U. S. DEPARTMENT OF AGRICULTURE.

# REPORT

OF

# THE CHEMIST

FOR

# 1903.

BY

H. W. WILEY.

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[From Annual Reports, Department of Agriculture.]




WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1903.

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## REPORT OF THE CHEMIST.

U. S. Department of Agriculture,
Bureau of Chemistry,
*Washington, D. C., September 8, 1903.*

Sir: I have the honor to submit herewith my report of the operations of the Bureau of Chemistry for the fiscal year ended June 30, 1903, together with an outline of the proposed work for the fiscal year ending June 30, 1904, and an estimate of the probable expenses of the Bureau for the fiscal year ending June 30, 1905.

Respectfully,

H. W. Wiley, *Chemist.*

Hon. James Wilson, *Secretary.*

### WORK OF THE YEAR, WITH RECOMMENDATIONS.

The year just ended has been the most active of any in the history of this office.

#### NEW INVESTIGATIONS.

##### TABLE SIRUP FROM ORDINARY SUGAR-PRODUCING PLANTS.

Two important additions were made to the investigations of the Bureau during the year. One of these was the investigation of the methods of making a better table sirup from the ordinary sugar-producing plants, such as the maple tree, sorghum, and sugar cane. Investigations carried on some years ago by the Division of Chemistry showed that table sirups were generally adulterated; in other words, they were not produced exclusively by the clarification and concentration of sugar-bearing juices. Testimony taken before the committees of the House and Senate charged with investigating food adulteration elicited the fact that it was a common practice to manufacture maple sirup of ingredients corresponding to the price which the purchaser wished to pay. If he were willing to pay the high price of $1 or $1.25 per gallon, he would be provided with the pure article. If he could pay only 30 cents a gallon, he would get a maple sirup which contained practically none of the pure maple product. Glucose—that is, the water-white, thick, sirupy liquid made from the partial conversion of starch into sugar and the purification and concentration of the product—is a very common material used as a basis for table sirups. The result of all this sophistication and adulteration has been to depress the price of the genuine articles to a point which renders their profitable manufacture problematical.

The object of our investigations was to determine the methods in vogue in the manufacture of table sirups and to ascertain, by analysis

or experiment, methods whereby the product could be made better, of a more pleasing appearance, with less tendency to crystallization, and have a greater resistance to fermentative processes. The experiments were conducted chiefly with sugar cane in Georgia, Alabama, Mississippi, and Florida. A considerable amount of experimental work was, however, done with sorghum in Minnesota and Kansas.

The agricultural work connected with the investigations consisted in studying the methods of fertilizing and cultivating sugar cane in order to secure the highest financial returns. These experiments were conducted in different localities, mostly in those mentioned above, and particularly at Cairo, Ga. With the collaboration of Mr. W. B. Roddenbery, of that place, an elaborate series of experiments was conducted which will prove of the utmost benefit in practice. A full detailed account of these experiments is found in Bulletin No. 75 of the Bureau of Chemistry.

The manufacturing data connected with the investigation have not yet been tabulated, but will be soon published in a separate bulletin. This bulletin will contain a statement relating to the ordinary methods of manufacturing and will deal particularly with the experimental work conducted through the courtesy of Mr. J. T. Wells at his factory at Guyton, Ga. A further reference to this subject will be found in the part of this report dealing with the activity of the sugar laboratory.

### EFFECT OF PRESERVATIVES AND COLORING MATTER UPON HEALTH.

The other important addition to the work of the Bureau was the beginning of the experimental study of the effect of preservatives and coloring matters upon digestion and health. This work was especially authorized by Congress for the purpose of reaching, if possible, definite conclusions on many disputed points. Experts of high character have in great numbers declared for the wholesomeness, or at least innocuousness, of many common preservatives. On the other hand, experts equally as renowned and working apparently with as great care have reached conclusions of an opposite character. Since the law authorizes the Secretary of the Treasury to exclude from the ports of the United States food products to which any injurious substance has been added, it is highly important, in order to properly execute the law, that these differences of opinion be investigated and a wise and just conclusion reached. It was to this end, as well as for the general benefit of the public, and for the information of manufacturers, that the elaborate experiments to determine these matters were inaugurated. The organization of the experimental work is here given.

In arranging for the experiments, in carrying them out, and in discussing the data, an earnest effort was made to put aside every theory or personal impression or prejudice connected with the subject. The object in view has been solely to ascertain the facts, to establish them if possible beyond cavil, to collate them in what seems a scientific and reasonable manner, and at the end to draw such conclusions as judgment, uninfluenced by prejudice, would approve. Some of the above purposes, it is hoped, will be fully accomplished, because we propose to set forth in detail the manner in which the experiments were conducted, to record all the facts observed just as they occurred, to tabulate the work in the most scientific manner possible, and thus present to competent experts a basis for conclusions. When all this is done

it is evident that different conclusions may be derived from the premises by different persons. Whatever our conclusions may be, therefore, we do not claim for them any special virtue, but we do hope so to establish the facts on which they are based that the necessity for a repetition of the work may be relegated to the remote future. The enormous amount of work connected with such experiments and the great expense which necessarily attends them render it extremely advisable that the work should be thoroughly done, with every possible regard for accuracy, with elimination as far as possible of all sources of disturbance and error and with the establishment on as firm a basis as possible of the recorded observations.

An outline of the method of making the experiments will be useful in explaining the detail of the work.

In the first place, it is evident that no mere theorizing on the chemical and physical properties of preservatives and coloring matters can be of much value in work of this kind. It is further evident that pharmacological experiments made upon other animals than men, valuable as they are, will not lead to absolutely definite results. It is well known that the digestive organs of other animals are different from those of man, that the processes of assimilation vary, and that what might be innocuous to such an animal might in other circumstances prove harmful to man, and vice versa. It was therefore concluded that the experiments, to be of full value, should be made upon the human animal. Fortunately, the Department of Agriculture is richly provided with subjects for experiments if only their consent thereto can be obtained.

First of all, therefore, a statement was made of the object of the experiments, and this was submitted to a number of young men connected with the Department, who were, for the most part, college graduates or students engaged in scientific pursuits, but employed at a low rate of compensation. The only inducement offered to these young men to engage their attention and consent, in addition to the contributions to the progress of science which they would make, was that of free board during the period of the experiment. This, indeed, must be considered as a very small reward for the restrictions under which they were compelled to live for so long a period. Nevertheless, large numbers of volunteers presented themselves, far in excess of the actual demand. Each applicant was requested to fill out the blank which follows:

*Descriptive blank to be filled out by applicant for hygienic table.*

1. Name and address: ———.
2. Date of birth: ———.
3. Have you had any sickness confining you to your room within a year? ———. If so, state nature and duration: ———.
4. Are you subject to indigestion? ———. If so, state character and frequency: ———.
5. Do you use coffee, tea, or chocolate with your meals? ———. If so, state at which meals and what beverage you prefer: ———.
6. Do you use tobacco? ———. If so, state in what form, at what times, and quantity: ———.
7. Do you use wine, beer, or other alcoholic beverages? ———.
8. Do you go to stool regularly? ———. At what hours? ———.
9. At what hours do you usually urinate? ———.
10. At what hour do you go to bed? ———. How many hours do you usually sleep? ———.
11. Do you engage in any unusual or violent exercise? ———. If so, what? ———.

The object of the above blank was to get an idea of the personal habits of the applicant, and especially to ascertain if he had been lately subject to any serious disease, or if he had any hereditary tendency to disease. It was also desirable to know whether the applicant was addicted to the use of tobacco or of alcoholic drinks, and if so, to what extent. I had hoped to be able to secure a sufficient number of applicants who used neither tobacco nor alcohol to make up the corps of cadets, but in this I was unsuccessful. Only a very small percentage of the applicants used neither tobacco nor alcohol. Since many scientific men recognize in alcohol a positive food value, and it was desirable to eliminate this beverage from the hygienic table, I finally decided to reject the application of all those who used, even to a moderate degree, alcoholic beverages. I then decided to accept, in so far as it was necessary to make out the number, the applications of those who used tobacco moderately.

It was decided at the beginning that the number at the experimental table should be 12, divided into two classes of 6 each. It was evidently impracticable for a young man to continue for seven or eight months in so strenuous a life at so small a compensation. The object of having two classes was that one should be resting while the other was undergoing experimental treatment, thus dividing the time as nearly as possible equally between the two. The number under experiment was subsequently increased to 14 for some special purposes. The members of the table having been selected, each one was required to subscribe to the following pledge:

I hereby agree, on my honor, to follow implicitly the rules and regulations governing the hygienic table of the Bureau of Chemistry during the time that I am a member thereof. I agree, during my attendance at the table of observation, to use no other food or drink than that which is provided for me, with the exception of water, and that any water not used at the table will be measured and reported daily as a part of the ration. I further agree that I will continue to be a member of the hygienic table for a period of at least six months, from December 1, 1902, unless prevented by some illness, accident, or unavoidable absence. I agree to continue the regular habits of my life, to indulge in no unusual excess of labor or exercise, and if tobacco be used it shall be used at such times and in such amounts as will be agreed upon between myself and the chief of the Bureau of Chemistry.

I further agree that I will not hold the Department of Agriculture, nor any person connected therewith, responsible for any illness or accident that may occur during my connection with the hygienic table.

It is evident that in experiments on the human animal it is necessary to rely to a certain extent upon the honor of the person under observation. I have every reason to believe that the members of the hygienic table kept their pledges faithfully. They were young men of high standing, fine character, with no bad habits, and they all took a lively personal interest in the work to which they were devoting themselves. They were required, as is seen by the pledge, to pursue their daily vocations in the usual way. In the case of those who used tobacco a statement of the quantities used, the character of the tobacco employed, and the times at which it was taken, was made, and they agreed to continue the use in exactly the same way during the entire period.

At the completion of an experimental period, in retiring from the experimental table and passing to the recreation table, the candidate was required to subscribe to the following certificate:

I hereby certify on my honor that during the period beginning ——— and ending ——— I have not partaken of any food or drink (except water reported) other than

that furnished at the hygienic table of the Bureau of Chemistry, and that I have accurately recorded all the items of food and drink received at the table.

I further certify that I have not engaged in any excessive or unusual physical exercise; that I have followed, in so far as possible, the regular tenor of my daily life in respect of work, exercise, and sleep; that I have observed to the best of my ability and recorded accurately the data relating to weight, temperature, and pulse; and that I have observed faithfully all the regulations connected with the experimental work at the hygienic table.

By thus placing the young men on their honor, by interesting them in their work, and by giving them periods of rest, during which they were at liberty to eat moderately at other tables than those set in the Bureau of Chemistry, I secured practically the results which would have been obtained by an absolute control of animals experimented upon both during the periods of eating and the intervening periods.

It may be asked: Why were so many persons selected? To this I reply that the idiosyncrasy of the human animal is very marked. Experiments made upon a single, or even two individuals, are apt to be very misleading by reason of this idiosyncrasy. I would gladly have extended the experiment to include 20, 30, or even 50 persons if it had been possible to do the analytical work necessitated by such a large number. One of the chief differences between the series of experiments under consideration and those previously made has been in this particular. A much greater number of subjects and longer period of time were involved than in any of the similar experiments that have heretofore been conducted. We have thus to this extent eliminated more completely the errors due to imperfect observation, imperfect control, and idiosyncrasy.

The installation of the kitchen was in one of the rooms of the basement of the Bureau of Chemistry which up to this time had been used as a storeroom. The cooking was done on two gas stoves and under the supervision of a cook certified by the Civil Service Commission.

The dining room was one of the rooms set apart for the road-material laboratory, which, however, could be used for the dining room without interfering materially with the work carried on in that room, as this was done chiefly at desks around the sides.

The food of each member of the table under observation was weighed or measured, the liquids, such as coffee, milk, tea, and water, being measured and calculated to weight from the density of the solution, the solid foods being weighed upon a torsion balance sensitive to half a gram.

A sample of the food furnished at each meal was taken for analysis, immediately placed in a bottle, stoppered and sealed with paraffin, so that no moisture could escape in the necessary interval of time before weighing and subsampling of the sample could be accomplished. Foods which could be used in bulk, such as prepared cereals, etc., were sampled only for each lot, thus reducing to some extent the labor of analytical work which was conducted in the food laboratory.

Not only did the analytical work include samples of all the foods used for each meal, but also samples of the urine and feces, which were carefully collected and weighed for each of the members of the table and subjected to analysis. In short, an account was opened with each member of the table exactly similiar in character to a bank account. Each member was charged with all that was given him in food and credited with all that was returned in the excretions. The balance represented the food consumed in the production of heat and

energy within the system, provided the bodily weight remained constant. Thus an exact and accurate control was kept of each individual which would have made it impossible for him to have violated the rules by taking nourishment in addition to that given him, because all such additional nourishment would have at once been detected by a disturbance of the balance sheet. Each member of the observation table was weighed carefully on a delicate balance each day before dinner, since the determination of the weight of the body and its variations under the experiment are two of the most important of the data to be obtained. Each member of the table was furnished with blanks with which to keep an account of the foods received, the meals at which they were eaten, to enter a record of his weight, of the temperature before and after eating, of the pulse, and all other data connected with the income and outgo of the food. One of these blanks was filled up for each meal and the daly blank filed. From these blanks a statement of the foods consuimed was made for each period of observation.

In the beginning of each experimental period there was first determined how much of the food would be necessary to secure as nearly as possible an even weight of the body. This part of the experiment was called the "fore period," and lasted for about ten days. At the end of this time the daily ration for each member of the table had been determined, and this was established as the standard of the ration which he should have during the remaining portion of the experimental period.

The "middle period" represented that portion of the time during which each member of the table ate the rations previously determined, together with the added preservatives, borax or boric acid. This period extended generally from ten to fifteen days.

This was followed by the "after period," during which the same ration as first determined continued, but the preservative was withdrawn, the object being to restore the body to its normal condition in case it had been disturbed by the use of the preservatives. The after period, as a rule, was ten days in length. Thus, the whole period under observation varied in each class from thirty to forty days.

The period of observation extended from December 1 to June 30, inclusive, and the only preservatives used were borax and boric acid. It is believed that the data obtained, although not yet fully tabulated, will go far to settle many disputed points and to establish on a firm scientific basis the principles which should guide the makers of legislation relating to the use of borax and boric acid. At the same time the other important purpose which was kept in view, viz, the guidance of the officials connected with the enforcement of the pure-food law, will have been attained as regards these two substances at least.

On account of the importance of the hygienic work in connection with the experiments in determining the effect of preservatives, coloring matters, and other added substances, upon health and digestion, it will be of interest to give the tables showing the amount of the principal items of food consumed during the period of experiments lasting from December 1, 1902, to June 30, 1903. The average number of persons fed, including the members of the table, cook, waiter, and other attendants, was 17. The amount of each particular food used, showing the amount purchased, the waste in cooking and other waste, and the net amount consumed as food, is found in the tables on the next page.

*Details of food used in experiments.*

ROAST BEEF.

| Date. | Meal. | Amount purchased. | Weight before cooking. | Weight after cooking. | Loss in cooking. | Other loss and waste. | Net weight. |
|---|---|---|---|---|---|---|---|
| 1903. | | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* |
| March 30 | Dinner | 9 | 7 | 5½ | 1½ | 1¼ | 4¼ |
| April 6 | do | 9½ | 9½ | 7½ | 1½ | 1⅞ | 5⅝ |
| April 8 | do | 8 | 6¾ | 5⅞ | ⅞ | 1¾ | 4⅛ |
| April 13 | do | 9 | 8½ | 7 | 1½ | 2 | 5 |
| April 15 | do | 9 | 8½ | 5¾ | 2½ | 1½ | 4¼ |
| April 20 | do | 9 | 8 | 6¾ | 1¼ | 1¼ | 5½ |
| May 4 | do | 7½ | 6½ | 4¾ | 1¾ | 2½ | 2¼ |
| May 6 | do | 7 | 6 | 5 | 1 | 2 | 3 |
| May 11 | do | 8 | 7½ | 5¾ | 1¾ | 1¾ | 4 |
| May 13 | do | 7½ | 6¾ | 4¾ | 2 | 2 | 2¾ |
| May 15 | do | 7½ | 7 | 5½ | 1½ | 2½ | 3 |
| May 18 | do | 7 | 6 | 5¼ | ¾ | 3¼ | 2 |
| May 20 | do | 7¾ | 7 | 6¼ | ¾ | 3½ | 2¾ |
| May 22 | do | 7¾ | 6½ | 5¾ | ¾ | 3½ | 2¼ |
| May 25 | do | 8 | 6½ | 5¾ | ¾ | 3 | 2¾ |
| May 29 | do | 6¾ | 5½ | 4½ | 1 | 2¼ | 2¼ |
| June 1 | do | 8 | 7 | 5¾ | 1¼ | 2¼ | 3½ |
| June 3 | do | 7 | 6 | 5 | 1 | 3½ | 1½ |
| June 5 | do | 7¼ | 6 | 4¾ | 1¼ | 2½ | 2¼ |
| June 8 | do | 7 | 6 | 5¼ | ¾ | 3 | 2¼ |
| June 10 | do | 7 | 5½ | 4½ | 1 | 2½ | 2 |
| June 12 | do | 7¼ | 6 | 4¾ | 1¼ | 3 | 1¾ |
| June 15 | do | 7¾ | 6½ | 5¼ | 1¼ | 3 | 2¼ |
| June 17 | do | 7¾ | 6½ | 5¼ | 1¼ | 2¾ | 2½ |
| June 19 | do | 7 | 6 | 5 | 1 | 2½ | 2½ |
| June 22 | do | 7 | 6 | 4¾ | 1¼ | 2 | 2¾ |
| June 26 | do | 7 | 5¾ | 4¾ | 1 | 2 | 2¾ |
| June 29 | do | 7½ | 6½ | 5½ | 1 | 2¾ | 2¾ |
| Total | | 215¾ | 186½ | 152⅛ | 34⅜ | 67⅝ | 84½ |
| Average | | 7.7 | 6.66 | 5.43 | 1.23 | 2.41 | 3.02 |

Loss in cooking, 18.43 per cent.

ROAST LAMB.

| 1903. | | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* |
|---|---|---|---|---|---|---|---|
| May 2 | Dinner | 6½ | 5¾ | 4½ | 1¼ | 2 | 2½ |
| May 5 | do | 6¼ | 5¾ | 4 | 1¾ | 2 | 2 |
| May 9 | do | 6½ | 6¼ | 4¼ | 2 | 1½ | 2¾ |
| May 12 | do | 6½ | 6¼ | 5¼ | 1 | 2 | 3¼ |
| May 16 | do | 6½ | 6½ | 3¾ | 2½ | 2 | 1¾ |
| May 19 | do | 6¾ | 5¼ | 4¼ | 1 | 2 | 2¼ |
| May 23 | do | 6½ | 6¼ | 4¾ | 1½ | 1¾ | 3 |
| May 26 | do | 7 | 6¼ | 4 | 2¼ | 1¼ | 2¾ |
| May 30 | do | 6½ | 5¾ | 4½ | 1¼ | 2 | 2½ |
| June 2 | do | 5¾ | 5½ | 3½ | 2¼ | 1¼ | 2 |
| June 6 | do | 6½ | 6 | 3¾ | 2¼ | 1½ | 2¼ |
| June 9 | do | 6 | 5½ | 3¾ | 1¾ | 2 | 1¾ |
| June 13 | do | 6¾ | 5½ | 3¾ | 1¾ | 2 | 1¾ |
| June 16 | do | 6 | 5¼ | 4¼ | 1 | 1½ | 2¾ |
| June 20 | do | 7 | 6½ | 4½ | 2 | 1¾ | 2¾ |
| June 23 | do | 7 | 6¼ | 5⅛ | 1⅛ | 1¼ | 3⅞ |
| June 27 | do | 6½ | 6 | 3½ | 2½ | 1¾ | 1¾ |
| Total | | 110½ | 100¼ | 71⅛ | 29⅛ | 29½ | 41⅝ |
| Average | | 6.5 | 5.9 | 4.18 | 1.72 | 1.73 | 2.45 |

*Details of food used in experiments*—Continued.

BEEFSTEAK.

| Date. | Meal. | Amount purchased. | Bone and other loss. | Weight before cooking. | Weight after cooking. | Loss in cooking. | Net weight. |
|---|---|---|---|---|---|---|---|
| 1903. | | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* |
| April 2 | Breakfast | 3½ | ¾ | 2¾ | 1½ | 1¼ | 1½ |
| April 3 | do | 4 | ½ | 3½ | 2 | 1½ | 2 |
| April 6 | do | 3¼ | ¾ | 2½ | 1½ | 1 | 1½ |
| April 10 | do | 3¾ | 1 | 2¾ | 1½ | 1¼ | 1½ |
| April 16 | do | 3½ | ¾ | 2¾ | 1¾ | 1 | 1¾ |
| April 17 | do | 4 | ½ | 3½ | 2½ | 1 | 2½ |
| May 2 | do | 5½ | 2¾ | 2¾ | 1⅞ | ⅞ | 1⅞ |
| May 9 | do | 4⅞ | 2⅜ | 2½ | 1¾ | ¾ | 1¾ |
| May 12 | do | 4½ | 2 | 2½ | 1½ | 1 | 1½ |
| May 14 | do | 5¼ | ½ | 4¾ | 2½ | 2¼ | 2½ |
| May 16 | do | 4⅞ | 2⅛ | 2¾ | 1¾ | 1 | 1¾ |
| May 18 | do | 5¾ | 2 | 3¾ | 2½ | 1¼ | 2½ |
| May 20 | do | 5¼ | 2¾ | 2½ | 1¾ | ¾ | 1¾ |
| May 23 | do | 5 | 2 | 3 | 1½ | 1½ | 1½ |
| May 25 | do | 5 | 2½ | 2½ | 1½ | 1 | 1½ |
| May 30 | do | 5½ | 1¼ | 4¼ | 2¼ | 2 | 2¼ |
| June 1 | do | 2¾ | 1¾ | 3 | 1½ | 1½ | 1½ |
| June 3 | do | 6 | 3½ | 2½ | 1½ | 1 | 1½ |
| June 4 | do | 5 | 2½ | 2½ | 1½ | 1 | 1½ |
| June 8 | do | 4½ | 2 | 2½ | 1¾ | ¾ | 1¾ |
| June 10 | do | 4¾ | 2 | 2¾ | 1¼ | 1½ | 1¼ |
| June 15 | do | 4 | 2⅛ | 1⅞ | 1 | ⅞ | 1 |
| June 17 | do | 4 | 2⅛ | 1⅞ | 1¼ | ⅝ | 1¼ |
| June 18 | do | 3¾ | 2 | 1¾ | 1 | ¾ | 1 |
| June 20 | do | 3⅜ | 1½ | 1⅞ | 1¼ | ⅜ | 1¼ |
| June 24 | do | 3¼ | 1½ | 1¾ | 1⅛ | ⅛ | 1⅛ |
| June 27 | do | 4 | 2 | 2 | 1¼ | ¼ | 1¼ |
| Total | | 120⅝ | 47½ | 73⅛ | 44 | 29⅛ | 44 |
| Average | | 4.47 | 1.75 | 2.72 | 1.63 | 1.09 | 1.63 |

CHICKEN.

| Date. | Meal. | Weight before cooking. | Weight after cooking. | Loss in cooking. | Bone and other loss. | Net Weight. |
|---|---|---|---|---|---|---|
| 1903. | | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* | *Pounds.* |
| April 5 | Dinner | 3½ | 2½ | 1 | 1 | 1½ |
| April 9 | do | 3½ | 2½ | 1 | 1½ | 1⅜ |
| May 7 | do | 6 | 4½ | 1½ | 2½ | 2½ |
| May 10 | do | 5½ | 4 | 1½ | 2½ | 2½ |
| May 14 | do | 6 | 5 | 1 | 2½ | 2⅜ |
| May 21 | do | 7 | 4¾ | 2¼ | 2½ | 2½ |
| May 24 | do | 6½ | 5 | 1½ | 2½ | 2½ |
| May 31 | do | 5 | 3½ | 1½ | 2 | 1½ |
| June 4 | do | 5½ | 3 | 2½ | 1½ | 1½ |
| June 7 | do | 5 | 3 | 2 | 1½ | 1½ |
| June 11 | do | 4½ | 3½ | 1½ | 2 | 1½ |
| June 14 | do | 5 | 3¾ | 1¼ | 2⅜ | 1⅜ |
| June 18 | do | 4⅛ | 3⅛ | 1⅛ | 1⅜ | 1¼ |
| June 21 | do | 4½ | 3¾ | ¾ | 2 | 1¾ |
| June 25 | do | 5¾ | 4¼ | 1½ | 2 | 2 |
| Total | | 77½ | 55⅜ | 22⅛ | 29¾ | 26⅜ |
| Average | | 5.2 | 3.7 | 1.5 | 1.98 | 1.8 |

## COLLABORATION WITH EXECUTIVE DEPARTMENTS.

An important part of the work during the past year, which has not been committed to any single laboratory, was the collaboration authorized by Congress between the Bureau of Chemistry and other Departments of the Government whose respective heads apply to the Secretary of Agriculture for chemical work. This collaboration during the year has extended to almost every branch of the service. The most extensive work has been conducted in connection with the Treasury Department.

WORK FOR THE TREASURY DEPARTMENT.

SUGAR TESTS.—The chief of the Bureau of Chemistry continues to exercise the functions devolved upon him by the joint action of the Secretary of the Treasury and the Secretary of Agriculture in making him supervisor of sugar tests at the appraisers' laboratories in Philadelphia, New York, and Boston. Exchange samples from these laboratories are received each day at the Bureau of Chemistry and subjected to a very careful analysis, far more care being exercised, naturally, than can possibly be used in the routine work in the appraisers' laboratories. These exchange samples are sent to each of the ports, and thus a daily check is secured upon the polarizations at the several ports of entry. At the end of each month these data are tabulated, in order that a monthly comparison may be made between the results obtained at the several ports and in the Bureau of Chemistry. Whenever any variation of a marked character arises in the polarizations an immediate investigation is made, and, if possible, the cause of variation ascertained and removed. This collaborative work, which has now extended over three years, has been productive of the most useful results. The wide differences in polarizations which formerly existed at the several ports have been practically eliminated and a surprising approximation in monthly averages has been secured.

ALCOHOL.—A most interesting investigation in connection with the Treasury Department was undertaken to determine the percentage of ethyl alcohol in certain fusel oils imported into this country. Ethyl (ordinary) alcohol pays a much higher rate of duty than the other alcohols of commerce, and is the only one of them which is at all suitable for use as a beverage. The other alcohols are extremely poisonous, and some of them, such as methyl alcohol which exerts a specific paralytic action on the optic nerve, are extremely dangerous even when taken in small quantities. As it is possible to separate, with more or less success, ethyl from the other alcohols, it might be that importation under the guise of fusel oil would seriously affect the revenue of the Government.

EXAMINATION OF PRESERVED FRUITS.—Another important investigation in connection with the Treasury Department was undertaken during the year, viz, the examination of pineapples from different parts of the world, in order to determine their natural content of sugar.

EXAMINATIONS OF WATER AND ICE.—Samples of water and ice were examined for the Bureau of Engraving and Printing, for the purpose of determining whether they were suitable for potable purposes. The examination showed that ice is apt to be contaminated by organic matter in a putrid or semiputrid condition, and such ice is totally unsuitable for human consumption in any form. The analysis of the sample of water disclosed the fact that the alum which had been used to precipitate the silt had not been allowed to act long enough to secure complete precipitation before filtering. The continued action of the alum after filtering produced turbidity and discoloration, causing the suspicion of the purity of the sample. The use of alum in water should never be practiced except under expert supervision, otherwise the health of the consumer may be seriously menaced.

WORK FOR THE INTERIOR DEPARTMENT.

Coal.—At the request of the Secretary of the Interior, a series of examinations was conducted during the year to determine the character of coal consumed at the National Hospital for the Insane. The object of these investigations was to determine the calorific power of the samples furnished, and also the amount of sulphur or other injurious substances which the samples contained. The investigations, therefore, were not in the nature of complete analyses, but were confined only to those processes which would fully establish the calorific power of the material furnished.

Paper.—Four samples of paper, used in the Geological Survey for its official business, were also received from the Interior Department. Three of these were ordinary printing papers, and were subjected to microscopic and chemical tests to ascertain their quality and strength. The fourth paper was one which was coated with casein and used especially for map printing.

WORK FOR THE DEPARTMENT OF JUSTICE.

Two investigations were made for the Department of Justice during the year, both of them relating to beverages claimed to be exempt from the restrictions of the law, offered for sale in the Indian Territory. The problems which the Attorney-General asked to be investigated were the following: (1) The determination of the alcohol; (2) whether the beverages submitted were malt liquors; and, (3) whether they were fermented liquors.

Many problems similar to these have been submitted by the Attorney-General. The difficulties of a chemical nature which they present are at once apparent. Skillful mixtures of alcohol, malt, sugar, and coloring matter, together with extract of hops, might well be made, resembling in every particular the chemical composition of the samples submitted and yet not being strictly either a malt liquor or a fermented liquor. In so far as their effect, however, upon the human system is concerned, it is doubtless true that they would be more injurious than genuine malt liquor or fermented liquor of the same alcoholic strength. The only absolutely certain method of determining these latter points would be an investigation of the processes of manufacture. Dealers offering beverages of this kind for sale might well be required to furnish a statement, under oath, showing the method of manufacture and all other data necessary to judge whether or not the offered beverage is a malt or fermented liquor.

WORK FOR THE GOVERNMENT PRINTING OFFICE.

Forty-three samples of glue for use in the Government Printing Office were submitted during the year for examination.

WORK FOR THE POST-OFFICE DEPARTMENT.

Three samples of powdered aluminum, used for painting letter boxes; two samples of sizing used for the same purpose in connection with the aluminum, one sample of painter's japan, one package of postage stamps, two samples of postal-card paper, a large number of inked pads, and thirty-three samples of inks were examined during the year for the Post-Office Department.

POSTAGE STAMPS.—The principal object of the examination of the postage stamps was to determine whether the different inks used in canceling them could be removed without defacing the stamp to such an extent as to prevent reuse in the mails.

### FACILITIES FOR COLLABORATIVE WORK.

In the interests of economy and efficiency in the public service it seems important that more elaborate provisions be made for the work which may be asked for by other Departments of the Government in the solution of chemical problems of various kinds. It is evident that the establishment of separate laboratories for such purposes would be extremely costly, as well as requiring the employment of experts, who would be necessarily selected for a specific purpose and for a limited time. The character of such miscellaneous work would be affected by lack of supervision and uniformity, and the results obtained would not carry the weight and authority which would attach to them if done under the supervision of this Department, or some other Department authorized by Congress to conduct such work in a systematic manner. The equipment of the Bureau of Chemistry has appeared to offer better facilities for this collaborative work than that of any other Government laboratory in Washington, and for this reason little by little the amount of this work has grown until now it is of a magnitude to employ constantly one or more of the chemists connected with the Bureau and to utilize a portion of the laboratory supplies and fixtures. It would be impracticable to exactly estimate the amount expended during the fiscal year for this service, but it is probably not less than $5,000. The growing needs of the service, the increasing amount of the work, and its growing importance warrant a more elaborate provision for conducting it, which will be referred to again in the part of this report devoted to the estimates for the fiscal year beginning July 1, 1904.

### WORK OF THE LABORATORIES.

The particular work of the different laboratories connected with the Bureau will be found in the following summary:

### THE FOOD LABORATORY.

The work of the laboratory in the examination of olive oils, which was in progress at the beginning of this fiscal year, has been completed. In addition to the olive oils previously examined 48 new samples have been secured, and the results of the complete investigation have been compiled and will shortly be issued as a bulletin.

The examination of tropical fruits has also been continued, and 24 samples of prepared fruit products from Cuba have been examined. In addition to the usual examinations complete analyses have been made of the ash of all the samples of tropical fruits and fruit products examined. The work on this subject has been completed, and the results will be included in a bulletin to be issued during the coming year.

The study of the composition of fruit, with special reference to the changes in composition during ripening in different methods of storage, has been continued in collaboration with the Pomologist. Three varieties of apples were sampled at different periods during their growth and maturity, allowed to ripen under different conditions, and their

composition determined. The manner of ripening of apples picked and stored at different stages of maturity has also been studied, and two varieties picked both in the mature and immature states will be held in cold storage to study the effect of long keeping on their composition. Many perplexing problems have presented themselves in connection with this study. In order to make the work of sufficient scope for satisfactory results it was considered necessary to determine solids, ash, starch, sucrose, reducing sugar, pectin bodies, tannin, cellulose, and nitrogen. It may also be of importance to note at different stages of the maturity of the fruit the relative amount of certain of these substances which are present in the insoluble state.

There has not been time to make a systematic attempt to perfect methods for all the determinations mentioned, but considerable attention has been given to the determination of starch, pectin bodies, tannin, and cellulose. The methods employed with many agricultural products for the determination of starch are not applicable to fruit, because of the impossibility of separating starch, or the product of its hydrolization with diastase, from the apple cell. It was therefore found necessary to remove the sugars by washing and hydrolyze the soluble material directly with hydrochloric acid. As is to be expected, too high a result was obtained, owing to the hydrolization of other substances by means of the acid. By a change in the apparatus and the details of manipulation this error has been considerably decreased.

The problem of distinguishing the various kinds of cellulose in the growing apple was given considerable attention, and the methods now employed enable us to determine the percentage of ordinary cellulose and of ligno and cuto cellulose. The former are present in but very small amounts in the fibrovascular bundles, while the latter constitute the greater part of the peeling of the apple. It is believed that considerable progress has been made with the methods employed for this work, though owing to the complex nature of the product there is still much to be desired.

Aside from the experimental work in the examination of methods, 130 samples of apples have been analyzed in connection with this study. The work of the past year also includes studies of the respiration of apples and of the nature of what is commonly known as "scald."

An important part of the work of the food laboratory has also been done, as heretofore, at the request of other Departments. The study of the composition of pineapples has already been mentioned in the account of collaborative work with the Treasury Department. A summary of the results obtained from this investigation was printed in the Journal of the American Chemical Society for March, 1903. The work done in this laboratory at the request of other Departments also includes the examination of samples of fusel oil for the Secretary of the Treasury, the examination of nonalcoholic beers for the Attorney-General, and of samples received from the subsistence departments of the Army and the Navy.

One hundred and thirty-four samples of fruit sirups and nonalcoholic beverages have been secured in the open markets and examined. The examination of grape juices, which was made in this connection, is of considerable interest in the improvement indicated since our last work on the commercial method of preserving this product. It is but a few years since practically all of the unfermented grape juices on the

market were chemically preserved. In the samples examined during the last fiscal year, however, chemical preservatives were the exception, the great majority having been preserved by sterilization alone. In this class is also included a number of malt extracts, whose examination is somewhat difficult, owing to the necessity of distinguishing the preparations made from malt from those of cheaper and inferior grade.

The food laboratory has also done an important work during the last fiscal year, as heretofore, in investigating and comparing methods for the examination of a large variety of foods. This work was undertaken at the request of the Association of Official Agricultural Chemists, in which the chief of the food laboratory is at present referee on food adulteration. He has worked in collaboration with 19 prominent food chemists in the United States and Canada in the preparation and collection of these methods. Among the contributions of the food laboratory to this subject may be mentioned the determination and correction for temperature of refractive indices of oils, which was published in the Journal of the American Chemical Society for August, 1903; the comparison of different methods for iodin absorption, published in the Journal of the American Chemical Society for March, 1903, and the study of the methods for the determination of the ordinary food preservatives.

Two members of the food laboratory staff have done considerable work as associate referees on sugar for the Association of Official Agricultural Chemists. The effect on the rotatory value of invert sugar of hydrochloric acid employed in the determination of cane sugar has been studied, and a formula suggested to correct an error which has commonly been made in the determination of cane sugar in substances containing a large amount of invert sugar. Considerable attention has also been given in the same connection to the study of the methods employed for the determination of reducing sugars with the idea of establishing a method and constructing tables which will make it possible to determine all of the various reducing sugars by the use of a common solution and manipulation. This important study is far from complete, but considerable progress has been made.

During the last fiscal year Bulletin No. 69 (parts 1 to 5, inclusive), which consists of a compilation of the food laws in force in the United States, has been published in addition to the other publications noted above.

Since the 1st of December, 1902, the work of the food laboratory has been largely confined to the analytical work in connection with the study of the effect of preservatives on human nutrition. In this work about 5,500 samples have been examined and the results calculated and tabulated. The difficulties encountered were due to the large volume of work undertaken, making it necessary to devise special apparatus and facilities and to systematize the work to the utmost extent. The determination of boric acid in the urine probably afforded more difficulty than any other portion of this investigation. Owing to the great number of determinations to be made it was found impracticable to make use of the old method, depending on distillation with methyl alcohol, and the error occasioned by the slight solubility of barium phosphate constituted an objection to the volumetric method. This difficulty, however, was to a large extent overcome and satisfactory results obtained.

THE INSECTICIDE AND AGRICULTURAL WATER LABORATORY.

During this year 45 samples of mineral waters were examined, the results on 35 of which are to be used in the preparation of a bulletin upon the composition of the commonly used mineral waters of the United States. Each of these examinations embraced the determination of 20 constituents.

Ninety-eight irrigation waters were either wholly or partially examined. This work was performed in collaboration with the office of irrigation investigations.

Forty-two sanitary examinations of waters were made. Thirty of these are to be incorporated in a bulletin, while the remaining 12 were, in the main, made upon the request of the health authorities of small towns where the water supply was suspected of causing disease, or upon the request of other departments of the National Government.

One hundred and fifteen insecticides were analyzed. One hundred and seven of these examinations were reported in Bulletin No. 76, of this Bureau. The remaining 8 were made by request of the Division of Entomology.

The arsenic content of 528 wall papers, 43 pairs of stockings, 95 ribbons and cloths, 12 fur rugs, and 34 fur pieces was determined, so that a bulletin might be prepared showing how much arsenic is contained in these classes of goods, and what the probable effect would be upon the health of the community.

Nine toxicological examinations were made, 5 for the Division of Entomology and 4 for individuals. The examinations made for the Division of Entomology were to determine whether bees had been killed by poisons used in spraying.

Forty-one cattle foods were examined, most of which examinations are to be reported in bulletin form.

The determination of alkaloids in 24 samples of drugs was made by this laboratory for the Bureau of Plant Industry before a drug laboratory was established.

Three hundred and fifty determinations of the fat content of foods and feces were made in duplicate for the food laboratory.

Twenty-one miscellaneous examinations were made for the U. S. Fish Commission and individuals.

INVESTIGATIONS AND THEIR RESULTS.—The examination of the prominent mineral waters sold upon the American market is not yet completed, but will be during the coming year. Enough work has been done, however, to show that in many cases the waters do not possess the advertised composition. This is especially true of the lithia waters, many of which contain only traces of this element.

The examination of 107 samples of pyrethrum powders shows that these are often adulterated with lead chromate to give them a yellow color. While such an adulteration may be demanded by the trade, it is very reprehensible in that the breathing of lead chromate day by day by human beings is apt to cause lead poisoning. The results of this investigation have been published as Part I of Bulletin No. 76, entitled "Insecticide studies." Part II of this bulletin is made up of a compilation of analyses of insecticides and fungicides made by the various experiment stations, while Part III includes the State laws governing the composition and sale of Paris green and other insecticides.

The examination of wall papers, furs, and fabrics for their arsenic

content has not yet been completed, but enough work has been done to show that this poisonous metal is very widely distributed in goods of this character, especially in fur rugs, black stockings, and red and black cloth.

A study of the free arsenious oxid in Paris green that can be endured by trees is under way, but the results are not yet ready for publication. This spraying work is in progress not only in this laboratory, but samples have also been sent to ten of the experiment stations, which will report on the results during the autumn.

The chief of this laboratory, as referee on insecticides and fungicides of the Association of Official Agricultural Chemists, has spent some time during the last year in comparing methods of analysis for these classes of compounds, and in outlining the work which is to be presented at the fall meeting of this association.

Besides the above investigations, one of the members of this laboratory has published two articles, one upon "Comparative methods of determining formaldehyde," and the other upon "The determination of formaldehyde in milk." Another member has published an article entitled "A modification of the Avery-Beans method for determining total arsenious oxid in Paris green." An investigation is now in progress upon a method for determining iodin and bromin when present in very small quantities in mineral waters. In addition to the publications above mentioned this laboratory has issued the following papers during the past year: "Analysis of waters and interpretation of the results," an article for the Yearbook; "Report of the referee on insecticides and fungicides for 1902," a report to the Association of Official Agricultural Chemists; "A review of the progress in the chemistry of insecticides and fungicides since July 1, 1900," and "A review of the progress in the analysis of cattle foods since July 1, 1900," for the Fifth International Congress of Applied Chemistry.

### THE SUGAR LABORATORY.

The following-named samples have been analyzed in this laboratory:

Nine hundred and twelve samples of sugar for the Treasury Department, on which were determined the sucrose and water (on one-half).

Two hundred and ninety-nine samples of sugar beets, on which were determined the loss in topping, average weight, yield per acre, solids in juice, sucrose, fiber, and purity.

One hundred and ninety-eight samples of cane sirup, 71 samples of sorghum sirup, and 1 sample beet molasses, on which were determined the color, viscosity, total solids, ash, sucrose, reducing sugar, and purity.

Twelve samples of sugar cane, 2 samples of sorghum, 160 samples of sugar-cane juice, and 45 samples of sorghum juice, on which were determined the solids in the juice, sucrose, reducing sugar, and purity.

Twenty-three samples of muskmelons from the Potomac Flats and from several of the experiment stations, on which the following determinations were made: Proportions of rind, edible portion, and center; solids, ash, sucrose, and reducing sugar in juices of rind and edible portion.

Twenty-one samples of honey, on which were determined the sucrose and reducing sugar.

In all, 1,744 samples have been examined, with an average of 3.7 determinations on each.

A color standard for sirups was devised and 8 sets of standard colors made up for distribution.

A "flow" viscosimeter, designed by the chief of the Bureau, and made by the machinist of the road material laboratory, was carefully standardized with pure-sugar solution, and a viscosity table made from the determinations was used throughout the sirup work. In connection with this work, it was attempted to determine the moisture in the sirups by drying a part of the samples in a vacuum oven at 70° C., and the rest in a water oven at 100° C. With only a very few exceptions, the results showed from 1 to 10 per cent more water than was possible with the amount of solids present, due probably to the breaking down by heat of some of the sugars. The results obtained from the vacuum oven were as wide as those from the water oven. The amount of error appears to be nearly proportional to the amount of reducing sugars present.

### THE DAIRY LABORATORY.

The number of samples examined more or less thoroughly and reported upon during the year was 1,056. Of this number, 807 were reported to the dairy division of the Bureau of Animal Industry, 233 were samples of milk and butter consumed at the experimental or hygienic table, and 16 were reported to individuals.

In addition to the samples reported, a considerable number have been analyzed in the study of methods proposed for distinguishing renovated from genuine butter, for detecting adulteration of butter, and for simplifying present methods of analysis. The results of these studies are upon record, and some of them, after further prosecution of the work, may prove worthy of publication.

The greatest difficulty encountered in the work of the year has been in the study of butter from the South, produced by the liberal feeding of cotton seed or cotton-seed meal. The difficulty lies in distinguishing with certainty between some such butters in their purity and similar ones moderately adulterated with foreign fats. It is intended to continue the study of this subject more thoroughly the coming year.

The chief of the dairy laboratory on two occasions during the year served as a witness for the Bureau of Animal Industry in a renovated butter case tried in the United States court for the western (Buffalo-Elmira) district of New York.

### THE CONTRACTS LABORATORY.

The work of this laboratory, which was necessarily of a rather heterogeneous character, consisted mainly in the examination of samples submitted with bids for contract work for different branches of the Government, and in the development of qualitative and quantitative methods for the analysis of the same. The total number of samples as entered upon the index book was 135, and many other minor analyses were made in the course of the work for the purpose of determining special points at issue.

Of the 135 samples, 40 were miscellaneous, and included 8 dyes used by the native Indians for face powder and blanket dyeing; a sample of wocas hulls used by the Indians for a black dye; 6 samples of dyes furnished by the Indian Rights Association to the Navajo Indians for blanket dyeing, 4 of which required only a qualitative examination; 10

requiring both qualitative and quantitative determinations of impurities of reagents furnished the Bureau of Chemistry, including some very careful work in the estimation of caustic and carbonated alkali in sodium and potassium hydroxid, c. p., and comparative tests of the value of methyl orange and phenolphthalein as indicators, and 11 samples of rosin oils and rosin spirits from different manufacturers, from which, by careful fractional distillation, there was prepared a scale of fractions that it was hoped might be of service in the ink determinations.

Of the contract work, properly so called, 60 samples were inks furnished by the Post-Office Department; 33 were samples of paints from the Bureau of Engraving and Printing, Treasury Department, and the other two were a stamp pad for use with rubber stamps, received from the Post-Office Department, and a specimen of khaki cloth from the Navy Department.

A complete inorganic chemical analysis of the sample of khaki cloth was made. The dressing, ash, hygroscopicity, and tensile strength were determined, and many other physical and chemical tests were made. The special purpose of the investigation of stamp pads was the determination of the value of a layer of blotting paper placed between the two layers of felt forming the pad. Microscopical and physical tests of the stamping value, working qualities, and penetrative ability of blotting paper were made, and quantitative determinations of the amount of lampblack filtered out by the paper and by the felt of the pad.

The work on paints included extensive comparative tests of the value of various quantitative methods for the determination of the essential ingredients of the paints, such as lead, chromium, iron, zinc, and manganese; qualitative examinations of all of the paints submitted; quantitative determinations of the impurities in many of them; the determination of the ash and moisture; and an extended and laborious research, having for its object the development of a method of separation by fractional elutriation of finely divided paints, such as barytes, the value of which depends upon its lack of coarser particles which abrade the plates used in printing and engraving. Much work was done also in the determination of the carbonaceous matter in black paints by means of the combustion furnace.

The work with inks included the development of a set of methods for testing canceling inks for rubber and metal stamps, as well as the ingredients used in the making of the same. This branch of the work also included the examination of a large number of samples submitted for test under the methods. Much comparative work was done to establish the best method for determining each essential characteristic of an ink for a special purpose, and, the method well determined, it was applied in the testing of many substances. For instance, having established a good method for determining volatility by means of a comparison of the best methods in use, the volatility of different kinds of rosin oils and rosin spirits, of many miscellaneous samples of inks, of pure glycerin, and of mixtures of glycerin with water, alcohol, acetic acid, etc., in different proportions, was determined.

Similarly, when studying the sedimentation test, many different kinds of lampblack were treated as described in the methods for determining the degree of fineness required for an ink of good sedimentation value, as given in Circular 12, Bureau of Chemistry. A

large number of specific-gravity determinations were made with the pyknometer; various dyes used in the manufacture of inks were tested for solubility, resistance to light and reagents, etc.; the saponification numbers of rosin oils, inks, ink residues, olive oil, linseed oil, and varnishes were ascertained, with a view to applying such figures in the work with inks; and a number of sample inks were prepared according to recipes developed in the laboratory, some of which were sent to the Post-Office Department to have their working qualities tested.

In the manner above outlined each test as described in the methods was first developed and then applied in the determination of a number of substances, so as to establish a set of standards whereby to judge of an unknown ink.

THE ROAD-MATERIAL LABORATORY.

The work of this laboratory has proceeded along the same general lines as in previous years, though with more expedition, due chiefly to a larger and more efficient working force.

The work of the chemist included a research to investigate the cause of the binding or cementing power of rock dust, gravels, and clays. It involved many complete analyses and the determination of the water of combination of over 100 samples. The results of the research were satisfactory and have been published as a contribution from the Bureau of Chemistry in the Journal of the American Chemical Society.

A series of experiments were also made on the burning and clinkering of clays, with a view to their use as road materials.

A research is contemplated, and already something has been done, to determine whether the binding power of materials can be increased by artificial means.

In addition to research, considerable time has been given to experimental work in connection with various analytical methods with a view to modifying, improving, and shortening the ordinary methods of rock analysis to meet the especial needs of road-material work. The modified scheme is published in Bulletin No. 79 of the Bureau of Chemistry.

In the regular routine work complete chemical analyses have been made of 123 samples and 17 samples have been identified. Besides the chemical analyses for the identification and classification of rocks, 66 petrographical analyses have been made, which required the cutting and mounting of 80 thin rock sections. In this petrographical work a new method has been devised and put in operation in the laboratory by which the percentage of various minerals composing a rock can be determined with a very fair degree of accuracy. The routine physical and mechanical tests include 42 abrasion tests, 97 cementation tests, which required the testing of 485 briquettes, 3 complete rattler tests on paving brick, 150 tests on Portland cement, and 38 determinations of specific gravity.

In collaboration with the Bureau of Forestry 9 complete tests on full-size timber were made and numerous minor tests. A report was prepared for the Bureau of Forestry containing a complete scheme for the future timber investigations. The effect of volatile oils on the strength of timber was also suggested and partially investigated, and a method and the necessary apparatus were devised for determining the percentage of volatile oils in wood. A new apparatus was also designed for determining the moisture in wood more accurately than it has heretofore been done. An automatic and autographic universal testing machine of 200,000 pounds capacity was installed in the laboratory by

the Bureau of Forestry, and is intended primarily for the testing of timber.

An impact machine has been designed and constructed and is now in operation by which the toughness of rock can be determined. This is an entirely new field of investigation, having never been undertaken elsewhere. A machine for determining the hardness of rock has also been designed and constructed and is now in operation. This machine is modeled closely after the Dorry machine of the National School of Roads and Bridges of France.

Besides the general work of construction and repair for the laboratory, the machinist of the laboratory has done eighty-three days' work for other laboratories of the Bureau.

### THE DRUG LABORATORY.

The drug laboratory went into operation on March 1, 1903, and the work is now fairly well organized. Already there have been analyzed in this laboratory 120 samples, consisting of material sent from the Bureau of Plant Industry, samples from the Post-Office Department, the Government Printing Office, and a goodly number of chemicals as delivered to the Bureau of Chemistry. No particular difficulties have been encountered in the work.

A number of representative samples of drugs for investigation have been secured, but only a part of the work has thus far been finished on these samples. The results on some of these investigations, especially in the work done on chemicals, shows that these articles are of very unsatisfactory quality.

The manuscript has been prepared for a bulletin to be entitled "Adulterated drugs and chemicals."

### CLERICAL WORK.

With the expansion of the laboratory work of the Bureau the clerical work has greatly increased in magnitude and become much more diversified in character. During the year ending June 30, 1903, 7,342 letters have been written, covering 8,872 pages of typewriting. Numerous papers embodying results of investigations and records of research work have been prepared, representing, in round numbers, 4,000 pages of typewriting. A simple statement of the number of typewritten pages gives no accurate idea of the amount of work done, since much of it has involved the looking up of original matter, verifying references, and abstracting articles of a strictly scientific character.

The hygienic experiments of the Bureau have entailed a mass of tabulation, indexing, and calculation for which the present clerical force is entirely inadequate. It was found necessary to call upon the Division of Statistics for assistance in this work, and valuable help has been given by that Division continuously during the conduct of the experiments. A large amount of this work, however, has been done in the Bureau. Since December 8, 1902, 5,500 samples of the food used in connection with the hygienic table have been indexed, about 33,000 calculations made, 10,660 food and temperature charts made out, 1,600 pages of manuscript typewritten, and hundreds of tabulations made, in addition to a card index giving detailed information in regard to the work, abstracts of literature bearing on the subject, etc.

In addition to the work mentioned above, tabulations of the results of the analytical work of the Bureau have been made, chemicals purchased, and miscellaneous samples received for examination have been indexed, the accounts of the Bureau kept up to date, and a vast amount of miscellaneous work performed which it is impossible to classify and enumerate.

## EDITORIAL WORK.

Thirty-eight publications, including bulletins, circulars, and reprints, have been issued during the fiscal year. Of this number, 14 were new bulletins and 2 circulars, the remainder being reprints. These publications contained a total of 3,000 pages, of which 1,312 pages were new matter. In addition to this a special report on wine making in France has been submitted for publication as a Congressional report.

The job printing for the Bureau has included, besides the usual supplies, circular letters, postal cards, etc., the issuing of outlines of work for the food standards committee and the referees of the Association of Official Agricultural Chemists, and a number of forms for the conduct of the experimental work in food adulteration.

The mailing list of the Bureau has been carefully revised by correspondence and reduced about 50 per cent. The names remaining on the list have been classified so as to make possible the most efficient and economic distribution of the bulletins, a step made necessary by the specialization of the work of the Bureau and the consequent effect upon the reports issued, such widely differentiated topics being treated that but few persons would be interested in all of the publications.

## FINANCIAL STATEMENT.

The expenses of the Bureau during the fiscal year are itemized as follows:

| | |
|---|---|
| Statutory roll | $13,200.00 |
| Miscellaneous fund | 52,333.27 |
| Sirup | 8,166.73 |
| | 73,700.00 |

### MISCELLANEOUS FUND.

| | |
|---|---|
| Pay roll | 30,792.20 |
| Rent | 2,800.00 |
| Gas | 508.20 |
| Electricity | 187.08 |
| Chemicals | 2,972.22 |
| Apparatus and equipment | 9,422.70 |
| Lumber | 241.68 |
| Office supplies and furniture | 433.50 |
| Plumbing and hardware | 817.92 |
| Kitchen and dining-room furnishings | 317.78 |
| Food and provisions | 1,694.86 |
| Letters for travel and samples | 1,408.00 |
| Miscellaneous | 487.13 |
| Balance unexpended | 250.00 |
| | 52,333.27 |

### SIRUP FUND.

| | |
|---|---|
| Pay roll | 5,283.43 |
| Travel and supplies | 2,883.30 |
| | 8,166.73 |

## OUTLINE OF WORK PROPOSED FOR THE FISCAL YEAR ENDING JUNE 30, 1904.

### LABORATORY WORK.

#### FOOD LABORATORY.

The work of the food laboratory during the coming fiscal year will be almost entirely devoted to the analytical work connected with the study of the influence of preservatives on human nutrition, and to the work incidental to the enforcement of the food law. In the plan submitted herein it is taken for granted that the work necessitated by the food law will not require the time of more than one analyst. In case a larger volume of work than is expected should be involved, a correspondingly greater amount of assistance will be necessary. It is expected that this investigation will be taken up again about the 1st of October, and the determinations which were made during the last fiscal year will be continued, and in addition thereto the sulphur in both food and excrement will be determined.

It is proposed to continue the study of the ripening of fruit in collaboration with the Pomologist, and to take up, in addition, during the summer months the study of the banana in connection with the section of tropical agriculture of the Bureau of Plant Industry.

The work of the laboratory in connection with the Association of Official Agricultural Chemists on the study of food methods will be continued. In this connection a study will be made of the amount of aldehydes and salicylic acid which may occur naturally in foods of various classes with the idea of determining the probability of errors from such bodies in the examination of foods.

The estimate for 1904–5 is based on the supposition that the work required by the food law will reach considerable proportions during that fiscal year and that we shall then not be able to secure the assistance now received from the Statistician. In case the analytical work expected of the food laboratory is not greater than at present, and assistance can still be obtained from the Statistician, it will be possible to reduce the estimates for salaries to about $13,000. These estimates do not take into consideration the salary of the chief of the laboratory, as his name is now on the statutory roll.

*Estimate of expenses for food laboratory.*

| | |
|---|---|
| 2 assistants, at $1,800 | $3,600 |
| 3 assistants, at $1,000 | 3,000 |
| 2 assistants, at $840 | 1,680 |
| 2 assistants, at $720 | 1,440 |
| 1 clerk, at $1,000 | 1,000 |
| 3 calculators, at $840 | 2,520 |
| 2 laborers, at $480 | 960 |
| Total salary of assistants | 16,105 |
| Traveling expenses, purchase of samples, and special apparatus | 1,400 |
| Total | 17,505 |

#### THE INSECTICIDE AND AGRICULTURAL WATER LABORATORY.

During the coming year the study of the arsenic content of wall paper, fabrics, etc., will be continued and will doubtless be finished by autumn.

The work upon the mineral waters sold on the American market will also be continued. Since these waters are so often used as medicinal remedies, yet do not contain the ingredients claimed by the owners of the springs, it appears that they are well worthy of further study, and it is purposed to buy a number of these waters, not to be obtained in Washington. An authorization of $65 for traveling expenses and purchasing samples is recommended.

It is also intended to undertake a study of cattle foods sold upon the American market. For this study an authorization of $100 for the purchase of samples is necessary.

The studies on the effect of the free arsenious oxid in Paris green on foliage will be continued and extended to the study of agricultural products that have been sprayed with poisonous metals in order to determine whether they contain such poisonous metals when they reach the consumer.

The collaboration with the Division of Entomology in a study of insecticides and with the office of irrigation investigations in a study of irrigation waters will also be maintained.

The following estimate of the expenses for conducting this laboratory for the fiscal year ending June 30, 1905, does not include the cost of glassware, chemicals, etc.:

*Estimate of expenses for insecticide and agricultural water laboratory.*

| | |
|---|---|
| Salary of chief | $2,500 |
| Salary of 2 assistants, at $1,200 | 2,400 |
| Salary of 1 student assistant | 480 |
| Purchase of samples | 300 |
| Total | 5,430 |

THE SUGAR LABORATORY.

For the ensuing year the work on the Treasury sugars will go on as usual. The work on sugar cane and cane sirups will be even more extensive than during the past year, as also will the work in the field on the cultivation of sugar cane and the manufacture of sirups for the table on a commercial scale.

The object in view is to establish the principles of a chemico-technical nature governing the manufacture of table sirups, in order to secure uniform quality, standard color, freedom from fermentation, and security against crystallization. If these points can be established, there will doubtless be a marked increase in the demand for palatable and wholesome sirups of this character.

It is also desired to undertake more extensive investigations in the growth and utilization of cassava, especially for starch and glucose manufacture. The problems relating to the uses of cassava for cattle food have been well solved, but others of a more technical nature invite further investigation.

The utilization of the sweet potato and the yam, which grow so abundantly in the sandy soils of the Southeastern States, will also receive attention. This study involves very important problems of a chemico-technical nature, which, if correctly solved, will add much to the agricultural wealth and industries of the regions named.

An addition of $5,000 to the fund appropriated for the current fiscal year would enable this laboratory to undertake the additional problems, and, therefore, the estimate for the sugar laboratory for the ensuing year is placed at $20,000.

THE DAIRY LABORATORY.

The principal lines of work which it is intended to pursue during the year are as follows:

(1) Continuation of the study of methods for distinguishing renovated from genuine butter.

(2) Continuation of the study of Poda's method of butter analysis, with modifications.

(3) Complete analysis of samples of all brands of canned milk or cream, condensed milk, and milk powders sold in the markets of the United States.

(4) A thorough study of the fat of cotton-seed butters, especially those produced by excessive feeding of cotton-seed products.

(5) Any work in dairy chemistry that may be desired by this and other Bureaus of the Department.

The expense of conducting the laboratory on a satisfactory basis is estimated as follows:

*Estimate of expenses for dairy laboratory.*

| | |
|---|---|
| Salary of chief | $2,000 |
| Salary of assistant | 720 |
| Salary of helper | 600 |
| Supplies | 180 |
| Total | 3,500 |

THE CONTRACTS LABORATORY.

The work of the contracts laboratory for the coming year must necessarily depend to a large extent upon the number and nature of samples submitted by this and other Departments with bids for contracts. During the past year this class of work was confined largely to paints and inks. At present a large number of inks are on hand upon which a preliminary report has been made. The examination of these inks is to be continued for the purpose of establishing the nature of the base and the dyes used, and the resistance of these dyes to the action of sunlight and other agents. It is believed that the power of an ink to carry carbon into the paper depends largely upon the solvent used. A few of the inks examined possess this quality to a marked degree, while others are entirely devoid of this power. Since the indelibility of canceling ink depends upon the penetration of the carbon into the paper this property is of great value. In connection with the investigation of inks there is need that the effect of different ink bases upon the rubber stamp used for canceling purposes be studied.

In accordance with General Order No. 68, issued April 15, 1903, in which "chiefs of Bureaus, Divisions, and Offices of the Department are requested to collaborate with the chief of the Bureau of Chemistry in securing data and materials for an investigation to be undertaken for the purpose of ascertaining the factors which determine the durability and other qualities of typewriter ribbons," a number of samples of ribbons have been sent in and a study of these will be made.

Owing to the extensive use of oils for lubricating purposes and in the manufacture of materials on Government contract, such as paints, inks, etc., and to the fact that these oils are quite commonly adulterated, it is suggested that an investigation of these be taken up during the coming year and continued as time allows. Work of this

kind must necessarily be done in connection with the study of the bases used in the manufacture of ink, and can then be extended to include other materials. This work can be made a very important part of the investigations of the contracts laboratory. A report was made upon the amount of ethyl alcohol in fusel oils, this work having been taken up at the request of the Treasury Department.

It seems highly desirable that the work of this laboratory be continued along the lines mapped out by Mr. E. E. Ewell, viz, to establish methods that will be of practical value in determining the quality of various materials submitted with bids for contracts, and of the ingredients entering into their composition, and then so far as seems practicable, to establish specifications for these materials. This has already been done in the case of inks and is possible with many other classes of materials.

If the work of this laboratory is developed this year, as it now seems probable that it will be, the amount of work required and its usefulness will be greatly increased. It is probable, too, that considerable special apparatus will be required for the laboratory. It is therefore suggested that the estimates be sufficiently large to provide at least one additional assistant and such special apparatus as may be necessary. A total of $10,000 will be sufficient to cover the probable expenses of this laboratory for the year 1904–5.

### THE ROAD MATERIAL LABORATORY.

During the coming year two new tests will be adopted by this laboratory for determining the hardness and toughness of rock. These tests will be regularly carried out on all routine samples and reported on, and it is believed that they will be of much assistance to road builders. Aside from these two tests, the general testing of rock for macadam roads will be carried on in the same manner as before. Much work has already been done by this laboratory for determining the quality of clay best adapted for burning, and it is hoped that it will be possible during the coming year to make a thorough practical test of burnt clay for country highways. If such an experiment proves successful, one of the greatest road-material problems will be solved, for there are vast areas throughout our country where the only material on which and from which roads can be constructed is clay.

At least two new bulletins are contemplated for the coming year—one on the cementing value of road materials and the other on the uses of concrete in road making.

The testing of cement and concrete in relation to road foundations, drains, and highway bridges will also be taken up and more tests will be made on paving bricks.

The present salary roll of the road material laboratory is as follows:

*Salaries of road material laboratory.*

| | |
|---|---|
| Chief | $2,500 |
| Engineer | 2,000 |
| Chemist | 1,500 |
| Mineralogist | 1,000 |
| Machinist | 900 |
| Three assistants | 1,920 |
| Stenographer | 720 |
| Total | 10,540 |

The allotment of funds for carrying on the work of this laboratory for the current year is $10,000, this sum being a portion of that appropriated for Public Road Inquiries.

It can be seen from the above figures that the salary roll of the laboratory alone consumes more than the total allotment; but, as the work is being carried on in collaboration both with the Bureau of Chemistry and the Office of Public Road Inquiries, an arrangement has been made whereby the current expenses of the year can be met. The work, however, is growing so rapidly that it is most essential that an increased allotment be made for the fiscal year ending June 30, 1905, namely, $15,000.

### THE DRUG LABORATORY.

The character and scope of the work for next year has been outlined as follows: The chemicals for the laboratories will be examined as they are delivered by the manufacturer. Samples of the best quality of chemicals have been ordered and it is intended to establish a standard for chemical reagents. The potent drugs of the market will also be investigated to ascertain their quality and at the same time establish a standard for such articles. The quality of drugs imported into this country will also be considered.

Arrangements have been made with the chief of the insecticide and agricultural water laboratory to undertake a joint investigation of some chemicals, with a view to determining the amount of arsenic content in them and how it is introduced.

It is also intended to secure the cooperation of a number of pharmaceutical chemists in this country to work in unison for the purpose of making a careful study of the principal available analytical methods, and in this manner to determine which will give the best results.

The expenses for the fiscal year ending June 30, 1905, will be approximately as follows:

*Estimate of expenses for drug laboratory.*

| | |
|---|---|
| Chief | $2,500 |
| Assistant chemist | 1,000 |
| Two scientific aids, at $480 | 960 |
| Clerk | 400 |
| Chemicals and apparatus | 1,000 |
| Samples and incidental expenses | 1,000 |
| Total | 6,860 |

### CLERICAL WORK.

The clerical work for the next fiscal year will be along practically the same lines as during the present year, but much more extended. It is desired to perfect the system of recording the results of the analytical work so as to make them available for ready reference.

The growth of each laboratory, as well as the addition of new laboratories, and the necessity of properly executing the food laws and carrying on the food adulteration experiments make it imperative that the clerical force be augmented in order to properly conduct such work and promptly and efficiently record and report its results. To this end, I recommend the appropriation of $2,000 for additional clerical help.

EDITORIAL WORK.

It is the intention, beginning with July 1, 1903, to keep a card catalogue record of the printing work of the Bureau, showing the progress of all work through the press, the issuance and distribution of bulletins, and to file samples of all job work, keeping a card index of the same. As the results of considerable cooperative work are awaiting compilation (including experiments on wheat, muskmelons, beets, etc.) and several important bulletins on methods, etc., need revision, there is urgent need of an additional editorial clerk to assist in the compiling and comparing necessary to accuracy in preparing such reports for the press.

The additional work of an editorial nature involved in the execution of the pure food laws is another matter of great importance. It relates especially to the preparation of circulars to agents of the Department charged with collaboration in the execution of the law, and especially the preparation and perfection of circulars issued in collaboration with the Department of Agriculture by other Departments, viz, the Treasury and the State Departments. The collection and publication of the decisions of the courts respecting the execution of food laws is also of the greatest importance in this line of work. An additional editorial clerk at $1,200 is therefore recommended.

LIST OF SKILLED ASSISTANTS.

The Bureau of Chemistry perhaps suffers more in proportion to the total number of its members than any other Bureau or Division of the Department from incursions into its ranks from other scientific institutions. From the 1st of January, 1903, to the 30th of June, inclusive, this Bureau lost by resignation the services of three chiefs of laboratories, viz, Mr. E. E. Ewell, chief of the contracts laboratory and assistant chief of the Bureau; Mr. E. G. Runyan, chief of the fertilizer laboratory; and Mr. W. H. Krug, chief of the dendrochemical laboratory. In addition to this, the chief of the sugar laboratory has requested that he be relieved after the present year from the duties of that position and be appointed a special agent of the Department for the time which he can give to its service, making in all a loss of four chiefs of laboratories in six months. In addition, other members of the force have resigned to accept more lucrative positions in other institutions. In all cases these resignations have been for the purpose of accepting more lucrative and promising positions either with public or private institutions.

It is evident, therefore, that if the Department of Agriculture wishes to retain the services of young men who distinguish themselves in their particular lines the compensation for these services must be increased. With the exception of the chiefs of laboratories, it is a matter of common record that the scientific assistants in the Bureau of Chemistry are not paid any more than is given for ordinary clerical services; yet, in order to discharge the duties of a scientific assistant, it is necessary not only that a college training be secured, but also a special professional training. Thus, the young man comes to the service of the Government after from four to six years of professional studies, and if he develops the tact, the industry, and the ability to command the attention of other institutions and of private

parties and corporations, it is evident that he can not afford to remain in the service with no prospect of a larger compensation than is given for clerical services throughout the Departments of the Government.

## THE ESTIMATES FOR 1905.

In the estimates for 1905 I have included the amounts which, it seems to me, are necessary for the faithful prosecution of the work under the various lines of investigation which this Bureau has established. I desire in addition to call attention to the necessity of obtaining an appropriation whereby the collaborators in the agricultural experiment stations engaged in the study of important problems, under the direction of the Bureau of Chemistry, may receive some compensation. About 25 stations now collaborate in these experiments, and a grant of $200 for each one would not seem extravagant. On the contrary, it would be only a poor compensation for the amount of labor and time given to the work. I therefore submit an estimate of $5,000 for this collaborative work.

To properly execute the pure-food law we not only need, as we have already received, the cordial collaboration of the Department of Justice, the Treasury Department, and the Department of State, but we need an additional fund to enable representatives of the Bureau to be present at the taking of samples, to inspect the cargoes in bulk, and especially for the purpose of sending experts to certain localities where suspicious articles of food are prepared and from which they are shipped. It is only in this way that information of a practical nature sufficient to exclude misbranded and adulterated products can be secured. For instance, no chemical examination can determine whether or not a label correctly represents the place of manufacture. The difference between the chemical composition of a rare wine from one of the old chateaux of France and a very ordinary wine would not in all cases be sufficient to distinguish between them. Thus, to prevent gross imposition upon our consumers, it will be necessary to have experts visit the localities from which these wines and other food products come in order to verify the character of the labels. Congress has placed in the hands of the Secretary of Agriculture a means for protecting our people against the gross frauds which have been perpetrated upon them for so long a time by the introduction of adulterated, misbranded, and debased food products. It is only reasonable and just to ask from Congress now a sufficient sum to thoroughly execute this law.

In addition to this, Congress has authorized the inspection by the Secretary of Agriculture of food products intended for export, so that our foods can go to foreign countries with the same assurance of purity which we ask in those coming to us. This inspection requires chemical service, expense of securing samples, and often inspection of cargoes.

Thus, in order to properly execute the law relating to imported food products, and also that relating to exported food products, we need a sum sufficiently ample to lend effectiveness and validity to the acts of Congress. I therefore recommend that $50,000 be given to secure the proper execution of these two laws.