tested as regards its gluten and percentage of germination before being seeded. It seems absolutely necessary that the seed shall contain good gluten if the gluten is to be in the crop. * * *

To most successfully carry on the mechanical operations of milling it is first necessary to have plump wheat in which the hull has not been injured. Then the best flour, after the hull is gotten rid of, is made of that wheat which contains the most gluten and the least water. Other conditions of the wheat also enter as a factor.

To grow the best crops the first necessity is to have the germ of the wheat sound and then to have compactly stored up plenty of the proper kind of food—gluten, etc. Outside influences may cause the hull to be uneven or brittle without injuriously affecting the germ and its food; and this wrinkling of the hull may not be a property which will be transmitted by the seed to the crop, although in some cases it doubtless is. But certain changes in the character of the germ and its food are unmistakably transmitted. In blistered, rusted, and bleached wheats the superficial characteristics of the wheat are changed, while in frozen wheat changes seem to have been made in the reproductive faculties.

In any lot of wheat, even of the highest grade, some grains are vastly better than others for seed, and it is a simple matter to determine which they are and how to secure them. If it had not been clearly proven before, the last wheat crop has conclusively shown that the denser any grain of wheat the better it is for seed. These are the grains which are the heaviest for their size. If wheat is well cleaned by a blast of wind the lightest grains are cast out and the heaviest remain. In these the germ is best developed and protected and has most readily available the greatest amount of necessary food. Of this gluten is of chief importance and its quantity and quality can be easily determined.

The following method has been used by Dr. Harper for roughly determining the amount of gluten in samples of wheat. The wheat is first ground as fine as possible in a copper mill and then pounded in a mortar, care being taken to break up the hull or bran as little as possible. This finely ground wheat, after being weighed, is mixed in a porcelain dish with enough water to make a good dough. The dough is placed in a linen bag and let stand in water for a few minutes until it is thoroughly wet. Then by letting water run on the bag the starch is partially washed out. The wheat is then taken out of the bag and held in the hand, under running water, over a fine sieve. By this means the starch or bran is largely washed away and the remaining substance, when dried and weighed, may be safely reckoned as the gluten of the wheat. The dry gluten should weigh at least one tenth as much as the original sample of wheat. The test outlined above indicates also the quality of the gluten, for unless the wheat is in good condition the gluten cannot be separated by this process of "washing out."

*Stinking smut of wheat.**—Fifty-one different methods of treating stinking smut of wheat have been tried at the Kansas Station in 1890. Three of these treatments, viz, copper sulphate, 5 per cent solution, applied for twenty-four hours, Bordeaux mixture, thirty-six hours, and potassium bichromate, 5 per cent solution, twenty hours, prevented all the smut, though these fungicides injured the stand of the wheat somewhat. However, in spite of this injury they increased the yield to two or three times that of untreated plats. Of all the treatments tested that known as the Jensen or hot-water treatment is deemed perhaps the best for general use, though in these experiments it did not prevent all the smut. However, when used in its most favorable form only 5 heads out of 3,912 were smutted, and it is probable that these were accidental, since they grew on two hills on the edge of the field. This treatment was devised by J. S. Jensen,

* Kansas Station, Bulletin No. 12, W. A. Kellerman and W. T. Swingle.

of Denmark, and consists in immersing the seed for fifteen minutes in scalding water (131° to 132° F.).

COTTON.

Ten stations have reported experiments or observations on cotton, including those relating to the conditions of climate and soil favorable to its growth; the development of the roots; varieties; seeds; fertilizers; methods of planting and cultivation; and diseases injuring this plant.

Meteorological conditions favorable to cotton.—The results of studies on this subject were published in Bulletin No. 7 of the South Carolina Station, from which the following statements are compiled: Two periods in the growth of the cotton plant may be distinguished. The first extends from the time of planting, which in South Carolina is about the middle of April, to the middle of the summer. This is the time in which the plant makes its growth of stalk and foliage and gathers up nourishment to be later transferred and stored up in the seed. During this period tropical conditions are favorable, namely, moisture in the soil from frequent rather than long-continued rain, high temperature with small daily variation, plenty of sunshine, little wind, and a high relative humidity of the atmosphere to reduce evaporation to a minimum. During this period everything possible is done to prevent loss of water from the soil; grass and weeds are scrupulously excluded, and the surface of the soil is frequently stirred with the hoe or otherwise to conserve the moisture and increase the temperature of the soil.

Now, if these conditions of high temperature and large proportions of moisture in the soil continue the plant will keep on growing and developing stalk, will become perennial, and will produce only the coarser grades and smaller yield of cotton found in many tropical countries. But the meteorological conditions change and the plant goes through a second period of development. In the latter part of the season in South Carolina the temperature rapidly falls, the rain-fall diminishes, the plant is changed from a perennial to an annual, the yield of cotton is increased, and the quality of the lint is improved. The second period is the fruiting period of the crop, when all the energies of the crop are turned to the ripening of the fruit. During this period the physical properties and conditions of the soil have an important effect upon the crop production. It then becomes important to ripen the crop and to produce the fruit instead of the stalk and foliage; in other words, cotton instead of weed. Every means is taken to dry out the soil, cultivation ceases, and the soil is allowed to become hard and compact to favor the evaporation of the moisture. Grass and weeds are no longer feared, and rye and barley are frequently sown during the last part of the season, being supposed by many to be of value for drying out the soil. In the stiff soils or in the bottom-lands there is often an excess of moisture, and the crop is inclined to mature late and often fails to open before frost.

On the islands and in the country immediately adjoining the coast the fine grades of sea-island cotton are produced. In the lower pine belt, which is farther back from the coast and on the ridge lands, the cotton is coarser. It is urged that differences in moisture and temperature account for these differences in the crop; that the finer grades of cotton are produced only where the physical conditions of atmosphere, and especially of soils, are fitted for the development of the weed in the early part of the season and of the fruit in the later part, and that in some cases physical conditions of the soil have been so improved by tillage as to make a very marked difference in the crop. It is therefore important to study the differences in physical characters of the soils, with a view to getting light upon the means by which the systems of tillage and culture may be so regulated as to adapt temperature and moisture of the soil to the successful growth of the finer grades of cotton over larger areas.

On the development of cotton roots.—The same bulletin also treats of this subject. The root system of the cotton plant is naturally small and the individual roots are small and delicate. After the first picking of cotton eight plants which had grown on light, sandy soil, having sandy subsoil, were dug up and examined. The tap-roots extended "straight down below 2 or 3 feet." The lateral roots commenced about 3 inches below the surface and for the most part did not go below 9 inches. Out of more than twenty plants grown on heavier loam soil, with compact subsoil, only one was found with well-developed tap-root below 9 inches. Most of the lateral roots commenced and were contained within 3 to 9 inches of the surface.

Varieties of cotton.—In a single test of eleven varieties reported from Alabama* Peerless led in early maturing, and in yield (1,080 pounds per acre) was equaled only by Jones's Improved, though closely followed by Welborn's Pet and Zellner.

In the case of twelve varieties tested at the Alabama Canebrake Station* Okra was the first to blossom and open, and produced the greatest amount of seed cotton the first picking, but less than others the second and third pickings. Zellner, Barnett, and Jones's Improved produced the greatest yields of lint and seed, the last named being hard to gin. At the Louisiana State Station* in 1888, out of thirty-eight varieties the largest yields of seed and lint were given by Jones's Improved, Herlong, and Dearing's Small Seed. In nearly every case the yields of the same varieties at this station were smaller than those at the North Louisiana Station. At the Arkansas Station, out of eight varieties reported, Crawford and Peerless gave the largest yields of seed cotton. The five varieties giving the highest average yields of lint in 1888 and 1889 at the three farms of the South Carolina Station* were Rio Grande (synonyms Texas Wood, Peterkin, Crosland), Truitt, Dearing, Minter's, and Crawford.

At the Alabama College Station* samples of cotton representing eighteen varieties grown on the station farm—sea island cotton from Savannah, Georgia, and "Bailey" fiber from North Carolina—were examined microscopically. Among the questions considered were: "(1) How many real varieties of cotton exist? (2) In forcing the plant under high cultivation is the fiber improved, or is simply the 'weed' enlarged to the detriment of the staple? Is it not often the case that the fruit of the cotton plant is damaged by too rapid maturing, just as the fruit of the peach is known to be immature at the center in some early forced varieties?" The experiments indicate "that it is not always the large plant that produces the best condition of the fiber, and that the most excellent condition of the fiber is produced only on plants which are neither too rapid nor too slow in their development, and which are given all the advantages of judicious cultivation with

* Alabama College Stations, Bulletins Nos. 12 and 13; Alabama Canebrake Station, Bulletin No. 7; Louisiana Stations, Bulletin No. 26; South Carolina Station, Annual Report for 1889, p. 275.

the proper manuring and under the most favorable conditions of the atmosphere. In improving the grade of cotton the plant must be forced to produce fiber that is (1) long, and as nearly as possible uniform in length; (2) of uniform diameter throughout; (3) flat and ribbon-like, and well twisted." Seed selection should be repeated from year to year, and no inferior cotton planted near enough to vitiate the chosen variety with its pollen. In these experiments the strongest fiber was produced by the Truitt variety; the largest by Barnett; the smallest by No. 1, Hawkins' Improved and Peterkin; the longest by Okra Leaf; the shortest by No. 2; and the best twisted by Truitt, Rameses, and Cherry's Cluster.

"The largest percentage of fiber per boll was produced by Welborn's Pet, Okra Leaf, Peterkin, Hawkins' Improved, and King's Improved, in the order named. The largest percentage of seed per boll was produced by Zellner, Rameses, Southern Hope, and Truitt, in the order named. The best grade of cotton, taking all things into consideration, is Cherry's Cluster. The second best grade is Truitt."

Comparative earliness of cotton from Northern-grown seed.—At the Alabama Canebrake Station* an experiment was made in the endeavor to find a "variety from some Northern point that would mature a crop before attacked by the worms. Seeds were obtained from Somerville, Tennessee; Carter's, Northern Georgia; and Raleigh, North Carolina. The seeds from North Carolina were of an improved variety, and those from North Georgia and Tennessee were common. They were planted March 28, on one-third-acre plats, in black slough bottom-land." The results from these seeds were sufficiently better than those from seeds grown at the station to justify a repetition of the experiment.

Fertilizers for cotton.—Experiments on the poor, sandy soils of the three farms of the South Carolina Station† in 1888 and 1889 indicated "that marl and copperas produced no effect upon the crop; that separate applications of potash, phosphoric acid, and nitrogen were equally valueless; that their combinations produced marked effects; that phosphoric acid and nitrogen played the most important parts; that potash was of relatively less value than the other two; that excessive applications of one or all three gave no adequate returns."

Of nitrogenous fertilizers stable manure gave the best results, while those obtained from nitrate of soda, dried blood, cotton-seed meal, and cotton seed were nearly equal. In nearly every case the half ration of nitrogen gave as good results as the full ration.

Acid phosphate proved more effective than reduced phosphate, which in turn gave better results than slag and floats.

Kainit and muriate and sulphate of potash gave equally good results. As a rule kainit would be preferred on account of its relative cheapness.

In Arkansas‡ potash and phosphoric acid were profitably used in experiments in 1888 at Texarkana and Lufra; nitrogen, potash, and phosphoric acid, at Monticello; and nitrogen (in cotton-seed meal) at Pine Bluff, on land which had been almost continuously in cotton for thirty years.

In Alabama‡ experiments on sandy loam soil with clay subsoil indicated that phosphoric acid was the fertilizer especially needed.

*Alabama Canebrake Station, Bulletin No. 7.

† South Carolina Station, Annual Report for 1889.

‡ Arkansas Station, Annual Report for 1889; Alabama College Station, Bulletin No. 12.

At the North Louisiana Station* experiments have indicated that these particular soils need nitrogen very badly, but it is not so clear which is the best form to use. Cotton-seed meal gave results slightly better than any of the others, with cotton seed next. This, of course, simply tends to show that cotton seed or cotton-seed meal is a good form in which to apply the nitrogen, without prejudice to the claims of other forms, which may be excellent in their way. From a financial standpoint it seems probable that more than 24 pounds of nitrogen per acre can not be used with profit, especially on very poor soils. It also seemed probable that phosphoric acid in small quantities might profitably be applied to the soil used in the experiments. Potash apparently was not needed.

Pea vines as a fertilizer for cotton.—At the Alabama Canebrake Station† the results of experiments during the past five years have strongly favored the use of pea vines to restore fertility to worn-out soils, and implied that it is better to cut the vines for hay than to leave them on the ground. The increased yield by leaving the vines is small, and the land is much harder to prepare where the vines are left. From 2 to 5 tons of hay can be cut from 1 acre in vines. The increased cotton grown by leaving the vines to rot on the land was worth only $8.75 per acre, while the vines cured into hay would be worth not less than three times that sum. The effect of the vines upon crops after the first season has not been ascertained.

Cotton root rot.—The Texas Station has made a study of this disease and reported the results in Bulletin No. 7, from which the following statements are compiled: Root rot of cotton occurs in soils of various kinds, but is worse in black, cretaceous soils which are poorly drained. Moisture and heat are favorable to its development, but the character of the forest growth has nothing to do with this disease. "It occurs alike on the mesquite soils of Travis and Hays Counties and the post-oak lands of Eastern and the bois d'arc lands of Northern Texas." Theories as to its origin founded on the chemical constituents of soils and especially on the "alkali" present in many soils, are not sustained by the facts. Alkali, as the term is used, is very vague, and does not apply to the Texas soils where cotton dies from root rot. In California cotton succeeds admirably on "alkali" soils, while fibrous-rooted plants do not thrive on such lands. In Texas, on the other hand, the fibrous-rooted plants, like grasses, do not die from root rot. "Seedling rot" and "sore shin" should not be confounded with root rot. "Seedling rot" affects only young plants.

Root rot of cotton is caused by a fungus, *Ozonium auricomum*, invariably found on roots which have died from this disease. If plants are examined before they have wilted a white, mold-like fungus, the early stage of *Ozonium*, will be found on the surface of the roots. Young plants in pots inoculated with threads of the *Ozonium* died of the disease. The wart-like bodies found on the roots of cotton and other plants affected are masses of the fungus and retain vitality for a long time. The *Ozonium* does not, however, produce the knotty bodies often found on the roots of diseased apple-trees. A large number of plants are affected by this fungus, as sweet-potatoes, apple and some forest-trees, and also the weed known as common sida (*Sida spinosa*). The *Ozonium* prepares the way for a large num-

*Louisiana Stations, Bulletin No. 27.
†Alabama Canebrake Station, Bulletin No. 7.

ber of other fungi, which complete the destruction begun by the root rot. The lint from plants affected with root rot is much inferior in quality. Seeds from diseased stalks showed good capacity for germination.

Treatment.—Fungicides did not check the disease, except chloride of lime, and where this was used no cotton was produced. Rotation of crops is advised as practically the only thing, so far as known, which will stop the disease. Grasses should be grown in the rotation, allowing three years to intervene before cotton is again planted. Care should be taken not to obtain plants from an infected nursery or field.

LEGUMINOUS PLANTS.

During 1890 the Connecticut Storrs Station* has reported the results of experiments with different varieties of leguminous plants with regard to their value in Connecticut for hay and green fodder for manurial purposes. The following summary of practical conclusions is taken from Bulletin No. 6 of this station:

The legumes are especially valuable because of—

(1) Their large percentages of protein compounds, which serve to form blood, muscle, bone, and milk, and their consequent feeding value, which exceeds that of the grasses, corn fodder, corn stover, or straws. They may be used to supplement these fodders in place of the concentrated nitrogenous feeds, such as bran, cotton seed, linseed, gluten meals, etc. Hay from the legumes is twice or more than twice as rich in protein as that from the grasses.

(2) Their power of gathering large quantities of plant food from natural sources. Many, if not all, of our common legumes acquire considerable quantities of nitrogen from the air. Their roots penetrate deeply into the subsoil, and they thus obtain plant food from depths beyond the reach of plants with smaller root development.

(3) Their manurial value. When the crop is fed most of the nitrogen, phosphoric acid, potash, and other fertilizing ingredients go into the excrement, liquid and solid, and if preserved, make a rich manure. If the crop is plowed under its plant food, including that acquired from the air and gathered from the subsoil, becomes available for succeeding crops. The large amounts of plant food left behind in roots and stubble after the removal of the crop furnish a cheap and valuable store of plant food for following crops.

While the clovers will doubtless prove in the future, as they have in the past, the most valuable of the legumes for general purposes in Connecticut, the cow-pea, soja bean, and vetches are valuable for forage, silage, or hay, and the experiments and observations at the station and elsewhere indicate that they are worthy of careful trial.

Cow-peas.†—Experiments with cow-peas at the South Carolina Station led to the following conclusions:

The cow-pea seems especially adapted to meet the wants of our Southern farmers. Its extensive and deep-root system enables it to withstand the long dry spells common to our climate, and also to gather nourishment from soils on which shallow-growing crops would starve. It responds readily to fertilizers, and on fair soils will produce as large a yield of nutritive matter as almost any forage crop we can grow. It makes such a rapid growth that two crops can be grown in a season. The growth is so luxuriant that all noxious weeds are choked out. The most serious objections urged against this crop are its great bulk and the difficulty of curing it. It is not, however, more difficult to cure than clover, and properly managed, makes an excellent long forage. Chemical analyses of the cow-pea plant in both the green and cured state indicate that (1) for the production of a nitrogenous food, in the shape of a forage crop, the cow-pea vines are almost without a rival; (2) on an acre of ordinary land this crop will probably produce more digestible food than either oats or corn; (3) the manure resulting from feeding this crop is of the highest value, and should be carefully preserved and returned to the land.

*Connecticut Storrs Station, Bulletin No. 6, C. D. Woods and C. S. Phelps.

†South Carolina Station, Bulletin No. 8.

*Selection and production of fodder crops.**—As a result of his experience Dr. C. A. Goessmann, director of the Massachusetts State Station, states that the introduction of new crops, especially the legumes, which utilize the nitrogen of the air and soil, and the growth of a greater variety of fodder plants, enable us to meet better the differences in local conditions of climate and of soil, as well as the special wants of different branches of farm industry; and taking this view of the question, the great and valuable family of leguminous plants, such as clovers, vetches, lucern, serradella, peas, beans, lupines, etc., is, in a particular degree, well qualified for that purpose. They deserve also a decided recommendation in the interest of a wider range, for the introduction of economical systems of rotation, under the various conditions of soil, and different requirements of markets. Most of these fodder plants have an extensive root system, and for this reason largely draw their plant food from the lower portion of the soil. The lands are consequently better fitted for the production of shallow-growing crops, as grains, etc. Large productions of fodder crops assist in the economical raising of general farm crops; although the area devoted to cultivation is reduced, the total yield of the land is usually more satisfactory. In a number of instances the station has had good success in bringing up old, worn-out grass land by the use of leguminous forage plants.

THE ACQUISITION OF ATMOSPHERIC NITROGEN BY PLANTS.†

Farmers in all older portions of the country buy large quantities of nitrogen in artificial fertilizers. Nitrate of soda, sulphate of ammonia, dried blood, cotton-seed meal, and fish scraps owe their fertilizing value mainly, and Peruvian guano and tankage largely, to nitrogen, and the same element is one of the chief ingredients of bone manures, ammoniated phosphates, and many other fertilizers. According to an estimate by the Connecticut State Station not less than $500,000 are expended annually for commercial fertilizers in Connecticut. A large amount of this goes for nitrogen, which is one of the dearest of the ingredients of fertilizers and costs at retail from 8 to 18 cents or more a pound. The plants must have this nitrogen or they can not grow. They obtain part of it from the soil and the rest from the air. The nitrogen of the soil has either been accumulated in the past or is supplied in manures. A small quantity in the form of ammonia and other compounds of nitrogen is continually brought to the soil by rain or snow. Late research implies that soils require nitrogen from the air, by the aid of microbes or electricity, or probably both. The nitrogen in the soil is being continually leached away by drainage water, and more or less of it escapes into the air. Soils which are not cultivated, and from which the produce is not removed, accumulate more nitrogen than they lose, so that many virgin soils have a large stock. By ordinary cultivation and cropping the nitrogen is gradually exhausted, unless it is returned by manures or otherwise.

Of the total weight of the air four fifths are nitrogen. This means that over every square inch of the earth's surface there are 12 pounds of nitrogen, and over every acre of land nearly 38,000 tons. Nearly all of the nitrogen of the air is in the form of what is called free nitro-

* Massachusetts State Station, Bulletin No. 36.

† Connecticut Storrs Station, Annual Report for 1889, W. O. Atwater and C. D. Woods.

gen, that is, not combined with any other chemical element. A minute proportion is combined with other elements, in the forms of ammonia, nitric acid, etc. The important question is: Can plants make use of atmospheric nitrogen to any considerable extent? It has been agreed on all hands that the combined nitrogen of the air may be used by the plants; but the quantity is so extremely small as to be of comparatively little consequence. From the practical standpoint it makes very little difference in what form the plants get the nitrogen, provided they can get enough. If there are plants which can be used to gather any considerable amount of nitrogen from the air without cost, the fact is of immense importance, and ought to be clearly understood and rightly applied in practice. Interesting as this problem is to the farmer, it is none the less so to the chemist and vegetable physiologist, and has been the subject of active discussion and experiment for more than fifty years. There are certain kinds of plants, like clover, beans, and others belonging to the family of the legumes which generally get on very well without nitrogenous fertilizers in worn-out soils, and it would seem as though these plants, at any rate, must in some way be able to make use of the nitrogen of the air. But the classic experiments of Boussingault in France, of Lawes and Gilbert in England, and others, have been widely accepted as proving that plants can not use the free nitrogen of the air, and that they get practically very little combined nitrogen from the air, so that they are dependent upon that previously stored in the soil or supplied in manures. Experiments in 1881 and 1882 at Wesleyan University by Professor Atwater, brought the first positive evidence that some plants do acquire large quantities of nitrogen directly from the air. These and later ones by Hellriegel and others in Europe, and those by the Storrs Station have led to the following conclusions:

(1) Peas, alfalfa, serradella, lupine, clover, and apparently leguminous plants in general, are able to acquire large quantities of nitrogen from the air during their period of growth.

(2) There is scarcely room to doubt that the free nitrogen of the air is thus acquired by plants.

(3) That there is a connection between tubercles found on the roots of certain plants and this acquisition of nitrogen is clearly demonstrated. What this connection is, what are the relations of micro-organisms to the root tubercles and the acquisition of nitrogen, and, in general, how the nitrogen is obtained, are questions still to be solved.

(4) The cereals with which experiments have been completed have not manifested this power of acquiring nitrogen, nor do they have such tubercles as are found on the roots of legumes.

(6) As a rule, the greater the abundance of root tubercles in these experiments, the larger and more vigorous were the plants and the greater was the gain of nitrogen from the air.

(7) In a number of these experiments, as in similar ones previously reported, there was a loss of nitrogen instead of gain. The loss occurred where there were no root tubercles; it was especially large with oat plants, and largest where they had the most nitrogen at their disposal in the form of nitrates. As the gain of nitrogen by the legumes helps explain why they act as "renovating crops," the loss in the case of the oats suggests a possible reason why they should appear to be an exhaustive crop.

Practical inferences.—The ability of legumes to gather nitrogen from the air helps to explain the usefulness of clover, alfalfa, peas, beans, vetches, and cow-peas as renovating crops, and enforces the importance of using these crops to restore fertility to exhausted soils. The judicious use of mineral fertilizers (containing phosphoric acid, potash, and lime) will enable the farmer to grow crops of legumes, which after being fed to his stock will, with proper care to collect and preserve all manure, both liquid and solid, enable him to return a "complete fertilizer," in the shape of barn-yard manure, to his land. A further advantage of growing these crops is that the nitrogenous material, protein, which they contain in such great abundance, is especially valuable for fodder.

FEEDING EXPERIMENTS.

*Feeding experiments with steers.**—Feeding experiments carried on at the Texas Station for two seasons, in which ninety-eight steers have been fed on the principal available feeding stuffs of the State, used in different mixtures and amounts, have led to the following conclusions:

(1) Of our different cattle foods, a ration made up of cotton hulls and cotton-seed meal is equal, if not superior, to a ration of any other two feeding stuffs used for fattening cattle, but a cheaper ration may be compounded of silage and cotton seed, or of corn, hay, and cotton seed, at the prices given.

(2) The addition of some other feeding stuff to the cotton hull and cotton-seed meal ration makes it more palatable to cattle, and produces better results in gain in weight. Corn meal, hay, silage, and molasses, each one added to cotton hulls and cotton-seed meal, made larger gains than hulls and meal alone, in the order named, molasses giving the best result.

(3) Of the several rations containing silage, silage with cotton hulls, and cotton-seed meal gave the best gains; silage with cotton-seed meal came second; silage with boiled cotton seed third; silage with corn-and-cob meal, and cotton-seed meal fourth; silage with corn-and-cob meal fifth. Dry corn fodder did not give as large gain as silage. Molasses did not improve the ration containing silage.

(4) Cotton hulls and cotton-seed meal, with hay, corn, silage, and molasses, gave larger gains than silage and cotton-seed meal, or silage and cotton seed.

(5) Cotton-seed meal, with other feeding stuffs and fodders, gave larger gains than cotton seed with other feeding stuffs and fodders.

(6) Cotton seed, with other feeding stuffs and fodders, made gains at less cost for food than cotton-seed meal with other feeding stuffs and fodders.

(7) After feeding any of the rations used without change for sixty days, the daily gain diminished, until finally, in some pens, it ceased entirely; but with a change of ration, the daily gain in all of the pens was largely increased, in some pens exceeding the average of the first period of feeding.

(8) Corn and hay alone are more costly, and will not fatten cattle as rapidly as rations containing cotton seed and cotton-seed meal with cotton hulls or silage; and boiled cotton seed added to the corn and hay ration makes more rapid gain than corn and hay alone, and at considerable less cost per pound for food consumed.

(9) The waste from cattle fed hay, corn, silage, and raw cotton seed was worth considerable more for hogs running after the steers than the waste from cattle fed silage, cotton hulls, and cotton-seed meal.

Feeding experiments with pigs.†—Feeding experiments with twelve pigs, carried on at various times during nearly eighteen months at the Maine Station, indicate that the profits of feeding swine may depend in part upon the way in which feeds are combined and not follow the market values. In six feeding periods where the rations compared contained practically the same digestible material, 2,643 pounds of digestible feed in one combination produced 890 pounds of growth while 2,651 pounds of digestible food in another combination with less of nitrogenous material produced only 617 pounds. In other words, it took nearly one half more feed to produce a pound of growth with one set of rations than with the other. A certain proportion of nitrogenous feeds, like skim-milk, pea meal, and gluten meal increased the efficiency of the ration in a marked manner. The advantage of a nitrogenous feed in the ration seems to pertain to the fattening period as well as to the period of growth. A mixture of pea meal and corn meal or of gluten meal and corn meal proved to be much more efficient than corn meal alone in feeding animals already well grown and quite fat. When we consider that over 70 per cent of the weight added to the body of a fattening hog is fat, while only 6.5 per cent is lean meat the favorable influence (at least indicated) of a liberal supply of protein upon fat production is very apparent. No marked

*Texas Station, Bulletin No. 10, F. A. Gulley and J. W. Carson.
† Maine Station, Annual Report, 1889, p. 85.

effect was noted upon growth by a wide variation in the amount of drink given the different animals. Pigs weighing about 109 pounds took approximately 7 quarts of water daily and made but slightly less gain than animals of the same size drinking only half as much. When unskimmed milk was substituted for part of a ration with corn meal, without changing the amount of dry matter fed, the efficiency of the ration was greatly increased. A still further substitution of milk for meal appeared not to increase the rate of growth. For instance, a ration, one third of the nutrients of which were furnished by skim-milk, in a single trial proved to be worth practically as much as a ration two thirds of the nutrients of which came from skim-milk. In the latter case the milk simply replaced corn meal in the ratio of 8 pounds of milk to 1 pound of meal, which is almost the exact ratio of equal quantities of digestible material.

*Skim-milk as food for pigs.**—The raising of pigs for the profitable utilization of skim-milk is an important auxiliary of dairying, which is the leading branch of farming in Vermont. Investigations at the Vermont Station having indicated that the methods of feeding employed by the best farmers involve a great waste of food materials, the station undertook experiments with special reference to economy in feeding. These were made with two pigs each of the three breeds, Berkshire, Chester White, and Yorkshire, which were fed from May 14 to November 11, 1889, on skim-milk, corn meal, and wheat bran, the rations being varied for each of four periods. The pigs sold for $5\frac{1}{4}$ cents per pound dressed weight (a lower price than the average), and shrank 18 per cent in dressing, making the selling price equal to 4.32 cents per pound live weight. The gross cost of the food consumed per pound of increase in live weight was 3.33 cents, and the value of the fertilizing ingredients in the food was 2.08 cents, making the net cost of the pork per pound, live weight, 1.25 cents. The value of the food consumed for each pound of increase in dressed weight was 4.06 cents, and the fertilizing value of this food 2.54 cents, leaving the net cost of a pound of dressed pork 1.52 cents. Since the pork sold for 5.25 cents a pound there was, on this basis, a net gain of 3.72 cents per pound. "If we suppose the manure to offset the care, and subtract from the amount received for the pork the amount paid for the grain fed, the remainder may be considered the amount realized for the skim-milk." The amount realized from 100 pounds of skim-milk averaged 24 cents.

Among the conclusions are the following:

(1) Pig feeding is profitable (in Vermont) even at the low price of $5\frac{1}{4}$ cents per pound dressed weight, provided the pig is sold at an early age, *i. e.* by the time it reaches a live weight of 180 pounds, or soon after.

(2) Grain can be fed to young pigs with profit; in feeding it to pigs weighing over 200 pounds there is a loss.

(3) Young pigs should be fed a ration in which the flesh-producing material is more prominent than the heat or fat-producing.

(4) The old saying, "Grow the pig and then fat him," should be changed to "Grow the pig and then sell him."

(5) This system of feeding and selling makes it possible to raise two sets of pigs in twelve months.

(6) The fertilizing value of the manure from the food consumed by the pig is in Vermont equal to nearly one half the value of the pork, and constitutes the largest gain from the feeding.

(7) In these trials the three breeds, Berkshire, Chester White, and Yorkshire showed but little difference, whatever difference there was being in favor of the Chester White.

* Vermont Station, Bulletin No. 18, W. W. Cooke.

In brief, the two points especially brought out in this experiment are, the value of skim-milk as food for pigs, and the fact that the largest profit is from the young animals. These results coincide essentially with those of many others made elsewhere. There is another important matter in this connection which is generally overlooked. In making pork, dairy farmers have the great advantage that skim-milk is a largely nitrogenous food. A large part of the pork produced in the United States is grown on corn, and in consequence is excessively fat. With nitrogenous food swine have better developed organs and their flesh is leaner. Lean pork is more valuable for nourishment and commands better prices. For further suggestions in this line, see Report of the Office of Experiment Stations in the Report of the Secretary of Agriculture, 1889, pp. 515-519.

*Feeding bone meal and hard-wood ashes to pigs living on corn.**—The Wisconsin Station has made three experiments in which the effects of feeding corn meal alone were compared with those where small amounts of either bone meal or wood ashes were fed with the corn meal. The animals were slaughtered at the close of the trial and the strength of the thigh bones tested. These bones were then burned to determine the amount of ash they contained. The conclusions drawn from these experiments were as follows:

(1) That the effect of the bone meal and ashes was to save about 130 pounds of corn, or 38 per cent of the total amount fed in producing 100 pounds of gain, live weight.

(2) That by feeding the bone meal we doubled the strength of the thigh bones; ashes nearly doubled the strength of the bones.

(3) There was about 50 per cent more ash in the bones of the hogs receiving bone meal and hard-wood ashes than in the others.

A careful examination revealed no difference in the proportion of lean to fat meat in the several carcasses. * * * The bone meal and ashes seemed to have no effect on the size or weight of any of the internal organs or the weight of blood. The effect is evident only in the building up and strengthening of the bones and aiding digestion. These experiments point to the great value of hard-wood ashes for hog feeding, and show that they should be regularly fed. Bone meal seems to build up somewhat stronger bones than ashes, but ashes do the work well enough and usually cost nothing with the farmer. Where they can not be obtained bone meal is strongly recommended.

SIMPLE METHODS FOR TESTING MILK.†

Farmers and dairymen have long known of the wide difference in the value of the milk of different cows for butter making. They are finding out that it is not always that cow of their herd which gives the largest quantity of milk that is worth the most for this purpose, and that cows which ordinarily pass for good cows may differ very widely in the amount of butter they produce. Many already understand also that the cost of keeping is not proportionate to the quality of the milk produced, *i. e.* that the cost of feed for the production of 1 pound of butter fat is a factor which varies widely with individual cows. Breeders are coming to appreciate the importance of judging of cows by the amount of butter fat in their milk. Creameries and patrons furnishing milk to creameries are learning that the paying for milk according to the quantity furnished is unjust, and that not the quantity of milk but the amount of butter fat which it contains should be the basis for payment.

The result is that a demand has grown up for a simple, quick,

*Wisconsin Station, Bulletin No. 25, W. A. Henry.

†This article was prepared by E. W. Allen, Ph. D., of this Office.

inexpensive, and sufficiently accurate test of the amount of fat in milk. The agricultural experiment stations realizing the importance of this subject, have within the past two or three years given considerable attention to it, and the result has been the devising and testing of several simple methods. These are another interesting application of the scientific principles of the laboratory to agricultural practice, for they place within the reach of the farmer and the breeder the means for finding out the value of each cow of his herd for dairy purposes, and of the creamery for testing the milk delivered by each patron, and that, too, with very little practice, little time, and no considerable expense.

There are several evils which the use of these tests will help to remedy. The first is the keeping of unprofitable cows in a herd. Nearly every farmer who has roughly studied his cows by the only means he has usually had, the yield of the churn, realizes that while some are profitable, others are much less so. As a matter of fact, many are really kept at a loss, and these latter naturally eat up part of the profits from the better animals. An illustration of the differences in cows, even in carefully bred herds, is furnished by the record given in Bulletin No. 9 of the Illinois Station, of tests of a herd of sixty-four cows which "had been selected and bred with more than average intelligence." The author says: "The average per cent of fat found was 4.21; the highest, 5.85; the lowest, 2.75—a variation of 3.10 per cent. The average of ten cows was 5.41; of ten others, 3.2. Dividing the herd into four equal lots, the average of one lot of sixteen was 5.18; of another lot of same number, 3.38." In another trial* the milk of thirty-eight cows, including three herds, was tested, and the total amount of butter fat contained in a single milking of each cow calculated. "If we compare Nos. 2, 3, 22, and 8 (the time since calving being in each case two hundred and forty days), we find that No. 2 produced twice as much butter fat as No. 3, and nearly five and one half times as much butter fat as No. 8, and that No. 22 produced seven and one half times as much butter fat as No. 8. Comparing No. 13 with No. 14 shows that nearly twice as much milk must be handled by the owner to get the same weight of butter fat from No. 14 as from No. 13. Besides these extreme cases mentioned, cows can be found all along the line from very profitable to very unprofitable."

To weed out these less profitable or unprofitable animals from a herd, and to make sure that every animal kept is qualified in a high and profitable degree to convert the hay and fodder articles of the farm into butter fat, is an important matter and one upon which success in dairying largely depends.

To gauge cows by the quantity of milk they give and the length of time a good yield is maintained is not sufficient if the milk is to be used for butter making. To know the amount of butter fat produced by an animal daily or weekly, not only the weight of the milk given but also the proportion of fat contained in the milk must be known. The two go hand in hand, and an estimate of a cow for butter making based on either one alone is not altogether correct, for a cow giving a relatively small quantity of milk rich in fat may yield a larger total amount of butter fat per day than one giving twice as large a quantity of milk poor in fat, and the reverse.

Another evil is a bad tendency in breeding, which is encouraged

* Illinois Station, Bulletin No. 10.

by the paying for milk according to quantity simply without regard to quality. In a late bulletin of the Vermont Station* Director Cooke refers to this in the following words:

A careful study of the herds of this State will show the evil effects of the present method of paying for milk. Wherever in this State a cheese factory has been run for many years it will be found that the herds in that vicinity all give thin milk and will produce but a small number of pounds of butter in a year. The reason of this is evident. The patrons have been paid entirely by the weight of their milk, and so all their efforts in breeding have been directed to getting cows that would give the largest quantity of milk without regard to its quality, and as a large flow of milk is almost always accompanied with a poor quality of milk, the natural result is that the general character of the milk of the neighborhood is lowered. But the evil goes further than this. Cows that give this large flow of milk that is watery usually dry up quickly, and there will be found all through this State in the vicinity of cheese factories herds of cows of large form and large udders, which are large consumers of food, give a large flow of thin milk during May and June, and are pretty well dried up by October, so that the total amount of milk produced per cow per year is less than 3,000 pounds, and the total butter which this milk will make is scarcely more than 100 pounds. On the contrary, the best herds in the State will be found where the product of the herd has been used at home in making butter, and the breeding has been with the view of getting the cow that would make the most butter per year on moderate food.

The third evil affects both the creamery and the farmer. Valuations based on quality, so largely used in other directions, are beginning to find application in the case of dairy products, and nowhere is the desirability of such valuation more felt. The importance of this matter to creameries where the milk of a large number of patrons is all paid for alike, according to its weight or measure, has already been felt, and attention has been called to it by several stations.

In Bulletin No. 9 of the Iowa Station Professor Patrick says:

The pooling system of purchasing milk, now universally practiced at separator creameries, is defensible only on grounds of expediency, as a makeshift to be endured only until a better system shall be developed. It makes no pretense to justice in its treatment of the individual patron; it places a premium on quantity rather than, and even at expense of, quality; it drives patrons possessing rich-milk dairy herds and those who feed liberally and intelligently, into private dairying; it tempts the short-sighted and cunning into dishonest practices, and tends in every way to demoralize the creamery industry.

The creamery proprietor is not, however, the chief sufferer. He can always save himself, and continue to profit by lowering the price of milk to correspond with the average quality of all received, as shown in the butter product. But the farmer who, producing milk of superior quality from a herd which has cost much time and money to bring together, is obliged to pool with those producing inferior milk from scrub herds and poor feed—not to mention the possibility of home skimming or watering—he, by long odds, is the greatest sufferer.

The following examples illustrate the wide differences in milk supplied by different patrons:

The Illinois Station† tested the milk brought to three large creameries in the State by one hundred and eighty-four patrons. This milk was found to vary all the way from 2.8 to 4.75 per cent in butter fat. If the milk containing 2.8 per cent of fat is paid for at the rate of 50 cents per 100 pounds, then the richer milk would be worth, on that basis, 84.8 cents per 100 pounds. The Vermont Station† tested the milk delivered by twenty-seven patrons to a creamery in that State and found it to vary from 3.35 to 4.91 per cent in fat. This creamery was at the time paying 60 cents per 100 pounds for all the milk it

* Vermont Station, Bulletin No. 21.
† Illinois Station, Bulletin No. 9.

received. Valued according to its quality at this rate, the poorest milk, with 3.35 per cent of fat, would be worth 52 cents, and the richest, with 4.91 per cent, 74 cents per hundred, a difference of 22 cents on every 100 pounds. As 270 pounds of the richer milk were brought in one day, this difference would make a considerable amount in the course of a year to the patron who furnished it. These are not uncommon cases picked out to serve a purpose, but similar tests at various other stations have shown equally striking variations. Obviously a system so unfair ought to be improved.

The churn test, which until recently has been the farmers' main dependence, requires too much time and labor to be commonly and rigidly applied. The ordinary methods of the chemical laboratory require too complex and costly apparatus and skillful manipulation to be adapted to the use of farmers or creameries.

Simple methods depending on the specific gravity (lactometer) or on the thickness of the cream layer in cream tubes, do not furnish satisfactory indication of the actual amount of fat. All methods dependent upon the color or transparency of the milk are likewise unreliable. The transparency of milk is affected by the size of the fat globules, so that samples of milk containing like percentages of fat may be unequally transparent.

The lactocrite, an apparatus by which the fat of a given quantity of milk, after having been set free by a mixture of sulphuric and acetic acids, is separated and collected by centrifugal force, is an expensive piece of apparatus and the method has not made its way into general use.

The "oil test," which is practically a churn test on a small scale, has been found* by actual comparison with a large churn to differ, with the same cream, by 3 to 4 per cent of butter fat, not all the material separated by the method being actually fat.

Numerous other methods, which from time to time have been proposed, have, because they were either too complicated, expensive, or insufficiently accurate, not seemed to answer the demand, or at least have not found general application.

No less than seven different methods, all quick and fairly reliable, but differing somewhat as to simplicity of apparatus and manipulation, have lately been devised and are being subjected to very rigid trials at the stations, both by experienced chemists and by farmers, dairymen, and others unaccustomed to chemical work. These simple methods all depend upon the same general principle. The casein, albumen, fibrin, etc. ("curd"), of the milk surround the minute fat globules and hinder their rising as cream and aggregating to make butter. By treating the milk with acids or alkali this curd is more or less acted upon or dissolved, thus diminishing the hinderance to the rising of the fat globules. These collect at the top of the solution in a layer, the thickness of which can be readily measured. This separation of the fat from the dissolved curd is aided by either collecting the fat in gasoline or ether, which is afterwards evaporated, or by adding hot water, or by centrifugal motion.

The Short method,† one of the first of these quick methods to make its appearance, is the only one in which the nature of the fat is changed. It depends upon the fact that when milk and a solution of strong alkali (caustic potash and soda) are heated together at the temperature of boiling water for a sufficient time the alkali and the

* Wisconsin Station, Bulletin No. 12.

† Wisconsin Station, Report for 1888, p. 124.

fat of the milk unite to form a soap, as occurs in ordinary soap manufacture where fats and grease are heated with alkali (potash or soda). This soap is dissolved in the hot liquid. The casein and albumen are changed by the alkali and become much more easily soluble. If an acid is now added (a mixture of acetic and sulphuric acids being used in this method) the alkali of the soap is taken away by the acid, leaving the fat free. The casein, albumen, etc., are first precipitated and then dissolved by the acid. There is then nothing left in the milk to prevent the fat from following the law of gravity and rising and collecting in a narrow tube at the top of the liquid, where it may be measured by a graduated scale like that of a thermometer. The percentage of fat indicated by this reading is found by reference to a table. The author states that this method does not give accurate results where less than 0.5 per cent of fat is present, unfitting it for the testing of skim and buttermilks low in fat. In one hundred and forty-six comparisons made by different stations, of this method and the gravimetric methods ordinarily used by chemists, twenty-one showed differences of 0.2 per cent or more from the gravimetric, this difference being very rarely more than 0.3 per cent. Of six samples of skim-milk tested four differed by 0.2 to 0.22 per cent. The time required for a single analysis is approximately three and a half hours, although several analyses may be made at the same time.

*Parsons method.**—The measured milk, according to this method, is shaken with alkali (soda solution), alcoholic soap solution, and gasoline. The gasoline under these conditions dissolves the fat and rises with it to the surface. A part of this solution of fat in gasoline is measured out, the gasoline evaporated, a few drops of strong acetic acid added, the fat dried in an oven, and what remains behind measured in a narrow, graduated tube. From this measurement the percentage of fat in the milk can be quickly calculated by means of a table. The time required for the analysis is about two and a half hours, but several analyses may be made at the same time. Of ninety-three trials made with whole milk six differed from the gravimetric determination by 0.2 per cent or over; of seventeen tests of cream, five differed by 0.2 per cent or over, the greatest error being 0.52 per cent; and of thirteen tests of skim-milk the error was in no case as large as 0.15 per cent. The cost of the necessary apparatus is from $5 to $10, depending upon the number of duplicates to be made at once.

Failyer and Willard method.†—The casein, albumen, etc., are dissolved by heating the milk with strong hydrochloric acid, the fat is dissolved and collected at the surface by gasoline, and the gasoline is evaporated by gentle heat, leaving the fat free. Hot water is now added, which brings the fat up into the narrow graduated neck of the tube where it can be read off.

The time required is about half an hour for a single sample, or an hour and a quarter for four samples. In five out of twenty-two trials made there was a difference of 0.2 per cent or over from the gravimetric analyses.

Patrick method; Iowa Station milk test.‡—The curd (albumen, casein, etc.) of the milk is dissolved by boiling the milk with a mix-

*New Hampshire Station, Report for 1888, p. 69; New York State Station, Bulletin No. 19 (new series).
†Kansas Station, Report for 1888, p. 149.
‡Iowa Station, Bulletins Nos. 8 and 11.

ture of sulphuric and hydrochloric acids and sulphate of soda, the last being used to prevent the formation of a scum of undissolved materials which holds the fat. The acid mixture, as recently modified, contains rectified methyl alcohol. The liquid is then cooled, the fat rises to the surface, is heated again to clarify it, a part of the acid solution is drawn off through a small hole in the body of the tube ordinarily closed by a rubber ring, and the column of fat is read off on the scale. The time required is about twenty minutes for a single test, or six may be made in one and a half hours. The cost of chemicals is not more than 1 cent for each analysis. In thirty-five trials of this method the results of only three differed by 0.2 per cent from the results obtained by the gravimetric (laboratory) method; and in thirteen tests of skim-milk, only one test differed by 0.2. The method has not given good success with samples of buttermilk.

*Cochran method.**—The chemicals used in this method to dissolve the casein, etc., are sulphuric and acetic acids, which are heated with the milk about six minutes. After cooling ether is added, which dissolves out the fat and brings it to the surface. The ether is evaporated by gentle heat, and the liquid poured into a narrow measuring tube, where, after the addition of hot water, the fat collects in a clear layer and is read off. A table gives the per cent of fat corresponding to the reading of the tube.

In ten trials out of fifty-nine made by this method the results differed by 0.2 per cent of fat or over from the results by chemical analysis. In nine analyses of skim-milk this difference was in only one case as high as 0.15 per cent; in six tests of buttermilk the greatest difference was 0.27, all others being under 0.15 per cent.

The method is covered by a patent. It is not a station method but has been tested by several stations. The cost of apparatus and the right to use the method varies from $10 for the dairyman's outfit sufficient for testing four samples at a time, to $50 for the large creamery outfit for making sixty tests at one time. The cost of chemicals is about one half cent per analysis, and the time required one half hour for a single test, or one and a half hours for twenty-four tests.

Babcock method.†—In this method the curd is dissolved by sulphuric acid, no heat being applied. The separation of the fat is then aided by a simple centrifugal apparatus, consisting of a wheel fitted with pockets and surrounded by a tank filled with hot water (about 200° F.). The bottles containing the liquid are placed in an inclined position within the pockets of the wheel with the mouths toward the axis, and whirled rapidly for several minutes. The acid and the dissolved curd and water of the milk being much heavier than the fat, are thrown outward (to the bottom of the bottle) by the rapid motion and the fat collects near the neck. The separation of the fat is rapid and very complete. Hot water is now added to bring the fat up into the graduated neck, and the bottles are whirled for a few minutes more to clarify it. The reading of the column of fat gives the per cent directly. No complicated or expensive centrifugal machine is necessary, any arrangement by which a horizontal wheel, surrounded by a tank for the hot water and fitted with

* Journal Analytical Chemistry, Vol. III, p. 381; also New York Cornell Station, Bulletin No. 17, and Pennsylvania Station, Bulletin No. 12.

† Wisconsin Station, Bulletin No. 24.

pockets for the bottles, may be made to revolve at the rate of from seven to eight hundred revolutions per minute, answering the purpose.

The method is applicable with buttermilk, skim-milk, cheese, and cream. Out of thirty tests the results of only one showed a difference as large as 0.2 per cent from the results by chemical analysis. Out of four tests of cream the largest difference was 0.3 per cent; two tests of skim-milk were both within 0.8 per cent of the gravimetric; and the largest error in three tests of buttermilk was 0.23 per cent. Tests have also been made with whey, condensed milk, and cheese. In one test out of four which were made with cheese, the error was as high as 0.4 per cent of fat.

"Two samples of milk may be tested in duplicate in fifteen minutes, including all the work, from the mixing of samples to the cleaning of the bottles. After the milk has been measured sixty tests may be made in less than two hours, including the cleaning of the bottles." The cost of acid for the test should not exceed one half cent per test. With properly made bottles the breakage is very slight.

*Vermont Station test.**—This test, which is similar to the one devised by Dr. Babcock, depends on dissolving the curd by treating the milk with a mixture of hydrochloric acid and amyl alcohol and with concentrated sulphuric acid, without the application of heat, and whirling the bottles containing the liquid in an improved centrifuge for from one half to one minute. This is said to be sufficient to cause the fat to collect in the narrow neck of the bottle where it is read off, the reading indicating the per cent of fat in the milk taken. No hot-water jacket around the separator or hot water in the bottles is used. The time required for a single test is not more than five minutes, and twenty-five samples can be tested in an hour.

In the case of twenty-four samples which were tested by an inexperienced person, 75 per cent of the results were within 0.1 per cent of the chemical analyses, and in no case was the error as large as 0.3 per cent. Professor Cooke says: "If the sample has been correctly taken, and the column of fat in the tube is correctly read, there is no chance for the results to be wrong." Skim and buttermilks containing less than 1 per cent of fat can not be accurately tested by this method. The cost of chemicals is not more than one fifth cent per test. The machine is patented and costs, including bottles, from $20 to $50, according to the size, the one suggested for creameries carrying six bottles and costing $25.

"The method of analysis is so easy and cheap that it would be a very simple matter for each patron of the creamery or cheese factory to bring to the factory samples of milk of his individual cows and learn which were good cows and which ones should be discarded. In this way a single machine at a central point would be sufficient to test the milk of several hundred cows. Any one can see at once what an immense stride Vermont dairying would make under these conditions."*

Several of the stations offer to teach those wishing to learn the use of these simple tests, or to test the accuracy of the graduated tubes used for measuring the separated fat. As all the methods depend for their accuracy quite largely on the correctness of this measurement, the correct gradation of the apparatus is of vital importance.

* Vermont Station, Bulletin No. 21.

Considerable trouble has been experienced in securing apparatus for some of the methods made with proper care in this respect.

The providing, in these ways, of reliable means for testing a large number of samples of milk in a short time has led to the proposal, and in several cases the adoption at creameries, of the so-called "relative value plan." This consists in paying for the milk of each patron according to its quality, as well as quantity, by allowing so many cents for every pound of butter fat delivered in the milk, as indicated by one of these rapid methods. It is claimed that this system is sure, sooner or later, to supplant the present irrational one, the greatest hinderance to its general adoption being the large amount of work it is supposed to involve. This, however, is not so great as would at first seem. Three plans have been proposed for the sampling. One, where a sample is taken from each patron's milk as it is delivered at the creamery, to be tested by itself and recorded with the weight of milk. Another, advocated by Professor Patrick, of the Iowa Station,* in which a sample proportional in size to the amount of milk brought, is taken each day when the milk is delivered, the daily samples of each patron's milk being kept together by themselves for from seven to ten days, and then the average quality of the patron's milk for that time ascertained by a single test. Some preservative is added to the milk to prevent its spoiling. According to Professor Patrick's experiments, corrosive sublimate, although open to serious objections, being a violent poison, gives the best results of any agent yet found. Some magenta or aniline color is to be added to each sample containing corrosive sublimate to prevent accidental poisoning. The third plan advocated by Professor Cooke, of the Vermont Station,† is the taking of samples of each patron's milk by means of a sampling tube, which he describes, about three times a week, preserving the milk by means of corrosive sublimate, and analyzing the composite sample at the end of the week.

Tables indicating the prices to be paid for milk with different percentages of fat have been worked out, and have been printed with directions for their use in the bulletins of several stations.‡

These tests are being subjected to the test of practical experience as well as of the laboratory, and, doubtless, improvements will be suggested. There is every reason to expect that great benefit will result to the farmer, the breeder, and to the dairy interest in general from their use.

THE AGRICULTURAL COLLEGES AND THE EXPERIMENT STATIONS.

By the terms of the act of Congress of March 2, 1887, under which nearly all the stations are organized, they are departments of the colleges receiving the benefits of the land grant made to the States under the act of Congress of July 2, 1862. As a rule the colleges have welcomed the establishment of the stations and have carried out the spirit of the acts of Congress by aiding the stations with land, buildings, libraries, apparatus, and other facilities for the successful

* Iowa Station, Bulletin No. 9.

† Vermont Station, Bulletin No. 21.

‡ Vermont Station, Bulletin No. 16; New York State Station, Bulletin No. 19 (new series); Pennsylvania Station, Bulletin No. 12.

conduct of their investigations. The inauguration of original research in agriculture on so extended and useful a scale at the land grant institutions, has undoubtedly done much to attract renewed attention to their agricultural features and to increase the demand for their strengthening and enlargement in the direction of such instruction as will tend to provide their graduates with a suitable equipment for the practical duties of the farm, as well as of the laboratory or the shop. There has been impatience with what have appeared to be failures on the part of some of these institutions to meet the demand for technical training in agriculture. In one or two instances this has resulted in the removal of the agricultural departments from the colleges to which the land grant funds were originally given, and the establishment of new agricultural colleges on separate foundations. In the majority of cases it has been deemed best to follow the modern tendency to group instruction in numerous and varied branches of knowledge in large institutions comprising more or less closely associated colleges or departments.

Public attention is now strongly attracted to the land grant colleges because of the passage of an act at the last session of Congress making grants of public funds for the maintenance and endowment of these institutions. The chief provisions of this act are as follows: Annual appropriations are to be made out of the proceeds of sales of public lands, to each State and Territory, for the more complete endowment and maintenance of the colleges for the benefit of agriculture and mechanic arts established in accordance with the act of Congress, July 2, 1862. Fifteen thousand dollars are appropriated for the year ending June 30, 1890, and there is to be an annual increase of $1,000 in the amount of the appropriation thereafter for ten years, after which time the annual amount to be paid to each State and Territory is to be $25,000. These funds are to be applied only to instruction in agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural, and economic science, with special reference to their applications in the industries of life, and to the facilities for such instruction. It is also stipulated that no money shall be paid under this act to any State or Territory for the support and maintenance of a college where a distinction of race or color is made in the admission of students. But the establishment and maintenance of such colleges separately for white and colored students shall be held to be in compliance with this act if the funds received under the act are equitably divided between the two races. Payments of appropriations from the United States Treasury are to be made on the warrant of the Secretary of the Interior, and detailed reports of the amounts so received and of their disbursement are required to be made to the Secretary of Agriculture and to the Secretary of the Interior on or before the first day of September of each year. No portion of these funds can be applied to the purchase, erection, preservation, or repair of any building or buildings. In case these funds are in any way diminished, lost, or misapplied in any State or Territory the loss must be made good by the State or Territory before it can receive further appropriations under this act.

An annual report regarding the condition and progress of the college must be made by the president of each of the colleges receiving the benefits of the act to the Secretary of Agriculture and to the Secretary of the Interior. This report must include statistical information relating to receipts and expenditures, libraries, number of students and professors, and also as to any improvements and experiments made under the direction of any experiment station attached to the college with the cost and results, and such other industrial and economical statistics as may be regarded as useful. If for any reason the Secretary of the Interior shall refuse to certify that any State or Territory is entitled to receive its share of the annual appropriation under this act the facts and reasons for this refusal must be reported to the President in order that the State or Territory may have an opportunity to appeal to Congress from his decision. The Secretary of the Interior is charged with the proper administration of the law and is required to report to Congress the disbursements made under this act and whether the appropriation of any State or Territory has been withheld and, if so, the reasons therefor.

There is every reason to believe that the stations as well as the colleges will be greatly benefited by the provisions of this act, for many of the institutions which from lack of fuuds, have not had properly equipped agricultural departments, will now be able to supply themselves with more adequate facilities for instruction and research in these lines, and will be able hereafter to extend much more efficient aid to the stations than they have hitherto been able to give. It is to be expected also that the increased endowment will bring increased numbers of students to these departments and that the instruction given will be more thorough. The result will be that we shall have more young men prepared for efficient service as investigators in the stations and on the farms where co-operative experiments are carried on under the supervision of the stations.

The experience of thirty years as well as the advancement in agricultural science during that period has taught us much concerning what should be included in courses of study for agricultural colleges. The farmers themselves are also very much more alive to their needs in technical education; it is to be expected, therefore, that the funds granted under this act will be economically expended to help to make larger numbers of our youths intelligent farmers and to raise the general plane of agricultural practice in this country.

AGRICULTURAL COLLEGES RECENTLY ORGANIZED.

A list of the agricultural colleges in the United States, with locations and names of chief officers, will be found on pages 548–550. The following brief statements relate to colleges recently organized:

College of Agriculture of the University of Arizona.—The University of Arizona was established by an act of the legislature of the Territory passed during the session of 1888–89. It is located near Tucson, and the schools of agriculture and mines will be opened for students in January, 1891. Other departments of the university will be organized as soon as practicable. The faculty thus far appointed are Merrill P. Freeman, chancellor; F. A. Gulley, M. S., professor of agriculture and director of the experiment station; C. B. Collingwood, B. S., professor of chemistry in the School of Agriculture.

Agricultural College of New Mexico.—This institution was established by an act of the legislature of the Territory during the session of 1888-89. It is located at Las Cruces, Doña Aña County, and its president is Hiram Hadley, M. A., who is also professor of mathematics. The other members of its faculty are: Ainsworth E. Blount, M. A., professor of horticulture and agriculture; Elmer O.

Wooton, B. S., professor of botany and chemistry; John P. Owen, professor of history and civics and principal of preparatory department; Phoebe Haines, M. S., teacher of drawing; Ida Jones, teacher of elementary classes, and Cosette Rynerson, teacher of instrumental music.

The college owns a fine tract of land, about 40 acres of which have been put into excellent condition and are being planted in an experimental orchard, vineyard, and field crops.

A two-story and basement brick building is nearing completion, and apparatus for the departments of chemistry, physics, botany, and mathematics has been purchased. Reference and general libraries have been begun. Eighty-five students are in attendance this year, about twenty of whom are in the college classes. The prospects for rapid growth are good.

The North Carolina College of Agriculture and Mechanic Arts.—This institution was established in accordance with an act of the legislature of North Carolina passed March 7, 1887. It is located at Raleigh, and its president is Alexander Q. Holladay. The other members of its faculty are: Joseph R. Chamberlin, B. S., professor of agriculture, live stock, and dairying; W. F. Massey, C. E., professor of horticulture, arboriculture, and botany; W. A. Withers, M. A., professor of general and agricultural chemistry; D. H. Hill, M. A., professor of English and book-keeping; J. H. Kinealy, D. E., professor of practical mechanics and mathematics; W. E. Weatherly, assistant instructor in practical mechanics; F. E. Emery, assistant professor of agriculture; B. S. Skinner, superintendent of farms and gardens.

The college was opened for students October 3, 1889, and the number of students in attendance this year is about one hundred. Two courses of study of four years each are offered, the agricultural course leading to the degree of Bachelor of Science in Agriculture, and the mechanical course leading to the degree of Bachelor of Engineering. The college has two buildings and an income of $7,500 from the land-grant fund of 1862. It also expects to receive a share of the appropriations made under the recent act of Congress. It has heretofore had the proceeds of a State license tax on fertilizers, amounting to $20,000 per annum, but as this tax has recently been declared by the courts to be unconstitutional this source of revenue has been cut off.

North Dakota Agricultural College.—This institution is located at Fargo and its president is H. E. Stockbridge, Ph. D. The other members of its faculty are H. L. Bolley, M. S., professor of botany, and E. F. Ladd, professor of chemistry.

Rhode Island State Agricultural School.—This institution was organized by an act of the legislature of Rhode Island, passed March 23, 1888. It is located at Kingston and its president is John H. Washburn, Ph. D., who is also professor of chemistry, dairying, and science of government. The other members of its faculty are: Charles O. Flagg, B. S., professor of agriculture and stock breeding; L. F. Kinney, B. S., professor of horticulture; Homer J. Wheeler, Ph. D., professor of geology; Samuel Cushman, lecturer on bee culture; F. E. Rice, M. D., M. R. C. V. S., professor of veterinary science, physiology, and zoology; Serena Stockbridge, instructor in French, English, and Latin; M. T. Rodman, superintendent of shops and instructor in woodwork. The buildings already erected are a laboratory, dormitory, boarding-house, veterinary hospital, and barns. The institution was opened for students September 23, 1890. The first class consists of twenty-six men and four women.

Clemson Agricultural College.—This institution was established by an act of the legislature of South Carolina passed March, 1889. It is located at Fort Hill, the former residence of John C. Calhoun, and its post-office address is Pendleton. H. A. Strode is president of the college and director of the experiment station connected with it.

Agricultural College of Utah.—This institution was established by an act of the legislature of the Territory passed March 8, 1888. It is located at Logan, and its president is J. W. Sanborn, B. S., who is also professor of agriculture. The other members of its faculty are Evert S. Richman, B. S., professor of horticulture and botany; William P. Cutter, B. S., professor of chemistry; Abbie L. Marlatt, B. S., professor of domestic economy; John T. Caine, jr., professor in the preparatory department; Alonzo A. Mills, B. S., farm superintendent. The buildings include a college building, experiment station building, horticultural building, boarding-house, farm-house, two cottages, and farm and station barn. The college farm has been planted with experimental crops. The college was opened to students September 4, 1890, and seventy-six students are now in attendance. Industrial courses in agriculture, mechanic arts, civil engineering, and domestic arts have been established. A business course is also contemplated.

THE ASSOCIATION OF AMERICAN AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS.

The Association of American Agricultural Colleges and Experiment Stations held its fourth annual convention November 11–13, at Champaign, Illinois, with the University of Illinois. The Association is made up of representatives of the land grant colleges and experiment stations and of the United States Department of Agriculture.

The meeting was the largest the Association has yet held. There were one hundred and ten delegates, representing thirty-nine States and Territories, and about seventy colleges and stations. It was noticeable and the cause of frequent congratulation that this convention contained an unusually large number of the experiment station workers in addition to the directors. President Smart, of the Purdue University of Indiana, presided at the general sessions. As a full report of the proceedings will be published as a separate bulletin of the Office of Experiment Stations, only general references to the action of the convention need be made here.

An amendment to the constitution adopted at the Washington convention in 1889 provided for the division of the Association into sections, or permanent committees as they were originally called. Sections have been organized in agriculture, botany, chemistry, college work, entomology, and horticulture. Their meetings were held during the recess of the general Association and consumed the greater part of the time allotted to the convention. They were taken up with discussions of a technical character.

At the first general meeting of the Association the chairmen of the sections elected at the last meeting were called upon for reports of progress made in their several lines of work at the stations and elsewhere during the past year. The papers presented justified the expectation of the last convention that these reports would furnish a most important feature of the Association meetings. Especially full and valuable were the reports upon chemistry and entomology.

At the first public meeting, held on the evening of November 11, after short addresses by Regent Peabody, of the University of Indiana, by a representative of the city of Champaign, and by several members of the convention, President Smart's annual address was read. He laid stress upon the value and importance of technical and mechanical education and asserted its right to a place of honor by the side of the old classical and disciplinary college course.

In accordance with regulations that at each annual convention certain sections should present in the general session of the Association papers upon topics of especial importance, papers were read from the horticultural section on "The work of experiment stations in the reform of vegetable nomenclature," by L. H. Bailey, of New York, and on "Methods of work in variety testing," by W. J. Green, of Ohio. Both papers were well received and furnished the subjects of interesting discussions.

A. W. Harris, Assistant Director of the Office of Experiment Stations, read a paper outlining a plan for a co-operative exhibit by the Office of Experiment Stations and the experiment stations to be made in connection with the exhibit of the United States Department of Agriculture at the Columbian Exposition. A committee of five appointed to consider the matter reported the following resolutions, which were adopted:

Resolved, That, in the opinion of this Association, it is advisable to have a co-operative station exhibit at the World's Columbian Exposition,

Resolved, That to formulate and carry out such preliminary steps as are necessary during the year a special committee, with power to represent the Association, be appointed by this convention to co-operate with the Department of Agriculture and to take such other action as may be necessary.

Resolved, That the executive committee be authorized to pay from the funds of the Association the actual and necessary expenses incurred by the above-named committee in the discharge of its duties.

In pursuance of these resolutions the following committee was appointed: H. P. Armsby, Pennsylvania, chairman; G. E. Morrow, Illinois; C. E. Thorne, Ohio; S. M. Tracy, Mississippi; W. A. Henry, Wisconsin.

W. O. Atwater, Director of the Office of Experiment Stations, addressed the Association on the work of the Office. With other subjects he presented a plan for a co-operative index of station publications and other literature to be prepared by the Office of Experiment Stations for the stations. At the close of the convention an informal meeting of station directors and others interested was held for the consideration of this and other matters. The need of an index of station literature was very clearly brought out, and the Office was urged to begin its preparation as soon as practicable. The Association of Official Economical Entomologists held its sessions at the time of the convention, its meetings alternating with those of the section of entomology.

The following officers were elected for the ensuing year: President, H. H. Goodell of Massachusetts; vice-presidents, O. Clute of Michigan, A. Q. Holladay of North Carolina, E. D. Porter of Missouri, I. P. Roberts of New York, and J. W. Sanborn of Utah; secretary and treasurer, M. A. Scovell of Kentucky; executive committee, H. E. Alvord of Maryland, M. C. Fernald of Maine, H. H. Goodell of Massachusetts, W. M. Hays of Minnesota, J. A. Myers of West Virginia, M. A. Scovell of Kentucky, and J. H. Smart of Indiana.

On the evening of the 13th of November, after the close of the convention, the delegates and visitors present were tendered a reception by Regent Peabody at his residence. After the convention some fifty members visited the Fat Stock Show in Chicago, at the invitation of the Illinois State Board of Agriculture.

THE TEACHINGS OF EXPERIENCE REGARDING THE WORK OF THE STATIONS.

Two years have passed since the stations organized under the act of Congress of March 2, 1887, fairly began their operations. Some of our stations have been established ten or even fifteen years. The European stations have an experience of forty years. It will be of interest to note briefly some of the information that experience has brought as to the methods and results of our station work, the success gained and in prospect, and especially as to the ways in which improvement can be made. Now that the stations have passed the period of organization they are subject to criticism from various sources. This is felt most keenly by the station workers themselves, and they are making strenuous efforts to discover the real needs of their work, and the best methods for accomplishing the ends for which the stations were created. At such a time it is highly important to distinguish between the real faults of our stations and those which are alleged as the result of misapprehension of the proper aims and methods of experimental inquiries in agriculture.

One way in which the work of the stations can be improved is by more specialization. One of the misfortunes of American universities and colleges is that the teachers have to cover too much ground. The experiment stations meet with the same difficulty. The men who manage them and do their work are expected to undertake more questions than they can properly handle or hope to solve. In this matter our stations are having the same experience that the European stations have gone through. The managers, the boards of control, and the station workers are anxious to meet the demands of the agriculture of their respective localities. These demands are numerous and pressing. It requires long experience to realize the full force of the truth, that to satisfactorily settle questions which seem simple requires a large amount of abstract and long-continued labor. To undertake too many questions means to study each superficially and to fail to obtain reliable answers. It is a real fault of the stations that they undertake too many lines of inquiry.

There is also need of more abstract research. One of the chief difficulties the stations have to meet is the demand for so-called practical as distinguished from scientific investigation. In this practical, pushing country of ours the idea is current that the profounder study is very appropriate for philosophers and for institutions devoted to abstract research, but that it is not in place where things for use in daily life and work are to be found out, whereas the fact is that the experiments which on the surface seem most practical are apt in the long run to be least useful. The inquiries which bring the best fruit, the results that are most important and useful for practical workers in their daily life, are those which reach down to the laws which underlie practice. The very things which seem most abstruse are often of the most practical importance. Just the abstract inquiry which is often decried is what is wanted to bring the information that ordinary people need. It is safe to say that a very large amount of our experiment station work is wasted, or at least fails of its fullest usefulness because of the lack of such inquiry. The future usefulness of the stations will depend upon what they discover of permanent value, and that it is from such inquiry that this must come, and it is a real fault of the stations that they are doing relatively so much of so-called practical work, and so little of abstract investigation.

Closely connected with the demand for practical results is the failure in too many cases to secure skilled specialists for the experimental work of the stations. It is true in the experiment stations as it is in the university, the banking house, or the railroad office that expert men are required for expert work, and if the men lack the training the interests of the enterprise suffer. Of course we have to face the fact that a large number of stations have been suddenly called into being, and the country does not furnish enough of well-trained specialists. Fortunately a large number of young men of ambition and ability are realizing this fact and are putting themselves in training in the best schools and experiment stations in this country and in Europe, so that gradually the want will be supplied. Meanwhile it remains a real fault that the stations do not have enough specialists for the work, though under the circumstances this is more a misfortune than a fault.

Parallel with the two last-named difficulties is another, namely, that the stations are in numerous cases giving relatively too much attention to the experimenting on the farm and too little to the work of the laboratory. It seems perfectly natural to suppose that the best place to find out what farmers need to know about farming is on the farm where the farming is done. In some cases this is true. In the newer regions, where there is as yet very little of accumulated farming experience, the experiment stations may be called upon to gather more or less of such experience by practical farm work, and even where it has been gathered from years and generations of the experience of good farmers there still remain experiments which may be best conducted on the farm, but in general the farm should not be the essential feature but the adjunct of the station, one of the numerous appliances for its work. An experiment station is not and should not be a model farm. The man to do good farming is the good farmer; the man to do useful experimenting is the trained specialist.

With the pressing need of information of so many kinds, it is really too bad that when a given question has been studied the best methods of inquiry learned by long-continued and costly inquiry, our farmers should be without the results and our stations should be planning and conducting experiments on the same question as if no attention had been given it. Yet just this is the case with us to-day. During the past forty years experiment stations and kindred institutions in Europe have been at work on the same problems which perplex our farmers, and many important discoveries have been made and much valuable experience gained. But our farmers, and what is just now worse, many of our experiment station workers, are ignorant of what has been done. Hence the stations are in too many instances going over old ground, making old mistakes, and devoting precious time and energy to the study of problems already solved.

This is more their misfortune than their fault. They are eager to get light but are unable to do so. They have not the libraries, which would be very expensive, nor the training which is necessary to make good use of them, and which requires years of special study at home and abroad. Nor would they, if they had the training and the books, have the time to use them, so manifold and pressing are the duties of their routine work. As stated elsewhere, this Office is endeavoring to assist them in so far as its inadequate means will allow. It is then a real fault of our stations that they do not utilize the fruits of experience already obtained, but it is a fault for which they are not entirely responsible.

Another difficulty with the work of the stations is the indefiniteness of many of the experiments. The questions are often broad and general when they ought to be narrow and specific. The conditions are often such that instead of testing the question proposed, a number of complicating features are involved. In consequence the results are indefinite and inconclusive and lacking in practical value. A field experiment is made to test the effect of a given fertilizer, as cotton-seed meal alone or with other fertilizers on the growth of cotton, or nitrate, phosphate, and potash, singly or in combination, on the growth of corn. But the physical and chemical properties of the soil are not known, and the character of the subsoil, the amounts of water supplied by rain-fall and from below are not determined. There may be a large stock of available plant food at the disposal of the plant which will obscure the action of the fertilizers. The supply of both water and plant food vary on the different experimental plats. In short, a number of conditions materially affecting the growth of the plant and affecting it differently on the different plats, are entirely undetermined. There is no way to tell how much of the differences in yield are due to these and other unknown conditions and how much to the effect of the fertilizers. The results are of little value for the field and the farm where the experiment was made and of still less value anywhere else. There are two ways of getting rid of this difficulty. One is by better field experiments. For these it is necessary to find soil of uniform character without a large store of available plant food; to plan the experiments rationally; to study the geological, physical, and chemical characters of the soil and subsoil; to observe the temperature and rain-fall; to conduct the experiments in a number of places, and through series of years. The other way is to make experiments on a small scale in boxes, pots, or otherwise, in which the conditions can be thoroughly controlled. Then by making the questions very specific, that is to say, by testing the effects of given fertilizing materials on a given crop; by comparing the effects of different fertilizers on the same crop, or the same fertilizers on different crops, definite and reliable information will be obtained. When the principles are found out and explained to the farmer, he will be able to apply them to his own lands and his own crops and verify and supplement them by experiments of his own. This means the labor of years, but it is the only way to get the definite results that are wanted. The same principle applies in other kinds of experimental inquiry.

The advantage of division of labor is a fundamental principle of political economy. It needs to be applied more effectively to station work. It has already been urged that the individual stations are studying too many questions. The other side of this fact is that too many stations are studying the same question.

"United, we stand; divided, we fall," has been a cardinal doctrine of American statesmen from the days of the Revolution. People are finding that the principle has a wider application, especially to our industrial system. Farmers are applying it to their organizatons; shrewd corporations are making use of it in ways to conduce to their advantage. The stations need to apply it in co-operative experimenting. The individual station worker can do at best only a little and in a few narrow lines. The things which he can do are inextricably interwoven with those which his fellow-workers in other stations can and ought to do. It is proper that the stations should unite in the planning and in the execution of their work. By series of experiments on a common plan, rationally devised and carefully executed, more reliable results can be obtained, and obtained in much shorter time than in any other way. It is a real fault of the stations that their work is not better divided and that there is not more co-operation.

But while the stations are not doing all their work as well as it might be done, or as well as they will do it when they shall have had more experience, more trained experimenters and more help in collating the fruits of research and in planning and conducting their inquiries, the public are no less at fault in their demands upon the stations and their judgment of the merits of the work of the stations.

Among the causes of popular misapprehension are that people do not understand until they have had the experience how much labor and what a high order of scientific inquiry are needed to get reliable answers to seemingly simple, practical questions. The complaint is common that a station is too scientific, that it ought to deal more with the practical wants of the farmer. In most cases the real difficulty is the other way. The stations are, on the whole, doing too little of abstract research and too much of so-called practical work. The questions asked of them are more numerous than they can successfully grapple, many of these questions require years of painstaking investigation, and the more thoroughly scientific the work the quicker will the answer come and the more useful will it be.

There is also a mistaken idea in some quarters that the stations feel above the plain, hard-working farmer, and do not sympathize with his wants. No one who is familiar with the stations, has associated with their workers, and has listened to their discussions in the meetings in which they gather for conference, can fail to appreciate the fact that in general they are thoroughly in earnest to do the work intrusted to them, and that to this end they are faithfully trying to learn the farmers' needs and how they may best work to meet them.

In many localities the real nature and purpose of the work of the stations are not appreciated. An extreme example will illustrate this. At the beginning of its work a station most wisely planned a systematic inquiry into the soils of its State, the best methods for developing their productive capacity, the most advantageous crops to grow upon them, the best methods of culture of these crops, and the best ways of using the products for the feeding of animals. In other words, it planned a system of experimenting which would bring the largest benefit to the agriculture of the State and to that of other States as well. But the people at large who were not familiar with such inquiries did not rightly understand the situation; they saw that immediate practical results were not following rapidly; the work of the station did not receive full and hearty support, and just as it was successfully begun the legislature provided for the removal of the station to another place, and it is to be feared that much of the work so well begun will meet with serious interruption.

The task of the stations is broad, complex, and difficult. In many of the States there is much preliminary work to be done in studying the agricultural capabilities of regions which have been only superficially explored; in other and older States the farmers must be aroused to the desirability of departing from traditional methods or of introducing new products. In large measure the conditions under which our stations are working are different from those which obtain in Europe and in the older countries of the world. The magnitude and diversity of the problems which they are set to solve are beyond all precedents in the lines of agricultural research. It requires great wisdom to make a right choice of the material for immediate investigation, and to adapt the principles of experimenting, founded on past experience, to the peculiar conditions of agriculture, which exist in such bewildering variety and complexity within the vast territory of the United States.

Our stations must not only seek after new truths, but they must also verify previous researches. They must apply well-known principles to new conditions. They must aid in the introduction of new products. Besides finding new principles and applying old ones they have to do a large amount of routine work in the protection of the farmer against fraud in fertilizers, seeds, and feeding stuffs, and they must for a considerable period at least aid in diffusing among the farmers elementary knowledge of the principles and processes of rational agriculture as taught by modern science and the advanced practice of the best farmers. Much of the energy of their officers is devoted to the answering of letters, to going about among the farmers, and to endeavoring in various ways to connect the stations as intimately as may be with the agriculture of their respective States. The large task which the stations have to perform may be better realized when we consider that as a rule there is only a single station for each State. Such great States as Pennsylvania, Illinois, and Texas have each only one station. The large problems which the farmers of each of those States are urging the stations to investigate are numbered by scores and the individual questions by hundreds, and yet, as we have seen, one of the first conditions of successful experimenting is that only a very few problems shall be undertaken and that these shall be worked upon systematically and through long periods of years.

Our station workers are to a large extent pioneers. Some of the problems they have to deal with have never been dealt with by men of science before. The settler who takes up new land in a new country can not have the careful methods of culture that are found in older regions. If our stations are wasteful and at times unsuccessful they have the enthusiasm and vigor of youth, the purpose to do their best, are already achieving much, and with kindly criticism and generous support their future success will be assured.

The public has a duty to the stations which it can not justly neglect—to study their operations, look into the details of their work, offer suggestions, and at the same time learn why things that are done are done in the way they are.

The stations need the active sympathy and support of every intelligent farmer. In many cases they will desire the co-operation of practical farmers in carrying out experiments or making observations. They also need, and in numerous cases have already received, financial aid from States, communities, societies, and individuals for the furtherance of the interests of agriculture in their respective States.

Very many of the station publications have, of course, been mainly reports of progress relating to incomplete investigations, from which positive conclusions can not yet be drawn. On the other hand, some of the results of experiment station work, especially in the case of the older stations, are of great importance. Their inspection of fertilizers has saved the farmers millions of dollars. Their investigations on the feeding of animals have already made important changes in the methods of the stock raiser. The business of dairying is being largely influenced by results of recent investigations at the stations. They are devising means by which the farmer may protect his crops and his animals against the ravages of disease. They are gaining and disseminating an amount of information which is of incalculable value. They are an educating influence of inestimable importance.

To impress upon the farmers of the country the necessity of applying intelligence and systematic effort to farming as to other forms of business will be of the greatest benefit to the country. There is every reason to believe that the stations are doing their share in this great work.

Few persons realize the magnitude and the usefulness of the movement represented by the agricultural experiment stations in the United States. This system, established and supported by Congress and aided by the several States, with the Department of Agriculture as its center, constitutes the most extensive enterprise for agricultural experimenting which any nation has organized. The results which are being constantly achieved show that while we supply the Old World with our agricultural produce, we are also vieing with it in the higher fields of inquiry and the use of brains in farming.

That the stations are receiving more attention from farmers, journalists, and legislators is a sure evidence of their growing strength and importance. Chiefly in those sections of our country where there is the most widespread ignorance, and consequently the most complete disregard of the demands of a progressive agriculture, have the stations encountered serious difficulties in their organization and in the prosecution of their work. In fact it may safely be claimed that the establishment of the stations was due to the growing sentiment among the masses of our people in favor of the application of science to the practical needs of our common life. It may, therefore, be confidently expected that as long as our stations are faithful to the high and important duties for which they were created and do not lose sight of the great problems they were set to solve in a vain endeavor to secure a cheap popularity by doing small things, they will gain a stronger place in the regard and support of the American people.

LIST OF PUBLICATIONS OF THE OFFICE OF EXPERIMENT STATIONS.

The following publications of this Office are intended for general distribution. Others which were printed for special use and are not of permanent importance, are not mentioned here:

Farmers' Bulletins:

No. 1.—The What and Why of Agricultural Experiment Stations; issued June, 1889.

No. 2.—The Work of the Agricultural Experiment Stations—Better Cows; Fibrin in Milk; Bacteria in Milk; Silos and Silage; Alfalfa; Field Experiments with Fertilizers; issued June, 1890.

Experiment Station Bulletins:

No. 1.—Organization of the Agricultural Experiment Stations in the United States; issued February, 1889.

No. 2.—Digest of Annual Reports of Stations in the United States for 1888, Part I; issued June, 1889.

No. 3.—Report of Meeting of Horticulturists at Columbus, Ohio; issued July, 1889.

No. 4.—List of Horticulturists of the Agricultural Experiment Stations in the United States; issued November, 1889.

No. 5.—Organization List of the Agricultural Experiment Stations and Agricultural Schools and Colleges in the United States; issued March, 1890.

No. 6.—List of Botanists of the Agricultural Experiment Stations in the United States, with an Outline of the Work in Botany at the Several Stations; issued May, 1890.

Miscellaneous Bulletins:

No. 1.—Proceedings of Association of American Agricultural Colleges and Experiment Stations at Knoxville, Tennessee, January, 1889; issued March, 1889.

No. 2.—Proceedings of Association of American Agricultural Colleges and Experiment Stations at Washington, District of Columbia, November, 1889.

Circulars:

No. 7.—Co-operative Field Experiments with Fertilizers; issued March, 1889. This contains the report of the conference of representatives of stations regarding co-operative field experiments with fertilizers, directions and explanations for soil tests with fertilizers, and suggestions for further experiments.

No. 8.—Explanations and Directions for Soil Tests with Fertilizers; issued March, 1889. This is intended for the use of farmers experimenting under the direction of the stations. It is included in Circular No. 7, but was also printed separately for convenience.

No. 11.—Rules for Naming Vegetables, Report of Committee of Experiment Station Horticulturists; issued September, 1889.

Experiment Station Record:

Vol. I, 6 numbers, with index. Vol. II, 5 numbers, issued in 1890.

LIST OF AGRICULTURAL SCHOOLS AND COLLEGES IN THE UNITED STATES.

ALABAMA.—*Auburn:* Agricultural and Mechanical College, Alabama Polytechnic Institute; president, William LeRoy Broun, LL. D. *Abbeville:* Southeast Alabama Agricultural School; principal, J. S. Espy, M. A. *Athens:* North Alabama Agricultural School; principal, C. L. Newman, B. S.

ARIZONA.—*Tucson:* University of Arizona; president, Merrill P. Freeman.

ARKANSAS.—*Fayetteville:* Arkansas Industrial University; president, Edward Hunter Murfee, LL. D.

CALIFORNIA.—*Berkeley:* College of Agriculture of the University of California; president, Horace Davis, LL. D.; dean, Irving Stringham, Ph. D.

COLORADO.—*Fort Collins:* State Agricultural College of Colorado; president, Charles L. Ingersoll, M. S.

CONNECTICUT.—*Mansfield* (post-office, Storrs): Storrs Agricultural School; principal B. F. Koons, Ph. D. *New Haven:* Sheffield Scientific School of Yale University; president, Timothy Dwight, D.D., LL.D.; director, George J. Brush, LL. D.

DELAWARE.—*Newark:* Delaware College; president, Albert N. Raub, Ph. D.

FLORIDA.—*Lake City:* Florida State Agricultural and Mechanical College; president, Frank L. Kern, M. A.

GEORGIA.—*Athens:* Georgia State College of Agriculture and Mechanic Arts; chancellor, William E. Boggs, D. D., LL. D. *Cuthbert:* Southwest Georgia Agricultural College; president, A. J. Clark. *Dahlonega:* North Georgia Agricultural College; president, William S. Basinger, M. A. *Milledgeville:* Middle Georgia Military and Agricultural College; president, J. Colton Lynes, Ph. D. *Thomasville:* South Georgia College; president, G. M. Lovejoy. *Hamilton:* West Georgia Agricultural and Mechanical College; president, H. A. Hayes, B. A.

ILLINOIS.—*Urbana:* College of Agriculture of the University of Illinois; regent, Selim H. Peabody, Ph. D., LL. D.; dean, George E. Morrow, M. A.

INDIANA.—*La Fayette:* School of Agriculture, Horticulture, and Veterinary Science of Purdue University; president, James H. Smart, LL. D.

IOWA.—*Ames:* Iowa State College of Agriculture and Mechanic Arts; president, W. I. Chamberlain, LL. D.

KANSAS.—*Manhattan:* Kansas State Agricultural College; president, George T. Fairchild, M. A.

KENTUCKY.—*Lexington:* Agricultural and Mechanical College of Kentucky; president, James K. Patterson, Ph. D.

LOUISIANA.—*Baton Rouge:* Louisiana State University and Agricultural and Mechanical College; president, J. W. Nicholson, M. A.

MAINE.—*Orono:* Maine State College of Agriculture and the Mechanic Arts; president, Merritt C. Fernald, Ph. D.

MARYLAND.—*College Park:* Maryland Agricultural College; president, Henry E. Alvord, C. E.

MASSACHUSETTS.—*Amherst:* Massachusetts Agricultural College; president, Henry H. Goodell, M. A. *Jamaica Plain:* Bussey Institution of Harvard University; president, Charles W. Eliot, LL. D.; dean, F. H. Storer, B. S.

MICHIGAN.—*Agricultural College:* Michigan Agricultural College; president, Oscar Clute, M. S.

MINNESOTA.—*St. Anthony Park:* College of Agriculture of the University of Minnesota; president, Cyrus Northrop, LL. D. State School of Agriculture of the University of Minnesota; principal, W. W. Pendergast.

MISSISSIPPI.—*Agricultural College:* Agricultural and Mechanical College of Mississippi; president, S. D. Lee. *Rodney:* Alcorn Agricultural and Mechanical College; president, John H. Burrus, M. A.

MISSOURI.—*Columbia:* Agricultural and Mechanical School of the University of the State of Missouri; chairman of faculty, M. M. Fisher, D. D., LL.D.

NEBRASKA.—*Lincoln:* Industrial College of the University of Nebraska; president, Charles E. Bessey, Ph. D.

NEVADA.—*Reno:* School of Agriculture of the Nevada State University; president, Stephen A. Jones, Ph. D.

NEW HAMPSHIRE.—*Hanover:* New Hampshire College of Agriculture and the Mechanic Arts (in connection with Dartmouth College); president, Samuel C. Bartlett, D. D., LL. D.; dean, Charles H. Pettee, M. A., C. E.

NEW JERSEY.—*New Brunswick:* Rutgers Scientific School of Rutgers College; president, Austin Scott, Ph. D.

NEW MEXICO.—*Las Cruces:* Agricultural College of New Mexico; president, Hiram Hadley, M. A.

NEW YORK.—*Ithaca:* College of Agriculture of Cornell University; president, Charles Kendall Adams, LL. D.

NORTH CAROLINA.—*Raleigh:* The North Carolina College of Agriculture and Mechanic Arts; president, Alexander Q. Holladay.

NORTH DAKOTA.—*Fargo:* North Dakota Agricultural College; president, H. E. Stockbridge, Ph. D.

OHIO.—*Columbus:* Ohio State University; president, William H. Scott, LL. D.

OREGON.—*Corvallis:* Oregon State Agricultural College; president, B. L. Arnold, M. A.

PENNSYLVANIA.—*State College:* The Pennsylvania State College; president, George W. Atherton, LL. D.

RHODE ISLAND.—*Kingston:* Rhode Island State Agricultural School; president, John H. Washburn, Ph. D. *Providence:* Agricultural and Scientific Department of Brown University; president, Elisha Benjamin Andrews, D. D., LL. D.

SOUTH CAROLINA.—*Pendleton:* Clemson Agricultural College; president, H. A. Strode. *Orangeburgh:* Claflin University, College of Agriculture and Mechanics' Institute; president, L. M. Dunton, D. D.

SOUTH DAKOTA.—*Brookings:* South Dakota Agricultural College; president, Lewis McLouth, Ph. D.

TENNESSEE.—*Knoxville:* State Agricultural and Mechanical College of the University of Tennessee; president, Charles W. Dabney, jr., Ph. D., LL. D.; dean, Thomas W. Jordan, M. A.

TEXAS.—*College Station:* State Agricultural and Mechanical College of Texas; chairman of college faculty, Louis L. McInnis, M. A.

UTAH.—*Logan:* Agricultural College of Utah; president, J. W. Sanborn, B. S.

VERMONT.—*Burlington:* University of Vermont and State Agricultural College; president, Matthew H. Buckham, D. D.

VIRGINIA.—*Blacksburgh:* Virginia Agricultural and Mechanical College; president, L. L. Lomax. *Hampton:* Hampton Normal and Agricultural Institute; president, Samuel C. Armstrong, LL. D.

WEST VIRGINIA.—*Morgantown:* West Virginia University; president, E. M. Turner, LL. D.

WISCONSIN.—*Madison:* College of Agriculture of the University of Wisconsin; president, T. C. Chamberlin, Ph. D., LL. D.

The legal names, locations, and directors of the agricultural experiment stations in the United States.

State.	Name of station.	Location.	Director.
Alabama	Agricultural Experiment Station of the Agricultural and Mechanical College of Alabama.	Auburn	J. S. Newman.
Alabama	Canebrake Agricultural Experiment Station.	Uniontown	W. H. Newman, M. S. [a]
Alabama	North Alabama Branch Agricultural Experiment Station.	Athens	C. L. Newman, B. S.
Alabama	Southeast Alabama Agricultural Experiment Station.	Abbeville	T. M. Watlington, B. S.
Arizona	Agricultural Experiment Station of the University of Arizona.	Tucson	F. A. Gulley, M. S.
Arkansas	Arkansas Agricultural Experiment Station. (Substations at Newport and Pine Bluff.)	Fayetteville	A. E. Menke, D. Sc.
California	Agricultural Experiment Station of the University of California. (Substations at Cupertino, Fresno, Glen Ellen, Jackson, Mission San José, Paso Robles, Pomona, and Tulare.)	Berkeley	E. W. Hilgard, Ph. D., LL. D.
Colorado	Agricultural Experiment Station. (Substations at Del Norte and Rocky Ford.)	Fort Collins	C. L. Ingersoll, M. S.
Connecticut	The Connecticut Agricultural Experiment Station.	New Haven	S. W. Johnson, M. A.
Connecticut	Storrs School Agricultural Experiment Station.	Storrs	C. D. Woods, B. S. [b]
Delaware	The Delaware College Agricultural Experiment Station.	Newark	A. T. Neale, Ph. D.
Florida	Agricultural Experiment Station of Florida. (Substations at De Funiak and Fort Myers.)	Lake City	J. P. DePass.
Georgia	Georgia Experiment Station	Experiment [c]	R. J. Redding.
Illinois	Agricultural Experiment Station of the University of Illinois.	Champaign	S. H. Peabody, Ph. D., LL. D.
Indiana	Purdue University Agricultural Experiment Station.	La Fayette	J. H. Smart, LL. D. [b]
Iowa	Iowa Agricultural Experiment Station.	Ames	James Wilson.
Kansas	Kansas Agricultural Experiment Station.	Manhattan	G. T. Fairchild, M. A. [d]
Kentucky	Kentucky Agricultural Experiment Station.	Lexington	M. A. Scovell, M. S.
Louisiana	No. 1. Sugar Experiment Station	Audubon Park, New Orleans.	W. C. Stubbs, Ph. D.
Louisiana	No. 2. State Experiment Station	Baton Rouge	W. C. Stubbs, Ph. D.
Louisiana	No. 3. North Louisiana Experiment Station.	Calhoun	W. C. Stubbs, Ph. D.
Maine	Maine State College Agricultural Experiment Station.	Orono	W. H. Jordan, M. S.
Maryland	Maryland Agricultural Experiment Station.	College Park	H. E. Alvord, C. E.

[a] Assistant director in charge.
[b] Acting director.
[c] Freight and express office, Griffin.
[d] Chairman of Council.

The legal names, locations, and directors of the agricultural experiment stations in the United States—Continued.

State.	Name of station.	Location.	Director.
Massachusetts	Massachusetts State Agricultural Experiment Station.	Amherst	C. A. Goessmann, Ph. D. LL. D.
Massachusetts	Hatch Experiment Station of the Massachusetts Agricultural College.	Amherst	H. H. Goodell, M. A.
Michigan	Experiment Station of Michigan Agricultural College.	Agricultural College.	O. Clute, M. S.
Minnesota	Agricultural Experiment Station of the University of Minnesota.	St. Anthony Park.	N. W. McLain, LL. B.
Mississippi	Mississippi Agricultural Experiment Station.	Agricultural College.	S. M. Tracy, M. S.
Missouri	Missouri Agricultural College Experiment Station.	Columbia	E. D. Porter, Ph. D.
Nebraska	Agricultural Experiment Station of the University of Nebraska.	Lincoln	H. H. Nicholson, M. A.
Nevada	Nevada Agricultural Experiment Station.	Reno	S. A. Jones, Ph. D.
New Hampshire	New Hampshire Agricultural Experiment Station.	Hanover	G. H. Whitcher, B. S.
New Jersey	New Jersey State Agricultural Experiment Station.	New Brunswick	J. Neilson. *b*
New Jersey	New Jersey Agricultural College Experiment Station.	New Brunswick	J. Neilson. *b*
New Mexico	Agricultural Experiment Station of New Mexico.	Las Cruces	H. Hadley, M. A.
New York	New York Agricultural Experiment Station.	Geneva	P. Collier, Ph. D.
New York	Cornell University Agricultural Experiment Station.	Ithaca	I. P. Roberts, M. Agr.
North Carolina	North Carolina Agricultural Experiment Station.	Raleigh	H. B. Battle, Ph. D.
North Dakota	North Dakota Agricultural Experiment Station.	Fargo	H. E. Stockbridge, Ph. D.
Ohio	Ohio Agricultural Experiment Station.	Columbus	C. E. Thorne.
Oregon	Oregon Experiment Station	Corvallis	B. L. Arnold, M. A.
Pennsylvania	The Pennsylvania State College Agricultural Experiment Station.	State College	H. P. Armsby, Ph. D.
Rhode Island	Rhode Island State Agricultural Experiment Station.	Kingston	C. O. Flagg, B. S.
South Carolina	South Carolina Agricultural Experiment Station.	Pendleton	H. A. Strode.
South Dakota	South Dakota Agricultural Experiment Station.	Brookings	L. Foster, M. S. A.
Tennessee	Agricultural Experiment Station of the University of Tennessee.	Knoxville	F. L. Scribner, B. S.
Texas	Texas Agricultural Experiment Station.	College Station	G. W. Curtis, M. S. A.
Utah	Agricultural Experiment Station of Utah.	Logan	J. W. Sanborn, B. S.
Vermont	State Agricultural Experiment Station.	Burlington	W. W. Cooke, M. A.
Virginia	Virginia Agricultural and Mechanical College Experiment Station.	Blacksburgh	W. D. Saunders.
West Virginia	West Virginia Agricultural Experiment Station.	Morgantown	J. A. Myers, Ph. D.
Wisconsin	Agricultural Experiment Station of the University of Wisconsin.	Madison	W. A. Henry, B. Agr.

Table showing the total number of members in the working staffs of experiment stations in the United States and the number of such officers devoted to different specialties.

NOTE.—A capital letter signifies that one of the number which it follows represents an officer who, having two titles and belonging by his first title in the column for which the letter stands, has already been entered there. Thus the entry G under entomologists and opposite Florida means that one officer is known as "botanist and entomologist," and has already been entered by his first title in the G or botanists column. Two letters indicate that two of the preceding number have been entered elsewhere.

Stations.	Number in staff.	A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T	U
		Directors.	Secretaries and treasurers.	Librarians.	Clerks.	In charge of substations.	Agriculturists.	Botanists.	Biologists.	Chemists.	Entomologists.	Geologists.	Horticulturists.	Irrigation engineers.	Meteorologists.	Mycologists.	Microscopists.	Physicists.	Veterinarians.	Viticulturists.	Miscellaneous.
Alabama (College)	11	2			1		3 A	2	1	4 A					1 G						
Alabama (Canebrake)	2	2					1 A														
Alabama (North)	1	1																			
Alabama (Southeast)	2	1																			*a* 1
Arizona	3	1								1			1								
Arkansas	9	1					3			2	1		1						1		
California	21	1			1	*b* 11	1 I	1		4 A	1 U	1 A	1 U							2 H	*c* 5 I
Colorado	12	1	1			2	2	1		2			2 G	1 O	2						
Connecticut (State)	10	2		1	1 C					4 A						1					*d* 3
Connecticut (Storrs)	5	2					2 A			2											
Delaware	5	1						1		1	1 M		1		1						
Florida	6	1				2	1 A	1		2	1 G										
Georgia	5	2	1 M				1			2 A			1		1 A						*e* 1 F
Illinois	9	1	1				2	2 M		1			2						1		
Indiana	9	1					2 A	2		2	1		1						1		
Iowa	12	1	1				2 A	3		3	1		1						1		
Kansas	13	1	1				2	2		2	2 M		2						1		*f* 1
Kentucky	7	1	1				1	1 K		3 A	1		1								
Louisiana (Sugar)	10	1	1							1											*g* 7
Louisiana (State)	9	2	2					1		2	1		1 K						1		
Louisiana (North)	3	1								1											*h* 1
Maine	10	1			1		1	2		2	2 GG				1				1		*f* 1
Maryland	7	1	1		1		1			1			1								*i* 1
Massachusetts (State)	10	1					2			7 A						1					
Massachusetts (Hatch)	10	1	1				2				1		3		1						*j* 1
Michigan	20	1	1	1			3	2	2	4	1		4						1		
Minnesota	7	1			1		2 A	1 K		1	1		1						1		
Mississippi	11	2	1				2	1 A		2	1 M		2		1				1		
Missouri	11	1	2				2 A			2	2 M		1					2	2		*k* 1
Nebraska	10	1	1				1	1		3 A	1										*f* 1

Nevada	8	2		1			2	1 K		1	1		1 F								l 1
New Hampshire	9	1			1		2 A	1		2					1		1 G				m 2
New Jersey (State)	6	1			1		1 I			3											n 1
New Jersey (College)	9	1		1	2 C			1 M	1	2	1		1								k 1
New Mexico	3	1					1 M	1 I		1			1								
New York (State)	7	2			1		1			2			1								
New York (Cornell)	13	2	2 A				2 A	2		2	2		2						1		o 1 E
North Carolina	10	1	1				1	1		4 A	1 G		2				1				
North Dakota	5	1						1		1									1		o 1
Ohio	10	2			1		1	2 K			1		1 A		1				1		p 2
Oregon	7	1					1	1		1	1		1								k 1
Pennsylvania	12	2			1		1	1		5 A			1								q 2
Rhode Island	6	1					1 A			1			1						1		r 2
South Carolina	3	2								1											
South Dakota	9	1		1	1		1 A	2 M		1	2		1						1		
Tennessee	8	1			1		1	1 A		2	1		1								f 1
Texas	7	1					2 A			2 O			1		1				1		s 1
Utah	5	1			1					1	1 M		1								t 1
Vermont	9	1	1				2 A	1		2	1		1				1				
Virginia	9	2	1			1	2 A	u 1 A		2	u 1 A		u 2 A						1		
West Virginia	6	1			1		1	1		2 A	1						1 G				
Wisconsin	8	1			1		1			2			1					1			k 1
Office of Experiment Stations	9																				
Total	438	66	21	5	18	16	63	42	4	101	33	1	47	1	11	2	4	3	19	2	42

a Foreman.
b Seven patrons and four foremen of substations.
c One superintendent of grounds, who is also horticulturist and entomologist; one œcologist, who is also first assistant chemist in viticultural laboratory; one foreman of station grounds, one foreman of cellars, and one inspector of stations.
d One grass agent, one superintendent of buildings and grounds, and one laboratory assistant.
e Dairyman.
f Foreman of farm.
g One engineer and assistant, one man in charge of diffusion battery, one sugar maker and two assistants, one farm manager.
h Farm manager.
i Machinist.
j Auditor.
k Farm superintendent.
l Superintendent of mechanical department.
m One dairyman and one general assistant.
n Laboratory assistant and janitor.
o Arboriculturist.
p One foreman of farm and one foreman of gardens.
q One superintendent of farm and one gardener.
r One apiarist and one farmer.
s Assistant to director.
t Superintendent.
u The vice director is also botanist, entomologist, and horticulturist.

The lines of work pursued

[The plus marks indi-

	Stations.	METEOROLOGY AND CLIMATOLOGY.	SOIL.			FERTILIZERS.			CROPS.				FEEDING STUFFS.		SILOS AND SILAGE.	FEEDING OF ANIMALS.				
			Geology, physics, and chemistry.	Tillage, drainage, and irrigation.	Soil tests with fertilizers.	Analyses without control.	Analyses with control.	Field experiments.	Composition.	Manuring and cultivation.	Rotation.	Varieties.	Composition.	Digestibility.		For milk.	For beef.	For mutton.	For pork.	Methods.
1	Alabama (College)	+	×	×	+	×	+	+	×	+	×	+	×		+		×			
2	Alabama (Canebrake)	×		×	+			+	×	×	×	×			×		×		×	×
3	Alabama (North)			×	+			+		+	×	+								+
4	Alabama (Southeast)				+			+		×										
5	Arizona		×	×	×	×		×	×	×		×								
6	Arkansas	×			×		×	×	×	+	×	×	×	×	×		×			+
7	California	×	+	+	×	×		×	×	×		+								
8	Colorado	+	+	+					×	×	×	×	+				×		×	
9	Connecticut (State)				×		+	×	×	×			+							
10	Connecticut (Storrs)				+			+	+				×			+				
11	Delaware	+		×	+			+			×	×	+							
12	Florida		×	+	+	×		+	×	+	×	+			+					
13	Georgia	×	×	×	+			+	+	+	×	+	×							
14	Illinois	×		×		×		+	×	×	×	+	×		+		×		×	×
15	Indiana	×	×	×	×			+	×	×	×	×	×	×		×	×			
16	Iowa			+						×	×	×	+		×					
17	Kansas							×		+	×	+	×	×	+	×				
18	Kentucky		×	+	+	+		+	×	×	+	×	+	+		×	×	×	×	×
19	Louisiana (Sugar)																			
20	Louisiana (State)		×	+	+	+	+	+	+	+	+	+	+	+	×					
21	Louisiana (North)																			
22	Maine	×			+		×	+	+			×	+	+	×	+		×	×	+
23	Maryland	×	×	×	×			+	×	×	+	×	×		+		+		×	+
24	Massachusetts (State)		×	×	+	+	+	+	+	+	×	+	+		+	+	+	+	+	×
25	Massachusetts (Hatch)	+			+			×	×			×	×		×					
26	Michigan	×		×	×	×		×	×	×	+	+	×	×	×		+		×	
27	Minnesota		×	×	×			×	×	×	×	×	×	×	×	×		×	×	×
28	Mississippi		×	+	+		×	+	×	+	×	+	×	×		+	×			
29	Missouri	×		×	×			×	+	+	+	+	+	+		+	+			+
30	Nebraska	+	×	×																
31	Nevada	×	+	+	×				×		×	×								
32	New Hampshire		×	×	+	×		+	×	×	+	×	+	×	+	+	×		+	×
33	New Jersey (State)																			
34	New Jersey (College)				×	×	+	+	+	×	×	×	×			+				
35	New Mexico			+							+									
36	New York (State)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×		×	×
37	New York (Cornell)			×	×	×		×	×	×	×	×	×		×	×		+	×	+
38	North Carolina	+		×	×		+	×	+	×	×	×	×	+	×	×	×			
39	North Dakota		×	+							×	×	+							
40	Ohio	×		×	+			+		×	×	+			×	×				×
41	Oregon			+	×					+	×	+	×	×	×	×				
42	Pennsylvania		×			+		+	×	×		×	+	+	+	+	×			
43	Rhode Island	×		×	×	×		×		×		×								
44	South Carolina										×	×								
45	South Dakota	+	+	×	×			×		×	+	+								
46	Tennessee			×	×	×			+	×		+	+			+	×		+	
47	Texas	×	×	×	×	×		×	×	×	×	×	×	×	×	+	+		+	
48	Utah	×	×	×	×			×	×	×	×	×	×		×	×	×	×	×	×
49	Vermont	×			×	×	+	×	×	×		×	+	×	+	+			×	
50	Virginia				×	×		×	×	+	+	+	×		×		×		×	×
51	West Virginia	×			+	×		+	×	×		×	×						×	
52	Wisconsin			+					+			+	+		+	+		+	+	+
	Totals	25	22	36	39	20	11	39	36	39	35	44	36	17	26	22	20	7	19	17

at the several stations.

cate specialties.]

DAIRYING.				CHEMISTRY.		BOTANY.				HORTICULTURE.					FORESTRY.	ENTOMOLOGY.	VETERINARY SCIENCE AND PRACTICE.				APICULTURE.	AVICULTURE.	TECHNOLOGY.—Sugars, wines, etc.	
Chemistry of milk.	Bacteria of milk.	Creaming of milk.	Butter making and creameries.	Special analyses.	Methods of analysis.	Systematic and physiological.	Mycology.	Seeds.	Weeds.	Vegetables.	Small fruits.	Grapes.	Orchard fruits.	Nuts.			General.	Hog cholera.	Texas fever.	Dehorning.				
+			×	×	+	+	+	×	×	+	+	+	+	×		+					×			1
										×	×	×	×	×										2
		+								+	×	+	+								+	×		3
												×	×											4
				×						×	×	×	×	×	×									5
				×						×	+	×	+			×	×		+					6
				+	×	+	×	×	+	×	×	+	+	+	×	×							×	7
				×				+	+	+	+	+	+		+						×			8
×				×	×		+	×								×								9
+	+	×	×	×	×								×											10
×			+		×		+	×	×	×	+	×	+			+	×						×	11
							×	+	+	×	×	+	+	×		+								12
										+	+	×	+	×										13
×		+	×	+	×		+	×	×	+	×	×	×		+								×	14
				×	×		×	×		×	×	×	×			×		×					×	15
+			×	+		×	×			×			+			+							×	16
				+	×		×	×		+	×	+	×		+	+	×	×			×		×	17
		×	×	×	×	×	×	×	×	×	×	×	×		×	+		×						18
				+	+	+			+	+	+	+	+			+	+	×	+				+	19, 20, 21
+		×						×	×		×		×				×	×						22
				+	×		×			+	+	×	×		×									23
+		+	×	+	+	×	+	×			×	×	×		×									24
×										×	×	×	×			+								25
+		×		×				×	×	+	+	×	×	×		+	×				×			26
×			×	×		×	×			×	[illegible]	×	×		×	×	×						×	27
×			×	×		×	+			×	+	×	×	×		+								28
+	+	+	+	+	+		×	×	×	+	+	+	+			×	+	+	+	×	×	×	×	29
				×	×	+	+		×	×			×			+	×						+	30
				×	×	×		×	×	×	×	+	+		+	+								31
×	×	×	+		×	×																		32
+				×	×	×	×	×	×	×	×	×	×		×	×								33, 34
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×		×	×	×	×			×		×	×	×	×		×	×						×	×	36
×		×		×	×		+	×	×	+	+	+	+			+				×				37
		×	×	+			×	+	×	+	×	×	×	×		×								38
×	×	×	×	+			+	×	×	×	×				+	×							×	39
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				×	×			×		+	×				×									42
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×		+	+	×		×	×	×	×	×	×	×	×	×	×	×	×		+	×			×	47
×										×	×	×	×		×	×								48
+		+	+	×	+		+		+	+	+	×	×			+	×							49
				+	×	×	+	×	×	+	+	+	+	×		×								50
+	×	+	+	+	+	+	×	×	+	×	×	×	+	×	+	+								51
+			+						+		+	+	+										+	52
24	5	16	19	34	25	18	28	25	26	40	41	38	43	14	21	31	14	7	4	5	7	3	14	

Revenues and additions to the equipment of the agricultural experiment stations in* 1890, *and the aggregate value of funds and other property received by them previous to* 1890 *from other sources than the United States.

Stations.	Revenue for 1890 from—								Aggregate value of funds and other property received previous to 1890 from other sources than the United States.	Value of additions to equipment in 1890.						
	United States.	States.	Local communities.	Individuals.	Fees.	Farm produce.	Miscellaneous.	Total.		Farm.	Buildings.	Library.	Apparatus.	Live stock.	Miscellaneous.	Total.
Alabama (College)	$13,000	$10,810			$410			$24,220	$36,500	$1,000	$750	$300	$3,500			$5,550
Alabama (Canebrake)	2,000	2,500						4,500	4,500							
Alabama (North)		2,500			250			2,750	15,000		4,500				$1,000	5,500
Alabama (Southeast)		2,500						2,500								
Arizona	15,000	10,000						25,000								
Arkansas	15,000		$2,000					17,000	2,000	1,800	750	300	1,500		1,000	5,350
California	15,000	19,940	3,000					37,940	79,400	585	1,428	421	897	$400		3,731
Colorado	15,000	54,923			1,006	$1,631	$1,242	73,802			29,160	688	2,046	1,000	2,000	34,894
Connecticut (State)	7,500	6,000					4,269	19,769	79,500			266				266
Connecticut (Storrs)	7,500			$125		64	146	7,835			900			198		1,098
Delaware	15,000							15,000		1,600	382	148	414			2,544
Florida	15,000							15,000			2,626	75	120			2,821
Georgia	15,000					400		15,400	19,000		6,232			300	225	6,757
Illinois	15,000							15,000				450	250		100	800
Indiana	15,000	15,000				2,000		32,000			12,000	3,500		1,500		17,000
Iowa	15,000					420	36	15,456		82	977	306	155	2,900	137	4,557
Kansas	15,000							15,000				211	415			626
Kentucky	15,000				1,965	346		17,311	7,244		505	500	911	800		2,716
Louisiana (Sugar) Louisiana (State) Louisiana (North)	15,000	7,500		10,000	5,000	1,500		39,000	78,200		18,000	1,000	4,500	500	2,500	26,500
Maine	15,000					427		15,427	357		4,500					4,500
Maryland	15,000	1,200						16,200			750	150	1,250	500	100	2,750
Massachusetts (State)		10,000			1,500	1,030		12,500	12,500		450	300	700		200	1,650
Massachusetts (Hatch)	15,000							15,000	1,200		2,700	305	700			3,705
Michigan	15,000		500		880	272	77	16,729	3,963	500	1,000	254	408	455		2,617
Minnesota	15,000	3,000				2,797		20,797			300			1,509		1,809
Mississippi	15,000						410	15,410	456		600	225	800		500	2,125
Missouri	15,000	15,500				1,754		32,254	104,000		4,000	100	250	400	400	5,150
Nebraska	15,000							15,000		225		550	2,371			3,146
Nevada	15,000							15,000			500	125	800		150	1,575
New Hampshire	15,000					3,000		18,000			3,000	300		80		3,380
New Jersey (State)		11,000						11,000				613	597	500		1,710
New Jersey (College)	15,000							15,000								
New Mexico	15,000							15,000		7,500	25,000	800	1,000		1,000	35,300
New York (State)		30,000			20,000			50,000		583	500	200	1,500	327	447	3,557
New York (Cornell)	15,000					300		15,300	300		750	135	350	125		1,360
North Carolina	15,000	2,000				200	94	17,294	12,000	300	650		400	150	75	1,575
North Dakota	7,500					100		7,600		12,800		500	2,000		1,150	16,450

Ohio	15,000	2,000				7,081		24,081			844	175	64	319	243	1,645
Oregon	15,000							15,000			175	258	200		95	728
Pennsylvania	15,000	3,000			6,996	2,467		27,463	40,642		16,000					16,000
Rhode Island	15,000							15,000	14,924	408	700	614	1,723	430	1,397	5,262
South Carolina	15,000							15,000								
South Dakota	15,000							15,000		196	275	75	475			1,021
Tennessee	15,000					250		15,250								
Texas	15,000					3,294		18,294	5,567		150		300		200	650
Utah	15,000	11,200				231		26,431		1,200	12,300	300	2,000	200	2,000	18,000
Vermont	15,000					1,000		16,000	14,350		4,011	100	929	540		5,580
Virginia	15,000					1,440	140	16,580	310		566	29	450	49	120	1,214
Washington	15,000							15,000								
West Virginia	15,000						53	15,053	6,000		750	102	850	277	1,707	3,686
Wisconsin	15,000	4,000				2,000		21,000			2,000	500	1,500	500		4,500
Total	652,500	226,573	5,500	10,125	38,007	33,974	6,467	973,146	537,883	28,779	161,681	14,875	36,325	13,949	16,746	272,355

REPORT OF THE CHIEF OF THE DIVISION OF GARDENS AND GROUNDS.

SIR: Having prepared, by your direction, as stated on page 44, a descriptive list of the more important economic plants at present contained in the collection of the Department, I beg to offer the same in place of the usual report of work done in my Division, believing it to be of sufficient interest to justify its publication in your Annual Report.

Very respectfully,

WILLIAM SAUNDERS,
Superintendent of Gardens and Grounds.

Hon. J. M. RUSK,
Secretary.

DESCRIPTIVE CATALOGUE OF PLANTS.

1. ABELMOSCHUS MOSCHATUS.—This plant is a native of Bengal. Its seeds were formerly mixed with hair powder, and are still used to perfume pomatum. The Arabs mix them with their coffee berries. In the West Indies the bruised seeds, steeped in rum, are used, both externally and internally, as a cure for snake bites.

2. ABRUS PRECATORIUS.—Wild liquorice. This twining, leguminous plant is a native of the East, but is now found in the West Indies and other tropical regions. It is chiefly remarkable for its small oval seeds, which are of a brilliant scarlet color, with a black scar at the place where they are attached to the pods. These seeds are much used for necklaces and other ornamental purposes, and are employed in India as a standard of weight, under the name of Rati. The weight of the famous Kohinoor diamond is known to have been ascertained in this way. The roots afford liquorice, which is extracted in the same manner as that from the true Spanish liquorice plant, the *Glycyrrhiza glabra*. Recently the claim was made that the weather could be foretold by certain movements of the leaves of this plant, but experimental tests have proved its fallacy.

3. ABUTILON INDICUM.—This plant furnishes fiber fit for the manufacture of ropes. Its leaves contain a large quantity of mucilage.

4. ABUTILON VENOSUM.—This malvaceous plant is common in collections, as are others of the genus. They are mostly fiber-producing species. The flowers of *A. esculentum* are used as a vegetable in Brazil.

5. ACACIA BRASILIENSIS.—This plant furnishes the Brazil wood, which yields a red or crimson dye, and is used for dyeing silks. The best quality is that received from Pernambuco.

6. ACACIA CATECHU.—The drug known as catechu is principally prepared from this tree, the wood of which is boiled down, and the decoction subsequently evaporated so as to form an extract much used as an astringent. The acacias are very numerous, and yield many useful products. Gum arabic is produced by several species, as *A. vera*, *A. Arabica*, *A. Adansonii*, *A. verek*, and others. It is obtained by spontaneous exudation from the trunk and branches, or by incisions made in the bark, from whence it flows in a liquid state, but

soon hardens by exposure to the air. The largest quantity of the gum comes from Barbary. Gum senegal is produced by *A. vera*. By some it is thought that the timber of *A. Arabica* is identical with the Shittim tree, or wood of the Bible. From the flowers of *A. farnesiana* a choice and delicious perfume is obtained, the chief ingredient in many valued "balm of a thousand flowers." The pods of *A. concinna* are used in India as a soap for washing; the leaves are used for culinary purposes, and have a peculiarly agreeable acid taste. The seeds of some species are used, when cooked, as articles of food. From the seeds of *A. Niopo* the Guahibo Indians prepare a snuff, by roasting the seeds and pounding them in a wooden platter. Its effects are to produce a kind of intoxication and invigorate the spirits. The bark of several species is extensively used for tanning, and the timber, being tough and elastic, is valuable for the manufacture of machinery and other purposes where great strength and durability are requisite.

7. ACACIA DEALBATA.—The silver wattle tree of Australia. The bark is used for tanning purposes. It is hardy South.

8. ACACIA HOMOLOPHYLLA.—This tree furnishes the scented myall wood, a very hard and heavy wood, of an agreeable odor, resembling that of violets. Fancy boxes for the toilet are manufactured of it.

9. ACACIA MELANOXYLON.—The wood of this tree is called mayall wood in New South Wales. It is also called violet wood, on account of the strong odor it has of that favorite flower; hence it is in great repute for making small dressing cases, etc.

10. ACACIA MOLLISSIMA.—The black wattle tree of Australia, which furnishes a good tanning principle. These trees were first called wattles from being used by the early settlers for forming a network or wattling of the supple twigs as a substitute for laths in plastering houses.

11. ACROCOMIA SCLEROCARPA.—This palm grows all over South America. It is known as the great macaw-tree. A sweetish-tasted oil, called Mucaja oil, is extracted from the fruit and is used for making toilet soaps.

12. ADANSONIA DIGITATA.—The baobab tree, a native of Africa. It has been called the tree of a thousand years, and Humboldt speaks of it as "the oldest organic monument of our planet." Adanson, who traveled in Senegal in 1794, made a calculation to show that one of these trees, 30 feet in diameter, must be 5,150 years old. The bark of the baobab furnishes a fiber which is made into ropes and also manufactured into cloth. The fiber is so strong as to give rise to a common saying in Bengal, "as secure as an elephant bound with baobab rope." The pulp of the fruit is slightly acid, and the juice expressed from it is valued as a specific in putrid and pestilential fevers. The ashes of the fruit and bark, boiled in rancid palm oil, make a fine soap.

13. ADENANTHERA PAVONINA.—A tree that furnishes red sandal wood. A dye is obtained simply by rubbing the wood against a wet stone, which is used by the Brahmins for marking their foreheads after religious bathing. The seeds are used by Indian jewelers as weights, each seed weighing uniformly four grains. They are known as Circassian beans. Pounded and mixed with borax, they form an adhesive substance. They are sometimes used as food. The plant belongs to the Leguminosæ.

14. ADHATODA VASICA.—This plant is extolled for its charcoal in the manufacture of powder. The flowers, leaves, roots, and especially the fruit, are considered antispasmodic, and are administered in India in asthma and intermittent fevers.

15. ÆGLE MARMELOS.—This plant belongs to the orange family, and its fruit is known in India as Bhel fruit. It is like an orange; the thick rind of the unripe fruit possesses astringent properties, and, when ripe, has an exquisite flavor and perfume. The fruit and other parts of the plant are used for medicinal purposes, and a yellow dye is prepared from the skin of the fruits.

16. AGAVE AMERICANA.—This plant is commonly known as American aloe, but it is not a member of that family, as it claims kindred with the *Amaryllis* tribe of plants. It grows naturally in a wide range of climate, from the plains of South America to elevations of 10,000 feet. It furnishes a variety of products. The plants form impenetrable fences; the leaves furnish fibers of various qualities, from the fine thread known as pita-thread, which is used for twine, to the coarse fibers used for ropes and cables. Humboldt describes a bridge of upward of 130 feet span over the Chimbo in Quito, of which the main ropes (4 inches in diameter) were made of this fiber. It is also used for making paper. The juice, when the watery part is evaporated, forms a good

soap (as detergent as castile), and will mix and form a lather with salt water as well as with fresh. The sap from the heart leaves is formed into pulque. This sap is sour, but has sufficient sugar and mucilage for fermentation. This vinous beverage has a filthy odor, but those who can overcome the aversion to this fetid smell indulge largely in the liquor. A very intoxicating brandy is made from it. Razor strops are made from the leaves; they are also used for cleaning and scouring pewter.

17. AGAVE RIGIDA.—The sisal hemp, introduced into Florida many years ago, for the sake of its fiber, but its cultivation has not been prosecuted to a commercial success. Like many other of the best vegetable fibers found in leaves, it contains a gummy substance, which prevents the easy separation of the fiber from the pulp.

18. ALEURITES TRILOBA.—The candleberry tree, much cultivated in tropical countries for the sake of its nuts. The nuts or kernels, when dried and stuck on a reed, are used by the Polynesians as a substitute for candles and as an article of food; they are said to taste like walnuts. When pressed, they yield largely of pure palatable oil, as a drying oil for paint, and known as artists' oil. The cake, after the oil has been expressed, is a favorite food for cattle. The root of the tree affords a brown dye, which is used to dye cloths.

19. ALGAROBIA GLANDULOSA.—The mezquite tree, of Texas, occasionally reaching a height of 25 to 30 feet. It yields a very hard, durable wood, and affords a large quantity of gum resembling gum arabic, and answering every purpose of that gum.

20. ALLAMANDA CATHARTICA.—This plant belongs to the family of *Apocynaceæ*, which contains many poisonous species. It is often cultivated for the beauty of its flowers; the leaves are considered a valuable cathartic, in moderate doses, especially in the cure of painter's colic; in large doses they are violently emetic. It is a native of South America.

21. ALOE SOCOTRINA.—Bitter aloe, a plant of the lily family, which furnishes the finest aloes. The bitter, resinous juice is stored up in greenish vessels, lying beneath the skin of the leaf, so that when the leaves are cut transversely, the juice exudes, and is gradually evaporated to a firm consistence. The inferior kinds of aloes are prepared by pressing the leaves, when the resinous juice becomes mixed with the mucilaginous fluid from the central part of the leaves, and thus it is proportionately deteriorated. Sometimes the leaves are cut and boiled, and the decoction evaporated to a proper consistence. This drug is imported in chests, in skins of animals, and sometimes in large calabash-gourds, and although the taste is peculiarly bitter and disagreeable, the perfume of the finer sorts is aromatic, and by no means offensive. It is common in tropical countries.

22. ALSOPHILA AUSTRALIS.—This beautiful tree-fern attains a height of stem of 25 to 30 feet, with fronds spreading out into a crest 26 feet in diameter. These plants are among the most beautiful of all vegetable productions, and in their gigantic forms indicate, in a meager degree, the extraordinary beauty of the vegetation on the globe previous to the formation of the coal measures.

23. ALSTONIA SCHOLARIS.—The Pali-mara, or devil tree, of Bombay. The plant attains a height of 80 or 90 feet; the bark is powerfully bitter, and is used in India in medicine. It is of the family of *Apocynaceæ*.

24. AMOMUM MELEGUETTA.—Malaguetta pepper, or grains of paradise; belonging to the ginger family, *Zingiberaceæ*. The seeds of this and other species are imported from Guinea; they have a very warm and camphor-like taste, and are used to give a fictitious strength to adulterated liquors, but are not considered particularly injurious to health. The seeds are aromatic and stimulating, and form, with other seeds of similar plants, what are known as cardamoms.

25. AMYRIS BALSAMIFERA.—This plant yields the wood called Lignum Rhodium. It also furnishes a gum resin analogous to Elemi, and supposed to yield Indian Bdellium.

26. ANACARDIUM OCCIDENTALE.—The cashew nut tree, cultivated in the West Indies and other tropical countries. The stem furnishes a milky juice, which becomes hard and black when dry, and is used as a varnish. It also secretes a gum, like gum arabic. The nut or fruit contains a black, acrid, caustic oil, injurious to the lips and tongue of those who attempt to crack the nut with their teeth; it becomes innocuous and wholesome when roasted, but this process must be carefully conducted, the acridity of the fumes producing severe inflammation of the face if approached too near.

27. ANANASSA SATIVA.—The well-known pineapple, the fruit of which was described three hundred years ago, by Jean de Lery, a Huguenot priest, as being of such excellence that the gods might luxuriate upon it, and that it should only be gathered by the hand of a Venus. It is supposed to be a native of Brazil, and to have been carried from thence to the West, and afterwards to the East Indies. It first became known to Europeans in Peru. It is universally acknowledged to be one of the most delicious fruits in the world. Like all other fruits that have been a long time under cultivation, there are numerous varieties that vary greatly, both in quality and appearance. The leaves yield a fine fiber, which is used in the manufacture of pina cloth; this cloth is very delicate, soft, and transparent. and is made into shawls, scarfs, handkerchiefs, and dresses.

28. ANDIRA INERMIS.—This is a native of Senegambia. Its bark is anthelmintic, but requires care in its administration, being powerfully narcotic. It has a sweetish taste, but a disagreeable smell, and is generally given in the form of a decoction, which is made by boiling an ounce of the dried bark in a quart of water until it assumes the color of Madeira wine. Three or four grains of the powdered bark acts as a powerful purgative. The bark is known as bastard cabbage bark, or worm bark. It is almost obsolete in medicine.

29. ANDROPOGON MURICATUS.—The Khus-Khus, or Vetiver grass of India. The fibrous roots yield a most peculiar but pleasing perfume. In India the leaves are manufactured into awnings, blinds, and sunshades; but principally for screens, used in hot weather for doors and windows, which, when wetted, diffuse a peculiar and refreshing perfume, while cooling the air.

30. ANDROPOGON SCHŒNANTHUS.—The sweet-scented lemon grass, a native of Malabar. An essential oil is distilled from the leaves, which is used in perfumery. It is a favorite herb with the Asiatics, both for medicinal and culinary purposes. Tea from the dried leaves is a favorite beverage of some persons.

31. ANONA CHERIMOLIA.—The Cherimoyer of Peru, where it is extensively cultivated for its fruits, which are highly esteemed by the inhabitants, but not so highly valued by those accustomed to the fruits of temperate climates. The fruit, when ripe, is of a pale greenish-yellow color, tinged with purple, weighing from 3 to 4 pounds; the skin thin; the flesh sweet, and about the consistence of a custard; hence often called custard apple.

32. ANONA MURICATA.—The sour-sop, a native of the West Indies, which produces a fruit of considerable size, often weighing over 2 pounds. The pulp is white and has an acrid flavor, which is not disagreeable.

33. ANONA RETICULATA.—The common custard apple of the West Indies. It has a yellowish pulp and is not so highly esteemed as an article of food as some others of the species. It bears the name of Condissa in Brazil. The Anonas are grown to some extent throughout southern Florida.

34. ANONA SQUAMOSA.—The sweet-sop, a native of the Malay Islands, where it is grown for its fruits. These are ovate in shape, with a thick rind, which incloses a luscious pulp. The seeds contain an acrid principle, and, being reduced to powder, form an ingredient for the destruction of insects.

35. ANTIARIS INNOXIA.—The upas tree. Most exaggerated statements respecting this plant have passed into history. Its poisonous influence was said to be so great as not only to destroy all animal life but even plants could not live within 10 miles of it. The plant has no such virulent properties as the above, but, as it inhabits low valleys in Java where carbonic acid gas escapes from the crevices in volcanic rocks which frequently proves fatal to animals, the tree was blamed wrongly. It is, however, possessed of poisonous juice, which, when dry and mixed with other ingredients, forms a venomous poison for arrows, and severe effects have been felt by those who have climbed upon the branches for the purpose of gathering the flowers.

36. ANTIARIS SACCIDORA.—The sack tree; so called from the fibrous bark being used as sacks. For this purpose young trees of about a foot in diameter are selected and cut into junks of the same length as the sack required. The outer bark is then removed and the inner bark loosened by pounding, so that it can be separated by turning it inside out. Sometimes a small piece of the wood is left to form the bottom of the sack. The fruit exudes a milky, viscid juice, which hardens into the consistency of beeswax, but becomes black and shining.

37. ANTIDESMA BUNIAS.—An East India plant which produces small, intensely black fruit about the size of a currant, used in making preserves. The bark

furnishes a good fiber, which is utilized in the manufacture of ropes. A decoction of the leaves is a reputed cure for snake bites. The whole plant is very bitter.

38. ARALIA PAPYRIFERA.—The Chinese rice paper plant. The stems are filled with pith of very fine texture and white as snow, from which is derived the article known as rice paper, much used in preparing artificial flowers.

39. ARAUCARIA BIDWILLI.—The Bunya-Bunya of Australia, which forms a large tree, reaching from 150 to 200 feet in height. The cones are very large, and contain one hundred to one hundred and fifty seeds, which are highly prized by the aborigines as food. They are best when roasted in the shell, cracked between two stones and eaten while hot. In flavor they resemble roasted chestnuts. During the season of the ripening of these seeds the natives grow sleek and fat. That part of the country where these trees most abound is called the Bunya-Bunya country.

40. ARAUCARIA BRASILIENSIS.—The Brazilian Araucaria, which grows at great elevations. The seeds of this tree are commonly sold in the markets of Rio Janeiro as an article of food. The resinous matter which exudes from the trunk is employed in the manufacture of candles.

41. ARAUCARIA CUNNINGHAMI.—The Morton Bay pine. This Australian tree forms a very straight trunk, and yields a timber of much commercial importance in Sidney and other ports. It is chiefly used for house building and some of the heavier articles of furniture.

42. ARAUCARIA EXCELSA.—This very elegant evergreen is a native of Norfolk Island. Few plants can compare with it in beauty and regularity of growth. The wood is of no particular value, although used for building purposes in Norfolk Island.

43. ARDISIA CRENATA.—A native of China. The bark has tonic and astringent properties, and is used in fevers and for external application in the cure of ulcers, etc.

44. ARECA CATECHU.—This palm is cultivated in all the warmer parts of Asia for its seed. This is known under the name of betel nut, and is about the size of a nutmeg. The chewing of these nuts is a common practice of hundreds of thousands of people. The nut is cut into small pieces, mixed with a small quantity of lime, and rolled up in leaves of the betel pepper. The pellet is chewed, and is hot and acrid, but possesses aromatic and astringent properties. It tinges the saliva red and stains the teeth. The practice is considered beneficial rather than otherwise, just as chewing tobacco-leaves, drinking alcohol, and eating chicken-salad are considered healthful practices in some portions of the globe. A kind of catechu is obtained by boiling down the seeds to the consistence of an extract, but the chief supply of this drug is Acacia catechu.

45. ARGANIA SIDEROXYLON.—This is the argan tree of Morocco. It is remarkable for its low-spreading mode of growth. Trees have been measured only 16 feet in height, while the circumference of the branches was 220 feet. The fruit is much eaten and relished by cattle. The wood is hard and so heavy as to sink in water. A valuable oil is extracted from the seeds.

46. ARISTOLOCHIA GRANDIFLORA.—The pelican flower. This plant belongs to a family famed for the curious construction of their flowers, as well as for their medical qualities. In tropical America various species receive the name of "Guaco," which is a term given to plants that are used in the cure of snake bites. Even some of our native species, such as *A. serpentaria*, is known as snake-root, and is said to be esteemed for curing the bite of the rattlesnake. It is stated that the Egyptian jugglers use some of these plants to stupify the snakes before they handle them. *A. bracteata* and *A. indica* are used for similar purposes in India. It is said that the juice of the root of *A. anguicida*, if introduced into the mouth of a serpent, so stupefies it that it may be handled with impunity. The Indians, after having "guaconized" themselves, that is, having taken Guaco, handle the most venomous snakes without injury.

47. ARTANTHE ELONGATA.—A plant of the pepper family, which furnishes one of the articles known by the Peruvians as Matico, and which is used by them for the same purposes as cubebs; but its chief value is as a styptic, an effect probably produced by its rough under surface, acting mechanically like lint. It has been employed internally to check hemorrhages, but with doubtful

effect. Its aromatic bitter stimulant properties are like those of cubebs, and depend on a volatile oil, a dark-green resin, and a peculiar bitter principle called *maticin*.

48. ARTOCARPUS INCISA.—This is the breadfruit tree of the South Sea Islands, where its introduction gave occasion for the historical incidents arising from the mutiny of the "Bounty." The round fruits contain a white pulp, of the consistence of new bread. It is roasted before being eaten, but has little flavor. The tree furnishes a viscid juice containing caoutchouc, which is used as glue for calking canoes. In the South Sea Islands the breadfruit constitutes the principal article of diet; it is prepared by baking in an oven heated by hot stones.

49. ARTOCARPUS INTEGRIFOLIA.—The jack of the Indian Archipelago, cultivated for its fruit, which is a favorite article among the natives, as also are the roasted seeds. The wood is much used, and resembles mahogany. Bird-lime is made from the juice.

50. ASTROCARYUM VULGARE.—Every part of this South American palm is covered with sharp spines. It is cultivated to some extent by the Indians of Brazil for the sake of its young leaves, which furnish a strong fiber for making bow-strings, fishing nets, etc. The finer threads are knitted into hammocks, which are of great strength. It is known as Tucum thread. The pulp of the fruit furnishes an oil. In Guiana it is called the Aoura palm.

51. ATTALEA COHUNE.—This palm furnishes Cahoun nuts, from which is extracted cohune oil, used as a burning oil, for which purpose it is superior to cocoanut oil. Piassaba fiber is furnished by this and *A. funifera*, the seeds of which are known as Coquilla nuts; these nuts are 3 or 4 inches long, oval, of a rich brown color, and very hard; they are much used by turners for making the handles of doors, umbrellas, etc. The fiber derived from the decaying of the cellular matter at the base of the leaf-stalks is much used in Brazil for making ropes. It is largely used in England and other places for making coarse brooms, chiefly used in cleaning streets.

52. AVERRHOA BILIMBI.—This is called the blimbing, and is cultivated to some extent in the East Indies. The fruit is oblong, obtuse-angled, somewhat resembling a short, thick cucumber, with a thin, smooth, green rind, filled with a pleasant, acid juice.

53. AVERRHOA CARAMBOLA.—The caramba of Ceylon and Bengal. The fruit of this tree is about the size of a large orange, and, when ripe, is of a rich yellow color, with a very decided and agreeable fragrance. The pulp contains a large portion of acid, and is generally used as a pickle or preserve. In Java it is used both in the ripe and unripe state in pies; a sirup is also made of the juice, and a conserve of the flowers. These preparations are highly valued as remedies in fevers and bilious disorders.

54. BACTRIS MAJOR.—The Marajah palm, of Brazil, which grows upon the banks of the Amazon River. It has a succulent, rather acid fruit, from which a vinous beverage is prepared. *B. minor* has a stem about 14 feet high and about an inch in diameter. These stems are used for walking canes, and are sometimes called Tobago canes.

55. BALSAMOCARPON BREVIFOLIUM.—This shrub is the algarrobo of the Chilians. It belongs to the pea family. Its pods are short and thick, and when unripe contain about 80 per cent of tannic acid; the ripe pods become transformed into a cracked resinous substance, when their tanning value is much impaired; this resinous matter is astringent, and is used for dyeing black and for making ink.

56. BALSAMODENDRON MYRRHA.—A native of Arabia Felix, producing a gum resin, sometimes called Opobalsamum, which was considered by the ancients as a panacea for almost all the ills that flesh is heir to. *B. Mukul* yields a resin of this name, and is considered identical with the Bdellium of Dioscorides and of the Scriptures. The resin has cordial and stimulating properties, and is burnt as an incense. In ancient times it was used as an embalming ingredient.

57. BAMBUSA ARUNDINACEA.—The bamboo cane, a gigantic grass, cultivated in many tropical and semitropical countries. The Chinese use it in one way or other for nearly everything they require. Almost every article of furniture in their houses, including mats, screens, chairs, tables, bedsteads, and bedding, is made made of bamboo. The masts, sails, and rigging of their ships consist chiefly of bamboo. A fiber has been obtained from the stem suitable for mixing

with wool, cotton, and silk; it is said to be very soft and to take dyes easily. They have treatises and volumes on its culture, showing the best soil and the seasons for planting and transplanting this useful production.

58. BAUHINIA VAHLII.—The Maloo-climber of India, where the gigantic shrubby stems often attain a height of 300 feet, running over the tops of the tallest trees, and twisting so tightly around their stems as to kill them. The exceedingly tough fibrous bark of this plant is used in India for making ropes and in the construction of suspension bridges. The seeds form an article of food; they are eaten raw, and resemble cashew nuts in flavor.

59. BEAUCARNEA RECURVIFOLIA.—This Mexican plant is remarkable for the large bulbiform swelling at the base of the stem. It is a plant of much elegance and beauty, resembling a drooping fountain.

60. BERGERA KONIGI.—The curry-leaf tree of India. The fragrant, aromatic leaves are used to flavor curries. The leaves, root, and bark are used medicinally. The wood is hard and durable, and from the seeds a clear, transparent oil, called Simbolee oil, is extracted.

61. BERRYA AMMONILLA.—This furnishes the Trincomalee wood of the Philippine Islands and Ceylon, and is largely used for making oil casks and for building boats, for which it is well adapted, being light and strong.

62. BERTHOLLETIA EXCELSA.—This furnishes the well known Brazil nuts, or cream nuts of commerce. The tree is a native of South America and attains a height of 100 to 150 feet. The fruit is nearly round and contains from eighteen to twenty-four seeds, which are so beautifully packed in the shell that when once removed it is found impossible to replace them. A bland oil is pressed from the seeds, which is used by artists, and at Para the fibrous bark of the tree is used for calking ships, as a substitute for oakum.

63. BIGNONIA ECHINATA.—A native of Mexico, where it is sometimes called Mariposa butterfly. The branches are said to be used in the adulteration of sarsaparilla. *B. chica*, a native of Venezuela, furnishes a red pigment, obtained by macerating the leaves in water, which is used by the natives for painting their bodies. The long flexible stems of *B. kerere* furnish the natives of French Guiana with a substitute for ropes. *B. alliacea* is termed the Garlic shrub, because of the powerful odor of garlic emitted from its leaves and branches when bruised. These plants all have showy flowers, and the genus is represented with us by such beautiful flowers as are produced by *B. radicans* and *B. capreolata*.

64. BIXA ORELLANA.—Arnotta plant. This plant is a native of South America, but has been introduced and cultivated both in the West and East Indies. It bears bunches of pink-colored flowers, which are followed by oblong bristled pods. The seeds are thinly coated with red, waxy pulp, which is separated by stirring them in water until it is detached, when it is strained off and evaporated to the consistence of putty, when it is made up into rolls; in this condition it is known as flag or roll arnotta, but when thoroughly dried it is made into cakes and sold as cake arnotta. It is much used by the South American Caribs and other tribes of Indians for painting their bodies, paint being almost their only article of clothing. As a commercial article it is mainly used as a coloring for cheese, butter, and inferior chocolates, to all of which it gives the required tinge without imparting any unpleasant flavor or unwholesome quality. It is also used in imparting rich orange and gold-colored tints to various kinds of varnishes.

65. BLIGHIA SAPIDA.—The akee fruit of Guinea. The fruit is about 3 inches long by 2 inches wide; the seeds are surrounded by a spongy substance, which is eaten. It has a subacid, agreeable taste. A small quantity of semisolid fatty oil is obtained from the seeds by pressure.

66. BŒHMERIA NIVEA.—A plant of the nettle family, which yields the fiber known as Chinese grass. The beautiful fabric called grasscloth, which rivals the best French cambric in softness and fineness of texture, is manufactured from the fiber of this plant. The fiber is also variously known in commerce as rheea, ramie, and in China as Tchow-ma. It is a plant of the easiest culture, and has been introduced into the Southern States, where it grows freely. When once machinery is perfected so as to enable its being cheaply prepared for the manufacturer, a great demand will arise for this fiber.

67. BOLDOA FRAGRANS.—A Chilian plant which yields small edible fruits; these, as well as all parts of the plant, are very aromatic. The bark is used for tanning, and the wood is highly esteemed for making charcoal. An alkaloid

called *boldine*, extracted from the plant, has reputed medicinal value, and a drug called Boldu is similarly produced.

68. BORASSUS FLABELLIFORMIS.—The Palmyra palm. The parts of this tree are applied to such a multitude of purposes that a poem in the Tamil language, although enumerating eight hundred uses, does not exhaust the catalogue. In old trees the wood becomes hard and is very durable. The leaves are from 8 to 10 feet long, and are used for thatching houses, making various mattings, bags, etc. They also supply the Hindoo with paper, upon which he writes with a stylus. A most important product called toddy or palm wine is obtained from the flower spikes, which yield a great quantity of juice for four or five months. Palm-toddy is intoxicating, and when distilled yields strong arrack. Very good vinegar is also obtained from it, and large quantities of jaggery or palm sugar are manufactured from the toddy. The fruits are large and have a thick coating of fibrous pulp, which is cooked and eaten or made into jelly. The young palm plants are cultivated for the market, as cabbages are with us, and eaten, either when fresh or after being dried in the sun.

69. BOSWELLIA THURIFERA.—This Coromandel tree furnishes the resin known as olibanum, which is supposed to have been the frankincense of the ancients. It is sometimes used in medicine as an astringent and stimulant, and is employed, because of its grateful perfume, as an incense in churches.

70. BROMELIA KARATAS.—The Corawa fiber, or silk-grass of Guiana, is obtained from this plant, which is very strong, and much used for bowstrings, fishing lines, nets, and ropes.

71. BROMELIA PINGUIN.—This is very common as a hedge or fence plant in the West Indies. The leaves, when beaten with a blunt mallet and macerated in water, produce fibers from which beautiful fabrics are manufactured. The fruit yields a cooling juice much used in fevers.

72. BROSIUM ALICASTRUM.—The bread-nut tree of Jamaica. The nuts or seeds produced by this tree are said to form an agreeable and nutritious article of food. When cooked they taste like hazelnuts. The young branches and shoots are greedily eaten by horses and cattle, and the wood resembles mahogany, and is used for making furniture.

73. BROSIMUM GALACTODENDRON—The cow tree of South America, which yields a milk of as good quality as that from the cow. It forms large forests on the mountains near the town of Cariaco and elsewhere along the seacoast of Venezuela, reaching to a considerable height. In South America the cow tree is called Palo de Vaca, or Arbol de Leche. Its milk, which is obtained by making incisions in the trunk, so closely resembles the milk of the cow, both in appearance and quality, that it is commonly used as an article of food by the inhabitants of the places where the tree is abundant. Unlike many other vegetable milks, it is perfectly wholesome, and very nourishing, possessing an agreeable taste, and a pleasant balsamic odor, its only unpleasant quality being a slight amount of stickiness. The chemical analysis of this milk has shown it to possess a composition closely resembling some animal substances; and, like animal milk, it quickly forms a cheesy scum, and after a few days' exposure to the atmosphere, turns sour and putrifies. It contains upwards of 30 per cent of a resinous substance called *galactine*.

74. BRYA EBENUS.—Jamaica or West India ebony tree. This is not the plant that yields the true ebony-wood of commerce. Jamica ebony is of a greenish-brown color, very hard, and so heavy that it sinks in water. It takes a good polish, and is used by turners for the manufacture of numerous kinds of small wares.

75. BYRSONIMA SPICATA.—A Brazilian plant, furnishing an astringent bark used for tanning, and also containing a red coloring matter employed in dyeing. The berries are used in medicine, and a decoction of the roots is used for ulcers.

76. CÆSALPINIA BONDUC.—A tropical plant, bearing the seeds known as nicker nuts, or bonduc nuts. These are often strung together for necklaces. The kernels have a very bitter taste, and the oil obtained from them is used medicinally.

77. CÆSALPINA PULCHERRIMA.—This beautiful flowering leguminous plant is a native of the East Indies, but is cultivated in all the tropics. In Jamaica it is called the "Barbados flower." The wood is sought after for charcoal, and a decoction of the leaves and flowers is used in fevers.

78. CÆSALPINIA SAPPAN.—The brownish-red wood of this Indian tree furnishes the Sappan wood of commerce, from which dyers obtain a red color, principally used for dyeing cotton goods. Its root also affords an orange-yellow dye.

79. CALAMUS ROTANG.—This is one of the palms that furnish the canes or rattans used for chair bottoms, sides of pony-carriages, and similar purposes. It is a climbing palm and grows to an immense length; specimens 300 feet long have been exhibited, climbing over and amongst the branches of trees, supporting themselves by means of the hooked spines attached to the leaf stalks. *C. rudentum* and *C. viminalis* furnish flexible canes. In their native countries they are used for a variety of manufacturing purposes, also for ropes and cables used by junks and other coasting vessels. In the Himalayas they are used in the formation of suspension bridges across rivers and deep ravines. *C. scipionum* furnishes the well-known Malacca canes used for walking sticks. They are naturally of a rich brown color. The clouded and mottled appearance which some of these present is said to be imparted to them by smoking and steaming.

80. CALLISTEMON SALIGNUM.—A medium-sized tree from Australia; one of the many so-called tea trees of that country. The wood, which is very hard, is known as stone wood and has been used for wood engraving. Layers of the bark readily peel off; hence it also receives the name of paper-bark plant.

81. CALLITRIS QUADRIVALVIS.—This coniferous plant is a native of Barbary. It yields a hard, durable, and fragrant timber, and is much employed in the erection of mosques, etc., by the Africans of the North. The resin that exudes from the tree is used in varnish under the name of gum-sandarach. In powder it forms a principal ingredient of the article known as pounce.

82. CALOPHYLLUM CALABA.—This is called calaba tree in the West Indies, and an oil, fit for burning, is expressed from the seeds. In the West Indies these seeds are called Santa Maria nuts.

83. CALOTROPIS GIGANTEA.—The inner bark of this plant yields a valuable fiber, capable of bearing a greater strain than hemp. All parts of it abound in a very acrid milky juice, which hardens into a substance resembling gutta-percha; but in its fresh state it is a valuable remedy in cutaneous diseases. The bark of the root also possesses similar medical qualities; and its tincture yields *mudarine*, a substance that has the property of gelatinizing when heated, and returning to the fluid state when cool. Paper has been made from the silky down of the seeds.

84. CAMELLIA JAPONICA.—A well-known green-house plant, cultivated for its large double flowers. The seeds furnish an oil of an agreeable odor, which is used for many domestic purposes.

85. CAMPHORA OFFICINARUM.—This tree belongs to the Lauracæ. Camphor is prepared from the wood by boiling chopped branches in water, when, after some time, the camphor becomes deposited and is purified by sublimation. It is mainly produced in the island of Formosa. The wood of the tree is highly prized for manufacturing entomological cabinets. As the plant grows well over a large area in the more Southern States, it is expected that the preparation of its products will become a profitable industry.

86. CANELLA ALBA.—This is a native of the West Indies, and furnishes a pale olive-colored bark with an aromatic odor, and is used as a tonic. It is used by the natives as a spice. It furnishes the true canella bark of commerce, also known as white-wood bark.

87. CAPPARIS SPINOSA.—The caper plant, a native of the South of Europe and of the Mediterranean regions. The commercial product consists of the flower-buds, and sometimes the unripe fruits, pickled in vinegar. The wood and bark possess acrid qualities which will act as a blister when applied to the skin.

88. CARAPA GUIANENSIS.—A meliaceous plant, native of tropical America, where it grows to a height of 60 to 80 feet. The bark of this tree possesses febrifugal properties and is also used for tanning. By pressure, the seeds yield a liquid oil called carap-oil or crab-oil, suitable for burning in lamps.

89. CARICA PAPAYA.—This is the South American papaw tree, but is cultivated in most tropical countries. It is also known as the melon-apple. The fruit is of a dingy orange-color, of an oblong form, about 8 to 10 inches long, by 3 or 4 inches broad. It is said that the juice of the tree, or an infusion of the leaves and fruit, has the property of rendering tough fiber quite tender. Animals fed upon the fruit and leaves will have very tender and juicy flesh.

90. CARLUDOVICA PALMATA.—A pandanaceous plant from Panama and southward. Panama hats are made from the leaves of this plant. The leaves are cut when young, and the stiff parallel veins removed, after which they are slit into shreds, but not separated at the stalk end, and immersed in boiling water for a short time, then bleached in the sun.

91. CARYOCAR NUCIFERUM.—On the river banks of Guiana this grows to a large-sized tree. It yields the butter-nuts, or souari-nuts of commerce. These are of a flattened kidney shape, with a hard woody shell of a reddish-brown color, and covered with wart-like protuberances. The nuts are pleasant to eat, and yield, by expression, an oil called Piquia oil, which possesses the flavor of the fruit.

92. CARYOPHYLLUS AROMATICUS.—This myrtaceous plant produces the well-known spice called cloves. It forms a beautiful evergreen, rising from 20 to 30 feet in height. The cloves of commerce are the unexpanded flower-buds; they are collected by beating the tree with rods, when the buds, from the jointed character of their stalks, readily fall, and are received on sheets spread on purpose; they are then dried in the sun. All parts of the plant are aromatic, from the presence of a volatile oil. The oil is sometimes used in toothache and as a carminative in medicine.

93. CARYOTA URENS.—This fine palm is a native of Ceylon, and is also found in other parts of India, where it supplies the native population with various important articles. Large quantities of toddy, or palm-wine, are prepared from the juice, which, when boiled, yields very good palm sugar or jaggery, and also excellent sugar candy. Sago is also prepared from the central or pithy part of the trunk, and forms a large portion of the food of the natives. The fiber from the leaf stalk is of great strength; it is known as Kittool fiber, and is used for making ropes, brushes, brooms, etc. A woolly kind of scruf, scraped off the leaf stalks, is used for calking boats, and the stem furnishes a small quantity of wood.

94. CASIMIROA EDULIS.—A Mexican plant, belonging to the orange family, with a fruit about the size of an ordinary orange, which has an agreeable taste, but is not considered to be wholesome. The seeds are poisonous; the bark is bitter, and is sometimes used medicinally.

95. CASSIA ACUTIFOLIA.—The cassias belong to the leguminous family. The leaflets of this and some other species produce the well-known drug called senna. That known as Alexandria senna is produced by the above. East Indian senna is produced by *C. elongata*. Aleppo senna is obtained from *C. obovata*. The native species, *C. marylandica*, possesses similar properties. The seeds of *C. absus*, a native of Egypt, are bitter, aromatic, and mucilaginous, and are used as a remedy for ophthalmia. *C. fistula* is called the Pudding-Pipe tree, and furnishes the cassia pods of commerce. The seeds of *C. occidentalis*, when roasted, are used as a substitute for coffee in the Mauritius and in the interior of Africa.

96. CASTILLOA ELASTICA.—This is a Mexican tree, which yields a milky juice, forming caoutchouc, but is not collected for commerce except in a limited way.

97. CASUARINA QUADRIVALVIS.—This Tasmanian tree produces a very hard wood of a reddish color, often called Beef wood. It is marked with dark stripes, and is much used in some places for picture frames and cabinetwork. This belongs to a curious family of trees having no leaves, but looking like a gigantic specimen of Horse-tail grass, a weed to be seen in wet places.

98. CATHA EDULIS.—This plant is a native of Arabia, where it attains the height of 7 to 10 feet. Its leaves are used by the Arabs in preparing a beverage like tea or coffee. The twigs, with leaves attached, in bundles of fifty, and in pieces from 12 to 15 inches in length, form a very considerable article of commerce, its use in Arabia corresponding to that of the Paraguay tea in South America and the Chinese tea in Europe. The effects produced by a decoction of the leaves of Cafta, as they are termed, are described as similar to those produced by strong green tea, only more pleasing and agreeable. The Arab soldiers chew the leaves when on sentry duty to keep them from feeling drowsy. Its use is of great antiquity, preceding that of coffee. Its stimulating effects induced some Arabs to class it with intoxicating substances, the use of which is forbidden by the Koran, but a synod of learned Mussulmans decreed that, as it did not impair the health or impede the observance of religious duties, but only increased hilarity and good humor, it was lawful to use it.

99. CECROPIA PELTATA.—The South American trumpet tree, so called because its hollow branches are used for musical instruments. The Waupe Indians form

a kind of drum by removing the pith or center of the branches. The inner bark of the young branches yields a very tough fiber, which is made into ropes. The milky juice of the stem hardens into caoutchouc.

100. CEDRELA ODORATA.—This forms a large tree in the West India Islands, and is hollowed out for canoes; the wood is of a brown color and has a fragrant odor, and is sometimes imported under the name of Jamaica cedar.

101. CEPHÆLIS IPECACUANHA.—This Brazilian plant produces the true ipecacuanha, and belongs to the *Cinchonaceæ*. The root is the part used in medicine, it is knotty, contorted, and annulated, and of a grayish-brown color, and its emetic properties are due to a chemical principle called *emetin*.

102. CERATONIA SILIQUA.—The carob bean. This leguminous plant is a native of the countries bordering on the Mediterranean. The seed pods contain a quantity of mucilaginous and saccharine matter, and are used as food for cattle. Besides the name of carob beans, these pods are known as locust pods, or St. John's bread, from a supposition that they formed the food of St. John in the wilderness. It is now generally admitted that the locusts of St. John were the insects so called, and which are still used as an article of food in some of the Eastern countries. There is more reason for the belief that the husks mentioned in the parable of the prodigal son were these pods. The seeds were at one time used by singers, who imagined that they softened and cleared the voice.

103. CERBERA THEVETIA.—The name is intended to imply that the plant is as dangerous as Cerberus. The plant has a milky, poisonous juice. The bark is purgative; the unripe fruit is used by the natives of Travancore to destroy dogs, as its action causes their teeth to loosen and fall out.

104. CEREUS GIGANTEA.—The suwarrow of the Mexicans, a native of the hot, arid, and almost desert regions of New Mexico, found growing in rocky places, in valleys, and on mountain sides, often springing out of mere crevices in hard rocks, and imparting a singular aspect to the scenery of the country, its tall stems often reaching 40 feet in height, with upright branches looking like telegraph posts for signaling from point to point of the rocky mountains. The fruits are about 2 or 3 inches long, of a green color and oval form; when ripe they burst into three or four pieces, which curve back so as to resemble a flower. Inside they contain numerous little black seeds, imbedded in a crimson-colored pulp, which the Indians make into a preserve. They also eat the ripe fruit as an article of food.

105. CEREUS MACDONALDIÆ.—A night-blooming cereus, and one of the most beautiful. The flowers when fully expanded are over a foot in diameter, having numerous radiating red and bright orange sepals and delicately white petals. It is a native of the Honduras.

106. CEROXYLON ANDICOLA.—The wax palm of New Grenada, first described by Humboldt and Bonpland, who found it on elevated mountains, extending as high as the lower limit of perpetual snow. Its tall trunk is covered with a thin coating of a whitish waxy substance, giving it a marbled appearance. The waxy substance forms an article of commerce, and is obtained by scraping the trunk. It consists of two parts of resin and one wax, and, when mixed with one third of tallow, it makes very good candles. The stem is used for building purposes, and the leaves for thatching roofs.

107. CHAMÆDOREA ELEGANS.—This belongs to a genus of palms native of South America. The plant is of tall, slender growth; the stems are used for walking canes, and the young, unexpanded flower spikes are used as a vegetable.

108. CHAMÆROPS FORTUNII.—This palm is a native of the north of China, and is nearly hardy here. In China, the coarse brown fibers obtained from the leaves are used for making hats and also garments called So-e, worn in wet weather.

109. CHAMÆROPS HUMILIS.—This is the only European species of palm, and does not extend farther north than Nice. The leaves are commonly used in the south of Europe for making hats, brooms, baskets, etc. From the leaf fiber a material resembling horse hair is prepared, and the Arabs mix it with camel's hair for their tent covers.

110. CHAVICA BETEL.—This plant is found all over the East Indies, where its leaf is largely used by Indian natives as a masticatory. Its consumption is im-

mense, and has been said to equal that of tobacco by Western peoples. It is prepared for chewing by inclosing in the leaves a slice of the areca nut, and a small portion of lime. It is thought to act as a stimulant to the digestive organs, but causes giddiness and other unpleasant symptoms to those not accustomed to its use.

111. CHIOCOCCA RACEMOSA.—This plant is found in many warm countries, such as in southern Florida. It is called cahinca in Brazil, where a preparation of the bark of the root is employed as a remedy for snake bites. Almost every locality where snakes exist has its local remedies for poisonous bites, but they rarely prove to be efficient when truthfully and fairly tested.

112. CHLORANTHUS OFFICINALIS.—The roots of this plant are an aromatic stimulant, much used as medicine in the Island of Java; also, when mixed with anise, it has proved valuable in malignant smallpox.

113. CHLOROXYLON SWIETENIA.—The satinwood tree of tropical countries. It is principally used for making the backs of clothes and hair brushes, and for articles of turnery-ware; the finest mottled pieces are cut into veneers and used for cabinet-making.

114. CHRYSOBALANUS ICACO.—The cocoa plum of the West Indies. The fruits are about the size of a plum, and are of various colors, white, yellow, red, or purple. The pulp is sweet, a little austere, but not disagreeable. The fruits are preserved and exported from Cuba and other West India Islands. The kernels yield a fixed oil, and an emulsion made with them is used medicinally.

115. CHRYSOPHYLLUM CAINITO.—The fruit of this plant is known in the West Indies as the star apple, the interior of which, when cut across, shows ten cells, and as many seeds disposed regularly round the center, giving a star-like appearance, as stars are generally represented in the most reliable almanacs. It receives its botanic name from the golden silky color on the under side of the leaves.

116. CICCA DISTICHA.—This Indian plant is cultivated in many parts under the name of Otaheite gooseberry. The fruits resemble those of a green gooseberry. They have an acid flavor; are used for preserving or pickling, and eaten either in a raw state or cooked in various ways.

117. CINCHONA CALISAYA.—The yellow bark of Bolivia. This is one of the so-called Peruvian Bark trees. The discovery of the medicinal value of this bark is a matter of fable and conjecture. The name cinchona is derived from that of the wife of a viceroy of Peru, who is said to have taken the drug from South America to Europe in 1639. Afterwards the Jesuits used it; hence it is sometimes called Jesuit's bark. It was brought most particularly into notice when Louis XIV of France purchased of Sir R. Talbor, an Englishman, his heretofore secret remedy for intermittent fever, and made it public.

There are various barks in commerce classified under the head of Peruvian barks. Their great value depends upon the presence of certain alkaloid substances called quinine, cinchonine, and quinidine, which exist in the bark in combination with tannic and other acids. Quinine is the most useful of these alkaloids, and this is found in greatest quantities in Calisaya bark. The gray bark of Huanuco is derived from *Cinchona micrantha*, which is characterized by its yield of cinchonine, and the Loxa or Loja barks are furnished in part by *Cinchona officinalis*, and are especially rich in quinidine. There is some uncertainty about the trees that produce the various kinds of bark. These trees grow in the forests of Bolivia and Peru, at various elevations on the mountains, but chiefly in sheltered mountain valleys, and all of them at a considerable distance below the frost or snow line. They are destroyed by the slightest frost. Plants of various species have been distributed from time to time, in localities which seemed most favorable to their growth, but all reports from these distributions have, so far, been discouraging.

118. CINNAMOMUM CASSIA.—This furnishes cassia bark, which is much like cinnamon, but thicker, coarser, stronger, less delicate in flavor, and cheaper; hence it is often used to adulterate cinnamon. The unexpanded flower buds are sold as cassia buds, possessing properties similar to those of the bark. It is grown in southern China, Java, and tropical countries generally.

119. CINNAMOMUM ZEYLANICUM.—A tree belonging to Lauraceæ, which furnishes the best cinnamon. It is prepared by stripping the bark from the branches, when it rolls up into quills, the smaller of which are introduced into the

larger, and then dried in the sun. Cinnamon is much used as a condiment for its pleasant flavor, and its astringent properties are of medicinal value. It is cultivated largely in Ceylon. The cinnamon tree is too tender to become of commercial importance in the United States. Isolated plants may be found in southern Florida, at least it is so stated, but the area suited to its growth must be very limited.

120. CISSAMPELOS PAREIRA.—The velvet plant of tropical countries. The root furnishes the *Pareira brava* of druggists, which is used in medicine.

121. CITRUS AURANTIUM.—The orange, generally supposed to be a native of the north of India. It was introduced into Arabia during the ninth century. It was unknown in Europe in the eleventh century. Oranges were cultivated at Seville towards the end of the twelfth century, and at Palermo in the thirteenth. In the fourteenth century they were plentiful in several parts of Italy. There are many varieties of the orange in cultivation. The blood red, or Malta, is much esteemed; the fruit is round, reddish-yellow outside and the pulp irregularly mottled with crimson. The Mandarin or Tangerine orange has a thin rind which separates easily from the pulp, and is very sweet and rich. The St. Michael's orange is one of the most productive and delicious varieties, with a thin rind and very sweet pulp. The Seville or bitter orange is used for the manufacture of bitter tincture and candied orange-peel. The Bergamot orange has peculiarly fragrant flowers and fruit, from each of which an essence of a delicious quality is extracted.

122. CITRUS DECUMANA.—The shaddock, which has the largest fruit of the family. It is a native of China and Japan, where it is known as sweet ball. The pulp is acid or subacid, and in some varieties nearly sweet. From the thickness of the skin the fruit will keep a considerable time without injury.

123. CITRUS JAPONICA.—This is the Kum-quat of the Chinese. It forms a small tree, or rather a large bush, and bears fruit about the size of a large cherry. There are two forms, one bearing round fruits, the other long, oval fruits. This fruit has a sweet rind and an agreeably acid pulp, and is usually eaten whole without being peeled. It forms an excellent preserve, with sugar, and is largely used in this form.

124. CITRUS LIMETTA.—The lime, which is used for the same purposes as the lemon, and by some preferred, the juice being considered more wholesome and the acid more agreeable. There are several varieties, some of them being sweet and quite insipid.

125. CITRUS LIMONUM.—The lemon; this plant is found growing naturally in that part of India which is beyond the Ganges. It was unknown to the ancient Greeks and Romans. It is supposed to have been brought to Italy by the Crusaders. Arabian writers of the twelfth century notice the lemon as being cultivated in Egypt and other places. The varieties of the lemon are very numerous and valued for their agreeable acid juice and essential oil. They keep for a considerable time, especially if steeped for a short period in salt water.

126. CITRUS MEDICA.—The citron, found wild in the forests of northern India. The Jews cultivated the citron at the time they were under subjection to the Romans, and used the fruit in the Feast of the Tabernacles. There is no proof of their having known the fruit in the time of Moses, but it is supposed that they found it at Babylon, and brought it into Palestine. The citron is cultivated in China and Cochin-China. It is easily naturalized and the seeds are rapidly spread. In its wild state it grows erect; the branches are spiny, the flowers purple on the outside and white on the inside. The fruit furnishes the essential oil of citron and the essential oil of cedra. There are several varieties; the fingered citron is a curious fruit, and the Madras citron is very long and narrow; the skin is covered with protuberances.

127. CLUSIA ROSEA.—A tropical plant which yields abundantly of a tenacious resin from its stem, which is used for the same purpose as pitch. It is first of a green color, but when exposed to the air it assumes a brown or reddish tint. The Caribs use it for painting the bottoms of their boats.

128. COCCOLOBA UVIFERA.—Known in the West Indies as the seaside grape, from the peculiarity of the perianth, which becomes pulpy and of a violet color and surrounds the ripe fruit. The pulpy perianth has an agreeable acid flavor. An astringent extract is prepared from the plant which is used in medicine.

129. COCOS NUCIFERA.—The cocoanut palm. This palm is cultivated throughout the tropics so extensively that its native country is not known. One reason

of its extensive dissemination is that it grows so close to the sea that the ripe fruits are washed away by the waves and afterwards cast upon far-distant shores, where they soon vegetate. It is in this way that the coral islands of the Indian Ocean have become covered with these palms. Every part of this tree is put to some useful purpose. The outside rind or husk of the fruit yields the fiber from which the well-known cocoa matting is manufactured. Cordage, clothes, brushes, brooms, and hats are made from this fiber, and, when curled and dyed, it is used for stuffing mattresses and cushions. An oil is produced by pressing the white kernel of the nut which is used for cooking when fresh, and by pressure affords stearin, which is made into candles, the liquid being used for lamps. The kernel is of great importance as an article of food, and the milk affords an agreeable beverage. While young it yields a delicious substance resembling blanc-mange. The leaves are used for thatching, for making mats, baskets, hats, etc.; combs are made from the hard footstalk; the heart of the tree is used as we use cabbages. The brown fibrous net work from the base of the leaves is used as sieves, and also made into garments. The wood is used for building and for furniture. The flowers are used medicinally as an astringent and the roots as a febrifuge.

130. COCOS PLUMOSUS.—A Brazilian species, highly ornamental in its long, arching leaves, and producing quantities of orange-colored nuts, in size about as large as a chestnut, inclosed in an edible pulp.

131. COFFEA ARABICA.—The coffee plant, which belongs to the *Cinchonaceæ* and is a native of Abyssinia, but is now cultivated in many tropical regions. It can not be successfully cultivated in a climate where the temperature, at any season of the year, falls below 55 degrees, although it will exist where the temperature all but falls short of freezing, but a low fall of temperature greatly retards the ripening of the fruit. Ripe fruits are often gathered from plants in the extreme south of Florida. The beans or seeds are roasted before use, and by this process they gain nearly one half in bulk and lose about a fifth in weight. Heat also changes their essential qualities, causing the development of the volatile oil and peculiar acid to which the aroma and flavor are due. The berries contain theine; so also do the leaves, and in some countries the latter are preferred.

132. COFFEA LIBERICA.—The Liberian coffee, cultivated in Africa, of which country it is a native. This plant is of larger and stronger growth than the Arabian coffee plant and the fruit is larger. This species is of recent introduction to commerce, and although it was reported as being more prolific than the ordinary coffee plant, the statement has not been borne out in Brazil and Mexico, where it has been tested. It is also more tender than the older known species.

133. COLA ACUMINATA.—An African tree, which has been introduced into the West Indies and Brazil for the sake of its seeds, which are known as Cola, or Kola, or Goora nuts, and extensively used as a sort of condiment by the natives of Africa. A small piece of one of these seeds is chewed before each meal to promote digestion. It possesses properties similar to the leaves of coca and contains theine. These nuts have from time immemorial occupied a prominent place in the dietetic economy of native tribes in Africa, and the demand for them has established a large commercial industry in the regions where they are obtained.

134. COLOCASIA ESCULENTA.—This plant has been recommended for profitable culture in this country for its edible root-stock. It is cultivated in the Sandwich Islands under the name of Tara. The young leaves are cooked and eaten in the same manner as spinach or greens in Egypt. They are acrid, but lose their acridity when boiled, the water being changed. The roots are filled with starch, and have long been used as food in various semitropical countries.

135. CONDAMINEA MACROPHYLLA.—This plant belongs to the cinchona family, and contains tonic properties. The Peruvian bark gatherers adulterate the true cinchona bark with this, but it may be detected by its white inner surface, its less powerful bitter taste, and a viscidity not possessed by the cinchonas.

136. CONVOLVULUS SCAMMONIA.—This plant furnishes the scammony of the druggists.

137. COOKIA PUNCTATA.—A small-growing tree from China, which produces a fruit known as the Wampee. This fruit is a globular berry, with five or fewer compartments filled with juice. It is much esteemed in China.

138. COPAIFERA OFFICINALIS.—This tree yields balsam of copaiba, used in medicine. The balsam is collected by making incisions in the stem, when the liquor is said to pour out copiously; as it exudes it is thin and colorless, but immediately thickens and changes to a clear yellow. Like many other balsams, it is nearly allied to the turpentines; it has a moderately agreeable smell, and a bitter, biting taste of considerable duration. Distilled with water it yields a limpid essential oil.

139. COPERNICA CERIFERA.—The Carnuba, or wax palm of Brazil. It grows about 40 feet high, and has a trunk 6 or 8 inches thick, composed of very hard wood, which is commonly employed in Brazil for building and other purposes. The upper part of the young stem is soft, and yields a kind of sago, and the bitter fruits are eaten by the Indians. The young leaves are coated with wax, called Carnaub wax, which is detached by shaking them, and then melted and run into cakes; it is harder than beeswax, and has been used for making candles. The leaves are used for thatch, and, when young, are eaten by cattle.

140. COPROSMA ROBUSTA.—A cinchonaceous shrub. The leaves of this plant were formerly used in some of the religious ceremonies of the New Zealanders.

141. CORDIA MYXA.—This produces succulent, mucilaginous, and emollient fruits, which are eaten. These qualities, combined with a slight astringency, have led to their use as pectorals, known as Sebestens. The wood of this tree is said to have furnished the material used by the Egyptians in the construction of their mummy cases; it is also considered to be one of the best woods for kindling fire by friction.

142. CORDYLINE AUSTRALIS.—The Australian Ti, or cabbage tree, a palm-like plant of 15 to 20 feet in height. The whole plant is fibrous, and it has been suggested as good for a paper-making material. The juice of the roots and stem contains a small amount of sugar, and has been employed for procuring alcohol.

143. CORYPHA UMBRACULIFERA.—The Talipot palm, a native of Ceylon, producing gigantic fan-like leaves. These leaves have prickly stalks 6 or 7 feet long, and when fully expanded form a nearly complete circle of 13 feet in diameter. Large fans made of these leaves are carried before people of rank among the Cinghalese; they are also commonly used as umbrellas, and tents are made by neatly joining them together; they are also used as a substitute for paper, being written upon with a stylus. Some of the sacred books of the Cinghalese are composed of strips of them. The hard seeds are used by turners.

144. COUROUPITA GUIANENSIS.—The fruit of this tree is called, from its appearance, the cannon-ball fruit; its shell is used as a drinking vessel, and when fresh the pulp is of an agreeable flavor.

145. CRATÆVA GYNANDRA.—This West Indian tree yields a small fruit which has a strong smell of garlic, hence it is called the garlic pear. The bark is bitter and used as a tonic.

146. CRESCENTIA CUJETE.—The calabash tree of the West Indies, where it is valued for the sake of its fruits, which resemble pumpkins in appearance and occasionally reach a diameter of 18 inches. Divested of their pulp, which is not edible, they serve various useful domestic purposes, for carrying water, and even as kettles for cooking. They are strong and light.

147. CROTON CALSAMIFERUM.—This West Indian shrub is sometimes called sea-side balsam or sage. A thick, yellowish, aromatic juice exudes from the extremities of the broken branches, or wherever the stem has been wounded. In Martinique a liquor called *Eau de Mantes* is distilled from this balsamic juice with spirits of wine. The young leaves and branches are used in warm baths, on account of their agreeable fragrance and reputed medicinal virtues.

148. CROTON ELEUTHERIA.—This plant furnishes cascarilla bark, used as an aromatic bitter tonic, having no astringency. It has a fragrant smell when burnt, on which account it has been mixed with smoking tobacco.

149. CROTON TIGLIUM.—A plant of the family *Euphorbiaceæ*, from the Indian Archipelago, which produces the seeds from whence croton oil is extracted. It is a very powerful medicine, and even in pressing the seeds for the purpose of extracting the oil, the workmen are subject to irritation of the eyes and other casualties.

150. CUBEBA OFFICINALIS.—A native of Java, which furnishes the cubeb fruits of commerce. These fruits are like black pepper, but stalked, and have an acrid, hot, aromatic taste; frequently used medicinally.

151. CURCAS PURGANS.—A tropical plant cultivated in many warm countries for the sake of its seeds, known as physic nuts. The juice of the plant, which is milky, acrid, and glutinous, produces an indellible brown stain on linen. The oil from the seeds is used for burning in lamps; and in paints. In China it is boiled with oxide of iron and used as a varnish. It is also used medicinally.

152. CURCUMA LONGA.—A plant belonging to the *Zingiberaceæ*, the roots of which furnish turmeric. This powder is used in India as a mild aromatic, and for other medicinal purposes. It also enters into the composition of curry-powder, and a sort of arrow root is made from the young tubers.

153. CURCUMA ZEDOARIA.—This plant furnishes zedoary tubers, much used in India as aromatic tonics.

154. CYATHEA MEDULLARIS.—This beautiful tree fern is a native of Australia, where it attains a height of 25 to 30 feet, having fronds from 10 to 15 feet in length. It contains a pulpy substance in the center of the stem, of a starchy, mucilaginous nature, which is a common article of food with the natives. The trees have to be destroyed in order to obtain it.

155. CYBISTAX ANTISYPHILITICA.—A plant of the order of *Bignoniaceæ*, called Atunyangua in the Andes of Peru, where the inhabitants dye their cotton clothes by boiling them along with the leaves of this plant; the dye is a permanent blue. The bark of the young shoots is much employed in medicine.

156. CYCAS REVOLUTA.—The sago palm of gardens. The stem of the plants abounds in starch, which is highly esteemed in Japan. A gum exudes from the trunk of the old plant, which is employed medicinally by the natives of India.

157. CYCAS CIRCINALIS.—A native of Malabar, where a kind of sago is prepared from the seeds, which are dried and powdered; medicinal properties are also attributed to the seeds.

158. DACRYDIUM FRANKLINII.—Called Huon pine, because of its being found near the Huon River, in Tasmania. It belongs to the yew family. It furnishes valuable timber, very durable, and is used for ship and house building; some of the wood is very beautifully marked, and is used in furniture making and cabinetwork.

159. DALBERGIA SISSOO.—A tree of northern India, the timber of which is known as Sissum wood. This wood is strong, tenacious, and compact, much used for railway ties and for gun-carriages.

160. DAMARA AUSTRALIS.—A singular plant of the *Coniferæ* family, called the Kauri pine. It forms a tree 150 to 200 feet in height, and produces a hard, brittle resin-like copal, which is used in varnish.

161. DASYLIRION ACROTRICHUM.—A plant of the pineapple family, from Mexico. The leaves contain a fine fiber, which may be ultimately more extensively utilized than it is at present.

162. DESMODIUM GYRANS.—An interesting plant of the pea family, called the moving plant, on account of the rotatory motion of the leaflets. These move in all conceivable ways, either steadily or by jerks. Sometimes only one leaf or two on the plant will be affected; at other times a nearly simultaneous movement may be seen in all the leaves. These movements are most energetic when the thermometer marks about 80°. This motion is not due to any external or mechanical irritation.

163. DIALIUM ACUTIFOLIUM.—The velvet tamarind, so called, from the circumstance that its seed-pods are covered with a beautiful black velvet down. The seeds are surrounded by a farinaceous pulp of an agreeable acid taste.

164. DIALIUM INDUM.—The tamarind plum, which has a delicious pulp of slightly acid flavor.

165. DICKSONIA ANTARCTICA.—The large fern tree of Australia. This plant attains the height of 30 or more feet, and its fronds or leaves spread horizontally some 20 to 25 feet. It is found in snowy regions, and would be perfectly hardy south. It is one of the finest objects of the vegetable kingdom when of sufficient size to show its true beauties.

166. DIEFFENBACHIA SEGUINA.—This has acquired the name of dumb cane, in consequence of its fleshy, cane-like stems, rendering speechless any person

who may happen to bite them, their acrid poison causing the tongue to swell to an immense size. An ointment for applying to dropsical swellings is prepared by boiling the juice in lard. Notwithstanding its acridity, a wholesome starch is prepared from the stem.

167. DILLENIA SPECIOSA.—An East Indian tree, bearing a fruit which is used in curries and for making jellies. Its slightly acid juice, sweetened with sugar, forms a cooling beverage. The wood is very tough, and is used for making gun-stocks.

168. DION EDULE.—A Mexican plant, bearing large seeds containing a quantity of starch, which is separated and used as arrow root.

169. DIOSPYROS EBENUM.—An East Indian tree which in part yields the black ebony wood of commerce, much used in fancy cabinetwork and turnery, door knobs, pianoforte keys, etc.

170. DIOSPYROS KAKI.—The Chinese date plum or persimmon. The fruits vary in size from that of a medium-sized apple to that of a large pear; they also vary much in their flavor and consistency, some being firm, and others having a soft custard-like pulp, very sweet and luscious. The Chinese dry them in the sun and make them into sweetmeats; they are sometimes imported, and in appearance resemble large-sized preserved figs. These plants are being quite largely cultivated in some of the southern States, and the fruit is entering commerce.

171. DIPTERIX ODORATA.—This leguminous plant yields the fragrant seed known as Tonka bean, used in scenting snuff and for other purposes of prefumery. The odor resembles that of new-mown hay, and is due to the presence of *coumarine*. The tree is a native of Cayenne and grows 60 to 80 feet high.

172. DORSTENIA CONTRAYERVA.—A plant from tropical America, the roots of which are used in medicine under the name of Contrayerva root.

173. DRACÆNA DRACO.—The Dragon's Blood tree of Teneriffe. This liliaceous plant attains a great age and enormous size. The resin obtained from this tree has been found in the sepulchral caves of the Cuanches, and hence it is supposed to have been used by them in embalming the dead. Trees of this species, at present in vigorous health, are supposed to be as old as the pyramids of Egypt.

174. DRACÆNOPSIS AUSTRALIS.—Ti or cabbage tree of New Zealand. The whole of this plant is fibrous and has been used for paper making. The juice of the roots and stem contains a small amount of sugar and has been used for producing alcohol.

175. DRIMYS WINTERI.—This plant belongs to the magnolia family and furnishes the aromatic tonic known as Winter's bark. It is a native of Chili and the Strait of Magalhaens.

176. DRYOBALANOPS AROMATICA.—A native of the Island of Sumatra. It furnishes a liquid called camphor oil and a crystalline solid known as Sumatra or Borneo camphor. Camphor oil is obtained from incisions in the tree, and has a fragrant, aromatic odor. It has been used for scenting soap. The solid camphor is found in cracks of the wood, and is obtained by cutting down the tree, dividing it into blocks and small pieces, from the interstices of which the camphor is extracted. It differs from the ordinary camphor in being more brittle and not condensing on the sides of the bottle in which it is kept. It is much esteemed by the Chinese, who attribute many virtues to it. It has been long known and is mentioned by Marco Polo in the thirteenth century.

177. DUBOSIA HOPWOODII.—The leaves of this Australian plant are chewed by the natives of Central Australia, just as the Peruvians and Chilians masticate the leaves of the *Erythroxylon coca*, to invigorate themselves during their long foot journeys through the country. They are known as Pitury leaves.

178. DURIO ZIBETHINUS.—A common tree in the Malayan Islands, where its fruit forms a great part of the food of the natives. It is said to have a most delicious flavor combined with a most offensive odor, but when once the repugnance of the peculiar odor is overcome it becomes a general favorite. The unripe fruit is cooked and eaten, and the seeds roasted and used like chestnuts.

179. ELÆIS GUINEENSIS.—The African oil palm is a native of southwestern Africa, but has been introduced into other regions. It grows to a height of 20 to 30

feet and bears dense heads of fruit. The oil is obtained by boiling the fruits in water and skimming off the oil as it rises to the surface. It is used in the manufacture of candles. In Africa it is eaten as butter by the natives.

180. ELÆIS MELANOCOCCA.—A palm from tropical America which produces large quantities of oil.

181. ELÆOCARPUS HINAU.—A New Zealand tree, of the linden family. The bark affords an excellent permanent dye, varying from light brown to deep black. The fruits are surrounded by an edible pulp, and they are frequently pickled like olives.

182. ELETTARIA CARDAMOMUM.—This plant furnishes the fruits known as the Small or Malabar cardamoms of commerce. The seeds are used medicinally for their cordial aromatic properties, which depend upon the presence of a volatile oil. In India the fruits are chewed by the natives with their betel.

183. EMBLICA OFFICINALIS.—A plant belonging to *Euphorbiaceæ*, a native of India. In Borneo the bark and young shoots are used to dye cotton black, for which purpose they are boiled in alum. The fruits are made into sweetmeats, with sugar, or eaten raw, but they are exceedingly acid; when ripe and dry, they are used in medicine, under the name of *Myrobalani emblici.* The natives of Travancore have a notion that the plant imparts a pleasant flavor to water, and therefore place branches of the tree in their wells, especially when the water is charged with an accumulation of impure vegetable matter.

184. ENCKEA UNGUICULATA.—A plant of the family *Piperaceæ*, having an aromatic fruit like a berry, with a thick rind. The roots are used medicinally in Brazil.

185. ENTADA SCANDENS.—This leguminous plant has remarkable pods, which often measure 6 or 8 feet in length. The seeds are about 2 inches across, and half an inch thick, and have a hard, woody, and beautifully polished shell, of a dark-brown or purplish color. These seeds are frequently converted into snuff-boxes and other articles, and in the Indian bazars they are used as weights.

186. ERIODENDRON ANFRACTUOSUM.—The silk-cotton, or God tree of the West Indies. The fruit is a capsule, filled with a beautiful silky fiber, which is very elastic, but can not be woven, and is only used for stuffing cushions.

187. ERYTHRINA CAFFRA.—The Kaffir tree of South Africa. The wood is soft and so light as to be used for floating fishing nets. The scarlet seeds are employed for making necklaces. The Erythrinas, of which there are many species, are mostly remarkable for the brilliant scarlet of their flowers, and are known as Coral trees.

188. ERYTHRINA UMBROSA.—This is a favorite tree for growing in masses, for the purpose of sheltering cocoanut plantations, and inducing a proper degree of moisture in their neighborhood.

189. ERYTHROXYLON COCA.—The leaves of this plant, under the name of coca, are much used by the inhabitants of South America as a masticatory. It forms an article of commerce among the Indians, who carefully dry the leaves and use them daily. Their use, in moderation, acts as a stimulant to the nervous system and enables those who chew them to perform long journeys without any other food. The use of coca in Peru is a very ancient custom, said to have originated with the Incas. It is common throughout the greater part of Peru, Quito, New Granada; and on the banks of the Rio Negro it is known as Spadic. A principle, called *cocaine*, has been extracted from the leaves, which is used in medicine.

190. EUCALYPTUS AMYGDALINA.—The peppermint tree, a native of Tasmania. It produces a thin, transparent oil possessed of a pungent odor resembling oil of lemons, and tasting like camphor, which has great solvent properties. The genus *Eucalyptus* is extensive and valuable. The greater number form large trees, known in Australia as gum trees.

191. EUCALYPTUS GIGANTEA.—This stringy bark gum furnishes a strong, durable timber, used for shipbuilding and other purposes. *E. robusta* contains large cavities in its stem, between the annual concentric circles of wood, filled with a red gum. Many of the species yield gums and astringent principles and also a species of manna. The timber of these trees has been pronounced to be unsurpassed for strength and durability by any other timber known. The leaves of these trees are placed vertically to the sun, a provision suited to a dry and sultry climate.

192. EUCALYPTUS GLOBULUS.—The blue gum, a rapid-growing tree, attaining to a large size. Recently it has attracted attention and gained some repute in medicine as an antiperiodic. The leaves have also been applied to wounds with some success. It produces a strong camphor-smelling oil, which has a mint-like taste, not at all disagreeable.

193. EUGENIA ACRIS.—The wild clove or bayberry tree of the West Indies. In Jamaica it is sometimes called the black cinnamon. The refreshing perfume known as bay rum is prepared by distilling the leaves of this tree with rum. It is stated that the leaves of the allspice are also used in this preparation.

194. EUGENIA JAMBOSA.—A tropical plant, belonging to the myrtle family, which produces a pleasant rose-flavored fruit, known as the Roseapple, or Jamrosade.

195. EUGENIA PIMENTO.—The fruits of this West Indian tree are known in commerce as allspice; the berries have a peculiarly grateful odor and flavor, resembling a combination of cloves, nutmeg, and cinnamon; hence the name of allspice. The leaves when bruised emit a fine aromatic odor, and a delicate odoriferous oil is distilled from them, which is said to be used as oil of cloves. The berries, bruised and distilled with water, yield the pimento oil of commerce.

196. EUGENIA UGNI.—This small-foliaged myrtaceous plant is a native of Chili. It bears a glossy black fruit, which has an agreeable flavor and perfume, and is highly esteemed in its native country. The plant is hardy in the Southern States.

197. EUPHORBIA CANARIENSIS.—This plant grows in abundance in the Canary Islands and Teneriffe, in dry, rocky districts, where little else can grow, and where it attains a height of 10 feet, with the branches spreading 15 or 20 feet. It is one of the kinds that furnish the drug known as *Euphorbium.* The milky juice exudes from incisions made in the branches, and is so acrid that it excoriates the hand when applied to it. As it hardens it falls down in small lumps, and those who collect it are obliged to tie cloths over their mouths and nostrils to exclude the small, dusty particles, as they produce incessant sneezing. As a medicine its action is violent, and it is now rarely employed. There are a vast number of species of *Euphorbia*, varying exceedingly in their general appearance, but all of them having a milky juice which contains active properties. Many of them can scarcely be distinguished from cactuses so far as relates to external appearances, but the milky exudation following a puncture determines their true character. *E. grandidens* is a tall-growing, branching species, and attains a height of 30 feet. The natives of India use the juice of *E. antiquorum*, when diluted, as a purgative. The juice of *E. heptagona* and other African species is employed to poison arrows; the juice of *E. cotinifolia* is used for the same purpose in Brazil. The roots of *E. gerardiana* and *E. pithyusa* are emetic, while *E. thymifolia* and *E. hypericifolia* possess astringent and aromatic properties. The poisonous principle which pervades these plants is more or less dissipated by heat. The juice of *E cattimandoo* furnishes caoutchouc of a very good quality, which, however, becomes brittle, although soaking in hot water renders it again pliable. *E. phosphorea* derives the name from the fact of its sap emitting a phosphorescent light, on warm nights, in the Brazilian forests.

198. EUTERPE EDULIS.—The assai palm of Para. It grows in swampy lands, and produces a small fruit thinly coated with clotted flesh of which the inhabitants of Para manufacture a beverage called assai. The ripe fruits are soaked in warm water and kneaded until the fleshy pulp is detached. This, when strained, is of a thick, creamy consistence, and, when thickened with cassava farina and sweetened with sugar, forms a nutritious diet, and is the daily food of a large number of the people.

199. EUTERPE MONTANA.—The center portion of the upper part of the stem of this West Indian palm, including the leaf bud, is eaten either when cooked as a vegetable or pickled, but the tree must be destroyed in order to obtain it.

200. EXCŒCARIA SEBIFERA.—This Euphorbiaceous plant is the tallow tree of China. The fruits, are about half an inch in diameter, and each contains three seeds, thickly coated with a fatty substance which yields the tallow. This is obtained by first steaming the seeds, then bruising them to loosen the fat without breaking the seeds, which are removed by sifting. The fat is then made into flat circular cakes and pressed, when the pure tallow ex-

udes in a liquid state and soon hardens into a white, brittle mass. Candles made from this get soft in hot weather, which is prevented by coating them with insect wax. A liquid oil is obtained from the seeds by pressing. The tree yields a hard wood, used by the Chinese for printing blocks, and its leaves are used in dyeing black.

201. EXOGONIUM PURGA.—This plant furnishes the true jalap-tubers of commerce. They owe their well-known purgative properties to their resinous ingredients. Various species of Ipomœa furnish a spurious kind of this drug, which is often put in the market as the genuine article.

202. EXOSTEMMA CARIBÆUM.—This West Indian plant has become naturalized in southern Florida. It belongs to the cinchona family and is known as Jamaica bark. It is also known as Quinquina Caraibe. The bark is reputed to be a good febrifuge, and also to be employed as an emetic. It is supposed to contain some peculiar principle, as the fracture displays an abundance of small crystals. The capsules, before they are ripe, are very bitter, and their juice causes a burning itching on the lips.

203. FERONIA ELEPHANTUM.—The wood apple or elephant apple tree of India, belonging to the family *Aurantiaceæ*. It forms a large tree in Ceylon, and yields a hard, heavy wood, of great strength. It yields a gum, which is mixed with other gums and sold under the name of East Indian gum arabic. The fruit is about the size of an orange, and contains a pulpy flesh, which is edible, and a jelly is made from it, which is used in cases of dysentery. The leaves have an odor like that of anise, and the native India doctors employ them as a stomachic and carminative.

204. FEUILLÆA CORDIFOLIA.—The sequa or cacoon antidote of Jamaica. It belongs to the cucumber family, and climbs to a great height up the trunks of trees. The seeds are employed as a remedy in a variety of diseases, and are considered an antidote against the effects of poison; they also contain a quantity of semisolid fatty oil, which is liberated by pressing and boiling them in water.

205. FICUS ELASTICA.—This plant is known as the india-rubber tree. It is a native of the East Indies, and is the chief source of caoutchouc from that quarter of the globe, although other species of Ficus yield this gum, as well as several plants of other genera. It is a plant of rapid growth, and from the larger branches roots descend to the earth as in the case of the banyan tree.

206. FICUS INDICA.—The famous banyan tree of history. Specimens of this Indian fig are mentioned as being of immense size. One in Bengal spreads over a diameter of 370 feet. Another covered an area of 1,700 square yards. It is one of the sacred trees of the Hindoos. It was known to the ancients. Strabo describes it, and it is mentioned by Pliny. Milton also alludes to it as follows:

> Branching so broad along, that in the ground
> The bending twigs take root; and daughters grow
> About the mother tree; a pillared shade,
> High overarched, with echoing walks between.
> There oft the Indian herdsman, shunning heat,
> Shelters in cool; and tends his pasturing herds
> At loop-holes cut through thickest shade.

207. FICUS RELIGIOSA.—The pippul tree of the Hindoos, which they hold in such veneration that, if a person cuts or lops off any of the branches, he is looked upon with as great abhorrence as if he had broken the leg of one of their equally sacred cows. The seeds are employed by Indian doctors in medicine.

208. FLACOURTIA SEPIARIA.—A bushy shrub, used in India for hedges. Its fruit has a pleasant, subacid flavor when perfectly ripe, but the unripe fruit is extremely astringent. The Indian doctors use a liniment made of the bark in cases of gout, and an infusion of it as a cure for snake bites.

209. FOURCROYA CUBENSE.—This plant is closely related to the agave, and, like many of that genus, furnishes a fine fiber, which is known in St. Domingo as Cabuya fiber. These plants are very magnificent when in flower, throwing up stems 20 to 30 feet in height, covered with many hundreds of yucca-like blossoms.

210. FRANCISCEA UNIFLORA.—A Brazilian plant called Mercurio vegetal; also known as Manaca. The roots, and to some extent the leaves, are used in medicine; the inner bark and all the herbaceous parts are nauseously bitter; it is re-

garded as a purgative, emetic, and alexipharmic; in overdoses it is an acrid poison.

211. FUSANUS ACUMINATUS.—A small tree of the Cape of Good Hope and Australia. It bears a globular fruit of the size of a small peach, and is known in Australia as the native peach. It has an edible nut, called the Quandang nut, which is said to be as sweet and palatable as the almond.

212. GALIPEA OFFICINALIS.—This South American tree furnishes Angostura bark, which has important medical properties, some physicians in South America preferring it to cinchona in the treatment of fevers. Its use has been greatly retarded by bark of the deadly nux-vomica tree having been inadvertently sold for it. As this bark is sometimes used in bitters, a mistake, as above, might prove as fatal as cholera.

213. GARCINIA MANGOSTANA.—This tree produces the tropical fruit called mangosteen, a beautiful fruit, having a thick, succulent rind, which contains an astringent juice, and exudes a gum similar to gamboge. The esculent interior contains a juicy pulp, of the whiteness and solubility of snow, and of a refreshing, delicate, delicious flavor. The bark of the tree is used as a basis for black dye, and it has also some medicinal value.

214. GARCINIA MORELLA.—It is supposed that Siam gamboge is obtained from this tree, also that known as Ceylon gamboge. The juice is collected by incising the stems, or by breaking young twigs of the tree and securing the yellow gum resinous exudations in hollow bamboos, where it is allowed to harden. It is employed by artists in water colors and as a varnish for lacquer work.

215. GARCINIA PICTORIA.—A fatty matter known as gamboge butter is procured from the seeds of this tree in Mysore. They are pounded in a stone mortar, then boiled till the butter or oil rises to the surface. It is used as a lamp oil, and sometimes in food.

216. GARDENIA FLORIDA and GARDENIA RADICANS.—Cape Jasmines, so called from a supposition that they were natives of the Cape of Good Hope. The genus belongs to the cinchona family. *G. lucida* furnishes a fragrant resin somewhat similar to myrrh. The fruit of *G. campanulata* is used as a cathartic, and also to wash out stains in silks. *G. gummifera* yields a resin something like Elemi.

217. GASTROLOBIUM BILOBIUM.—A leguminous plant, having poisonous properties. In western Australia, where it is a native, farmers often lose their cattle through their eating the foliage. Cats and dogs that eat the flesh of these poisoned cattle are also poisoned. *G. obtusum* and *G. spinosum* possess similar properties.

218. GENIPA AMERICANA.—This belongs to the cinchona family, and produces the fruit called genipap or marmalade box. It is about the size of an orange, and has an agreeable flavor. The juice of the fruit yields a bluish-black dye, called Canito or Lana-dye. This color is very permanent, and is much used by Indians in South America.

219. GEONOMA SCHOTTIANA.—A pretty Brazilian palm; the leaves are used for thatching huts, and other parts of the plant are utilized.

220. GOUANIA DOMINGENSIS.—A plant of the buckthorn family, known in Jamaica as Chaw-Stick, on account of its thin branches being chewed as an agreeable stomachic. Tooth brushes are made by cutting pieces of the stem to convenient lengths and fraying out the ends. A tooth powder is prepared by pulverizing the dried stems. It is said to possess febrifugal properties, and owing to its pleasant bitter taste it is used for flavoring cooling beverages.

221. GREVILLEA ROBUSTA.—The silk oak tree of Australia; a tree that attains a large size, and is remarkable for the graceful beauty of its foliage.

222. GREWIA ASIATICA.—This Indian tree represents a genus of plants of considerable economic value. This particular species yields a profusion of small red fruits which are used for flavoring drinks, having a pleasant acid flavor. The fibrous inner bark is employed by the natives for making fishing nets, ropes, twine, and for other similar purposes.

223. GRIAS CAULIFLORA.—The anchovy pear of Jamaica. The fruit is pickled and eaten like the mango, having a similar taste.

224. GUAIACUM OFFICINALE.—The wood of this tree is called Lignum Vitæ. A resin, called gum guaiacum, exudes from the stem, and is otherwise obtained from the wood by artificial means. It is of a greenish-brown color,

with a balsamic fragrance, and is remarkable for the changes of color it undergoes when brought into contact with various substances. Gluten gives it a blue tint; nitric acid and chlorin change it successively to green, blue, and brown. The resin is used medicinally as also are the bark and wood.

225. GUAZUMA TOMENTOSA.—This plant is nearly allied to the chocolate-nut tree, and yields fruits that abound in mucilage, as also does the bark of the young shoots. The mucilage is given out in water, and has been used as a substitute for gelatin or albumen in clarifying cane juice in the manufacture of sugar. The timber is light, and is employed for the staves of sugar hogsheads; it is known in Jamaica as bastard cedar. A strong fiber is obtained from the young shoots.

226. GUILIELMA SPECIOSA.—The peach palm of Venezuela. The fruits are borne in large drooping bunches, and their fleshy outer portion contains starchy matter, which forms a portion of the food of the natives. They are cooked and eaten with salt, and are said to resemble a potato in flavor. A beverage is prepared by fermenting them in water, and the meal obtained from them is made into bread. The wood of the old trees is black, and so hard as to turn the edge of an ax.

227. HÆMATOXYLON CAMPECHIANUM.—The logwood tree. This dyestuff is largely used by calico printers and other dyeing manufacturers. It is also used as an ingredient in some writing inks. The heart wood is the part used for dyeing. This is cut into chips which yield their color to water and alcohol. The colors are various according to treatment, giving violet, yellow, purple, and blue, but the consumption of logwood is for black colors, which are obtained by alum and iron bases.

228. HARDENBERGIA MONOPHYLLA.—An Australian climbing plant of the leguminous family. The long, carrot-shaped, woody root was called, by the early settlers in that country, sarsaparilla, and is still used in infusion as a substitute for that root.

229. HARTIGHSEA SPECTABILIS.—A New Zealand tree, called Wahahe by the natives, who employ the leaves as a substitute for hops, and also prepare from them a spirituous infusion as a stomachic medicine.

230. HELICONIA BIHAI.—A plant of the order *Musaceæ*, from South America. The young shoots are eaten by the natives, and the fruits are also collected and used as food. It also furnishes a useful fiber.

231. HEVEA BRASILIENSIS.—A tree of tropical America growing in damp forests, especially in the Amazon valley, which, together with other trees called siphonia furnish the Para rubber, or American caoutchouc. The sap is collected from incisions made in the tree during the dry season, and is poured over clay molds and dried by gentle heat, successive pourings being made till a sufficiently thick layer is produced.

232. HIBISCUS ROSA SINENSIS.—The flowers of this malvaceous plant contain a quantity of astringent juice, and, when bruised, rapidly turn black or deep purple; they are used by the Chinese ladies for dyeing their hair and eyebrows, and in Java for blacking shoes.

233. HIBISCUS SABDARIFFA.—This species is known in the West Indies as red sorrel, on account of the calyxes and capsules having an acid taste. They are made into cooling drinks, by sweetening and fermentation. The bark contains a strong useful fiber which makes good ropes if not too much twisted. It is also known as the Roselee plant.

234. HIBISCUS TILIACEUS.—A plant common to many tropical countries. Its wood is extremely light when dry, and is employed by the Polynesians for getting fire by friction, which is said to be a very tedious and tiresome operation, and difficult to accomplish. Good fiber is also obtained from the bark.

235. HIPPOMANE MANCINELLA.—This is the poisonous manchineel tree of South America and other tropical regoins. The virulent nature of the juice of this tree has given it a reputation equal to that forced upon the upas tree of Java. The juice is certainly very acrid, and even its smoke, when burning, causes temporary blindness. The fruit is equally dangerous, and from its beautiful appearance is sometimes partaken of by those who are unaware of its deleterious properties, but its burning effects on the lips soon causes them to desist. Indians are said to poison their arrows with the juice of this tree.

236. HURA CREPITANS.—This tropical plant is known as the sand-box tree. Its deep-furrowed, rounded, hard-shelled fruit is about the size of an orange, and when ripe and dry, it bursts open with a sharp noise like the report of

a pistol; hence, it is also called the monkey's dinner bell. An emetic oil is extracted from the seeds, and a venomous, milky juice is abundant in all parts of the plant.

237. HYMENÆA COURBARIL.—The locust tree of the West Indies; also called algarroba in tropical regions. This is one of the very largest growing trees known, and living trees in Brazil are supposed to have been growing at the commencement of the Christian era. The timber is very hard, and is much used for building purposes. A valuable resin, resembling the anime of Africa, exudes from the trunk, and large lumps of it are found about the roots of old trees.

238. HYPHÆ THEBAICA.—The doum, or doom palm, or gingerbread of Egypt; it grows also in Nubia, Abyssinia, and Arabia. The fibrous, mealy husks of the seeds are eaten, and taste almost like gingerbread. In the Thebias this palm forms extensive forests, the roots spreading over the lurid ruins of one of the largest and most splendid cities of the ancient world.

239. ICICA HEPTAPHYLLA.—The incense tree of Guiana, a tall-growing tree, furnishing wood of great durability. It is called cedar wood on account of its fragrant odor. The balsam from the trunk is highly odoriferous, and used in perfumery, and is known as balsam of acouchi; it is used in medicine. The balsam and branches are burned as incense in churches.

240. ILEX PARAGUAYENSIS.—This is the tea plant of South America, where it occupies the same important position in the domestic economy of the country as the Chinese tea does in this. The *maté* is prepared by drying and roasting the leaves, which are then reduced to a powder and made into packages. When used, a small portion of the powder is placed in a vessel, sugar is added, and boiling water poured over the whole. It has an agreeable, slightly aromatic odor, rather bitter to the taste, but very refreshing and invigorating to the human frame after severe fatigue. It acts in some degree as an aperient and diuretic, and in overdoses produces intoxication. It contains the same active principle, theine as tea and coffee, but not their volatile and empyreumatic oils.

241. ILLICIUM ANISATUM.—This magnoliaceous plant is a native of China, and its fruit furnishes the star anise of commerce. In China, Japan, and India it is used as a condiment in the preparation of food, and is chewed to promote digestion, and the native physicians prescribe it as a carminative. It is the flavoring ingredient of the preparation *Anisette de Bordeaux*. Its flavor and odor are due to a volatile oil, which is extracted by distillation, and sold as oil of anise, which is really a different article.

242. ILLICIUM FLORIDANUM.—A native of the Southern States. The leaves are said to be poisonous; hence, the plant is sometimes called poison bag. The bark has been used as a substitute for cascarilla.

243. ILLICIUM RELIGIOSUM.—A Japanese species, which reaches the size of a small tree, and is held sacred by the Japanese, who form wreaths of it with which to decorate the tombs of their deceased friends, and they also burn the fragrant bark as incense. Their watchmen use the powdered bark for burning in graduated tubes, in order to mark the time, as it consumes slowly and uniformly. The leaves are said to possess poisonous properties.

244. INDIGOFERA TINCTORIA.—The indigo plant, a native of Asia, but cultivated and naturalized in many countries. The use of indigo as a dye is of great antiquity. Both Dioscorides and Pliny mention it, and it is supposed to have been employed by the ancient Egyptians. The indigo of commerce is prepared by throwing the fresh cut plants into water, where they are steeped for twelve hours, when the water is run off into a vessel and agitated in order to promote the formation of the blue coloring matter, which does not exist ready formed in the tissues of the plant, but is the result of the oxidation of other substances contained in them. The coloring matter then settles at the bottom; it is then boiled to a certain consistency and afterwards spread out on cloth frames, where it is further drained of water and pressed into cubes or cakes for market.

245. IPOMÆA PURGA.—A species of jalap is obtained from this convolvulaceous plant; this is a resinous matter contained in the juices.

246. IRIARTELLA SETIGERA.—A South American palm growing in the underwood of the forests on the Amazon and Rio Negro. The Indians use its slender stems for making their blow pipes or gravatanas, through which they blow small poisoned arrows with accuracy to a considerable distance.

247. JAMBOSA MALACCENSIS.—This Indian plant belongs to the myrtle family. It produces a good-sized edible fruit known as the Malay apple.

248. JASMINUM SAMBAC TRIFOLIATUM.—A native of South America. The flowers are very fragrant, and an essential oil, much used in perfumery under the name of jasmine oil, is obtained from this and other species.

249. JATROPHA CLAUCA.—An East-Indian plant the seeds of which when crushed furnish an oil which is used in medicine.

250. JATROPHA CURCAS.—The physic nut tree of tropical America. This plant contains a milky, acrid, glutinous juice, which forms a permanent stain when dropped on linen, and which might form a good marking ink. Burning oil is expressed from the seeds in the Philippine Islands; the oil, boiled with oxide of iron, is used in China as a varnish. It is used in medicine in various ways, the leaves for fomentations, the juice in treating ulcers, and the seeds as purgatives.

251. JUBÆA SPECTABILIS.—The coquito palm of Chili. The seed or nut is called cokernut, and has a pleasant, nutty taste. These are used by the Chilian confectioners in the preparation of sweetmeats, and by the boys as marbles, being in shape and size like them. The leaves are used for thatching, and the trunks or stems are hollowed out and converted into water pipes. A sirup called Miel de Palma or palm honey, is prepared by boiling the sap of this tree to the consistency of treacle, and is much esteemed for domestic use as sugar. The sap is obtained by cutting off the crown of leaves when it immediately begins to flow and continues for several months provided a thin slice is shaved off the top every morning. Full-grown trees will thus yield 90 gallons.

252. KÆMPFERIA GALANGA.—This plant belongs to the family of gingers. The root stocks have an aromatic fragrance and are used medicinally in India as well as in the preparation of perfumery. The flowers appear before the leaves upon very short stems.

253. KIGELIA PINNATA.—This plant is interesting from the circumstance of its being held sacred in Nubia, where the inhabitants celebrate their religious festivals under it by moonlight, and poles made of its wood are erected as symbols of special veneration before the houses of their great chiefs. The fruits, which are very large, when cut in half and slightly roasted, are employed as an outward application to relieve pains.

254. KRAMERIA TRIANDRIA.—This is one of the species that yield the rhatany roots of commerce. In Peru an extract is made from this species, which is a mild, easily assimilated, astringent medicine. It acts as a tonic, and is used in intermittent and putrid fevers. It is also styptic, and when applied in plasters is used in curing ulcers. The color of the infusion of the roots is blood-red, on which account it is used to adulterate, or rather it forms an ingredient in the fabrication of port wine.

255. KYDIA CALYCINA.—An Indian plant of the family *Byttneriaceæ*. The bark is employed in infusion as a sudorific and in cutaneous diseases, and its fibrous tissue is manufactured into cordage.

256. LAGETTA LINTEARIA.—The lace-bark tree of Jamaica. The inner bark consists of numerous concentric layers of fibers, which interlace in all directions, and thus present a great resemblance to lace. Articles of apparel are made of it. Caps, ruffles, and even complete suits of lace are made with it. It bears washing with common soap, and when bleached in the sun acquires a degree of whiteness equal to the best artificial lace. Ropes made of it are very durable and strong.

257. LANSIUM DOMESTICUM.—A low-growing tree of the East Indies, which is cultivated to some extent for its fruit, which is known in Java and Malacca as lanseh fruit, and is much esteemed for its delicate aroma; the pulp is of somewhat firm consistence and contains a cooling, refreshing juice.

258. LAPAGERIA ROSEA.—A twining plant from Chili. The flowers are very beautiful, and are succeeded by berries, which are said to be sweet and eatable. The root has qualities closely resembling sarsaparilla and used for the same purpose.

259. LATANIA RUBRA.—A very beautiful palm from the Mauritius. The fruit contains a small quantity of pulp, which is eaten by the natives, but is not considered very palatable by travelers.

260. LAWSONIA INERMIS.—This is the celebrated henna of the East. The use of the powdered leaves as a cosmetic is very general in Asia and northern Africa,

the practice having descended from very remote ages, as is proved by the Egyptian mummies, the parts dyed being usually the finger and toe nails, the tips of the fingers, the palms of the hands, and soles of the feet, receiving a reddish color, considered by Oriental belles as highly ornamental. Henna is prepared by reducing the leaves to powder, and when used is made into a pasty mass with water and spread on the part to be dyed, being allowed to remain for twelve hours. The plant is known in the West Indies as Jamaica Mignonette.

261. LECYTHIS OLLARIA.—This tree produces the hard urn-shaped fruits known in Brazil as monkey cups. The seeds are eatable and sold as Sapucaia nuts. The fruit vessels are very peculiar, being 6 inches in diameter and having closely fitting lids, which separate when the seeds are mature. The bark is composed of a great number of layers, not thicker than writing paper, which the Indians separate and employ as cigar wrappers.

262. LEPTOSPERUM LANIGERUM.—A plant known throughout Australia as Captain Cook's tea tree, from the circumstance that, on the first landing of this navigator in that country, he employed a decoction of the leaves of this plant as a corrective to the effects of scurvy among his crew, and this proved an efficient medicine. Thickets of this plant, along the swampy margin of streams, are known as Tea-tree scrubs. It is also known among the natives as the Manuka plant. The wood is hard and heavy, and was formerly used for making sharp-pointed spears. It belongs to the myrtle family of plants.

263. LICUALA ACUTIFIDA.—This palm is a native of the island of Pulo-Penango, and yields canes known by the curious name of Penang Lawyers. It is a low-growing plant, its stems averaging an inch in diameter. The stems are converted into walking canes by scraping their rough exteriors and straightening them by means of fire heat.

264. LIMONIA ACIDISSIMA.—An East India shrub which produces round fruits about the size of damson plums, of a yellowish color, with reddish or purplish tints. They are extremely acid, and the pulp is employed in Java as a substitute for soap.

265. LIVISTONIA AUSTRALIS.—This is one of the few palms found in Australia. The unexpanded leaves, prepared by being scalded and dried in the shade, are used for making hats, while the still younger and more tender leaves are eaten like cabbage.

266. LUCUMA MAMMOSUM.—This sapotaceous plant is cultivated for its fruit, which is called marmalade, on account of its containing a thick agreeably flavored pulp, bearing some resemblance in appearance and taste to quince marmalade. A native of South America.

267. MABA GEMINATA.—The ebony wood of Queensland. The heart wood is black, and the outside wood of a bright red color. It is close-grained, hard, heavy, elastic and tough, and takes a high polish.

268. MACADAMIA TERNIFOLIA.—An Australian tree which produces an edible nut called the Queensland nut. This fruit is about the size of a walnut, and contains within a thick pericarp, a smooth brown-colored nut, inclosing a kernel of a rich and agreeable flavor, resembling in some degree that of a filbert.

269. MACHÆRUM FIRMUM.—A South American tree which furnishes a portion of the rosewood of commerce. Various species of the genus, under the common Brazilian name of Jaccaranda, are said to yield this wood, but there is some uncertainty about the origin of the various commercial rosewoods.

270. MACLURA TINCTORIA.—The fustic tree. Large quantities of the bright yellow wood of this tree are exported from South America for the use of dyers, who obtain from it shades of yellow, brown, olive, and green. A concentrated decoction of the wood deposits, on cooling, a yellow crystalline matter called Morine. This tree is sometimes called old fustic, in order to distinguish it from another commercial dye called young fustic, which is obtained in Europe from a species of Rhus.

271. MACROPIPER METHYSTICUM.—A plant of the pepper family, which furnishes the root called Ava by the Polynesians. It has narcotic properties, and is employed medicinally, but is chiefly remarkable for the value attached to it as a narcotic and stimulant beverage, of which the natives partake before they commence any important business or religious rites. It is used by chewing the root and extracting the juice, and has a calming rather than an intoxicating effect. It is a filthy preparation, and only partaken of by the lower classes of Feejeeans.

272. MACROZAMIA DENISONII.—An Australian cycad, the seeds of which contain a large amount of farina, or starchy matter, which formerly supplied a considerable amount of food for the natives of that country. The fresh seeds are very acrid, but when steeped in water and roasted they become palatable and nutritious.

273. MALPIGHIA GLABRA.—A low-growing tree of the West Indies, which produces an edible fruit called the Barbadoes cherry.

274. MAMMEA AMERICANA.—The fruit of this tree, under the name of mammee apple, is very much esteemed in tropical countries. It often attains a size of 6 or 8 inches in diameter and is of a yellow color. The outer rind and the pulp which immediately surrounds the seeds are very bitter, but the intermediate is sweet and aromatic. The seeds are used as anthelmintics, an aromatic liquor is distilled from the flowers, and the acrid, resinous gum distilled from the bark is used to destroy insects.

275. MANETTIA CORDIFOLIA.—This climbing-plant is a native of South America, and belongs to the family of *Cinchonaceæ*. The rind of the root has emetic properties, and is used in Brazil for dropsy and other diseases. It is also exported under the name of Ipecacuan, chiefly from Buenos Ayres.

276 MANGIFERA INDICA.—The mango, in some of its varieties esteemed as the most delicious of tropical fruits, while many varieties produce fruit whose texture resembles cotton and tastes of turpentine. The unripe fruit is pickled. The pulp contains gallic and citric acid. The seeds possess anthelmintic properties. A soft gum resin exudes from the wounded bark, which is used medicinally.

277. MANICARIA SACCIFERA.—Bussu palm of South America. Its large leaves are used for thatching roofs, for which purpose they are well fitted and very durable. The fibrous spathe furnishes a material of much value to the natives. This fibrous matter when taken off entire is at once converted into capital bags, in which the Indian keeps the red paint for his toilet, or the silk cotton for his arrows, or he stretches out the larger ones to make himself a cap of nature's own weaving, without seam or joint.

278. MANIHOT UTILISSIMA.—This euphorbiaceous plant yields cassava or mandiocca meal. It is extensively cultivated in tropical climates and supplies a great amount of food. The root is the part used, and in its natural condition is a most virulent poison, but by grating the roots to a pulp the poison is expelled by pressure, and altogether dissipated by cooking. The expressed juice, when allowed to settle, deposits the starch known as tapioca.

279. MARANTA ARUNDINACEA.—The arrowroot plant, cultivated for its starch. The tubers being reduced to pulp with water, the fecula subsides, and is washed and dried for commerce. It is a very pure kind of starch, and very nutritious. The term arrowroot is said to be derived from the fact that the natives of the West Indies use the roots of the plant as an application to wounds made by poison arrows.

280. MAURITIA FLEXUOSA.—The Moriche, or Ita palm, very abundant on the banks of the Amazon, Rio Negro, and Orinoco Rivers. In the delta of the latter it occupies swampy tracts of ground, which are at times completely inundated, and present the appearance of forests rising out of the water. These swamps are frequented by a tribe of Indians called Guaranes, who subsist almost entirely upon the produce of this palm, and during the period of the inundations suspend their dwellings from the tops of its tall stems. The outer skin of the young leaves is made into string and cord for the manufacture of hammocks. The fermented sap yields palm wine, and another beverage is prepared from the young fruits, while the soft inner bark of the stem yields a farinaceous substance like sago.

281. MAXIMILIANA REGIA.—An Amazonian palm called Inaja. The spathes are so hard that, when filled with water, they will stand the fire, and are sometimes used by the Indians as cooking utensils. The Indians who prepare the kind of rubber called bottle rubber, make use of the hard stones of the fruit as fuel for smoking and drying the successive layers of milky juice as it is applied to the mold upon which the bottles are formed. The outer husk, also, yields a kind of saline flour used for seasoning their food.

282. MELALEUCA MINOR.—A native of Australia and the islands of the Indian Ocean. The leaves, being fermented, are distilled, and yield an oil known as cajuput or cajeput oil, which is green, and has a strong aromatic odor. It is

valuable as an antispasmodic and stimulant, and at one time had a great reputation as a cure for cholera. In China the leaves are used as a tonic in the form of decoction.

283. MELICOCCA BIJUGA.—This sapindaceous tree is plentiful in tropical America and the West Indies, and is known as the Genip tree. It produces numerous green egg-shaped fruits, an inch in length, possessing an agreeable vinous and somewhat aromatic flavor, called honey berries or bullace plums. The wood of the tree is hard and heavy.

284. MELOCACTUS COMMUNIS.—Commonly called the Turk's Cap cactus, from the flowering portion on the top of the plant being of a cylindrical form and red color, like a fez cap. Notwithstanding that they grow in the most dry sterile places, they contain a considerable quantity of moisture, which is well known to mules, who resort to them when very thirsty, first removing the prickles with their feet.

285. MESEMBRYANTHEMUM CRYSTALLINUM.—The ice plant, so called in consequence of every part of the plant being covered with small watery pustules, which glisten in the sun like fragments of ice. Large quantities of this plant are collected in the Canaries and burned, the ashes being sent to Spain for the use of glass makers. *M. edule* is called the Hottentot's fig, its fruit being about the size of a small fig, and having a pleasant, acid taste when ripe. *M. tortuosum* possesses narcotic properties, and is chewed by the Hottentots to induce intoxication. The fruits possess hygrometric properties, the dried, shriveled, capsules swelling out and opening so as to allow of the escape of the seeds when moistened by rain, which at the same time fits the soil for their germination.

286. MIKANIA GUACO.—A composite plant which has gained some notoriety as the supposed Cundurango, the cancer-curing bark. It has long been supposed to supply a powerful antidote for the bite of venomous serpents.

287. MIMUSOPS BALATA.—The Bully tree. This sapotaceous plant attains a great size in Guiana and affords a dense, close-grained, valuable timber. Its small fruits, about the size of coffee berries, are delicious when ripe. The flowers also yield a perfume when distilled in water, and oil is expressed from the seeds.

288. MIMUSOPS ELENGI.—A native of Ceylon, where its hard, heavy, durable timber is used for building purposes. The seed also affords a great amount of oil.

289. MONODORA GRANDIFLORA.—An African plant belonging to the Anonaceæ. It produces large fruit, which contains a large quantity of seeds about the size of the Scarlet-Runner bean. They are aromatic and impart to the fruit the odor and flavor of nutmeg; hence they are also known as calabash nutmegs.

290. MONSTERA DELLCIOSA.—This is a native of southern Mexico and yields a delicious fruit with luscious pineapple flavor. The outer skin of the fruit, if eaten, causes a stinging sensation in the mouth. This is easily removed when the fruit is ripe. The leaves are singularly perforated with holes at irregular intervals, from natural causes not sufficiently explained. In Trinidad the plant is called the Ceriman.

291. MORINGA PTERYGOSPERMA.—A native of the East Indies, where it bears the name of horse-radish tree. The seeds are called ben nuts and supply a fluid oil, highly prized by watchmakers, called oil of ben. The root is pungent and stimulant and tastes like horse-radish.

292. MORONOBEA COCCINEA.—The hog gum tree, which attains the height of 100 feet. A fluid juice exudes from incisions in the trunk and hardens into a yellow resin. It is said the hogs in Jamaica when wounded rub the injured part against the tree so as to cover it with the gum, which possesses vulnerary properties; hence its name. The resin has been employed as a substitute for copaiba balsam, and plasters are made of it.

293. MUCUNA PRURIENS.—A tall climbing plant of the West Indies and other warm climates. It is called the cowage, or cow-itch, on account of the seed pods being covered with short brittle hairs, the points of which are finely serrated, causing an unbearable itching when applied to the skin, which is relieved by rubbing the part with oil. It is employed as a vermifuge. In East Africa it is called Kitedzi. The sea beans found on the coast of Florida are the seeds of Mucuna altissima. In Cuba these are called bulls' eyes.

294. MURRAYA EXOTICA.—A Chinese plant of the orange family. The fruit is succulent, and the white flowers are very fragrant. They are used in perfumery.

295. MUSA CAVENDISHII.—This is a valuable dwarf species of the banana from southern China. It bears a large truss of fine fruit, and is cultivated to some extent in Florida, where it endures more cold than the West India species and fruits more abundantly.

296. MUSA ENSETE.—This Abyssinian species forms large foliage of striking beauty. The food is dry and uneatable; but the base of the flower stalk is eaten by the natives.

297. MUSA SAPIENTUM.—The banana plant. This has been cultivated and used as food in tropical countries from very remote times, and furnishes enormous quantities of nutritious food, and serves as a staple support to a large number of the human race. The expressed juice is in some countries made into a fermented liquor and the young shoots eaten as a vegetable.

298. MUSA TEXTILIS.—This furnishes the fiber known as manilla hemp, and is cultivated in the Philippine Islands for this product. The finer kinds of the fiber are woven into beautiful shawls and the coarser manufactured into cordage for ships. The fiber is obtained from the leaf-stalks.

299. MUSSÆNDA FRONDOSA.—This cinchonaceous plant is a native of Ceylon. The bark and leaves are esteemed as tonic and ferbrifuges in the Mauritius, where they are known as wild cinchona. The leaves and flowers are also used as expectorants, and the juice of the fruit and leaves is used as an eye-wash.

300. MYRISTICA MOSCHATA.—The nutmeg tree. The seed of this plant is the nutmeg of commerce, and mace is the seed cover of the same. When the nuts are gathered they are dried and the outer shell of the seed removed. The mace is also dried in the sun and assumes a golden yellow color. The most esteemed nutmegs come from Penang. At one time the nutmeg culture was monopolized by the Dutch, who were in the habit of burning them when the crop was too abundant, in order to keep up high prices.

301. MYROSPERMUM PERUIFERUM.—This plant yields the drug known as balsam of Peru, which is procured by making incisions in the bark, into which cotton rags are thrust; a fire is then made round the tree to liquefy the balsam. The balsam is collected by boiling the saturated rags in water. It is a thick, treacly looking liquid, with fragrant aromatic smell and taste, and is not used so much in medicine as it formerly was.

302. MYROSPERUM TOLUIFERUM.—A South American tree, also called Myroxylon, which yields the resinous drug called balsam of Tolu. This substance is fragrant, having a warm, sweetish taste, and burns with an agreeable odor. It is used in perfumery and in the manufacture of pastiles, also for flavoring confectionery, as in Tolu lozenges.

303. MYRTUS COMMUNIS—The common myrtle. This plant is supposed to be a native of western Asia, but now grows abundantly in Italy, Spain, and the south of France. Among the ancients the myrtle was held sacred to Venus and was a plant of considerable importance, wreaths of it being worn by the victors of the Olympic games and other honored personages. Various parts of the plant were used in medicine, in cookery, and by the Tuscans in the preparation of myrtle wine, called *myrtidanum*. It is still used in perfumery, and a highly perfumed distillation is made from the flowers. The fruits are very aromatic and sweet, and are eaten fresh or dried and used as a condiment.

304. NANDINA DOMESTICA.—A shrub belonging to the family of berberries. It is a native of China and Japan, where it is extensively cultivated for its fruits. It is there known as Nandin.

305. NAUCLEA GAMBIR.—A native of the Malayan Islands, which yields the Gambir, or Terra Japonica of commerce. This is prepared by boiling the leaves in water until the decoction thickens, when it is poured into molds, where it remains until it acquires the consistency of clay; it is then cut into cubes and thoroughly dried. It is used as a masticatory in combination with the areca nut and betel leaf, and also for tanning purposes.

306. NECTANDRA LEUCANTHA.—The greenheart, or bibiru tree of British Guiana, furnishing bibiru bark, which is used medicinally as a tonic and febrifuge, its properties being due to the presence of an uncrystallizable alkaloid, also found in the seeds. The seeds are also remarkable for containing

upwards of 50 per cent of starch, which is made into a kind of bread by the natives. The timber of this tree is extensively employed in shipbuilding, its great strength and durability rendering it peculiarly well suited for this purpose.

307. NEPENTHES DISTILLATORIA.—This pitcher plant is a native of Ceylon. The pitchers are partly filled with water before they open; hence it was supposed to be produced by some distilling process. In Ceylon the old, tough, flexible stems are used as willows.

308. NEPHELIUM LITCHI.—This sapindaceous tree produces one of the valued indigenous fruits of China. There are several varieties; the fruit is round, about an inch and a half in diameter, with a reddish-colored, thin, brittle shell. When fresh they are filled with a sweet, white, transparent, jelly-like pulp. The Chinese are very fond of these fruits and consume large quantities of them, both in the fresh state and when dried and preserved.

309. NERIUM OLEANDER.—This is a well-known plant, often seen in cultivation, and seemingly a favorite with many. It belongs to a poisonous family and is a dangerous poison. A decoction of its leaves forms a wash, employed in the south of Europe to destroy vermin; and its powdered wood and bark constitute the basis of an efficacious rat-poison. Children have died from eating the flowers. A party of soldiers in Spain, having meat to roast in camp, procured spits and skewers of the tree, which there attains a large size. The wood having been stripped of its bark, and brought in contact with the meat, was productive of fatal consequences, for seven men died out of the twelve who partook of the meat and the other five were for some time dangerously ill.

310. NOTELÆA LIGUSTRINA.—The Tasmanian ironwood tree. It is of medium growth and furnishes wood that is extremely hard and dense, and used for making sheaves for ships' blocks, and for other articles that require to be of great strength. The plant belongs to the olive family.

311. OCHROMA LAGOPUS.—A tree that grows about 40 feet high, along the seashores in the West Indies and Central America, and known as the cork wood. The wood is soft, spongy, and exceedingly light, and is used as a substitute for cork, both in stopping bottles and as floats for fishing nets. It is also known as Balsa.

312. ŒNOCARPUS BATAVA.—A South American palm, which yields a colorless, sweet-tasted oil, used in Para for adulterating olive oil, being nearly as good for this purpose as peanut oil, so largely used in Europe. A palatable but slightly aperient beverage is prepared by triturating the fruits in water, and adding sugar and mandiocca flour.

313. OLEA EUROPÆA.—The European olive, which is popularly supposed to furnish *all* the olive oil of commerce. It is a plant of slow growth and of as slow decay. It is considered probable that trees at present existing in the Vale of Gethsemane are those which existed at the commencement of the Christian era. The oil is derived from the flesh of the fruit, and is pressed out of the bruised pulp; inferior kinds are from second and third pressings. The best salad oil is from Leghorn, and is sent in flasks surrounded by rush-work. Gallipoli oil is transported in casks, and Lucca in jars. The pickling olives are the unripe fruits deprived of a portion of their bitterness by soaking in water in which lime and wood ashes are sometimes added, and then bottled in salt and water with aromatics.

314. OPHIOCARYON PARADOXUM.—The snake nut tree of Guiana, so called on account of the curious form of the embryo of the seed, which is spirally twisted, so as to closely resemble a coiled-up blacksnake. The fruits are as large as those of the black walnut, and although they are not known to possess any medical properties, their singular snake-like form has induced the Indians to employ them as an antidote to the poison of venomous snakes. The plant belongs to the order of *Sapindaceæ*.

315. OPHIORHIZA MUNGOS.—A plant belonging to the cinchona family, the roots of which are reputed to cure snake bites. They are intensely bitter, and from this circumstance they are called earth-galls by the Malays.

316. OPHIOXYLON SERPENTINUM.—A native of the East Indies, where the roots are used in medicine as a febrifuge and alexipharmic.

317. OPUNTIA COCHINELLIFERA.—A native of Mexico, where it is largely cultivated in what are called the Nopal plantations for the breeding of the cochineal insect. This plant and others are also grown for a similar purpose in the

Canary Islands and Madeira. Some of these plantations contain fifty thousand plants. Cochineal forms the finest carmine scarlet dye, and at least there are 2,000 tons of it produced yearly, in value worth $2,000 per ton.

318. OPUNTIA TUNA.—This plant is a native of Mexico and South America generally. It reaches a height of 15 to 20 feet and bears reddish-colored flowers, followed by pear-shaped fleshy fruits 2 or 3 inches long, and of a rich carmine color when ripe. It is cultivated for rearing the cochineal insect. The fruits are sweet and juicy; sugar has been made from them. The juice is used as a water-color and for coloring confectionery.

319. OREODAPHNE CALIFORNICA.—The mountain laurel, or spice bush, of California. When bruised it emits a strong, spicy odor, and the Spanish Americans use the leaves as a condiment.

320. OREODOXA OLERACEA.—The West Indian cabbage palm, which sometimes attains the height of 170 feet, with a straight cylindrical trunk. The semicylindrical portions of the leaf-stalk are formed into cradles for children, or made into splints for fractures. Their inside skin, peeled off while green, and dried, looks like vellum, and can be written upon. The heart of young leaves, or cabbage, is boiled as a vegetable or pickled, and the pith affords sago. Oil is obtained from the fruit.

321. ORMOSIA DASYCARPA.—This is the West Indian bead tree, or necklace tree, the seeds of which are roundish, beautifully polished, and of a bright scarlet color, with a black spot at one end resembling beads, for which they are substitutes, being made into necklaces, bracelets, or mounted in silver for studs and buttons. It is a leguminose plant.

322. OSMANTHUS FRAGRANS.—This plant has long heen cultivated as Olea Fragrans. The flowers have a fine fragrance, and are used by the Chinese to perfume tea. It appears that they consider the leaves also valuable, for they are frequently found in what is expected to be genuine tea.

323. PACHIRA ALBA.—A South American tree the inner bark of which furnishes a strong useful fiber, employed in the manufacture of ropes and various kinds of cordage. The petals of the flowers are covered with a soft silky down which is used for stuffing cushions and pillows.

324. PANDANUS UTILIS.—The screw pine of the Mauritius, where it is largely cultivated for its leaves, which are manufactured into bags or sacks for the exportation of sugar. They are also used for making other domestic vessels and for tying purposes.

325. PAPPEA CAPENSIS.—A small tree of the soapberry or sapindaceous family, a native of the Cape of Good Hope, where the fruit is known as the wild plum, from the pulp of which a vinous beverage and excellent vinegar are prepared, and an eatable, though slightly purgative, oil is extracted from the seeds. The oil is also strongly recommended for baldness and scalp affections.

326. PAPYRUS ANTIQUORUM.—The paper-reed of Asia, which yielded the substances used as paper by the ancient Egyptians. The underground root-stocks spread horizontally under the muddy soil, continuing to throw up stems as they creep along. The paper was made from thin slices, cut vertically from the apex to the base of the stem, between its surface and center. The slices were placed side by side, according to the size required, and then, after being wetted and beaten with a wooden instrument until smooth, were pressed and dried in the sun.

327. PARITIUM ELATUM.—The mountain mahoe, a malvaceous plant, that furnishes the beautiful lace-like bark called Cuba bast, imported by nurserymen for tying their plants. It was at one time only seen as employed in tying together bundles of genuine Havana cigars. It forms a tree 40 feet or more in height, and yields a greenish-blue timber, highly prized by cabinet-makers.

328. PARKIA AFRICANA.—The African locust tree, producing seeds which the natives of Soudan roast, and then bruise and allow to ferment in water until they become putrid, when they are carefully washed, pounded into powder, and made into cakes, which are said to be excellent, though having a very unpleasant smell. The pulp surrounding the seeds is made into a sweet farinaceous preparation.

329. Parkinsonia aculeata.—This leguminous plant is called Jerusalem Thorn. Although a native of Southern Texas and Mexico, it is found in many tropical countries, and is frequently used for making hedges. Indians in Mexico employ it as a febrifuge and sudorific and also as a remedy for epilepsy.

330. Parmentiera cereifera.—In the Isthmus of Panama this plant is termed the Candle tree, because its fruits, often 4 feet long, look like yellow candles suspended from the branches. They have a peculiar, apple-like smell, and cattle that partake of the leaves or fruit have the smell communicated to the beef if killed immediately.

331. Passiflora quadrangularis.—The fruit of this plant is the Granadilla of the tropics. The pulp has an agreeable though rather mawkish taste. The root is said to possess narcotic properties, and is used in the Mauritius as an emetic.

332. Paullinia sorbilis.—The seeds of this climbing sapindaceous plant furnish the famous guarana of the Amazon and its principal tributaries. The ripe seeds, when thoroughly dried, are pounded into a fine powder, which made into dough with water, is formed into cylindrical rolls, from 5 to 8 inches long, becoming very hard when dry. It is used as a beverage, which is prepared by grating about half a teaspoonful of one of the cakes into about a teacup of water. It is much used by Brazilian miners, and is considered a preventive of all manner of diseases. It is also used by travelers, who supply themselves with it previous to undertaking lengthy or fatiguing journeys. Its active principle is identical with theine, of which it contains a larger quantity than exists in any other known plant, being more than double that contained in the best black tea.

333. Pavetta borbonica.—This belongs to the quinine family. The roots are bitter, and are employed as a purgative; the leaves are also used medicinally.

334. Pedilanthus tithymaloides.—This euphorbiaceous plant has an acrid, milky, bitter juice; the root is emetic, and the dried branches are used medicinally.

335. Pereskia aculeata.—The Barbadoes gooseberry, which belongs to the family *Cactaceæ*. It grows about 15 feet in height, and produces yellow-colored, eatable, and pleasant-tasted fruit, which is used in the West Indies for making preserves.

336. Persea gratissima.—The avocado or alligator pear, a common tree in the West Indies. The fruits are pear-shaped, covered with a brownish-green or purple skin. They are highly esteemed where grown, but strangers do not relish them. They contain a large quantity of firm pulp, possessing a buttery or marrow-like taste, and are frequently called vegetable marrow. They are usually eaten with spice, lime-juice, pepper, and salt. An abundance of oil, for burning and for soap-making, may be obtained from the pulp. The seeds yield a deep, indelible black juice, which is used for marking linen.

337. Phœnix dactylifera.—The date palm, very extensively grown for its fruit, which affords the principal food for a large portion of the inhabitants of Africa, Asia, and southern Europe, and likewise of the various domestic animals—dogs, horses, and camels being alike partial to it. The tree attains to a great age, and bears annually for two hundred years. The huts of the poorer classes are constructed of the leaves; the fiber surrounding the bases of their stalks is used for making ropes and coarse cloth; the stalks are used for the manufacture of baskets, brooms, crates, walking sticks, etc., and the wood for building substantial houses; the heart of young leaves is eaten as a vegetable; the sap affords an intoxicating beverage. It may be further mentioned that the date was, probably, the palm which supplied the "branches of palm trees" mentioned by St. John (xii, 13) as having been carried by the people who went to meet Christ on his triumphal entry into Jerusalem, and from which Palm Sunday takes its name.

338. Phormium tenax.—This plant is called New Zealand flax, on account of the leaves containing a large quantity of strong, useful fiber, which is used by the natives of that country for making strings, ropes, and articles of clothing. The plant could be grown in this climate, and would no doubt be largely cultivated if some efficient mode of separating the fiber could be discovered.

339. PHOTINIA JAPONICA.—The Japanese Medlar, or Chinese Lo-quat. It bears a small oval fruit of an orange color when ripe, having a pleasant subacid flavor. It stands ordinary winters in this climate, and forms a fine evergreen, medium-sized tree.

340. PHYSOSTIGMA VENENOSUM.—A strong leguminous plant, the seeds of which are highly poisonous, and are employed by the natives of Old Calabar as an ordeal. Persons suspected of witchcraft or other crimes are compelled to eat them until they vomit or die, the former being regarded as proof of innocence, and the latter of guilt. Recently the seeds have been found to act powerfully in diseases of the eye.

341. PHYTELEPHAS MACROCARPA.—The vegetable ivory plant, a native of the northern parts of South America. The fruit consists of a collection of six or seven drupes; each contains from six to nine seeds, the vegetable ivory of commerce. The seeds at first contain a clear, insipid liquid; afterwards it becomes milky and sweet, and changes by degrees until it becomes hard as ivory. Animals eat the fruit in its young green state; a sweet oily pulp incloses the seeds, and is collected and sold in the markets under the name of Pipa de Jagua. Vegetable ivory may be distinguished from animal ivory by means of sulphuric acid, which gives a bright red color with the vegetable ivory, but none with the animal ivory.

342. PICRASMA EXCELSA.—This yields the bitter wood known as Jamaica Quassia. The tree is common in Jamaica, where it attains the height of 50 feet. The wood is of a whitish or yellow color, and has an intensely bitter taste. Although it is used as a medicine in cases of weak digestion, it acts as a narcotic poison on some animals, and the tincture is used as fly poison. Cups made of this wood, when filled with water and allowed to remain for some time, will impart tonic properties to the water.

343. PINCKNEYA PUBENS.—This cinchonaceous plant is a native of the Southern States and has a reputation as an antiperiodic. It is stated that incomplete examinations have detected *cinchonine* in the bark. It has been used successfully as a substitute for quinine. A thorough examination of this plant seems desirable so that its exact medical value may be ascertained.

344. PIPER BETEL.—This plant belongs to the *Piperaceæ*. Immense quantities of the leaves of this plant are chewed by the Malays. It tinges the saliva a bright red and acts as a powerful stimulant to the digestive organs and salivary glands; when swallowed it causes giddiness and other unpleasant symptoms in persons unaccustomed to its use.

345. PIPER NIGRUM.—This twining shrub yields the pepper of commerce. It is cultivated in the East and West Indies, Java, etc., the Malabar being held in the highest esteem. The fruit when ripe is of a red color, but it is gathered before being fully ripe and dried in the sun, when it becomes black and shriveled. White pepper is the same fruit with the skin removed. When analyzed, pepper is found to contain a hot acrid resin and a volatile oil, as well as a crystalline substance called *piperin*, which has been recommended as a substitute for quinine.

346. PISTACIA LENTISCUS.—The mastic tree, a native of southern Europe, northern Africa, and western Asia. Mastic is the resin of the tree and is obtained by making transverse incisions in the bark, from which it exudes in drops and hardens into small semitransparent tears. It is consumed in large quantities by the Turks for chewing to strengthen the gums and sweeten the breath. It is also used for varnishing.

347. PISTACIA TEREBINTHUS.—The Cyprus turpentine tree. The turpentine flows from incisions made in the trunk and soon becomes thick and tenacious, and ultimately hardens. Galls gathered from this tree are used for tanning purposes, one of the varieties of morocco leather being tanned with them.

348. PISTACIA VERA.—The pistacia tree, which yields the eatable pistachio nuts. It is a native of western Asia. The nuts are greatly eaten by the Turks and Greeks, as well as in the south of Europe, either simply dried like almonds or made into articles of confectionery.

349. PITHECOLOBIUM SAMAN.—This leguminous plant yields eatable pods, which are fed to cattle in Brazil. Some Mexican species produce pods that are boiled and eaten, and certain portions contain saponaceous properties. The pods are sometimes called Manilla tamarinds. The leaves of this tree fold closely up at night, so that they do not prevent the radiation of heat from the surface of the ground, and dew is therefore deposited underneath its branches. The grass on the surface of the ground underneath this tree being thus wet

with dew, while that under other trees is found to be dry, has given it the name of rain tree, under the supposition that the leaves dropped water during the night.

350. Pittosporum undulatum.—A plant from New Zealand, which reaches a considerable size, and furnishes a wood similar to boxwood. The flowers are very fragrant.

351. Plagianthus betulinus.—The inner bark of the young branches of this plant yields a very fine fiber, sometimes called New Zealand cotton, though more like flax than cotton; it is the Akaroa of the New Zealanders. In Tasmania it bears the name of Currajong. Good cordage and twine for fishing nets are made from this fiber. A superior paper pulp is prepared from the wood; it is also employed in making handles to baskets, rims for sieves, and hoops for barrels.

352. Platonia insignis.—A Brazilian tree which bears a fruit known in that country as Pacoury-uva. The pulp of this fruit is semiacid, very delicious, and is employed in making preserves. The seeds embedded in this pulp have the flavor of almonds.

353. Plumbago scandens.—The root of this plant is called Herbe du Diable in San Domingo; it is acrid in the highest degree, and is a most energetic blistering agent when fresh.

354. Plumieria alba.—A South American plant. The flowers are used in perfumery, and furnish the scent known as Frangipane or Frangipani. In Jamaica the plant is known as red jasmine.

355. Pogostemon patchouly.—This plant affords the celebrated patchouli perfume. The peculiar odor of patchouli is disagreeable to some, but is very popular with many persons. The odoriferous part of the plant is the leaves and young tops, which yield a volatile oil by distillation, from which an essence is prepared; satchets of patchouli are made of coarsely powdered leaves. Genuine Indian shawls and Indian ink were formerly distinguished by their odor of this perfume, but the test does not now hold good. Ill effects, such as loss of sleep, nervous attacks, etc., have been ascribed to its extensive use.

356. Pongamia glabra.—Some years ago this tree was recommended as suitable for avenue-planting in the south of France. In India an oil called poonga is expressed from the seeds, which is much used for mixing with lamp oil. It is of a deep yellow color, and is fluid at temperatures above 60 F., but below that it becomes solid.

357. Portlandia grandiflora—This plant belongs to the cinchonaceous family, and is said to possess properties similar to those of the true cinchona. The bark is exceedingly bitter.

358. Psidium cattleyanum.—This is the purple guava from China. The fruits are filled with juicy, pale flesh, of a very agreeable acid-sweet flavor.

359. Psidium pyriferum.—The West Indian guava, a well-known fruit in the tropics, but only known here in the shape of guava jelly. The wood of the tree has a fine, close grain, and has been experimented with as a substitute for boxwood for engraving purposes, but it is too soft to stand the pressure of printing.

360. Psychotria leucantha.—A plant belonging to the cinchona family. Emetic properties are assigned to the roots, which are also used in dyeing. Native of Peru.

361. Pterocarpus marsupium.—This tree affords gum-kino, which is obtained by making incisions in the bark, from which the juice exudes and hardens into a brittle mass, easily broken into small angular, shining fragments of a bright ruby color. It is highly astringent. The wood is hard and valuable for manufacturing purposes.

362. Punica granatum.—The pomegranate, a native of northern Africa and western Asia. The fruit is valued in warm countries on account of its delicious cooling and refreshing pulp. Numerous varieties are grown, some being sweet and vinous, and others acid or of a bitter, stringent taste; the color also varies from light to dark red. The bark of the root abounds in a peculiar principle called *punicin*. This bark appears to have been known to the ancients, and used by them as a vermifuge, and is still used in Hindostan as a specific against tapeworm. The rind of the fruit of the bitter varieties contains a large amount of tannin, and is used for tanning morocco leather. The flowers yield a red dye.

363. QUASSIA AMARA.—The wood of this plant furnishes Surinam quassia. It is destitute of smell, but has an intensely bitter taste, and is used as a tonic. The root has also reputed medicinal value, as also have the flowers.

364. QUILLAJA SAPONARIA.—The Quillai or Cully of the Chilians. Its bark is called soap-bark, and is rough and dark-colored externally, but internally consists of numerous regular whitish or yellowish layers, and contains a large quantity of carbonate of lime and other mineral matters. It is also rich in *saponine*, and is used for washing clothes; 2 ounces of the bark is sufficient to wash a dress. It also removes all spots or stains, and imparts a fine luster to wool; when powdered and rubbed between the hands in water, it makes a foam like soap. It is to be found in commerce.

365. RANDIA ACULEATA.—A small tree native of the West Indies, also found in southern Florida. In the West Indies the fruit is used for producing a blue dye, and medicinal properties are assigned to the bark.

366. RAPHIA TŒDIGERA.—The Jupati palm. The leaf-stalks of this plant are used by the natives of the Amazon for a variety of purposes, such as constructing inside walls, making boxes and baskets, etc. *R. vinifera*, the Bamboo palm, is similarly used by the Africans, who also make a very pliable cloth of the undeveloped leaves. Palm wine is one of the products of the genus.

367. RAVENALA MADAGASCARIENSIS.—This plant is called the Traveler's tree, probably on account of the water which is stored up in the large cup-like sheaths of the leaf-stalks, and which is sought for by travelers to allay their thirst. The broad leaves are used in Madagascar as thatch to cover their houses. The seeds are edible, and the blue, pulpy aril surrounding them yields an essential oil.

368. RHAPIS FLABELLIFORMIS.—The ground rattan palm. This is supposed to yield the walking-canes known as rattan, which is doubted. It is a native of southern China, and is also found in Japan, where it is known by the name of Kwanwortsik.

369. RHIZOPHORA MANGLE.—This plant is known as the mangrove, possibly because no man can live in the swampy groves that are covered with it in tropical countries. The seeds germinate, or form roots before they quit the parent tree, and drop into the mud as young trees. The old plants send out aerial roots into the water, upon which the mollusca adhere, and as the tide recedes they are seen clinging to the shoots, verifying the statements of old travelers that they had seen oysters growing on trees. All parts of this tree contain tannin. The bark yields dyes, and in the West Indies the leaves are used for poulticing wounds. The fruit is edible; a coarse, brittle salt is extracted from the roots, and in the Philippines the bark is used as a febrifuge.

370. ROTTLERA TINCTORIA.—This plant belongs to the order *Euphorbiaceæ*, and reaches the size of a small tree in the Indian Archipelago and southern Australia. From the surface of the trilobed capsules of this plant, which are about the size of peas, a red, mealy powder is obtained, well known in India as kamala, and which is used by Hindoo silk-dyers, who obtain from it a deep, bright, durable orange or flame color of great beauty. This is obtained by boiling the powder in a solution of carbonate of soda. When the capsules are ripe the red powder is brushed off and collected for sale, no other preparation being necessary to preserve it. It is also used medicinally as an anthelmintic and has been successfully used in cases of tapeworm. A solution removes freckles and pistules and eruptions on the skin.

371. RUELLIA INDIGOTICA.—This small bush is extensively cultivated in China for the preparation of a blue coloring-matter of the nature of indigo. The pigment is prepared from the entire plant by a process similar to that employed in procuring the common indigo. It is sold in China in a pasty state. The water in which the plant is steeped is mixed with lime and rapidly agitated, when the coloring deposits at the bottom of the vessel.

372. SABAL ADANSONI.—This dwarf palm is a native of the Southern States. The leaves are made into fans, and the soft interior of the stem is edible.

373. SABAL UMBRACULIFERA.—This is a West Indian palm; the leaves are used for various purposes, such as making mats, huts, etc.

374. SACCHARUM OFFICINARUM.—The sugar cane. Where the sugar cane was first cultivated is unknown, but it is supposed to have been in the East Indies, for the Venetians imported it from thence by the Red Sea prior to the year 1148. It is supposed to have been introduced into the islands of Sicily, Crete,

Rhodes, and Cyprus by the Saracens, as abundance of sugar was made in these islands previous to the discovery of the West Indies in 1492 by the Spaniards, and the East Indies and Brazil by the Portuguese in 1497 and 1560. It was cultivated afterwards in Spain, in Valentia, Granada, and Murcia by the Moors. In the fifteenth century it was introduced into the Canary Islands by the Spaniards and to Madeira by the Portuguese, and thence to the West India Islands and to Brazil. The Dutch began to make sugar in the island of St. Thomas in the year 1610 and in Jamaica in 1644. Its culture has since become general in warm climates and its use universal.

375. SAGUERUS SACCHARIFER.—The arenga palm, which is of great value to the Malays. The black horsehair like fiber surrounding its leaf-stalks is made into cordage; a large amount of toddy or palm wine is obtained by cutting off the flower spikes, which, when inspissated, affords sugar, and when fermented a capital vinegar. Considerable quantities of inferior sago and several other products of minor importance are derived from this palm.

376. SAGUS RUMPHII.—This palm produces the sago of commerce, which is prepared from the soft inner portion of the trunk. It is obtained by cutting the trunk into small pieces, which are split and the soft substance scooped out and pounded in water till the starchy substance separates and settles. This is sago meal; but before being exported it is made into what is termed pearl sago. This is a Chinese process, principally carried on at Singapore. The meal is washed, strained, and spread out to dry; it is then broken up, pounded, and sifted until it is of a regular size. Small quantities being then placed in bags, these are shaken about until it becomes granulated or pearled.

377. SALVADORA PERSICA.—This is supposed to be the plant that produced the mustard seed spoken of in the Scriptures.

378. SANDORICUM INDICUM.—A tropical tree, sometimes called the Indian sandal tree, which produces a fruit like an apple, of agreeable acid flavor. The root of the tree has some medicinal value.

379. SANSEVIERA GUINEENSIS.—Called the African bowstring hemp, from the fibers of the leaves being used for bowstrings.

380. SANTALUM ALBUM.—This tree yields the true sandalwood of India. This fragrant wood is in two colors, procured from the same tree; the yellow-colored wood is from the heart and the white-colored from the exterior, the latter not so fragrant. The Chinese manufacture it into musical instruments, small cabinets, boxes, and similar articles, which are insect proof. From shavings of the wood an essential oil is distilled, which is used in perfumery.

381. SAPINDUS SAPONARIA.—The soapberry tree. The fruit of this plant is about the size of a large gooseberry, the outer covering or shell of which contains a saponaceous principle in sufficient abundance to produce a lather with water and is used as a substitute for soap. The seeds are hard, black, and round, and are used for making rosaries and necklaces, and at one time were covered for buttons. Oil is also extracted from the seeds and is known as soap oil.

382. SAPIUM INDICUM.—A widely distributed Asiatic tree which yields an acrid, milky juice, which, as also the leaves of the plant, furnishes a kind of dye. The fruit in its green state is acid, and is eaten as a condiment in Borneo.

383. SAPOTA ACHRAS.—The fruit of this plant is known in the West Indies as the sapodilla plum. It is highly esteemed by the inhabitants; the bark of the tree is astringent and febrifugal; the seeds are aperient and diuretic.

384. SAPOTA MULLERI.—The bully or balata tree of British Guiana, which furnishes a gum somewhat intermediate between India rubber and gutta-percha, being nearly as elastic as the first without the brittleness and friability of the latter, and requiring a high temperature to melt or soften it.

385. SCHINUS MOLLE.—The root of this plant is used medicinally and the resin that exudes from the tree is employed to astringe the gums. The leaves are so filled with resinous fluid that when they are immersed in water it is expelled with such violence as to have the appearance of spontaneous motion in consequence of the recoil. The fruits are of the size of pepper corns and are warm to the taste. The pulp surrounding the seeds is made into a kind of beverage by the Mexican Indians. The plant is sometimes called Mexican pepper.

386. SCHOTIA SPECIOSA—A small tree of South Africa called Boerboom at the Cape of Good Hope. The seeds or beans are cooked and eaten as food. The bark is used for tanning purposes and as an astringent in medicine.

387. SEAFORTHIA ELEGANS.—This palm is a native of the northern part of Australia, where it is utilized by the natives. The seeds have a granular fibrous rind, and are spotted and marked like a nutmeg.

388. SELAGINELLA LEPIDOPHYLLA.—This species of club moss is found in southern California, and has remarkable hygrometric qualities. Its natural growth is in circular roseate form, and fully expanded when the air is moist, but rolling up like a ball when it becomes dry. It remains green and acts in this peculiar manner for a long time after being gathered. Of late years numbers have been distributed throughout the country under the names of "Rose of Jericho" and "Resurrection Plant." This is, however, quite distinct from the true Rose of Jericho, *Anastatica hierochuntina*, a native of the Mediterranean region, from Syria to Algeria. This plant, when growing and in flower, has branches spread rigidly, but when the seed ripens the leaves wither, and the whole plant becomes dry, each little branch curling inward until the plant appears like a small ball; it soon becomes loosened from the soil, and is carried by the winds over the dry plains, and is often blown into the sea, where it at once expands. It retains this property of expanding when moistened for at least ten years.

389. SEMECARPUS ANACARDIUM.—The marking nut tree of India. The thick, fleshy receptacle bearing the fruit is of a yellow color when ripe, and is roasted and eaten. The unripe fruit is employed in making a kind of ink. The hard shell of the fruit is permeated by a corrosive juice, which is used on external bruises and for destroying warts. The juice, when mixed with quick-lime, is used to mark cotton or linen with an indelible mark. When dry it forms a dark varnish, and among other purposes it is employed, mixed with pitch and tar, in the calking of ships. The seeds, called Malacca beans, or marsh nuts, are eaten, and are said to stimulate the mental powers, and especially the memory; and finally they furnish an oil used in painting.

390. SERISSA FŒTIDA.—A cinchonaceous shrub, having strong astringent properties. The roots are employed in cases of diarrhea, also in ophthalmia and certain forms of ulcers. It is a native of Japan and China.

391. SHOREA ROBUSTA.—This tree produces the Saul wood of India, which has a very high reputation, and is extensively employed for all engineering purposes where great strength and toughness are requisite. It is stronger and much heavier than teak. An oil is obtained from the seeds, and a resin similar to Dammar resin is likewise obtained from the tree.

392. SIDA PULCHELLA.—A plant of the mallow family; the bark contains fibrous tissues available for the manufacture of cordage. The root of *S. acuta* is esteemed by the Hindoos as a medicine, and particularly as a remedy for snake bites. The light wood of these species is used to make rocket sticks.

393. SIMABA CEDRON.—A native of New Grenada, where it attains the size of a small tree, and bears a large fruit containing one seed; this seed, which looks like a blanched almond, is known in commerce as the cedron. As a remedy for snake bites it has been known from time immemorial in New Grenada. It is mentioned in the books of the seventeenth century. Recently it has obtained a reputation as a febrifuge, but its value as an antidote to the bites of snakes and scorpions is universally believed, and the inhabitants carry a seed with them in all their journeyings; if they happen to be bitten by any venomous reptile they scrape about two grains of the seed in brandy or water and apply it to the wound, at the same time taking a like dose internally. This neutralizes the most dangerous poisons.

394. SIMARUBA OFFICINALIS.—This tree yields the drug known as Simaruba bark, which is, strictly speaking, the rind of the root. It is a bitter tonic. It is known in the West Indies as the mountain damson.

395. SIPHONIA ELASTICA.—The South American rubber plant, from which a great portion of the caoutchouc of commerce is obtained. There are several species of siphonia which, equally with the above, furnish the India rubber exported from Para. The caoutchouc exists in the tree in the form of a thin, white milk, which exudes from incisions made in the trunk, and is poured over molds, which were formerly shaped like jars, bottles, or

shoes, hence often called bottle rubber. As it dries, the coatings of milky juice are repeated until the required thickness is obtained, and the clay mold removed. It belongs to the extensive family *Euphorbiaceæ*.

396. SMILAX MEDICA.—This plant yields *Mexican* sarsaparilla, so called to distinguish it from the many other kinds of this drug. The plant is a climber, similar to the smilax of our woods.

397. SPONDIAS MOMBIN.—This yields an eatable fruit called hog plum in the West Indies. The taste is said to be peculiar, and not very agreeable to strangers. It is chiefly used to fatten swine. The fruit is laxative, the leaves astringent, and the seeds possess poisonous qualities. The flower buds are used as a sweetmeat with sugar.

398. STRELITZIA REGINA.—A plant of the Musa or banana family. The flowers are very beautiful for the genus. It is a native of the Cape of Good Hope. The seeds are gathered and eaten by the Kaffirs.

399. STRYCHNOS NUX VOMICA.—This is a native of the Coromandel coast and Cochin-China. It bears an orange-like fruit, containing seeds that have an intensely bitter taste, owing to the presence of two most energetic poisons, *strychnine* and *brucine*. The pulp surrounding the seeds is said to be harmless, and greedily eaten by birds. The wood of the plant is hard and bitter, and possesses similar properties to the seeds, but in a less degree. It is used in India in intermittent fevers and in cases of snake bites. *S. tiente* is a Java shrub, the juice of which is used in poisoning arrows. *S. toxifera* yields a frightful poison called Ourari or Wourari, employed by the natives of Guiana. This is considered to be the most potent sedative in nature. Several species of *Strychnos* are considered infallible remedies for snake bites; hence are known as snakewood. *S. pseudo-quina*, a native of Brazil, yields Colpache bark, which is much used in that country in cases of fever, and is considered equal to quinine in value. It does not contain strychnine, and its fruits are edible. *S. potatorum* furnishes seeds known in India as clearing-nuts, on account of their use in clearing muddy water. St. Ignatius beans are supposed to be yielded by a species of Strychnos, from the quantity of strychnine contained in the seeds.

400. SWIETENIA MAHAGONI.—This South American plant furnishes the timber known in commerce as mahogany. The bark is considered a febrifuge, and the seeds prepared with oil were used by the ancient Aztecs as a cosmetic. The timber is well known, and much used in the manufacture of furniture.

401. TACCA PINNATIFIDA.—This is sometimes called South Sea arrowroot. The tubers contain a great amount of starch, which is obtained by rasping them and macerating four or five days in water, when the fecula separates in the same manner as sago. It is largely used as an article of diet throughout the tropics, and is a favorite ingredient for puddings and cakes.

402. TAMARINDUS INDICA.—The tamarind tree. There are two varieties of this species. The East Indian variety has long pods, with six to twelve seeds. The variety cultivated in the West Indies has shorter pods, containing one to four seeds. Tamarinds owe their grateful acidity to the presence of citric, tartaric, and other vegetable acids. The pulp mixed with salt is used for a liniment by the Creoles of the Mauritius. Every part of the plant has had medicinal virtues ascribed to it. Fish pickled with tamarinds are considered a great delicacy. It is said that the acid moisture exhaled by the leaves injures the cloth of tents that remain under them for any length of time. It is also considered unsafe to sleep under the trees.

403. TANGHINIA VENENIFERA.—This plant is a native of Madagascar, and of the family *Apocynaceæ*. Formerly, when the custom of trial by ordeal was more prevalent than now, the seeds of this plant were in great repute, and unlimited confidence was placed in the poisonous seeds as a detector of guilt. The seeds were pounded, and a small piece swallowed by each person to be tried; those in whom it caused vomiting were allowed to escape, but when it was retained in the stomach, it would quickly prove fatal, and their guilt was thus held to be proven.

404. TASMANNIA AROMATICA.—The bark of this plant possesses aromatic qualities, closely resembling Winter's bark. The small black fruits are used as a substitute for pepper.

405. TECTONA GRANDIS.—The teak tree. Teak wood has been extensively employed for shipbuilding in the construction of merchant vessels and ships of war; its great strength and durability, the facility with which it can be worked, and its freedom from injury by fungi, rendering it peculiarly suitable for these purposes. It is a native of the East India Islands, and belongs to the order *Verbenaceæ*.

406. TERMINALIA CATAPPA.—The astringent fruits of this tropical plant are employed for tanning and dyeing, and are sometimes met with in commerce under the name of myrobalans, and used by calico printers for the production of a permanent black. The seeds are like almonds in shape and whiteness, but, although palatable, have a peculiar flavor.

407. TETRANTHERA LAURIFOLIA.—This plant is widely dispersed over tropical Asia and the islands of the Eastern Archipelago. Its leaves and young branches abound in a viscid juice, and in Cochin-China the natives bruise and macerate them until this becomes glutinous, when it is used for mixing with plaster, to thicken and render it more adhesive and durable. Its fruits yield a solid fat, used for making candles, although it has a most disagreeable odor.

408. THEA VIRIDIS.—This is the China tea plant, whose native country is undetermined. All kinds and grades of the teas of commerce are made from this species, although probably it has some varieties. Black and green teas are the result of different modes of preparation; very much of the green, however, is artificially colored to suit the foreign trade. The finest teas do not reach this country; they will not bear a sea voyage, and are used only by the wealthy classes in China and Russia. The active principles of the leaves are theine and a volatile oil, to which latter the flavor and odor are due. So far as climate is concerned for the existence of the tea plant in the United States, it will stand in the open air without injury from Virginia southwards. A zero frost will not kill it. But with regard to its production as a profitable crop, the rainfall in no portion of the States is sufficient to warrant any attempt to cultivate the plant for commercial purposes. But this does not prevent its culture as a domestic article, and many hundreds of families thus prepare all the tea they require, from plants it may be from the pleasure ground or lawn, where the plant forms one of the best ornaments.

409. THEOBROMA CACAO.—This plant produces the well-known cacao, or chocolate, and is very extensively cultivated in South America and the West India Islands. The fruit, which is about 8 to 10 inches in length by 3 to 5 in breadth, contains between fifty and a hundred seeds, and from these the cacao is prepared. As an article of food it contains a large amount of nutritive matter, about 50 per cent being fat. It contains a peculiar principle, which is called *theobromine*.

410. THEOPHRASTA JUSSIÆI.—A native of St. Domingo, where it is sometimes called Le petit Coca. The fruit is succulent, and bread is made from the seeds.

411. THESPESIA POPULNEA.—A tropical tree, belonging to the mallow family. The inner bark of the young branches yields a tough fiber, fit for cordage, and used in Demerara for making coffee bags, and the finer pieces of it for cigar envelopes. The wood is considered almost indestructible under water, and its hardness and durability render it valuable for various purposes. The flower buds and unripe fruits yield a viscid yellow juice, useful as a dye, and a thick, deep, red-colored oil is expressed from the seeds.

412. THEVETIA NERIIFOLIA.—This shrubby plant is common in the West Indies and in many parts of Central America. Its bark abounds in a poisonous milky juice, and is said to possess powerful properties. A clear, bright, yellow-colored oil, called Exile oil, is obtained, by expression, from the seeds.

413. THRINAX ARGENTEA.—This beautiful palm is called the Silver Thatch palm of Jamaica, and is said to yield the leaves so extensively used in the manufacture of hats, baskets, and other articles. It is also a native of Panama, where it is called the broom palm, its leaves being there made into brooms.

414. TILLANDSIA ZEBRINA.—A South American plant of the pineapple family; the bottle-like cavity at the base of the leaves will sometimes contain a pint or more of water, and has frequently furnished a grateful drink to thirsty travelers.

415. Tinospora cordifolia.—A climbing plant, so tenacious of life that when the stem is cut across or broken, a rootlet is speedily sent down from above, which continues to grow until it reaches the ground. A bitter principle, *calumbine*, pervades the plant. An extract called galuncha is prepared from it, considered to be a specific for the bites of posionous insects and for ulcers. The young shoots are used as emetics.

416. Triphasia trifoliata.—A Chinese shrub, with fruit about the size of hazelnuts, red-skinned, and of an agreeable sweet taste; when green, they have a strong flavor of turpentine, and the pulp is very sticky. They are also preserved whole in sirup, and are sometimes called limeberries.

417. Tristania nerifolia.—A myrtaceous plant from Australia, called the turpentine tree, owing to its furnishing a fluid resembling that product.

418. Urceola elastica.—A plant belonging to the *Apocynaceæ*, a native of the islands of Borneo and Sumatra, where its milky juice, collected by making incisions in its soft, thick, rugged bark, or by cutting the trunk into junks, forms one of the kinds of caoutchouc called juitawan, but it is inferior to the South American, chiefly owing to want of care in its preparation, the milky juice being simply coagulated by mixing with salt water, instead of being gradually inspissated in layers on a mold. The fruit contains a pulp which is much eaten by the natives.

419. Urena lobata.—A malvaceous plant, possessing mucilaginous properties, for which it is used medicinally. The bark affords an abundance of fiber, resembling jute rather than flax or hemp.

420. Uvaria odoratissima.—An Indian plant which is supposed to yield the essential oil called Ylang-Ylang, or Alan-gilan. This oil is obtained by distillation from the flowers, and is highly esteemed by perfumers, having an exquisite odor partaking of the jasmine and lilac.

421. Vangueria edulis.—A cinchonaceous plant, the fruits of which are eaten in Madagascar under the name of Voa-vanga. The leaves are used in medicine.

422. Vanilla planifolia.—The vanilla plant, which belongs to the orchid family. The fruit is used by confectioners and others for flavoring creams, liquors, and chocolates. There are several species, but this gives the finest fruit. It is a climbing orchid, and is allowed to climb on trees when cultivated for its fruit. In Mexico, from whence is procured a large portion of the fruit, it is cultivated in certain favorable localities near the Gulf coast, where the climate is warm. Much of the value of the bean depends upon the process of its preparation for the market. In Mexico, where much care is given to this process, the pods are gathered before they are fully ripe and placed in a heap, under protection from the weather, until they begin to shrivel, when they are submitted to a sweating process by wrapping them in blankets inclosed in tight boxes; afterwards they are exposed to the sun. They are then tied into bundles or small bales, which are first wrapped in woolen blankets, then in a coating of banana leaves first sprinkled with water, then placed in an oven heated up to about 140° F. Here they remain for twenty-four to forty-eight hours, according to the size of the pods, the largest requiring the longest time. After this heating they are exposed to the sun daily for fifty or sixty days, until they are thoroughly dried and ready for the market.

423. Vateria indica.—This plant yields a useful gum resin, called Indian copal, piney varnish, white dammar, or gumanine. The resin is procured by cutting a notch in the tree, so that the juice may flow out and become hardened. It is used as a varnish for pictures, carriages, etc. On the Malabar coast it is manufactured into candles, which burn with a clear light and an agreeable fragrance. The Portuguese employ this resin instead of incense. Ornaments are fashioned from it under the name of amber. It is also employed in medicine.

424. Weinmannia racemosa.—A New Zealand tree called Towhia by the natives of that country. Its bark is used for tanning purposes, and as a red and brown dye, which give fast colors upon cotton fabrics.

425. Wrightia tinctoria.—The leaves of this plant furnish an inferior kind of indigo. The wood is beautifully white, close-grained, and ivory-like, and is much used for making Indian toys.

426. Xanthorrhœa arborea.—The grass gum tree of Australia, also called black boy. This is a liliaceous plant, which produces a long flower-stalk, bearing at the top an immense cylindrical flower-spike, and when the short

black stem is denuded of leaves, the plants look very like black men holding spears. The leaves afford good fodder for cattle, and the tender white center is used as a vegetable. A fragrant resin, called acaroid resin, is obtained from it.

427. XIMENIA AMERICANA.—A small tree, found in many warm regions; among others in southern Florida. In Brazil it is called the Native Plum on account of its small yellow fruits, which have a subacid and somewhat astringent aromatic taste. The wood is odoriferous and is used in the West Indies as a substitute for sandalwood.

428. YUCCA ALŒFOLIA.—The yucca leaves afford a good fiber, and some southern species are known as *bear's grass*. The root stems also furnish a starchy matter, which has been rendered useful in the manufacture of starch.

429. ZAMIA FURFURACEA.—This plant belongs to the order *Cycadeaceæ*, and is grown to some extent for the starchy matter contained in the stem, which is collected and used as arrowroot; but it is not the true arrowroot, that being produced by a species of *Maranta*.

430. ZAMIA INTEGRIFOLIA.—The coontie plant of Florida. The large succulent roots afford a quantity of arrowroot, said to be equal to the best of that from Bermuda. The fruit has a coating of an orange-colored pulp, which is said to form a rich edible food. It was from the roots of this plant that the Seminoles of Florida obtained their *white meal*.

431. ZINGIBER OFFICINALE.—This plant is cultivated in most warm countries for the sake of its rhizomes, which furnish the spice called ginger. It is prepared by digging up the roots when a year old, scraping them, and drying them in the sun. Ginger, when broken across, shows a number of little fibers embedded in floury tissue. Its hot pungent taste is due to a volatile oil. It also contains starch and yellow coloring matter. Ginger is used for various medicinal purposes, and in many ways as a condiment, and in the preparation of cordials and so-called teas.

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ERRATA.

Page 134, line 9, for might prove beneficial, read might not prove very objectionable.

Page 379, line 20, for *Brumus unioloides*, read *Bromus unioloides*.

Page 379, line 39, for *Paspalum dilitatum*, read *Paspalum dilatatum*.

Page 389, line 6, for *Linaria canadensis*, read *Linaria vulgaris*.