THIRTEENTH ANNUAL REPORT

OF THE

CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION

FOR THE YEAR

1900.

ITHACA, N. Y.

Cornell University, New York State College of Agriculture

THIRTEENTH ANNUAL REPORT

OF THE

CORNELL UNIVERSITY

Agricultural Experiment Station,

ITHACA, N. Y.

1900.

THIS REPORT IS NOT FOR GENERAL DISTRIBUTION.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899.

ORGANIZATION.

BOARD OF CONTROL:

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THE AGRICULTURAL COLLEGE AND STATION COUNCIL

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L. ANDERSON, Dairy Husbandry.
W. E. GRIFFITH, Dairy Husbandry.
MRS. A. B. COMSTOCK, Nature-Study.
ALICE G. McCLOSKEY, Nature-Study.

OFFICERS OF THE STATION.

I. P. ROBERTS, Director.
E. L. WILLIAMS, Treasurer.
EDWARD A. BUTLER, Clerk.

Office of Director, Room 20, Morrill Hall.

The regular bulletins of the Station are sent free to all who request them.

ITHACA, N. Y.,

To His Excellency, the Secretary of the Treasury,
Washington, D. C.

To His Excellency, the Secretary of Agriculture,
Washington, D. C.

To His Excellency, the Governor of the State of New York,
Albany, N. Y.

To His Excellency, the Commissioner of Agriculture,
of the State of New York, Albany, N. Y.

SIR :—

I have the honor to transmit herewith the thirteenth annual report of the Agricultural Experiment Station of Cornell University, in accordance with the Act of Congress of March 2, 1887, establishing the Station.

This document contains the report of the Director and the special reports of his scientific coadjutors, as well as copies of the bulletins, Nos. 171–182 inclusive, Nos. 2–5 inclusive of the Nature Study Quarterlies, Nos. 6–10 inclusive of the Reading Courses for Farmers, and Nos. 1–8 of the Junior Naturalist Monthlies, all of which have been published by the Station during the year, and a detailed statement of the receipts and expenditures.

The increased scope and effectiveness of the Experiment Station of Cornell University, due to the appropriations with which in recent years the Legislature of the State of New York has supplemented the annual appropriation from the Federal treasury, are notable and gratifying, and to this newer side of the work I would especially direct your attention.

I have the honor to be your obedient servant,

J. G. SCHURMAN,
President of Cornell University.

REPORT OF THE DIRECTOR.

To the President of Cornell University.

SIR :

I have the honor to transmit herewith the Thirteenth Annual Report of the Agricultural Experiment Station of Cornell University. The work of the Experiment Station and that for the "Promotion of Agricultural Knowledge throughout the State," under Chapter 430 of the Laws of 1899, are so closely allied that it seems appropriate to bind together in one volume and to transmit all of the principal publications of the Station together with those which have been issued by reason of the State appropriation.

The administration of the various Federal and State funds for the improvement of agriculture has been placed in the hands of the College of Agriculture, subject, however, to the approval of the College and Station Council, and, in the case of the State funds, to the approval of the Commissioner of Agriculture.

The investigations have been directed along two general lines :—those designed to solve as quickly as possible pressing questions, and those which have a far reaching and more scientific basis. Some of the bulletins embody the results of a single season's work, while others are the results of years of research. In addition to the research work carried on at the College and throughout the State, a Farmer's Reading Course has been established not only for the purpose of giving instruction, but with the view of inducing the farmers to become interested in the experimental work. The climate and soil vary so widely in this State that experiments carried on at the central station are often of little value in many other localities, hence it has been thought wise to induce the leading farmers to investigate either independently or under the direction of the Station. More than four hundred farmers are now experimenting under the immediate supervision of the station staff. Expert field agents are sent out to assist in mapping out the work and in selecting suitable ground and plantations. The agents inspect the work from time to time, give directions for harvesting, weighing and sampling, and so far as possible assist in harvesting the crops. This work, associated with other work of a somewhat different character for the "Promotion of Agricultural Knowledge," has been eminently successful. After three years' experience in sending out these traveling expert teachers and experimenters I am persuaded that no other line of effort has been more fruitful in results.

The Station and University Extension staff now consists of some thirty persons selected with special reference to fitness for the work which they are called on to perform.

Appended to, and a part of this report, are the reports of the various heads of divisions and a detailed statement of receipts and expenditures for the fiscal year ending June 30th, 1900.

Twelve bulletins, containing 385 pages and 87 cuts, have been issued on the following subjects:

No. 171, "Gravity or Dilution Separators."
No. 172, "The Cherry Fruit-Fly: A New Cherry Pest."
No. 173, "The Relation of Food to Milk-Fat."
No. 174, "The Problem of Impoverished Lands."
No. 175, "Fourth Report on Japanese Plums."
No. 176, "The Peach-Tree Borer."
No. 177, "Spraying Notes"
No. 178, "The Invasion of the Udder by Bacteria."
No. 179, "Field Experiments with Fertilizers"
No. 180, "The Prevention of Peach Leaf-Curl."
No. 181, "Pollination in Orchards."
No. 182, "Sugar Beet Investigations for 1899."

Four Nature-Study Quarterlies have been published on the following subjects:

No. 2, "A Handful of Soil."
No. 3, "Cuttings and Cuttings."
No. 4, "The Burst of Spring."
No. 5, "A Brook."

The following reading lessons for farmers have been issued:

No. 7, "Balanced Rations for Stock."
"Quiz on Reading Lesson No. 7."

No. 8, "A Farmer's View of Balanced Rations."
"Quiz on Reading Lesson No. 8."
No. 9, "Sample Rations for Milch Cows."
No. 10, "Peter's Idea of Improving 'Worn Out' Lands."

Two lessons for the Junior Naturalist Clubs have been published on the following subjects:

Lesson 1, "Seed Travelers."
Lesson 2, "The Story an Apple Tree Can Tell."

In December, 1899, this publication was changed to a Nature-Study Monthly.

No. 3, "How Shall We Please St. Nicholas."
No. 4, "Oxygen and Carbon in Partnership."
No. 5, "Waiting for the Birds."
No. 6, "The Coming of Spring."
No. 7, "The Four Chapters in an Insect's Life."
No. 8, "A Children's Garden."

Twenty-five thousand copies of each bulletin are issued except in rare cases when a bulletin is of a strictly scientific character when but five thousand copies are published for the use of scientific workers. At the present time in round numbers there are 20,000 farmers registered in the Reading-Course, 35,000 school children in the Junior Naturalist Clubs, and 30,000 public school teachers have applied for and are receiving the leaflets. We are fully persuaded that all of this work is preparing the farmer, the teacher and the child to investigate, to see and to love the natural objects which surround every rural home. Already many observed facts are being reported to us from the multitude of pupils who are interested in our work.

Respectfully submitted,

I. P. ROBERTS,
Director.

REPORT OF THE TREASURER.

The Cornell University Agricultural Experiment Station,
In account with
The United States Appropriation, 1899–1900.

		Dr.
To Receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1900, as per Act of Congress, approved March 2, 1887:		$13,500 00
	Cr.	
By Salaries	$9,508 14	
Labor	774 60	
Publications	1,620 11	
Postage and Stationery	387 59	
Freight and Express	112 78	
Heat, Light and Water	90 63	
Chemical Supplies	16 29	
Seeds, Plants and Sundry Supplies	191 89	
Fertilizers	15 60	
Feeding Stuffs	205 66	
Library	161 59	
Tools, Implements and Machinery	6 00	
Furniture and Fixtures	102 28	
Scientific Apparatus	99 73	
Live Stock	22 00	
Traveling Expenses	157 69	
Contingent Expenses	10 00	
Buildings and Repairs	17 42	
Total		$13,500 00

(Signed) E. L. WILLIAMS,
Treasurer.

We, the undersigned, duly appointed Auditors of the Corporation do hereby certify that we have examined the books and accounts of the Cornell University Agricultural Experiment Station for the fiscal year ending June 30, 1900; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $13,500.00, and the corresponding disbursements $13,500.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving no balance.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

Signed:

H. B. LORD, }
M. VAN CLEEF, } Auditors.

(Seal)

Attest: EMMONS L. WILLIAMS,
Custodian.

REPORT OF THE CHEMIST.

To the Director of the Cornell University Agricultural Experiment Station.

SIR :—

The work of the Chemical Department during the past year has been largely along the lines of the three previous years. The investigation of evaporation of water from soils under different methods of cultivation was continued during the summer of 1899, and is still in progress. This work, which is being done in connection with the Agricultural Department, requires determinations of soil moisture.

During the fall months the work on sugar beets was continued with special reference to the sugar content and purity of certain standard varieties. The subject of insecticides received attention and a number of samples of Paris green and substitutes for Paris green have been examined.

Some studies of the strawberry soils of Oswego County have been started. Several large experiments have been placed there by the Departments of Horticulture and Chemistry, and it is hoped that some light may be had on the fertilizer requirements of the strawberry plant. Complete analyses of these soils are in progress.

The work on starches for the A. O. A. C. has been taken up and also an investigation of the pentosans.

The following table shows the substances that have been analyzed wholly or in parts :

	SAMPLES.
Sugar beets	200
Soils	120
Feeds (food analysis)	26
Feeds (fertilizer analysis)	22
Gypsum	6
Manures	4
Commercial fertilizers	6
Paris green and arsenicals	13
Arsenic	1
Soaps	2
Mill waste	1
Peat	2
Ashes	1
Beet pulp	1

Respectfully submitted,

G. C. CALDWELL,
G. W. CAVANAUGH.

REPORT OF THE BOTANIST.

To the Director of the Cornell University Agricultural Experiment Station :

SIR :—

I have the honor to present the following report of the work of the Botanical Division for the past year.

The investigations on the edible and poisonous species of mushrooms, which have been in progress for several years, have been continued, and considerable information upon the development of certain species, as well as on the presence of species new to the United States, has been gained. These investigations are of such a nature that they must be continued for many years to come, but the new information is available for the publication of brief bulletins from time to time, in which the matter of economic importance can be brought before our constituents. Likewise the investigations on the diseases of timber caused by fungi are continued, and a fund of useful information is thus being brought together.

Mr. W. A. Murrill, the Assistant Cryptogamic Botanist appointed for the past year, has been prompt and successful in the discharge of his duties. He has been engaged separately in certain investigations, and jointly with myself in others. He published a short bulletin of inquiry on a root and trunk injury of apple trees, "The Crown Disease of the King Apple," Cornell University Agricultural Experiment Station, Oct. 31, 1899.

He has continued some investigations begun by Dr. Duggar, on the prevention of leaf curl of the peach, the results of which were published in one of the bulletins, "The Prevention of Peach Leaf-Curl." Bulletin 180, March, 1900. Botanical Division Cornell University Agricultural Experiment Station. These results indicate that this serious disease can be checked if promptly and properly treated.

Conjointly with myself he has been engaged in a study of the troubles and diseases to which shade trees are subject, especially in cities. A great amount of interesting and important information has been gained which we hope to present for a future bulletin.

Dr. Duggar, who has been absent on leave in Europe for the past year, now returns to us after a very profitable year's study. He has had an opportunity while in Europe to make a study of several obscure organisms belonging to a genus which we have found is doing considerable injury in this country, especially the genus *Rhizoctonia*. He will bring with him material of several species of this genus which he has collected on a number of different hosts in Europe. This will be made use of by him in a comparative study with the American species, and will assist him in clearing up much of the confusion which exists regarding this organism, and others which resemble it in the vegetative stage and in the mode of injury.

Respectfully submitted,

GEO. F. ATKINSON.

REPORT OF THE ENTOMOLOGIST.

To the Director of the Cornell University Agricultural Experiment Station.

SIR :—

As the Entomological work of the Station has been performed luring the past year almost entirely by the Assistant Entomolo-;ist, I have requested him to prepare a report on it, which I ıerewith transmit.

Very respectfully yours,

J. H. COMSTOCK.

To the Entomologist of the Cornell University Agricultural Experiment Station.

SIR :—

During the past year the Entomological Division of the Station nvestigated a new insect pest of the cherry, which did much lamage to this fruit in our state. The insect infests the fruit, ınd there is usually no indications of its presence until the ripe nd luscious fruit is being prepared for canning or for the table. The pest seems to be well protected against a warfare with nsecticides and it will apparently prove a serious pest and one ery difficult to combat. The results of our investigations were ublished in bulletin :

No. 172. "The Cherry Fruit-Fly : A New Cherry Pest."

Our extensive experiments against the peach-tree borer were ractically concluded during the year and the results embodied n bulletin :

No. 176. "The Peach-tree Borer."

An abridged edition of this bulletin was published for general istribution. We expect to further test some of the methods iscussed in the bulletin again this year, as it is claimed that our esults are not obtained with similar materials in other states ; or instance, Missouri peach-growers assert that gas tar kills heir trees, hence we have obtained some Missouri gas tar to use n our trees which were uninjured by the New York product.

A serious greenhouse pest, a little moth (*Phlyctænia ferrugalis*) whose caterpillar feeds upon the foliage of many greenhouse plants, has been investigated by a student, Mr. Franklin Sherman, Jr., and his observations and results may be embodied in a bulletin soon.

We are now investigating an apparently new insect pest of the strawberry in this State. It is a leaf-roller, and it has done much damage in at least one locality, ruining half the crop. We have been successful in breeding the insect in the insectary and expect to get our results ready for publication during the coming year.

A bulletin on canker-worms, embodying the results of our investigations during the past two or three years, is in preparation. All of the four or five kinds of canker-worms now at work in the State will be fully illustrated in the bulletin.

About 1500 photographic negatives of injurious insects and their work have been made at the insectary during the past ten years, and this collection receives additions almost daily. These negatives have furnished the excellent half-tone illustrations used in our bulletins, and we are now making a series of lantern slides, many of them colored from life, for illustrating lectures at Farmers' Institutes and similar meetings.

The correspondence of the Division continues to increase and requires a large share of our time. We have attended during the year several Farmer's Institutes and delivered addresses at the meetings of the Western and of the Eastern New York Horticultural Societies.

Respectfully submitted,

M. V. SLINGERLAND.

REPORT OF AGRICULTURIST.

To the Director of the Cornell University Agricultural Experiment Station.

SIR :—

The principal lines of work which are now under investigation by this division are a continuation of the tillage experiments with potatoes and sugar beets ; variety experiments with sugar beets and beans ; comparison of forage crops with reference to their adaptability to withstand drought ; renovation of pastures, and fertilizer experiments with various farm crops. A part of the series of permanent plats which has been cropped continuously for several years without the application of any fertilizers has now become so deficient in humus that the producing power is greatly reduced. An experiment has now been planned and started looking toward the restoration to fertility of this land by means of cover crops and green manuring. While it could be quickly brought into condition by means of fertilizer or manures, the purpose is to take a crop from the land each year and bring it up by means of "catch crops." In carrying out this experiment an acre of land has been taken on a neighboring farm, that being purposely selected which was in a very low state of fertility. This acre has been divided into three areas and various means have been adopted looking toward its improvement.

The use of silage is rapidly displacing soiling crops. A constantly increasing number of inquiries are being received asking for information concerning the construction of silos and the growth of crops suited for ensilage. That these inquiries may be answered correctly investigations are being conducted to determine the necessary losses of dry matter in silos of various construction, and also to determine the relative value of various crops for ensilage.

During the winter feeding experiments were conducted with steers, the object being to determine the relative feeding value of beet pulp and silage and the relative value of both these materials compared with good mixed hay. Thirty-two pigs were fed upon various rations to determine the feeding value of skimmed milk when fed in combination with various grain rations. Feeding experiments were also conducted with sheep.

The experiments throughout the state conducted by this division have been in charge of Mr. J. L. Stone. They have largely consisted in investigations relating to sugar beets, potatoes and beans. The aim has been in all the work to make it of practical benefit to the farmers of the State and it is believed that the Experiment Station is coming into closer relation each year with those whom it endeavors to aid.

Respectfully submitted,

L. A. CLINTON.

REPORT OF THE HORTICULTURIST.

To the Director of the Cornell University Agricultural Experiment Station:

SIR :—

In the past year there have been no important new departures in the work of the Horticultural Division of the Experiment Station. The chief line of inquiry is the investigation of matters relating to commercial fruit-growing, in which New York State excels. For many years the Cornell Experiment Station has been engaged in a propagandist movement for the better care of orchards, particularly with reference to clean tillage. At first the advice to keep orchards in clean tillage was rarely accepted ; but, at the present time, a most remarkable change of opinion has taken place. Most of the leading orchardists are now tilling their lands as carefully and thoroughly as they till corn or potatoes. This movement has been coincident with the movement looking toward the spraying of trees and the general increased attention to the destruction of insects and fungi. The result has been most gratifying. A number of profitable crops have raised the hopes of the fruit-growers of the State and have put the industry on a very profitable basis. Two or three dry seasons have also emphasized the value of conserving the moisture by clean tillage, thereby enabling the trees to bear a much finer quality of fruit. One of the next movements which needs to be inaugurated for the benefit of fruit-growers is one looking to greater care and attention in the harvesting and marketing of the produce.

At the home Station at Ithaca, experiments are continuing on the management of orchard plantations with respect to fertilizing, tilling, pruning, spraying, and the like. In the testing of varieties of fruits, little is now being done with the exception of the Japanese plum and the strawberry. It is the belief of those who are working in the Horticultural Division that the general or promiscuous testing of varieties is of little avail. When the experimenter takes up one or two distinct lines of variety tests and follows them year by year, he should be able to produce results which are of distinct value.

Next to the pomological interests in New York State are, perhaps, the floricultural interests. These are being watched and experiments are being made with many kinds of florist's plants. Considerable attention has been given to the growing of Easter lilies and to the effect of the electric light and other treatment of the crop. These results have not been published. Coincident with these are continuing experiments on the chrysanthemum. A large line of annual flowers is being grown for the purpose of studying varieties, methods of culture, and the like. The Station has also had a very large collection of pelargoniums and of these, after many of the unimportant varieties are sorted out, the number now comprises several hundred names.

Some years ago the Horticultural Division undertook a series of systematic studies on the winter forcing of vegetables. Whilst this subject is not now neglected, it is nevertheless the desire to give chief attention during the winter months for a few years to the forcing of fruits. Already nectarines, apricots, peaches and cherries have been fruited with gratifying success, and the problems which are associated with the industry are becoming understood. The Division is also making a study of various problems associated with the growing of mushrooms.

The Division is also growing a full set of the peaches which comprise what is known as the national peach experiment. Duplicates of these trees are growing in many of the experiment stations, and it is expected that results of distinct value will be secured when the fruiting period arrives. Although these trees were propagated in Florida, they have withstood our climate remarkably well, only one variety having failed outright. Some of the trees are bearing the present season.

The subjects associated with the spraying of plants are always to the fore. The testing of new machinery and new mixtures is carried on every year. However, the Department has taken the ground that it does not desire to test all the new compounds which are put on the market merely because they are new. This position is similar to that which it has assumed in the testing of varieties. When persons send us seeds of a new variety, we reply that we are making no effort to test all the varieties of horticultural plants, but that if the variety in question belongs to a group to which we are giving special attention, we will grow it and report. When new insecticides and fungicides have gained a sufficient standing that horticulturists ask us for our opinion, we are ready to test them ; but there are so many of these compounds coming into the market each year that it seems to be scarcely worth while to give each one of them the laborious test and scientific study which would be demanded of a thorough-going investigation.

More and more the Division is being asked for advice by the horticulturists of the State. We believe that a great part of the efficiency of the Division in the future will lie in the giving of personal advice and the answering of specific questions from correspondents.

Respectfully submitted,

L. H. BAILEY.

REPORT OF THE ASSISTANT PROFESSOR OF DAIRY HUSBANDRY AND ANIMAL INDUSTRY.

To the Director of the Cornell University Agricultural Experiment Station.

SIR:

The work of the Dairy Division of the Experiment Station has been continued during the year mainly along the lines of previous investigation and three bulletins, viz. No. 171, "Concerning Patents on Dilution Separators;" No. 173, "The Relation of Food to Milk Fat;" and No. 178, "The Invasion of the Udder by Bacteria," have been published. An investigation upon the usefulness for food of sugar beet pulp has also been made during the year. This matter is exceedingly timely at present, and the results of the investigation will be published shortly.

A work of considerable importance in the Dairy Division has been the supervision of butter records of thoroughbred cows at the homes of the owners. This work has been undertaken at the request of several of the Breeders' associations and is done in accordance with the rules subjoined.

Conditions Governing Butter Tests of Thoroughbred Cows.

The Cornell University Agricultural Experiment Station will send an authorized representative to supervise the milk and butter record of thoroughbred cows for any one desiring such tests made, upon the following conditions:

First—All tests shall be for seven consecutive days.

Second—The person for whom the test is made will pay all expenses in connection with the test, and the compensation for the station representative conducting the test shall be $2 per day for each day of the test, unless otherwise arranged. The person for whom the test is made will also pay the necessary traveling expenses and provide for the accommodation of the station representative while conducting the test.

Third—The cows shall be wholly under the control of the owner so far as kind and amount of food, time of milking and general treatment are concerned, but the representative of the Station shall have access to the cows at all times, in company with the owner or his representative.

Fourth—The station representative will be required to make a report of the kinds and quantity of feed given during the test.

Fifth—The owner shall furnish a statement of the name and herd book number of the cow, her age, and the time at which she dropped her last calf.

Sixth—The records of all tests shall be the joint property of the owner of the animals and of the Cornell University Agricultural Experiment Station for purposes of publication.

Seventh—Immediately after the the completion of the test, the Cornell University Agricultural Experiment Station will give to the owner, over the signature of its proper officer, a properly verified statement of the amount of milk and fat produced by each cow during the test.

Eighth—The Cornell University Agricultural Experiment Station will arrange dates, so far as possible, to suit the owners, but it cannot agree to make a test for any one at any specified time.

Parties having cows which they wish tested under these conditions should correspond with H. H. WING,

Professor of Dairy Husbandry,
Cornell University,
Ithaca, N. Y.

Directions for Station Representative in Conducting Official Tests of Dairy Cows.

First—The representative of the station shall see the cow or cows milked dry before the beginning of the test, and the test shall end seven days thereafter at the same hour.

Second—He must be present at each milking during the test and satisfy himself that at the close of each milking the pail contains nothing but the milk drawn from the cow under test.

Third—Under no circumstances shall more than one cow be milked at the same time. The station representative shall keep the milker in full view during the whole time of milking. Where more than one cow is under test the cows shall be milked in the same order at each milking.

Fourth—Immediately after the milk is drawn the station representative will weigh the same on balances provided by the experiment station and enter the exact weight of milk at once on his records. He will then sample the milk as follows:

Fifth—Immediately after weighing, the milk must be poured from one pail to another, then with a dipper, the milk must be stirred at least three times, from the bottom, taking care to empty the dipper each time. From the last dipperfull take half a pint or more for the test sample. This test sample must remain in the possession of the representative or under his lock and key till the test is complete. Testing shall be done immediately after milking except when a milking is made at or near midnight.

Sixth—Tests are always made in duplicate and the test sample must be preserved until a perfectly satisfactory test of the same has been made.

Seventh—If any of the milk or the test sample from a milking is accidently lost or is otherwise imperfect, it must be so reported with a note as to the character of the accident or omission.

Eighth—At the time the test of each milking is made, a sample comprising as many cubic centimeters as the number of pounds in the milking, is taken for a composite sample of the whole test. Sufficient preservative must be used and the representative must be responsible for such composite sample till it is delivered to the proper officer of the station for a check test.

Ninth—The station representative is not at liberty to waive or vary these directions in any particular.

This work has been done largely by advanced and graduate students and as it is done at the expense of the individual owner it makes no burden upon the resources of the Station and at the same time affords a large mass of valuable material for the study of milk secretion. During the past year the butter records of about one hundred and fifty cows, for seven days each, have been so supervised.

Under the Agricultural Extension Mr. W. W. Hall, Instructor in Cheese Making in the Dairy Course, has devoted considerable time with excellent results in visiting and giving help and expert advice at creamery and cheese factories throughout the State. Sixty-five factories in thirty-three counties have been so visited during the year.

The Dairy Division of the Experiment Station has suffered a loss in the resignation of Mr. LeRoy Anderson who for the two years past has been Assistant in the Division. Mr. Anderson leaves to establish a department of Animal Industry and Dairy Husbandry in the University of California. His services here have formed an important part of the work in this Division.

Respectfully submitted,

H. H. WING.

APPENDIX I.

BULLETINS PUBLISHED JUNE 30, '99—JULY 1, 1900.

No. 171. Concerning Patents on Gravity or Dilution Separators.
No. 172. The Cherry Fruit-Fly; A New Cherry Pest.
No. 173 The Relation of Food to Milk-Fat.
No. 174. The Problem of Impoverished Lands.
No. 175. Fourth Report on Japanese Plums.
No. 176. The Peach-Tree Borer.
No. 177. Spraying Notes.
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No. 179. Introduction to Field Experiments with Fertilizers.
No. 180. The Prevention of Peach Leaf-Curl.
No. 181. Pollination in Orchards.
No. 182. Sugar Beet Investigations for 1899.

Bulletin 171. **July, 1899.**

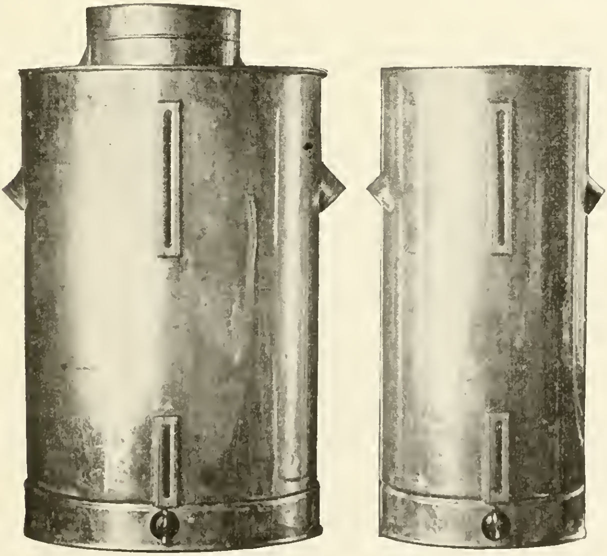
Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

DAIRY DIVISION.

CONCERNING PATENTS ON

Gravity or Dilution Separators.



By HENRY H. WING.

PUBLISHED BY THE UNIVERSITY,

ITHACA, N. Y.

1899.

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CONCERNING PATENTS ON GRAVITY OR DILUTION SEPARATORS.

In Bulletin No. 151 published in August, 1898, the efficiency of these creaming devices was summed up as follows:

"Gravity or dilution separators are merely tin cans in which the separation of cream by gravity process is claimed to be aided by dilution with water.

Under ordinary conditions the dilution is of no benefit. It may be of some use when the milk is all from 'stripper' cows, or when the temperature of melting ice cannot be secured.

These cans are not 'separators' in the universally accepted sense of that term and cannot rank in efficiency with them.

They are even less efficient than the best forms of deep setting systems, such as the Cooley Creamer.

They are no more efficient than the old fashioned shallow pan; but perhaps require rather less labor."

These conclusions have since been abundantly confirmed though there seem to be many who desire to use these cans on the score of the less labor required even though there may be in most cases some loss of fat.

One of the chief misleading features used by the promoters of this system is the way in which the term separator is used to imply that the dilution process is equal in efficiency to a centrifugal separator. This is well shown by the following quotation from a recent circular of the "Wheeler's Gravity Cream Separator."

"Those that keep only one or two cows, as well as the large dairyman, can have the advantage of a separator at a small cost, compared with the centrifugal separator or creamer."

In another way would-be users of the dilution process are being mislead and this is in regard to the patents that have been issued or applied for on the dilution process or on the various styles of cans in which it is to be used. At the present time certain parties are going about the state claiming a royalty from any who may be using the dilution process in any form of can but their own. The following is a type of the inquiries we are receiving concerning the matter.

———N. Y., MAY 26, 1899.

Cornell University Experiment Station :

There is in this vicinity an agent for the Wheeler Gravity Separator, who is trying to stop us from using every other separator or can of every description except his own, claiming that his manufacturer has a patent on the process, and that we have no right to mix water with our milk for the purpose of raising the cream, except by using his cans or by paying a royalty to his manufacturer. Respectfully,

———

This and similar inquiries have led us to make a careful examination of the files of the *Patent Office Gazette* and we find that during the past year numerous patents have been granted on various forms of gravity separators and creaming cans. Briefly described they are as follows:

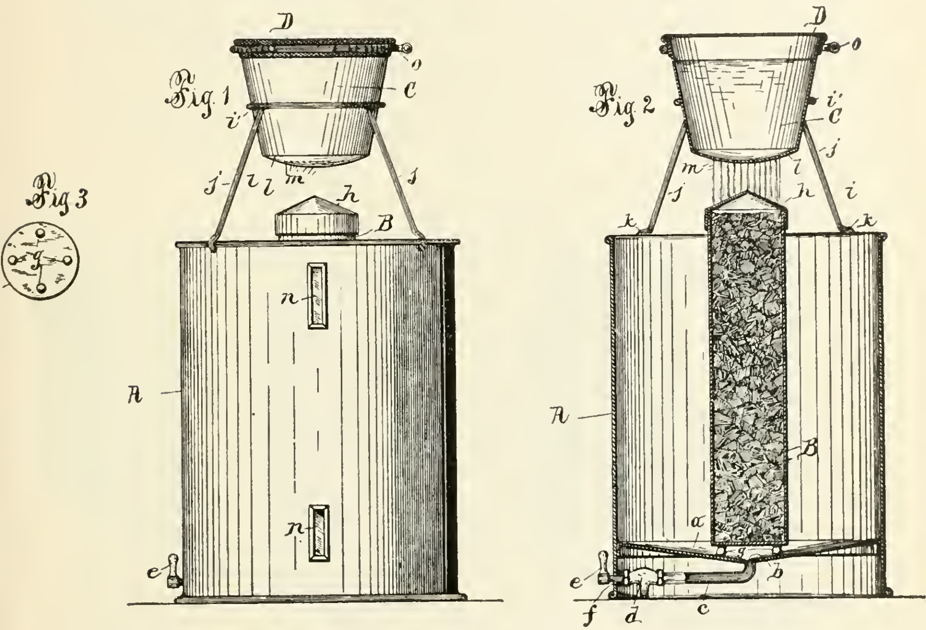
THE AQUATIC CREAM SEPARATOR.

This is manufactured under patent No. 605,252, granted June 7, 1898, to C. L. and F. G. Lee. Its character is shown by the following extract from the specifications and the claim under which the patent was granted.

"The improved results obtained by our apparatus are as follows: The milk is poured through the strainer D into the aerator C, whereby the sediment is removed therefrom. The milk then passes through the perforated bottom *l* of the aerator and is sprayed upon the conical top of the cover *h* of the cooler B, whereby it is deprived of its animal heat, and thence passes down the outside of the cooler. It is then allowed to stand until the temperature thereof is reduced sufficiently in order to prevent congealing of the same. The milk is then diluted by the introduction of water and is allowed to remain tranquil a sufficient period of time to allow the cream to rise to the top thereof, which action can be readily ascertained by means of a sight-glass *n*, secured in the side of the can A.''

''What we claim is—

An apparatus for separating cream from milk comprising a milk-can provided with a centrally-depressed bottom and hav-



1.—*The Aquatic Cream Separators.*

ing an outlet in the center of said bottom, a cooler within said can and provided on its bottom with feet supporting the cooler over said outlet with passages under the cooler, said feet serving to prevent eddying of the outflowing liquid and causing a draft of said liquid equally from all sides of the can to the outlet and also promoting the discharge of the sediment from the bottom of the can substantially as described.''

It will be seen that the peculiarity of this apparatus consists in the central cooler supported upon little legs over the outlet in the center of the bottom of the can and that while dilution is mentioned in the specifications as essential to the ''improved results" the claim is on the form of the can only and not upon the dilution. As a matter of fact this "separator" was at first made without legs to the cooler and with the outlet at the side, thus entirely ignoring the claim. A recent letter from the manufacturers says, "We are making the 'Aquatic' Cream Separator under patent No. 605,252, granted June 7, 1898. We also manufacture cheaper cans for the dilute process, but of course know that they will not do as good work."

THAYER'S CREAM SEPARATOR.

This constitutes patent No. 608,311, granted August 2, 1898, to Julius W. Thayer of Milton, Iowa.

The following extract from the specifications shows that dilution is considered an important part of the process though nothing whatever is said about it in the claim.

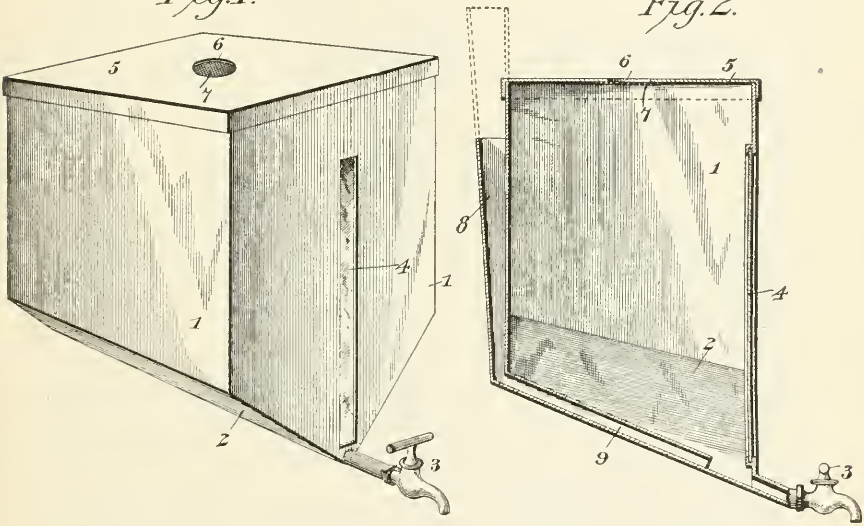
"In operation the milk while warm (as immediately after milking) is strained and introduced into the receptacle, after which water at a lower temperature than the milk (and preferably at a considerably lower temperature) is introduced through the tube 8 and gains access to the interior of the receptacle at the lowest point thereof. Obviously the extension of the inlet-tube approximately throughout the longitudinal center of the bottom of the receptacle has the effect of chilling the contiguous portions of the contents, and as the water enters and commingles with the milk the chilling thereof results in the separation of the cream which, rising to the top, remains supported by the heavier contents of the receptacle until the latter have been withdrawn through the faucet. The mixture of milk and water may be withdrawn to lower the level of the under surface of the cream to the most depressed point of the bottom of the receptacle, this point in the operation being visible through the sight-pane.

"It will be seen that in addition to the advantage gained by introducing the cooling agent at the lowest point of the bottom of the receptacle the inclination of the longitudinal center of said bottom and the lateral inclination of the side portions of the bottom have the effect of concentrating a lower stratum of the contents contiguous to the faucet, whereby in drawing off the milk almost the entire quantity thereof may be removed without disturbing the cream. The usual time necessary for accomplishing the complete separation of the cream from the milk is from twenty to thirty minutes, as I have discovered in practice."

"Having described my invention, what I claim is—

1. A cream-separator having a receptacle provided with a bottom of which the side portions are inclined downwardly and inwardly to the longitudinal center thereof, said longitudinal

Fig. 1. Fig. 2.



2.—*Thayer's Cream Separator.*

center being inclined downwardly from the rear toward the front wall of the receptacle, a faucet communicating with the receptacle at the most depressed point of its bottom, and an inlet-tube having an exposed inlet end, and an extension 9 arranged within the receptacle upon the inclined longitudinal center of its bottom, with its outlet end located contiguous to the said most depressed portion of the bottom of the receptacle, substantially as specified.

2. A cream-separator having a receptacle of which the bottom is inclined laterally from the side walls toward a central longitudinal line, this longitudinal center being inclined downwardly from the rear toward the front wall, a removable cover fitted upon the receptacle and provided with a ventilating-opening fitted with a gauze screen, a faucet communicating with the interior of the receptacle at the lowest point of its bottom, a vertical sight-pane through which the contents of the receptacle may be observed, and an inlet-tube having an exposed inlet end, and arranged at its outlet end contiguous to said depressed point of the bottom, an intermediate portion of the inlet-tube extending through the receptacle, substantially as specified."

The peculiar feature of this "separator" seems to be the tube through which the water is added. A letter addressed to the inventor was returned undelivered and it is not likely that this machine is on the market.

PHILLIPS' CREAM SEPARATOR.

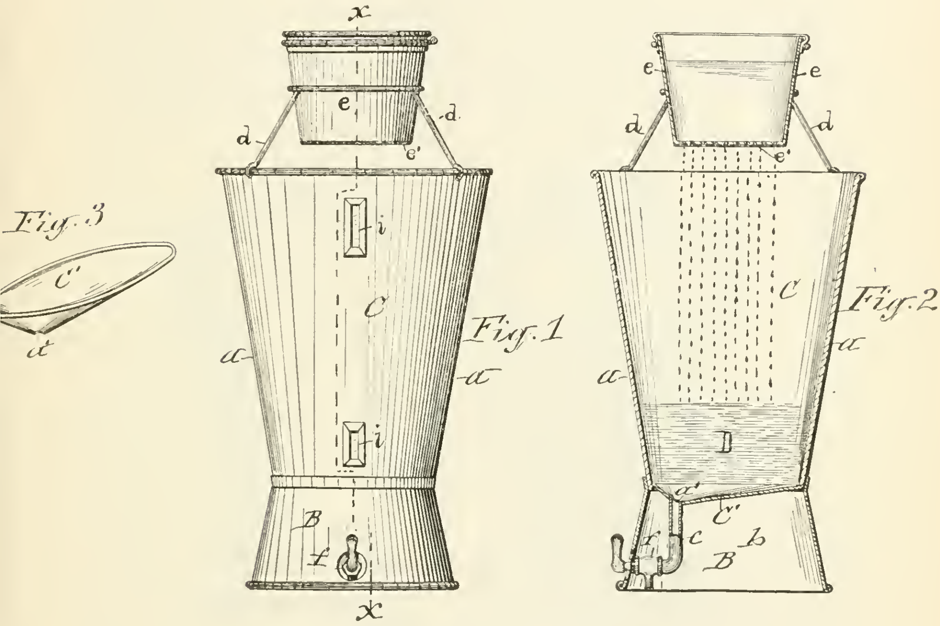
The patent on this "invention" is No. 609,461; it was granted Aug. 23, 1898, to John E. Phillips, Central Square, N. Y., and its operation and the claims for the patent are described in the following fanciful language:

"By practical tests it has been found that the separation of the cream from the milk is promoted by dilution of the milk, and this has been usually done by pouring water into the milk at the time of setting the same to allow the cream to rise to the surface of the diluted milk.

"The object of my present invention is to effect the separation of the cream from the milk more perfectly and expeditiously by dilution of the milk during the process of separating the cream therefrom; and to that end the invention consists in causing the milk containing the cream to fall in separate drops upon the surface of a tranquil body of water or suitable diluting liquid, and thereby diluting each drop separately and causing the cream thereof to be gathered on the surface of said liquid during the dilution of the drop. Said drops falling upon the water in the can, each drop is diluted separately and the cream thereof is detained upon the top of the water, while the milk becomes commingled with the water. In this manner the process of separating the cream from the milk is very much expedited and the separation is rendered more positive and effectual.''

''What I claim as my invention is—

The within described process of separating cream from milk by specific gravity, consisting in causing the creamy milk to fall



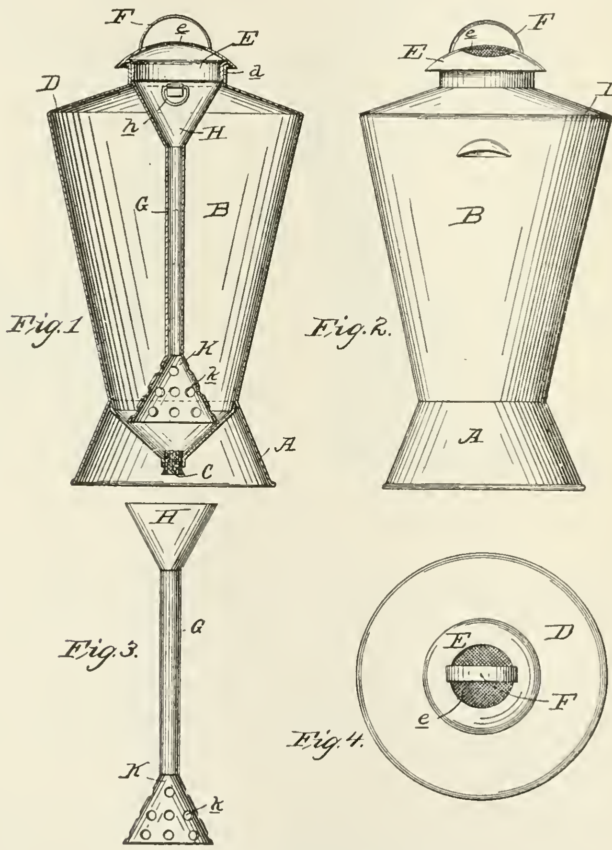
3.—*Phillips' Cream Separator.*

in separate drops through the air onto the surface of a tranquil body of diluting liquid, and thereby diluting each drop separately, and by the gentle diffusion of the milk of the successive drops in the diluting liquid causing the cream thereof to become separated from the diluted milk and form a stratum of cream upon the surface of the tranquil liquid, and subsequently drawing the diluted milk from under the supernatent stratum of cream as set forth.''

Without raising the question of the advantage or disadvantage of diluting ''creamy'' milk, would-be users of the dilution process may be assured that they are in danger of infringing the Phillips patent only when they "dilute each drop separately." However desirable it may be to "dilute each drop separately," it is extremely doubtful if it can be done even by using the Phillips can.

RECTOR'S CREAMING CAN.

The patent on this can is No. 611,275. It was granted Sept. 27, 1898, to Jas. A. Rector, Lancaster, Mo. The peculiar feature of this can seems to be the central tube or "distributing head"



4.—*Rector's Creaming Can.*

through which the water is introduced. While dilution with water is an essential feature of the operation of this can, as is seen by the following extract from the specifications, it will be further noticed that nothing whatever is claimed for dilution in the "claim" under which the patent is granted.

"In operation the milk is first placed in the can. The distributing device is then inserted. Water of low temperature is afterward introduced into the funnel at the top of the distributer. The water, being cold, immediately settles to the bottom, and being distributed regularly through the apertures of the distributing-head of the distributer, rises through the bottom of the can, carrying the particles of cream upward, while the blue milk is assimilated, the cream floating on the top. The milk is allowed to stand in this condition for a few moments, and the water and blue milk are then drawn off through the opening in the bottom of the can, leaving the cream in the can, from which it may be drawn at any time through the bottom opening.

"I have found that cream can be separated from the milk very rapidly by this means and with but little trouble, the animal heat of the milk passing off through the perforated top."

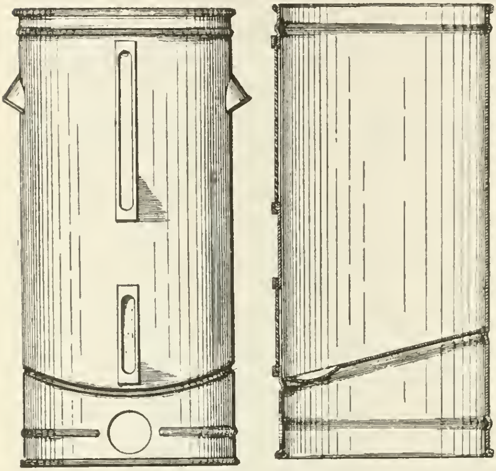
"Having thus described the invention, what is claimed, and desired to be secured by Letters Patent, is

In a creaming-can the combination with the can-body having a conical base formed with a discharge-opening in its apex, and a neck,of a distributing device located wholly within the can and consisting of a tube having a funnel-shaped upper end positioned in the neck and a perforated distributer at the lower end of the tube resting on the bottom, substantially as described."

WHEELER'S GRAVITY CREAM SEPARATOR.

Although several rivals secured patents earlier, this is claimed to be the only "true and original" gravity separator. On Nov. 22, 1898, a patent (No. 29,715) was issued to G. T. Wheeler, Mexico, N. Y., on the *design* for a can as shown in the cut. So far as we have been able to discover the only novel feature of this can lies in the fact that the bottom is both curved and slanting. Up to August, 1898, this separator was made and sold with a flat bottom, so that the peculiar shape of the bottom cannot be considered as essential even by the "inventors."

It is this concern that has been most strenuous as to the advantages of dilution and their extravagant claims as published in Bulletin No. 151, have been frequently copied and adopted by the manufacturers of the other styles of cans. It is the agents of the Wheeler separator too, that we have most frequently heard of as claiming a patent on the process of dilution and demanding a royalty therefor. We are personally assured by the manager however, that they are not now claiming a patent on the process and are so instructing their agents.



5.—*Wheeler's Gravity Cream Separator.*

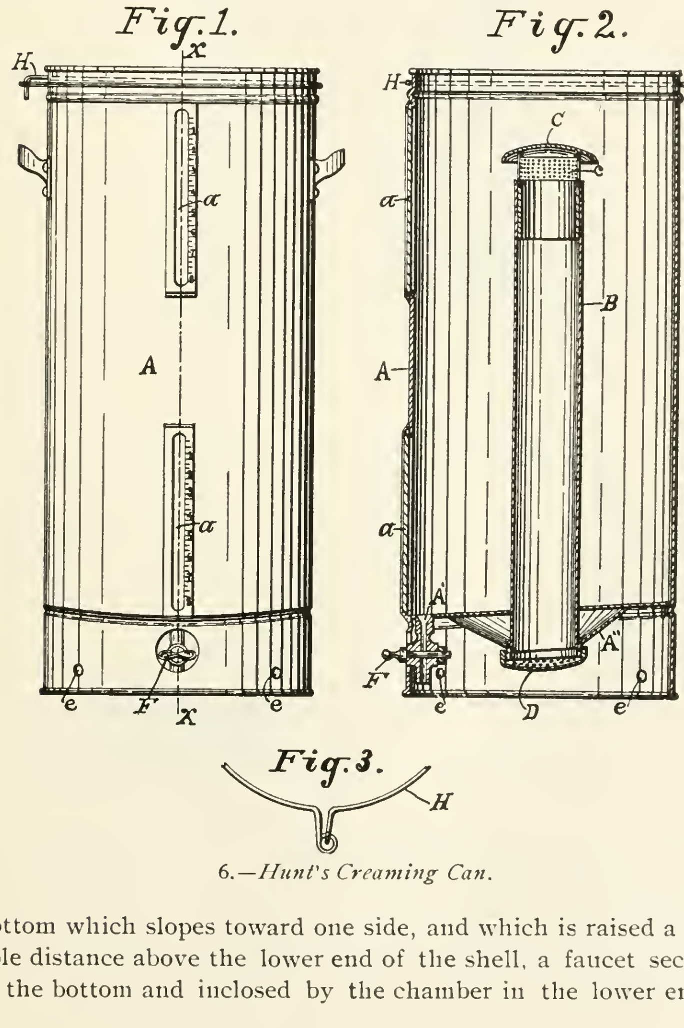
HUNT'S CREAMING CAN.

The patent on this can is No. 619,753 and it was granted Feb. 21, 1899, to Henry S. Hunt, Cato, N. Y. Its essential features are shown in the following extract from the specifications and the claim in full:

"In operation my invention of improved creaming-can is used as follows: Equal quantities of milk and water are placed in the vessel A, being run through a straining cloth secured over the top of the can, and the mixture is permitted to stand in the vessel A until the cream rises thereon, during which time the cap C is held in the position shown in Fig. 2, where the wire-cloth *c* is elevated above the tube B, so as to permit the free passage of air through said tube B for the purpose of providing a sufficient draft to carry off any deleterious gases which might arise from the milk and water, or which might otherwise be permitted to contaminate the cream."

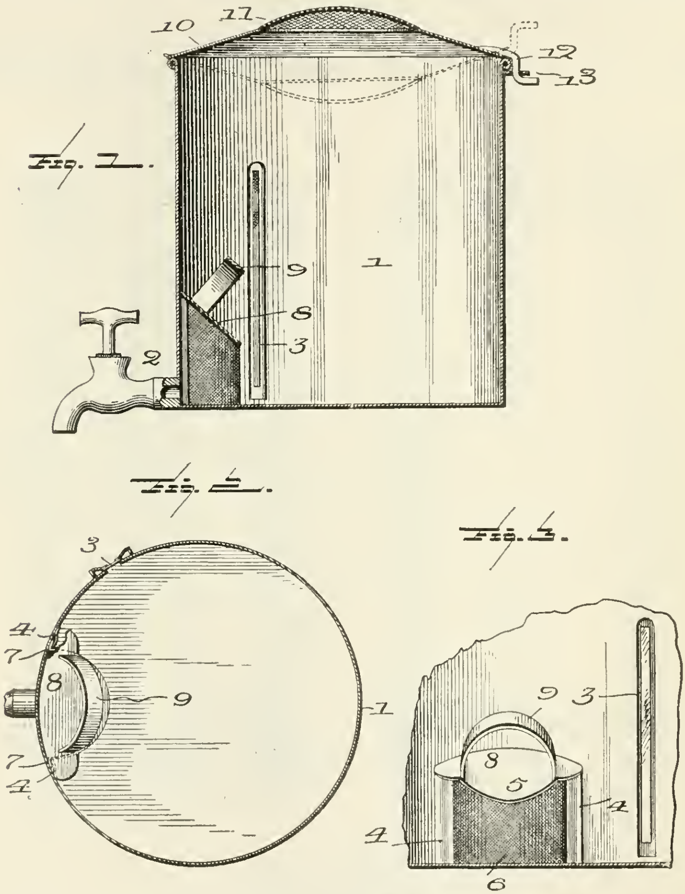
"Having described my invention, what I claim as new, and desire to secure by Letters Patent, is—

In a creaming-can, the cylindrical shell A, provided with a



6.—*Hunt's Creaming Can.*

bottom which slopes toward one side, and which is raised a suitable distance above the lower end of the shell, a faucet secured to the bottom and inclosed by the chamber in the lower end of the shell, and a central draft-tube which extends vertically in the shell within a short distance of its top, and which tube has its lower end to extend a suitable distance below the bottom, and



7.—*Rosback's Cream Separator.*

which tube has its lower end braced by the portion A (see cut), combined with a perforated cover D which is placed over the lower end of the tube, and the cap C placed above the end of the tube and provided with suitable perforations, substantially as shown and described."

It will be noticed that nothing whatever is said in the claim as to dilution and that the peculiar feature of the can rests in the "ventilating" tube passing through the middle of the can. This feature in actual practice has not only proved to be of no advantage but is a decided nuisance in washing and handling the can.

ROSBACK'S CREAM SEPARATOR.

This is a can patented by Joshua A. Rosback, Hermon, N. Y. The patent is No. 624,100 and was granted May 2, 1899. As will be seen by the extracts below, while dilution is recommended, the claim for the patent covers only the form of the strainer over the port to the faucet.

"The mode of practicing the invention is as follows: The milk is taken direct from the cow and placed in the can, and an equal amount of fresh cold water is added. The can is then placed in a cool place and is permitted to stand. The cream will rise to the top and the milk and water will settle to the bottom of the can."

"Having described my invention, what I claim as new, and desire to secure by Letters Patent, is—

A cream-separator consisting of a can, a faucet located near the bottom thereof, a convexed strainer located over the port to the faucet, the top of said strainer being imperforate and slanting at an angle toward the center of the can."

DOTY'S CREAM SEPARATOR.

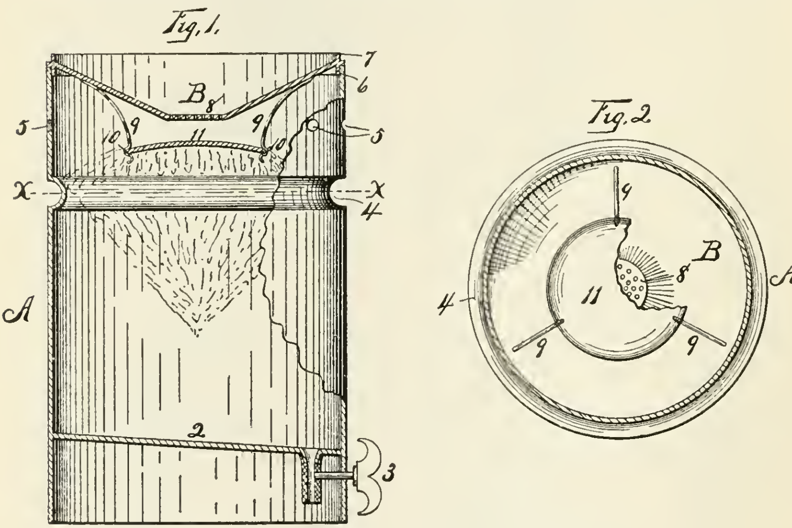
This was patented May 2, 1899, by Ellsworth P. Doty, Cato, N. Y., and bears the number 624,194. This like all the others mentions dilution as a part of the process, but the claim is only on an unimportant part of the can as the following extract from the specifications shows.

"The milk poured into the concave top or hopper is strained, falls onto the sprayer, flows over its surface, is discharged from its edges in streams, more or less of which fly against the convexity or neck-wall of the can and are thereby broken up into drops, which are deflected toward the center of the can or flow down over its innner walls and are thereby thoroughly aerated, the heated or displaced air flowing out through the vents, carrying with it the animal odor of the milk.

"If water is used to dilute the milk and expand the cream-globules to facilitate or quicken the raising of the cream, a sufficient quantity is first placed in the can and the milk falls into it."

"Having described my invention, what I claim, and desire to secure by Letters Patent, is—

In a cream-separator, the combination with a can having a constricted neck of a reversible concavo-convex cover having



7 —*Doty's Cream Separator.*

upward and downward flanges adjacent to its edge and in alinement with each other, a strainer at the center of said cover, spring-fingers separately secured to the convex side of said cover on converging lines and diverging from it, and a concavo-convex sprayer removably supported by said fingers adjacent to said extremities whereby the milk is thrown from said sprayer against said constricted neck and is thereby broken up."

In addition to these, two patents on designs have been recently issued, one, 30,741, on May 9, 1899, to Simon Reinsberg, Quincy, Ill., for a distributor similar to Rector's, the other 30,962 on June 6, 1899, to Frank C. Hawkins, Breesport, N. Y., for the bottom of a can similar to Wheeler's.

A striking similarity is observable in all these patents. In none of them except Phillips' is dilution mentioned in the claim, and there it covers not the dilution itself but the manner of it. In all of them, however, dilution is mentioned in the description as an essential part of the process. It would seem, therefore, that in patenting some minute or unessential feature of the can these people have sought to convey to the uninformed the idea that the whole can, process and all was subject to the patent. This is further borne out by the attempt in some cases to collect royalty from people using the dilution process in Cooley or other cans. Since some manufacturers have stated that an application has been made for a patent covering the process of diluting milk with water to facilitate the raising of the cream, it may be well to look into the matter of the possibility of such a patent being granted.

In the language of the patent office an invention, in order to receive a patent, must present "novel, useful, and patentable subject matter." Waiving altogether or granting entirely the usefulness and patentability of this process let us look only into its novelty. The process was certainly well known as early as 1890, for in that year it was the subject of investigation and report by at least three Agricultural Experiment Stations* in widely separated parts of the country. It has been argued that these reports, since they did not recommend the practice, should not be considered as evidence that the process was "well known and in common use." But one, at least, of the publications cited† did strongly recommend the process, and if recommendation were necessary to constitute publicity it would be easy to find it in the agricultural and dairy press of that period. The late Col. F. D. Curtis, to the personal knowledge of the writer, strongly recommended the dilutive process at numerous

*Vt. Agr. Expt. Sta. Newspaper Bulletin No. 3; Cornell Univ. Agr. Expt. Sta. Bull. No. 20, and Univ. of Illinois Agr. Expt. Sta. Bull. No. 12, p. 376.

†Vt. Agr. Expt. Sta. Bull. No. 3.

farmers' institutes in this state during the winters of 1889–90 and 1890–91, and frequently also recommended it in the press.*

Prof. E. F. Ladd, then of the State Agricultural Experiment Station at Geneva, now of the North Dakota Agricultural Experiment Station, also recommended† it under certain conditions, and it was frequently mentioned by other writers. It is also recommended for use in connection with the Cooley creamer in circular No. 214 of the Vermont Farm Machine Co., page 10. Under date of May 31, 1899, Mr. N. G. Williams, the manager of the company, informs me concerning the above. "These particulars were in April, 1890, and have been published in our circulars ever since. We had recommended it (dilution) before this." The process was then well known over large portions of the country at least nine years ago, but had almost completely disappeared from public view till revived by these boomers of patent cans about two years ago.

CONCLUSIONS.

Several patents have been granted covering unimportant details of the construction of cans in which the dilution of milk with water is recommended to facilitate the separation of the cream.

Anyone desiring to use this process of doubtful utility is perfectly free to do so without let or hindrance from the holder of any patent right whatever.

The Cornell University Agricultural Experiment Station will esteem it a favor to be put in communication with anyone who is demanding a royalty from persons who are diluting their milk in order to facilitate the raising of the cream.

*_Country Gentleman_, Dec. 12, 1889, p. 945; July 31, 1890, p. 611, and Aug. 21, 1890, p. 662.

†_Rural New-Yorker_, Aug. 16, 1890, p. 527.

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- 166 Sugar Beet Investigations for 1898.
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- 169. Studies in Milk Secretion.
- 170. Tent Caterpillars.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1899.

171. Gravity or Dilution Separators.

Bulletin 172. **September, 1899.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

ENTOMOLOGICAL DIVISION.

The Cherry Fruit-Fly

A

NEW CHERRY PEST

By M. V. SLINGERLAND.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899.

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THE CHERRY FRUIT-FLY.

Rhagoletis cingulata ? Loew.

Order DIPTERA ; sub-family TRYPETINÆ.

The growing of cherries is already an important phase of the fruit industry of New York and neighboring states. And cherry orchards now frequently supplement the few cherry trees often seen in door-yards, in gardens, or along lanes and roadsides. Everyone who eats this luscious fruit when fresh is familiar with the fact that cherries are often "wormy." Most cherry growers now understand that the cause of "wormy" cherries is that arch enemy of the plum—the plum curculio, shown enlarged in figure 9.

9. *The plum curculio, enlarged. The insect which "stings" or makes the crescent cut on the cherry, and is responsible for most "wormy" cherries.*

The crescent cut or "sting" of this little beetle is a very discouraging factor to the cherry grower ; and the resulting white and footless grub, with a brownish horny head, which revels in the juicy fruit, is a familiar and distracting object to most housewives. In view of these discouraging facts, we are somewhat loath to announce to cherry growers, through the medium of this bulletin, that another, and possibly even a more serious insect enemy, has recently appeared in at least one Massachusetts and in several New York cherry orchards. This new cherry pest works in the fruit, as does the plum curculio, and while it is capable of being equally as destructive, it also works in a much more inconspicuous manner. One can usually readily determine when a cherry is "wormy" from the attacks of the plum curculio, but this new pest gets in its work in such a way that the fruit it infests might easily be classed among the fairest and best on the tree, or in the dish on our breakfast table.

From the above statements, cherry growers can readily understand how serious a menace to their business this new pest might easily become, and how important it will be for them to learn all they can about it.

As we made our first acquaintance with the pest only about two months ago, we have had no opportunity to fully investigate its habits, and hence cannot tell its life-story in detail. For the same reason, we have not tested any remedial measures to control it, but, fortunately, we have at hand the literature giving the results of experiments against similar insect pests working in the fruits of European countries and of our antipodal neighbors in Australia, New Zealand and South Africa. This bulletin is therefore simply a preliminary report for the purpose of calling the attention of cherry growers to this new pest, with an account of what measures have been used against similar pests, all with a view of helping the growers of cherries to understand the nature of the enemy and to be on the lookout for it.

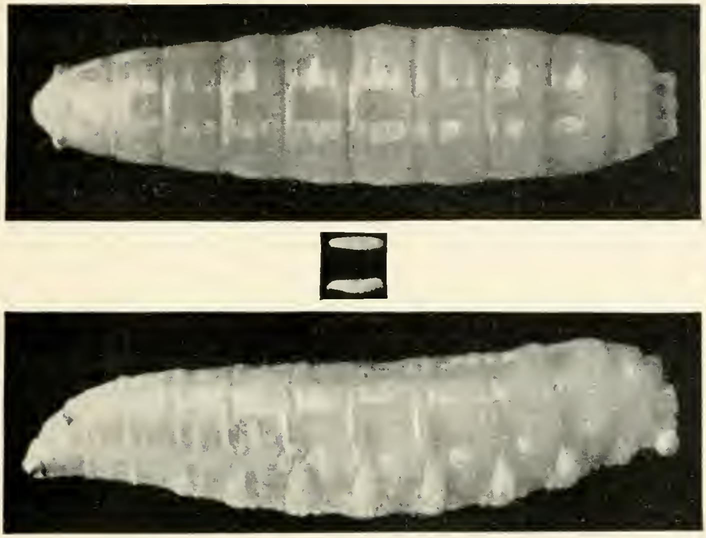
CHARACTERISTICS OF THE NEW PEST.

This new insect enemy of cherries is very different from the plum curculio, which has heretofore been justly accused of being the cause of all "wormy" cherries. The grub of the plum curculio is shown much enlarged in figure 10, while the "worm," which has been found in from one-fourth to one-third of the cherries on some trees the past summer, is shown, natural size and enlarged, in figure 11. As a comparison of these figures will show, this new cherry "worm" is quite different and can be easily distinguished from the *grub* (name applied to the larva of a beetle) of the plum curculio. This new cherry "worm" is instead a true *maggot*, a name given to the larvæ of the two-winged insects—the flies, like the common house-fly.

10.—*The grub of the plum curculio, enlarged. This is usually the culprit found in "wormy" cherries.*

The shape and size of these cherry maggots, when full-grown, are well shown in figure 11. They are of a very light yellowish-white color. From each side of the body near the head pro-

PLATE I.



11.—*Dorsal and lateral views of maggot of the cherry-fly. Natural size and much enlarged.*

12.—*Rhagoletis cingulata Leow. The fly which is supposed to be the adult or parent of the cherry maggot. The fly is shown natural size and enlarged, with wings spread and in the normal position when the fly is at rest. The enlarged wing below illustrates a variation in the markings.*

jects a minute, light-brown, fan-shaped organ, which is the cephalic opening of the breathing tubes; the caudal openings of these tubes or trachea form two peculiar, light-brown, slightly elevated, slit-like openings on the caudal end of the body. The mouth-parts consist of two black, minute, sharp, rasping jaws which usually project slightly from the pointed head.

We have as yet found no characteristics by which we can distinguish these cherry maggots from that common pest of the apple—the apple maggot. And we are not yet sure that this new cherry pest is not the apple maggot in a new rolé.

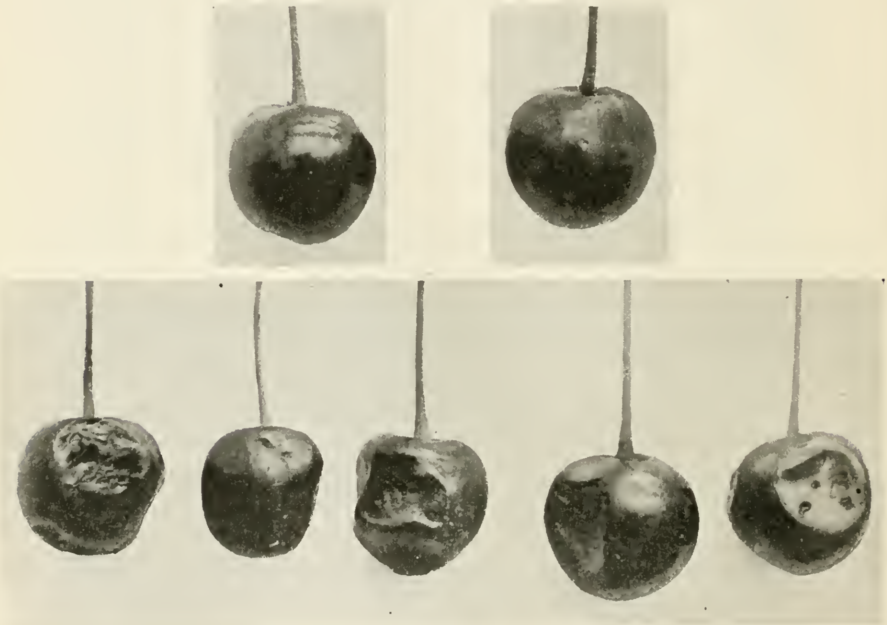
These maggots, which spend practically their whole life in the flesh of the cherry, are the only stage of the insect with which the consumers and most of the growers of the fruit will become familiar.

The maggots hatch from eggs laid by a pretty little fly, resembling in shape, but somewhat smaller than the common house-fly. We cannot know with absolute certainty just what kind of a fly is the parent of the cherry maggot until some of the maggots now in our breeding cages transform into the fly, and this will not take place until next spring. But for reasons to be given later on in discussing the identity of this new pest, we think that the adult form of it is the fly, shown natural size and enlarged, in figure 12. The body of this fly is black, and its head and legs are of a light yellowish-brown color; the lateral borders of the thorax are light yellow; the caudal borders of the segments of the abdomen are whitish; the wings and the scutellum are crossed by four blackish bands and have a blackish spot at their tip; this spot is sometimes confluent with the nearest band, as shown in the enlarged figure of a wing in the lower part of figure 12. The peculiar arrangement of these markings on its wings serves to easily distinguish this fly from any of its near known relatives.

One cherry grower tells us that he saw many of these flies on his trees when the fruit was being picked. He stated that the flies were then somewhat sluggish in their movements, often alighting on the picker's hand. Their black-banded wings render these flies quite conspicuous objects as they flit about from cherry to cherry, so that cherry growers should be able to familiarize themselves with the adult or fly stage of this new enemy.

How and When the Insect Works.

Unfortunately this cherry maggot works in a very inconspicuous manner, so that it will be a difficult matter to determine its presence until the mischief is wrought. All of those who suffered from its ravages the past summer did not know of its presence until their attention was called to it by the con-



13.—*Cherries infested by the Cherry Fruit-fly. All the cherries contained maggots, although the upper ones showed no external indications of being infested. Natural size.*

sumers of the cherries. One grower picked two basketsfull of what seemed to be the fairest and largest cherries, and took them home for canning. When the housewife came to pit them she was much surprised and disgusted to find that many of them were "wormy" with these cherry maggots. The two cherries in the upper part of figure 13 contained maggots, although they were apparently perfect fruits externally. If the cherries are allowed to remain on the tree, or are not used within a few days after picking, the work of the maggot will result in a rotting and sinking in of a portion of the fruit, as is shown by the five cherries in the lower part of figure 13. When this stage is reached, or often even before the fruit shows signs of rotting, the maggots are usually full-grown and soon crawl out of the fruits. One lover of this luscious fruit reports that when some cherries which had been left over from a meal the preceding day, were placed on the table the next morning for breakfast, it was found that several maggots had crawled out during the night. He is now wondering how many maggots were unwittingly eaten the day before !

14.—*Section of a cherry, enlarged, to show the maggot and the nature of its work. The small figures above show the maggot and its supposed parent, the fruit-fly. Natural size.*

The work of this cherry maggot is well illustrated in the enlarged picture of a cherry in section, in figure 14. The maggots feed upon the juicy flesh of the ripening cherry, usually near the pit. They form an irregular, rotten-appearing cavity which is represented by the black cavity near the pit in figure 14. Until the maggots get nearly full-grown their work does not show on the surface of the fruit. Soon after "picking-time," however, the rotting extends to the skin which sinks in. Usually but a single maggot is found in a cherry ; we have sometimes found a second, but always much smaller, maggot in the same fruit. The maggots do not tunnel all through the flesh of the cherry as does the apple maggot in apples.

We have had no opportunity to ascertain when this cherry maggot begins its work in the fruit. The maggot which works in cherries in Europe is said to begin work about the time the fruits are turning red, and there are indications that our new American pest begins about the same time. It is doubtful if the maggots feed more than three weeks in the fruit, and most of this must be done in the month of June. The maggots may begin their work in the latter part of May in early varieties of cherries, and we have found them in cherries left on the trees as late as August 5th. We also saw many of what we believe to be the adult insect on the cherries at this late date ; Mr. Lowe reports finding young maggots in fruits as late as August 16th. Our Massachusetts correspondent reports that some of his cherries began to " spoil " even before they had fully matured.

VARIETIES OF CHERRIES ATTACKED.

The European cherry maggot is said to confine its work to the sweet and sub-acid varieties, but its new American congener seems to be less particular in its tastes. The Massachusetts parties who first called our attention to the insect write us that " all our cherries were badly infested, the Downer and the black ones, but the Morellos were the worst." At Ithaca, N. Y., only the early varieties are reported infested ; while at Geneva, N. Y., the insect confined its work this year mostly to the English Morello and the Montmorency varieties, the latter being the worst infested. It thus seems that the pest may attack all varieties of cherrics whether sweet, sub-acid, or sour, or whether early or late ; the Morello and Montmorency varieties seem to have suffered the most this year.

IT MAY ATTACK PLUMS OR PRUNES.

One grower at Geneva, N. Y., reports that he fears the same insect worked in his prunes last year. Ten years ago maggots were found working in both cherries and plums in Northern Michigan. These were thought to have been the apple maggot, but we believe they were identical with those which have worked in the cherries of New York and Massachusetts this year. Our correspondents report that thus far this year they have found no indications of the maggots in their plums or prunes. It would not be surprising to find the maggots working in these fruits, which are oftentimes grown nearby, as they are not very dissimilar in their nature to the cherry. Thus growers of plums and prunes, as well as of cherries, should familiarize themselves with this serious menace to their business. Should anyone find maggots or "worms" of any kind in plums or prunes, we would like to be notified of the fact at once.

ITS DISTRIBUTION AND DESTRUCTIVENESS.

We have evidence of the work of this new cherry pest this year from Belmont, Mass., and Ithaca and Geueva, N. Y. The fly which we found on the fruit at Geneva, and which we feel quite sure is the adult insect, is recorded from the Middle States only. It was doubtless the same insect which worked in Northern Michigan ten years ago, as noted above. Thus cherry growers in the Eastern, Middle and Northern States should be on the lookout for the pest.

At Belmout, Mass., about one-third of a six or seven-ton crop of cherries were ruined by the maggots this year. The pest also destroyed from one-fourth to one-third of the crop of English Morello and Montmorency cherries in one orchard at Geneva, N. Y. These facts show that the new pest will become a serious menace to cherry growing in certain sections. Another serious phase of the matter is the fact that the presence of the pest may not be known until the fruit gets into the hands of the consumers, and such fruit will not help in making future sales to the same parties.

ITS HISTORY, IDENTITY AND NAME.

So far as we can find there are recorded but two earlier instances where maggots have been found in cherries in America.* For more than a century European cherry growers have suffered from the ravages of a maggot in the fruit. The first record we

*Although the bibliography appended to this bulletin includes several references to cherries being found infested by maggots, it may be noted that the records of Cook, Cordley and Davis all refer to the same case of infestation.

find of maggots in cherries in America was made by Dr. Hagen, of Cambridge, Mass., in 1883. That year maggots were very common in the fruit of a black cherry tree imported fron Prussia and set in his garden ten years before. He found no differences between his maggots and pupæ and those of the European cherry maggot, but stated that this was not sufficient evidence to prove the specific identity of the two cherry pests. He expected to raise the adult insect and thus settle the identity of our American cherry maggot, but evidently he did not rear the fly, as we are informed that no flies or even any of the maggots are to be found in the collections at Cambridge. It is an interesting fact that we received our first intimation of the existence of such a pest from Belmont, Mass., which is only a few miles from where Dr. Hagen found cherry maggots in 1883.

In 1889, specimens of cherries and plums badly infested with maggots were received at the Michigan Experiment Station from northern Michigan. Brief notices of this infestation were soon published (see bibliography) by Cook, Cordley and Davis. Cordley stated that "from the accounts of our correspondents describing the attack, and from a close examination of both the larva and pupal stages of the insects received, the cherries and plums seem to be badly infested with *Trypeta pomonella* (the apple maggot). Whether these are the descendants of small Trypetas which had formerly acquired a taste for apples, or whether certain individuals of those feeding upon the hawthorn have 'dropped their plebeian tastes and adopted a more refined table regimen,' it is unsafe to say, but from the fact that the apple maggot has never been known to attack the apple of northern Michigan, and from the fact that while the apple maggot is abundant on hawthorn everywhere in Michigan, and as it has not attacked the cherries nor plums elsewhere, it seems probable that a cherry and plum loving race of the apple maggot has developed or is being developed in northern Mchigan, directly from those which fed upon the hawthorn." Unfortunately none of the adult insects seem to have been bred, and we are informed that even none of the maggots are to be found in the Michigan College collection.

Some of the Geneva cherry growers noticed a few maggots in their cherries last year, and we are informed that they have been seen at Ithaca for a year or more, while our afflicted correspondent at Belmont, Mass., reports that they think their fruit has been infested for the last four or five years, but not nearly so bad as this year.

While there seems to be no evidence extant to ever enable one to determine just what insect is responsible for these two earlier records of maggots in cherries, yet we think the cherry maggots we received this year are the same as those previously recorded. And we furthermore seriously doubt if this new cherry pest is the same as the common apple maggot (*Rhagoletis pomonella*) in spite of the fact that we, like Cordley, have been unable to distinguish between the maggots found in cherries and those working in apple.

The facts recorded by Cordley, as quoted above, strongly indicate that the cherry maggot is a different and distinct insect, and we submit the following evidence in support of this theory. On August 4th we visited an infested orchard at Geneva, N. Y., and found quite a number of English Morello cherries still on the trees, and one or two trees bore many fruits of what the owner called a "sport" or reversion from the English Morello. Many of the fruits contained the maggots, and we soon saw many of the little flies shown in figure 12, on the trees, *almost always on the fruits*. Several of the flies were captured and found to be a species described in 1862 as *Rhagoletis cingulata*, from the Middle States. This fly is thus a very near relative of the apple maggot (*Rhagoletis pomonella*), and a still more significant point is the fact that Loew, in his original description of the fly we found on the cherries, says it is closely allied to the fly of the European cherry maggot. As Doane (1898) has recorded, six species (one, *zephyria*, may prove to be a synonym) of flies of the genus *Rhagoletis* have been described from the United States. The habits are known of only two of these flies, (*R. pomonella*, the apple maggot, and *R. ribicola*, the dark currant fly) and the maggots of these live in fruits.

As we saw no similar flies on the cherry trees, as we found *Rhagoletis cingulata on the fruits*, in considerable numbers, and in view of the facts just submitted regarding the relationships and probable fruit-feeding habits of this fly, it is easy to understand why we have been lead to think that the fly in figure 12 is the adult of our American cherry maggot, and that, therefore, this maggot is a distinct species from the apple maggot. When the adult insects emerge in our breeding cages next spring, our theory, outlined above, may be demolished, as we may get apple maggot flies or something else entirely unexpected, but this will not materially affect the purpose of this bulletin to record all we have been able to glean regarding an insect, whether old or new, which may certainly be classed as a *new cherry pest.*

For this new cherry pest we would propose the popular name of *the Cherry Fruit-fly*. We prefer this name to *the Cherry Maggot* as it is more expressive of the insect's habits, and similar fruit inhabiting maggots in other countries are known as *Fruit-flies.*

Possible Natural Food-Plants of the Insect.

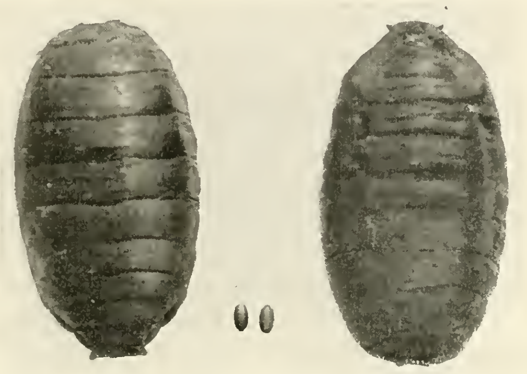
If this cherry fruit-fly turns out to be the well-known apple-maggot fly, then, of course, its native or original food-plant is the hawthorn. But if this new cherry pest is *Rhagoletis cingulata*, or some insect other than the apple maggot, then we must look to the native species of wild cherries, or possibly wild plums, and also to the species of *Berberis* and *Lonicera* for its natural food-plants. The latter plants are mentioned as possible native food-plants of the American cherry fruit-fly because the European cherry fruit-fly is known to breed in several species of *Berberis* and *Lonicera.*

The Story of Its Life.

Having first made the acquaintance of this new cherry pest only about two months ago, we have had, therefore, no opportunity to follow it through its yearly life-cycle. Hence we are unable to tell the story of its life in detail.

How it spends the winter.—The insect doubtless spends the winter in the soil, usually not more than an inch below the surface, in the condition shown, natural size and much enlarged, in figure 15. It is a dark brown, lifeless-looking object known as a *puparium.* Within this hard, stiff, brown shell, which is really the contracted and hardened skin of the maggot, the insect changes from a maggot to a *pupa.* Whether the pupa is formed before spring, we cannot yet say.

Emergence in the spring.—During the spring months the transformation from a pupa to the adult insect—the pretty little fly shown in figure 12—takes place. When the time for emergence comes, the little fly bursts open one end of the puparium (figure 15,) crawls out, works its way up through the inch or less of soil, and then flits away to find its mate and the food-plant for its progeny. As to when these cherry fruit-flies emerge in the spring we have no evidence. The yellow currant fruit-fly (*Epochra canadensis*) sometimes emerges in May, but the nearer relatives of the cherry fruit-fly, the dark fruit-fly (*Rhagoletis ribicola*) and the apple maggot fly (*Rhagoletis pomonella*) may emerge about the middle of June in the latitude of New York. Hence, we would infer from this that the cherry fruit-fly may be expected to emerge about June 15th, in New York. The date of appearance of the flies on the trees will doubtless vary somewhat with the latitude and the season. The flies will doubtless continue to emerge over a considerable period, perhaps a month or more ; the flies which we suspect are the adults of this pest were found on the fruit as late as August 4th.



15.—*Dorsal and ventral views of the puparia of the cherry fruit-fly. Natural size and enlarged.*

Egg-laying.—We have not seen the fly lay an egg, but think we have found its eggs in the cherries. We found many minute punctures through the skin of the fruits, and obliquely just beneath the skin in the flesh we could discern the remains of a hatched egg. In a few cases we found an unhatched egg, but always crushed it before we could disengage it from the flesh of the fruit. Hence, we are unable to describe or picture the egg. We feel quite sure, however, that the mother fly punctures the skin of the fruit with her ovipositor and then inserts obliquely an elongate, whitish egg in the flesh just beneath the skin. Mr. Lowe has recorded the following observations regarding the egg : "Egg-laying undoubtedly begins as soon as the first fruit ripens, as young maggots were found in some of the earliest fruits. It continues as late as the middle of August, and probably later. We have found young maggots as late as August 16th. On the same day an unhatched egg was found. The eggs are placed nearly or quite under the skin. One egg was found on the outside. A single egg measured 5 mm. (.02 inch), somewhat broader toward one end, and about one-fourth as wide as long, at the widest point. Beginning at the broad end and extending about one-fourth the length of the egg, the shell is roughened and somewhat darker ; color, a dirty yellow." The flesh of the fruit seems to slightly thicken or harden around the egg and adhere closely to it. Apparently the eggs are laid in any part of the fruit. Old egg-scars are quite easily discernable on the cherries ; the minute, round depressed spot on the right-hand cherry of the two upper ones in figure 13 is probably an egg-scar.

Egg-laying doubtless extends over a considerable period, probably beginning in June and continuing until into August, if any cherries remain on the trees so long. We have no data bearing on the duration of the egg-stage. The eggs probably hatch in a few days.

The maggot's life.—As the eggs are laid beneath the skin, the moment it hatches, the maggot finds itself surrounded with its favorite food, the juicy flesh of the fruit. It apparently soon makes its way to near the pit where it proceeds to revel in the flesh, soon forming a rotting cavity, as shown in figure 14. The maggot spends its whole life of three or four weeks in a single cherry, and rarely more than one maggot is to be found in the same fruit. Apparently many of the maggots are nearly full grown about the time the fruit is ready to pick, and they find their way into the consumer's hands. Afflicted orchardists report that but few of the infested cherries fall from the trees, hence when the maggots emerge they doubtless drop to the ground, where they soon bury themselves just beneath the surface. Very soon after entering the ground, probably within a day or two, the maggots contract, their skin hardens and turns brown, and the *puparium* stage is formed. The maggots will change to puparia in any convenient place, as the bottom of baskets, rubbish, etc.

Number of broods.—We have some puparia which were formed in our breeding cages as early as July 11th, from which no flies have yet emerged. Hence we conclude that the insect winters as a puparium, and furthermore, that there is but a single brood of this new cherry pest in a year. Evidently the insect may spend ten or even eleven months of its life in the soil in the *puparia* stage.

HOW THE INSECT MAY BE SPREAD.

As it infests only the fruit, one need have little or no fear of receiving this new cherry pest from nurserymen. If nursery trees happen to be grown under infested cherry trees, it is possible that a few puparia of the pest might be carried away in the soil adhering to the roots of the nursery stock.

As many of the maggots emerge from the fruits, after they reach the consumer's hand, the insect may thus obtain a foothold in new localities. It is quite possible that the insect may be more readily and widely spread in this manner than in any other.

Doubtless the pest will spread quite slowly from tree to tree and thus from orchard to orchard, as the adult insects are slow in their movements and are not long-fliers. This is a very important fact for it makes *the checking of this new cherry pest largely an individual matter, to be worked out independently by each cherry-grower.*

DISCUSSION OF REMEDIAL MEASURES.

It is to be hoped that this new cherry pest is not widely distributed, or that it will never become a serious factor in cherry growing, because it will prove a very difficult pest to control. We have not had time to test any remedial measures, hence can only suggest possible methods, drawn from our experience in combating other insects, from what we know of the habits of the insect, but more especially from the experience of fruit-growers in Australia, South Africa and Europe, where similar fruit-flies are serious drawbacks to fruit-growing.

Apparently there is no possible chance of getting at the insect with a spray of any kind while it is in the egg, in the maggot, or in the puparium stages. The egg is out of reach beneath the skin, in the flesh ; the maggot spends practically all its life inside the fruit, only a day or two is spent in getting from the fruit into the soil and changing into a puparium ; and this puparium would doubtless be impervious to any liquid applied to the soil in such quantities as not to spoil the soil or injure the tree.

If the maggots caused the infested cherries to fall prematurely, or so affected them as to render it easy to discover which fruits were infested, then one could do much toward controlling the pest by removing such fruits from the trees or by picking up the "windfalls" and destroying them. This latter method can be successfully employed against the apple maggot, which does cause the apples to drop prematurely and which rarely, if ever, leaves the fruit until it does fall or is picked. But afflicted cherry growers state that but few, if any, infested cherries fall prematurely, and also that there is no way of distinguishing the infested cherries from the others at picking time.

Hence there seems to be no practicable method of getting at the pest while it is in the fruit, except the heroic method of picking and destroying by boiling, burying, or otherwise, the whole crop on the infested trees just about the time the first fruits are ready to pick, or even before. This method, of course, involves the loss of the cherry crop for a season, but it is the only sure method we can conceive of to completely check the pest. Usually certain trees or certain varieties will become infested first, and the destruction of the crop on these few trees would not count for much as against their being a constant source of danger to the rest of the orchard. The pest could be quickly stamped out in this way and as it spreads very slowly, it might be a long time in again getting a foothold in the orchard. This method of destroying the crop of cherries for a season, while it is an heroic one, it yet deserves to receive the serious consideration of cherry growers who may be unfortunate enough to have this cherry fruit-fly to combat.

As the insect spends ten months or more of its life in the soil, usually less than an inch below the surface, it would seem as though some method might be devised to check it then. All of this time is spent in the puparium stage (figure 15), and as we have stated above, while in this form the insect would not be readily affected by insecticides of any sort. We doubt if any of the puparia could be killed by the application of any reasonable or practicable amount of any insecticide, especially such substances as the commercial fertilizers, gas lime, lime or salt. Gas lime has been tried in Australia with no success.

As the puparia are so near the surface of the soil from July until the following June, it would seem as if thorough cultivation might be successfully employed against the pest. But it is evident that the usual methods of cultivation employed by our most successful orchardists has little or no affect on the pest, for those who suffered from it this year were good, thorough cultivators. A possible explanation lies in the fact that the puparia are too small to be crushed, and they are so near the surface that the usual shallow cultivation of the orchard does not materially change their position relative to the surface. Possibly deep plowing, which is not often practicable in a cherry orchard, in late fall or early spring, might bury these puparia so deeply that the emerging flies could not get to the surface. Where only a few trees were infested it would be practicable to remove the surface soil to a depth of an inch or so from beneath the tree and either bury it deeply, put in the hen yard, or in a much-traveled roadway.

One afflicted cherry grower sends the following valuable hint. "We have growing in our hen-yard several cherry trees, and they were not as badly infested as the trees outside of it. We can only account for it in that the hens found the insects as food." Undoubtedly hens would find many of the brown puparia in the soil, and could doubtless be successfully employed against the pest on a few trees. Place a temporary wire-netting fence around one or more trees, turn the hens loose in the enclosure, and stir the soil every day or two to encourage them. Do this soon after the fruit is picked and we doubt if many of the puparia will escape the sharp eyes of the fowls.

Something can be done toward checking the pest by not allowing any cherries to remain on the trees after the last picking. If what few " windfalls " there might be were destroyed, all the marketable fruit picked and disposed of, and all fruits removed from the tree at the last picking, most of the infested cherries would be gotten out of the orchard before most of the maggots had matured and gotten into the soil Of course, where early and late varieties are infested in the same orchard, this plan might not noticeably diminish the numbers of the pest. It is well worthy of consideration, however.

There yet remains one stage of the insect against which we have not turned our destructive batteries. One of the first questions asked us by an afflicted cherry grower, when he understood how little chance there was of getting at the insect while in the fruit or in the soil, was, why cannot we either kill the flies, or deter or prevent them from laying their eggs in the cherries. He inquired if bad-smelling substances hung in the trees or sprayed upon them would not drive the flies away. Apparently no experiments along this line have been made in this country against similar flies, but, fortunately our Australian and South African fruit-growers, who are sorely afflicted with fruit-flies, have recently carried on valuable and instructive experiments against the flies. The following summary of their experiments and conclusions cannot fail to be of value and interest to our American cherry-growers.

The flies are not attracted to lights in Australia, so that trap-lanterns will be of no avail against the pest.

Messrs. Benson and Voller made a careful and extensive series of experiments in the orchards of Queensland, Australia last year. The objects of their experiments were to prevent or deter the flies from attacking the fruit, and to attract and destroy the flies.

In the first series of experiments they sprayed the fruit and trees with strong smelling substances that were deemed likely to deter or repel the fly. They sprayed with sulphide of lime, sulphide of soda, lime, sulphur, wood tar, bone oil, caustic soda, carbonate of soda, whale-oil soap, tobacco, pyrthum, black leaf tobacco extract, nicotine, and Redwood's specific. Most of the substances were used singly and in various combinations. None of the mixtures injured the fruit or trees to any extent. Many of the mixtures had a very strong and persistent smell, which was retained on the trees and fruit for at least a week after application, and the smell was not washed out by rain, but rather intensified for the time.

Balls of cotton waste saturated with bone oil and other strong smelling substances were also hung in various trees to determine if the odor will deter the flies or not. Flies were seen on fruit within a few inches of the cotton waste, and the trees so treated were as badly infested as any untreated ones.

No spray that was tried was a complete success, even though numerous applications were made; but some mixtures* seemed to keep the flies from the fruit for a certain time after their application, as in the case of the same varieties of fruits, on trees that were sprayed, they were unable to detect a single fly laying eggs, whereas the flies were numerous and busy on adjacent trees. No spray, however, was lasting, as where the applications were made from a week to ten days apart, part of the fruit was infested, but not to the same extent as on untreated trees, thus showing that the applications must be frequent during the ripening of the fruit to be of any avail.

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* *Mixture A*:—Boil two pounds of sulphur and one pound of 98 per cent. caustic soda in two gallons of water till the sulphur is dissolved, and a mixture known as sulphide of soda is formed. Add six pounds of whale-oil soap, 80 per cent.; and boil for half an hour, adding boiling water to make five gallons of mixture; and add forty fluid ounces of black leaf tobacco extract. Next add water to make forty gallons, and it is ready for use.

Mixture B:—Dissolve one pound of whale-oil soap, 80 per cent., in four gallons of boiling water. When dissolved, add twenty-five fluid ounces of bone oil and mix well; add water to make forty gallons, and it is ready for use.

Mixture C:—Mix equal parts of A and B.

The experimenters record their belief that careful and frequent sprayings with the mixtures noted above will protect a considerable portion of the crop, but at the same time they are confident that to be of any value the spraying must be very carefully carried out, and must be backed up by destroying all infested fruit and taking every possible precaution to keep the insects in check.

In the second series of experiments made by Messrs. Benson and Voller they tried to attract, catch, or poison the flies. They record that they had no success whatever, as they failed to attract the flies. They used highly-scented sticky baits, highly-scented poisoned baits, and poisoned fruit baits; but, though numerous insects of various kinds were caught or destroyed, the fruit-flies escaped. The experimenters could not find that the flies fed on anything, as, with the exception of seeing them occasionally apparently sucking the juice exuding from a puncture they had made in a fruit, they were never seen to be attracted by or feeding on anything.

In South Africa the only effectual method of preventing the fruit from attacks by these fruit-flies thus far devised is to enclose the trees in a fine-meshed mosquito netting during the time when the flies are about.

We may thus glean from the above summary of the results attained in other countries in combating similar fruit-flies, that there is but little hope of successfully combating our American cherry fruit-fly in the adult or fly state.

No careful experiments seem to have been made in Europe against the European cherry fruit-fly, and the recommendations made for combating the pest are few, usually theoretical, and add nothing new to what we have already suggested, with one exception, which may be of interest to housewives and eaters of the luscious fresh fruit. One German writer states that "it is known to those housewives who wish to can cherries that the maggots leave the fruits as soon as they have been soaked in water for several hours; and this precaution can therefore be taken with the cherries to be eaten fresh in those years when the cherries are badly infested." We wish the author of this suggestion had been a little more definite, for we are in some doubt as to what is to be done with those fruits from which the maggots have emerged. Are they to be canned or eaten with the rest.

MARK VERNON SLINGERLAND.

BIBLIOGRAPHY.

1862. Loew. Mon. of Diptera of N. Am., Part I., p. 76. Original description from a female. Habitat, Middle States. States it is closely allied to the European cherry fruit-fly. Figures a wing.

1873. Loew. Mon. of Diptera of N. Am., Part III., p. 263. Briefer description of male and female. Points out great variation in size. States it is closely allied to European *R. flavicincta*. Habitat, Middle States; Long Branch, N. J., in July. Figures a wing.

1878. Osten Sacken. Cat. of Diptera of N. Am., p. 191. References to Loew's descriptions.

1890. Smith. Cat. of New Jersey Insects, p. 398. Quotes Osten Sacken's record of Long Branch, N. J.

1898. Doane. Entomological News, IX., 69-72. Tables for separating the six species of *Rhagoletis*. *R. ribicola* described and compared with *R, cingulata*.

* * * * * *

The following are also included in this bibliography, as we believe they refer to this cherry fruit-fly. They are the only records known to us of the occurrence of fruit-fly maggots in cherries in the American literature.

1883. Hagen. Canadian Entomologist, XV., 159-160. Records *Trypeta* larvæ in fruit of a black cherry tree imported from Prussia; apparently did not differ from those of the cherry fruit-fly (*cerasi*), received from Europe. Did not breed the adults.

1889. Cook. 2d Ann. Rept. Mich. Expt. Station, p. 153. Records receiving plums and cherries from northern Michigan supposedly infested by Apple Maggot.

Cordley. Orchard and Garden, Oct., 1889, p. 192. Records closely examining larvæ and pupæ of plum and cherry maggots from northern Mich. with the result that they seemed to be those of *T. pomonella*. Says *pomonella* has not been known to attack apples in northern Mich., but does occur in haws. Cherry and plums were badly infested.

Davis. *The Ohio Farmer*, Nov. 9, 1889. Records practically same facts as Cordley (1889).

1890. Harvey. Ann. Rept. of Maine Expt. Station for 1889, pp. 192, 233, 234, 235. Records Cook's, Cordley's and Davis' observations and suggests that their plum and cherry maggots may be a distinct species from the Apple Maggot.

1899. Lowe. *Country Gentleman*, LXIV., 693, Aug. 31, 1899. Brief account of the work of the insect at Geneva, N. Y., with description of the different stages.

Slingerland. *Rural New Yorker*, Sept. 16, 1899. Brief, illustrated abstract of this bulletin, No. 172.

The Following Bulletins are Available for Distribution to Those Who may Desire Them.

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166 Sugar Beet Investigations for 1898.
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170. Tent Caterpillars.
171. Concerning Patents on Gravity or Dilution Separators.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1899.

171. Gravity or Dilution Separators.
172. The Cherry Fruit-Fly: A New Cherry Pest.

Bulletin 173. **November, 1899.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

DAIRY DIVISION.

The Relation of Food to Milk-Fat.

DAIRY BUILDING.

By LEROY ANDERSON.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899.

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THE RELATION OF FOOD TO MILK-FAT.

Can the per cent of fat in milk be increased through changes in the food of the cows? This is a question about which there has been more debate and which has been the subject of more experimentation than any other problem relating to the production of milk. Some experiments have seemed to indicate that certain foods possess the power of increasing the proportion of fat in milk, while others, and much the larger number, show that the variations in the quality of milk are not traceable to the food. All who are familiar with the handling of milk know that variations in the per cent of fat do exist and this with the same cow on the same feed and under uniform environment. Why the quality of milk fluctuates so widely under conditions which to all outward appearances are the same, has never been determined experimentally. The secretion of milk is so intricate and its processes so completely hidden from view that a clear understanding of them seems quite impossible. Nevertheless all careful experiments conducted with a view to solve the problem are valuable even though only negative results be obtained and although the conclusions reached may be more or less conjecture.

Experiments conducted for the purpose of determining the relation of food to milk production have usually shown that where a sudden and radical change in the food has taken place, this change has been accompanied by a more than ordinary variation in the per cent of fat. This variation may be either an increase or a decrease. After the cows become accustomed to the new feed their milk returns to its former average per cent of fat, which may be called the normal per cent. Such phenomena would seem to indicate that the per cent of fat in milk is subject to the peculiar constitution of the cow and that she will give milk of a certain average composition so long as nothing occurs to disturb the "even tenor of her way."

A definite knowledge of the relation of food to milk-fat would solve the question as to whether or not the per cent of fat may be permanently increased by feeding. But concerning this point we have little information except theories based upon the results of many experiments. One theory has been long and largely held that milk-fat is produced from the protein in the food. If this were the case a natural supposition would be that by increasing the amount of protein in the food, the proportion of fat in the milk would be thereby increased. Another theory is that milk-fat is produced from the fat in the food. Then feeding an increased amount of fat might be supposed to result in a higher per cent of fat in the milk; or, on the other hand, a decrease in the supply of food-fat would likewise cause a decrease in the per cent of milk-fat. A third theory, and the one which is most largely entertained, is that so long as the animal is well nourished the per cent of fat in the milk is not appreciably affected by even wide variations in the character of the food. Experiments supporting these three theories will be found in subsequent pages.

The question has a practical bearing in the economical management of the dairy. For, if by food we may increase the richness of the milk, then there is opportunity to enhance the value of all our cows. Butter-fat is the most valuable constituent of milk, and if the cow may be made to produce a milk richer in fat by giving her certain foods, or foods containing a large proportion of a particular nutrient, then the dairyman may increase the value of his cows to the extent that they may be made to respond to the particular foods by increased production of fat. In general this has not been found to be the case, otherwise why should so many cows be giving milk that is comparatively poor in fat? And why should they possess this same characteristic in common with their ancestors as long ago as their history is known to man.

Again, if feeding large amounts of protein tends to an increased production of milk-fat, then the dairyman will need to purchase foods containing a high proportion of protein, which foods usually command higher prices than those containing less protein. If, on the other hand, a large supply of protein is not essential to the production of milk-fat; if the per cent of milk-fat is dependent on the supply of food-fat; or, if it is not governed by the food so long as the cow is well nourished, then the dairyman is warranted in feeding those cheaper foods which contain less protein and more carbohydrates and fat.

A conclusive answer to the question asked at the beginning is not attempted in this bulletin. The record is given of two long experiments with rations having different nutritive ratios, and also a less extended one with a ration containing varying quantities of palm nut meal. Considerable space is given to a summary of the leading experiments relating to the influence of food on milk production with especial reference to the quality of the milk by which is meant here its percentage of fat.

The records of these experiments are gleaned from all reliable sources both domestic and foreign. The object is to place before the general farmer and reader a knowledge of what has been done to solve the mooted question of "feeding fat into milk" by experimenters abroad as well as at home. In collecting this data free use has been made of all experimental literature obtainable and reference is usually made to the original article. The Experiment Station Record has been used freely, especially for translations of foreign experiments which are reported in periodicals not found in our own library. The attempt has been to make this summary as brief as possible and yet give a fair idea of the plan and scope of the experiment, together with the results or conclusions obtained.

SUMMARY OF EXPERIMENTS CONCERNING THE RELATION OF FOOD TO THE PERCENTAGE OF FAT IN MILK.

Jordan* experimented on five cows with three different kinds of rations during three periods, the rations being made up so as to contain varying amounts of vegetable fats, and found that the yield of milk diminished somewhat in passing from the ration rich in fat to the one containing less fat, and increased slightly after changing again to the fat rich ration. "The composition of the milk varied but little and no more, or even less, during the three periods than is often observed when the ration is not changed."

In a later experiment† Jordan fed three cows during three

* Maine Station Annual Report, 1891, p. 62.

† Same, 1893, p. 73.

periods of 35 days each on two rations, one having a nutritive ratio of 1:6.7 and the other 1:12.3 and found that "the yield of milk from the nitrogenous ration was from one-fifth to more than one-third larger than that from the carbonaceous ration. In general the milk was materially richer while the cows were fed the ration rich in protein. * * The composition of the milk solids seemed to be independent of the ration. In general the proportion of fat increased throughout the experiment without regard to what the cows were fed, and no evidence is furnished in support of the notion that by changing the food it is possible to produce more butter-fat without an accompanying increased production of the other milk solids."

Whitcher,* after studying the effect of pasture and silage, and of changing the nutritive ratio on the quality of the milk, found very little variation in the per cent of fat and concludes: "I feel warranted in saying that a given animal by heredity is so constituted that she will give a milk of certain average composition; by judicious or injudicious feeding the amount of milk may be largely varied, but the quality of the product will be chiefly determined by the individuality of the cow."

Wood,† in experimenting on the effect of some coarse fodders on quantity and quality of milk during several experimental periods of two weeks each, found "no variation in the quality of the milk that could be attributed to the character of the food."

Later,‡ he fed three cows for two weeks on a basal ration of silage, clover hay, vetch hay, oats and middlings. Then in three subsequent periods of two weeks each, palm oil, cotton-seed oil, corn oil, oleo oil, cocoanut oil and stearin were fed to different cows at the rate of 12 ounces per 1000 pounds live weight, making a nutritive ratio of 1:6.8. The conclusions reached were: "That the first effect of an increase of fat in a cow's ration is to increase the per cent of fat in her milk."

"That with the continuance of such a ration the tendency is for the milk to return to its normal condition."

"That the increase in fat is not due to the oils but to the unnatural character of the ration."

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*New Hampshire Station Bulletin 9, 1890.

†New Hampshire Station, Bulletin 18, 1892.

‡Same, Bulletin 20, 1894.

"That the results of this experiment tend to confirm the conclusions expressed in previous bulletins from this Station; that the composition of a cows' milk is determined by the individuality of the cow, and that although an unusual food may disturb for a time the composition of the milk, its effect is not continuous."

Hills* studied the effect of heavy feeding of grains on milk production by giving two cows for two months a continually increasing amount of grain until they were receiving all they would eat. He found that there was little change in the composition of the milk on increasingly heavy grain feeding, and that no connection could be traced between the quality of the milk and the food given.

Again,† in a series of feeding tests covering five periods of four weeks each, and using thirty-one cows, he experimented with various coarse fodders, grains and mixed feeds. The invariable conclusion was that there was no material change in the quality of the milk as a result of the change in ration.

Cooke‡ in reporting an experiment in feeding sugar meal, cream gluten meal, and germ meal to nine cows for four months in periods of four weeks each, says: "We are led to the conclusion that sugar meal and cream gluten have a slight effect toward an increase in the richness of the milk."

Lindsey§ fed six cows in nine and fourteen-day periods with seven days preliminary feeding to each period on rations containing amounts of protein which varied from 1.3 to 3.76 pounds per head daily, and the nutritive ratio varied from 1:4.4 to 1:10. The periods were rather short, but the "indications are that the composition of the milk, especially the fat, appeared to be favorably affected by the addition of protein up to three pounds, although there was considerable difference in the cows in this respect."

Lindsey, Holland and Billings‖ varied the nutritive ratio of

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*Vermont Station, Annual Report, 1890, p. 75.

†Same, 1895, p. 203.

‡Vermont Station, Bulletin 31, 1892.

§Massachusetts (State) Station Annual Report, 1894, p. 42.

‖Massachusetts (Hatch) Station, Annual Report, 1896, p. 100.

the ration from 1:3.86 to 1:9.43 while feeding six cows in two lots of three each, during four periods of 21 to 26 days each, with a seven-day preliminary period. They conclude :

"That the same amount of digestible matter in the narrow rations produced from 11.8 to 12.9 per cent more milk than did a like amount of digestible matter in the wide rations, and that neither the narrow nor wide rations produced any decided change in the composition of the milk.

Jordan and Jentner* changed the ration of a cow in three ways : "(1) By decreasing the fat in the food from about the usual quantity to practically none ; (2) by producing wide variations in the protein supply and nutritive ratio, and (3) by producing wide variations in the supply of total digestible material." The cow was "fed during ninety-five days on a ration from which the fats had been nearly all extracted, and she continued to secrete milk similar to that produced when fed on the same kinds of hay and grain in their normal condition." The food-fat eaten during this time was 11.6 pounds, 5.7 pounds of which was digested, while the yield of milk-fat was 62.9 pounds. Throughout the whole experiment, "the composition of the milk bore no definite relation to the amount and kind of food."

Wing† added ordinary beef tallow to the usual grain ration of ten cows, giving them at first four ounces per head, and increasing the amount gradually until each cow was consuming two pounds daily, which amount was fed for six or seven weeks. He found "no increase in the per cent of fat in the milk as a result of feeding tallow in addition to a liberal grain ration."

Waters and Hess‡ gave rations varying in nutritive ratio from 1:3.9 to 1:6.65 to nine cows through four periods of thirty days each, and say : "It appears that the narrower nutritive ratio tended to increase the per cent of fat."

Farrington§ studied the effect of heavy grain feeding by giving three cows from December 1 to June 1, in eight periods ranging from 6 to 51 days, an amount of grain increasing con-

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*New York (State) Station, Bulletin 132, 1897.

†New York (Cornell) Station, Bulletin 92, 1895.

‡Pennsylvania Station, Annual Report, 1895, p 56.

§Illinois Station, Bulletin 24, 1894.

tinually from 12 to 24 pounds per head daily where it was held for two months, when it was decreased gradually until the cows went to pasture, May 1.

The nutritive ratio varied from 1:4 to 1:9.4. He found "that the increase of feed was accompanied by a considerable increase in the pounds of milk produced, and consequently in the pounds of solids, fat, and solids not fat in the milk ; but with the exception of one or two days, there were no greater changes in the percentages of fat in the milk after the increase of feed than before it was made."

Wilson, Kent, Curtiss and Patrick* compared corn and cob meal with sugar meal by feeding them to four cows in alternating periods of 21 days each with a 10-day preliminary period, and conclude that "quality of milk, so far as measured by its percentage of fat, was changed by feed to a much greater degree than was quantity. Sugar meal produced 17 per cent more fat and six per cent more total solids per 100 pounds of milk than did the corn and cob meal."

Armsby,† during three periods of three weeks each with two cows compared bran with corn meal and found that while there were slight changes in the composition of the milk there was "no indication that the feeding had anything to do with these changes." Again in comparing in a similar manner bran with oil meal there were slight changes as before, but "we may safely conclude that whatever changes took place in the composition of the milk-solids were due to advancing lactation and not to the feed."

Woll‡ in comparing the feeding value of ground oats and bran for milk production, found that "the cows invariably did better on oats, going up in milk yield when coming on oats and going down when bran was fed, while the fat content of the milk remained the same on an average."

Linfield§ studied the effect of two rations varying in nutritive ratio on the per cent of fat in milk with ten cows during eight periods of three weeks each. He concludes, "this test adds but

*Iowa Station Bulletin 14, 1891.

†Wisconsin Station Annual Report 1886, pp. 115 and 130.

‡Wisconsin Station Annual Report 1890, p. 65.

§Utah Station, Bulletin 43, 1895.

another item to the fairly well established fact that an increase in the quantity of concentrated food in the ration of a cow, does not increase the richness of the milk provided the cows are well fed to start with."

Dean* carried on experiments during several years to ascertain the effect of food on the quality and quantity of milk. The results obtained from feeding coarse fodder with and without grain, from comparing pasturage with and without grain, from feeding slop, and from other experiments, generally agree with this statement made in Bulletin No. 80, that "the general conclusion would seem to be that the food does not affect the quality of the milk to any appreciable extent so long as the animals are in good condition."

Speir† reports at least three different experiments on the effect of foods on milk production. He tested a large number of different kinds of feeding stuffs both singly and in various combinations during periods of four to five weeks in length. Some of his conclusions are that "an increase of oil in the food does not seem to give any increase of fat in the milk. Rations having an extremely high albuminoid ratio seem to have a depressing effect on the milk yield, well mixed foods giving the best results in this respect. Every food when first given, seems to have more or less effect in increasing or decreasing the percentage of fat in the milk. This effect, however, is transitory and the milk returns to its normal composition about the end of the fifth week."

Stohmann,‡ in experimenting with goats found that the fat content of the milk was proportional to the fat content of the fodder, but that by a great increase in the nitrogenous foods, the milk-fat did not increase in the same way as when the fat content of the food was increased.

Kühn§ carried on extensive feeding trials with bean meal,

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*Ontario Agricultural College and Farm Report 1891, p. 154; 1893, p. 148; 1894, pp. 147 and 148.

†Transactions of the Highland and Agricultural Society, Scotland, 1894, p. 83; 1896, p. 269; 1897, p. 296.

‡Journal für Landwirtschaft, 1868, pp. 135, 307 and 420.

§Journal für Landwirtschaft 25 (1877), p. 332.

palm nut cake and malt sprouts, having in all 42 experiments with 10 cows. The feeding periods varied from 21 to 47 days in length. The grains were fed separately in addition to a normal ration and in quantities of 1.5, 2 and 3 kilograms* per head daily. According to his results the fat content of the milk increased proportionately with the increase of protein fed, but did not decrease in the same proportion when the protein in the food was decreased. He concludes "that the palm nut cake exerted on the whole a favorable influence upon milk production and especially upon the fat content of the milk." The bean meal and malt sprouts did not have a like favorable effect. He found that the addition of one-half kilogram of oil to the ration increased the quantity and quality of the milk. But he considered "that this added fat had no *direct* influence on milk production; that it has an indirect effect in this manner: that a certain quantity of protein is thereby made available for milk production which before the feeding of the fat was used in sustaining the animal body, but the fat now performs this office and permits the protein to be used for producing milk." He concludes also "that these experiments, according to all observations, prove in the clearest manner how greatly the milk production, and the possibility of influencing arbitrarily through feeding the amount or composition of the product, are dependent upon the individuality of the animal."

Heinrich† compared peanut cake with cocoanut cake, the latter ration containing 350 grams more fat than the former. The rations were alternated in periods of four weeks each and three cows were used. He found that the fat of the milk was considerably increased, both in percentage and total amount, when the cocoanut ration was fed, but there was much difference in the animals regarding this point. It is his opinion that the increased yield of fat may be accounted for by the increased amount of fat in the food.

Kochs and Ramm‡ fed three cows during four periods of about four weeks each, on rations which contained practically the same

*One kilogram (kg.)=2.2 pounds.

†Translation in Experiment Station Record Vol. 3 (1891), p. 67.

‡Landwirtschaftliche Jarhbücher 21 (1892) p. 809.

amounts of dry matter, and nearly equal amounts of digestible non-nitrogenous matter, but the amount of protein fed was such as to make the nutritive ratio vary from 1:8.19 to 1:5.42 to 1:4.31 and to 1:8.19 in the successive periods. They found that "the proportional fat content of the milk remained unchanged by the very wide changes in the food."

Klein* found that the addition of sunflower cake to the usual ration of four cows was followed by an increased milk yield, while it seemed to have no specific effect on the fat content of the milk.

Maercker and Morgen† report a series of coöperative experiments with farmers in which the effect of watery foods on milk secretion was studied. Beet diffusion residue (beet pulp) was fed alone and also with potato residue (from starch manufacture) in addition to a basal ration of hay, straw and grain. The amounts of residue fed daily were such as to give quantities of water ranging from 43 to 150 pounds per head. The experimental periods were ten days each. They found that the quantity of milk increased regularly with the increase of watery food up to 116 pounds, and that the increase in watery food was without discernible effect upon the composition of the milk.

Juretschke‡ has found as a result of the addition of 4 to 5 pounds, per thousand pounds live weight, of cotton seed cake, rape cake, and peanut cake to a basal ration consisting of hay, straw, brewers' grains and wheat bran, that the "milk secretion is not directly but only indirectly affected by feeding and that the feeding of large amounts of fat does not increase the amount of butter-fat in the milk."

Backhaus§ found by feeding ten cows on a basal ration of hay, straw, brewers' grains, etc. and alternating in periods of two weeks with peanut cake, palm nut cake and cotton-seed oil cake, that in order to bring about changes in the fat content of milk very little can be accomplished by the kind of food, and that the favorable effect of some concentrated foods which have been

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* Milch Zeitung 21 (1892) p. 673.

† Translation in Experiment Station Record, Vol. 3 (1892) p. 557.

‡ Molkerei Zeitung 7 (1893) p. 518.

§ Journal für Landwirtschaft 41 (1893) p. 328.

found to increase the fat takes place only when large quantities are fed.

Soxhlet* reports some investigations on the production of milk richer in fat. He says nothing of the plan or extent of his experiments and gives nothing but the conclusions and a discussion of theories. As compared with hay alone, the addition of fourteen pounds of starch, treated with malt and given as a sweet drink, with sixteen pounds of hay made no appreciable increase in milk yield but a noticeable decrease (about 0.7 per cent) in fat. The fat content was practically the same when four pounds of rice gluten containing 71 per cent of protein was fed as when hay was fed alone. When sesame oil, linseed oil or tallow was added to the ration in the form of emulsions thoroughly mixed with the drinking water, the milk contained as high as 5.8 per cent of fat. When 1.5 to 2 pounds of linseed oil were added to 18 to 22 pounds of hay the milk averaged 5.24 per cent of fat for four days; when 1 to 2 pounds of tallow were added to the same amount of hay the milk contained from 4.24 to 5.5 per cent of fat, the average for eight days being 4.7 per cent. The author believes that the addition of oils to the ration in the form of emulsions will increase the per cent of fat in the milk while the addition of the same oils in other forms will not so increase it, because the oils are more easily digested in the form of emulsion. He does not believe that the fat of the food goes directly into the milk, but that it forces the body fat, *i. e.* tallow, over into the milk, and thus indirectly increases the quantity of milk-fat. He further states that the fat of the food alone, and not the protein or carbohydrates, is capable of bringing about a one-sided increase in the fat content of the milk.

Beglarian† studied the effect of linseed oil, given in water as an emulsion and of ground flaxseed with four cows during four periods of eight days each. The cows shrank in milk yield while taking the oil ration and increased on the flaxseed ration. The author considers the results entirely negative since the oil was not accompanied by an appreciable rise in the fat content, while it had an unfavorable effect on the digestion and comfort of the

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*Translation in Experiment Station Record, Vol. 8 (1897), p. 1016.

†Milch Zeitung 26 (1897) p. 522.

cows. The ground flaxseed had no effect on the quality of the milk and a less unfavorable influence on the animal's digestion.

Holtsmark* found that feeding cows as much as 77 pounds of turnips per head daily in connection with a liberal ration of concentrated feed and cut straw, caused no decrease in the fat content of the herd milk, as compared with the feeding of the regular ration of hay, straw, concentrated feed and a small quantity of roots.

Ramm† to study the effect of different foods on milk production gave ten cows a basal ration consisting of 14 kg. of hay, 6 kg. straw and 50 kg. of beets, to which, for periods of ten days each, he added separately eighteen different foods. He found much variation in the fat content of the milk but no marked increase except with palm nut cake (7.91 kg.) alone and with a mixture of equal parts (8.25 kg.) of palm nut cake and beet molasses, this mixture being accompanied with a higher per cent of fat and total fat in the milk than any other food. For this reason the author thinks molasses has a greater effect on the quality of milk than palm nut cake. He found no relation between the fat content of the milk and the fat content of the food.

In a later experiment, Ramm made further comparison of the feeding value of various molasses mixtures. The mixtures used were peat molasses (80 per cent molasses and 20 per cent peat), liquid molasses, equal parts of molasses and palm nut meal, molasses pulp (molasses mixed with fresh potato pulp and dried), molasses chips (fresh beet pulp and molasses mixed and dried), barley meal and palm nut cake of average quality. The basal ration consisted of hay, straw and beets. There were seven experimental periods of 20 days each, the last five days only being used in comparison. Eight cows were used. He found the barley meal to excel the molasses preparations for milk production, but concludes that the latter induce an increase in the fat content of the milk.

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* Translation by F. W. Woll in Experiment Station Record, vol. 9 (1897) p. 92.

† Landwirtschaftliche Jahrbücher 26 (1897) pp. 693, 731.

Winternitz* fed a goat on sesame oil mixed with a small amount of iodin. He found a portion of the iodin was absorbed by the milk-fat and thus concludes that a direct transmission of the fat of the food into the milk may take place.

Albert and Maercker† studied the effect of rations rich and poor in fat, on ten cows during six periods ranging from 7 to 18 days, with preliminary periods ranging from 2 to 16 days in length. The amount of protein in the rations was kept constant while the fat was increased from .297 kilograms to 1.706 kilograms per head daily. They found that the feeding of such large amounts of fat increased the percentage of fat in the milk, but reduced the yield so much as to make such feeding unprofitable.

Kellner and Andrä‡ compared sugar beets with dried and ensiled beet diffusion residue by feeding them alternately to twenty-four cows during four periods of twenty days each. They found that ,, the substitution of 4.4 kg. of dried diffusion residue for 27.5 kg. of sugar beets increased the milk yield .953 kg. and the substitution of 41.8 kg. of ensiled diffusion residue for the above amount of sugar beets increased the milk yield 1.721 kg. per cow (of 550 kg. live weight) without causing any material change in the quality of the milk."

Friis§ reviews the co-operative cow feeding experiments conducted by the Experiment Station at Copenhagen, Denmark since 1888, with especial reference to the effect of food on the fat content of the milk. The summary of 76 series of experiments is given. The rations used were such as could be regarded normal for milch cows, such as are met with in the feeding practice on Danish dairy farms. The question whether abnormal feed mixtures can appreciably change the fat content of milk was not included in the investigation. The author says "it was found that different feeding stuffs and food mixtures in a very large measure influence the quantity of milk yielded as well as

* Zeitschrift Physiol. Chem. 24 (1898) p. 425.

† Landwirtchaftliche Jahrbücher 27 (1898) p. 188.

‡ Landwirtschaftliche Versuchs Stationen 49 (1898) p. 402.

§ Translation by F. W. Woll in Experiment Station Record Vol. 10 (1898) p. 86.

the health and general condition of the cows. The feed under practical conditions as found in this country, exerts an entirely insignificant influence on the fat content of the milk.

Rhodin* emulsified linseed oil in a specially constructed machine and fed from 250 to 750 grams of the emulsion daily as a drink in water to each of two cows during seven-day periods in addition to a normal mixed ration. During the first periods of feeding the oil, the fat content of the milk was increased, but during the third period the per cent of fat not only ceased to increase, but fell back to the same point as before the oil was fed.

Ramm and Winthrop † made a comparison of some new feeding stuffs using five cows for six months. The foods were corn bran, cocoa-molasses (hot molasses and finely ground cocoa shells), blood molasses (blood, molasses and refuse of cereals) and molasses distillery refuse (residue from manufacture of alcohol from beet molasses). They found a wide fluctuation in the fat content of the milk during different periods and believe that the molasses increased the fat content wherever it was fed, while the corn bran seemed to reduce the fat content. When feeding rations rich in fat they could see no relation between the fat content of the ration and the fat content of the milk.

Hagemann ‡ conducted some experiments to determine whether a fat rich fodder produces a fat rich milk. During five periods, varying in length from 21 to 35 days, he fed two cows on rations containing from 175 to 720 grams of fat. In addition to a basal ration the grains added were corn meal, linseed-oil meal, malt sprouts and peanut cake mixed with cocoa molasses. In the sixth period of seven days he gave 1.1 pounds of sesame oil to each cow daily as an emulsion in drinking water. He concludes that "the proportional and absolute fat content of milk is not dependent upon the amount of fat in the food."

We have now reviewed the reports of forty-four separate experiments. They may be classified in the following manner in answer to the question: Was the percentage of fat in the milk increased by the food given the cows?

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* Milch Zeitung 27 (1898) p. 306; p. 323.

† Milch Zeitung 27 (1898) p. 513.

‡ Landwirtschaftliche Jahrbücher 28 (1899) p. 485.

	Yes.	No.	A tendency to increase.
Feeding fat	4	8	1
Feeding protein and mixed foods	3	20	3
Feeding watery foods	—	2	—
Feeding molasses preparations	3	—	—
Total	10	30	4

Of the four experiments where the fat in the food increased the proportion of milk-fat, one reports so great a reduction in the yield as to make such feeding unprofitable. The noted experiment of Soxhlet whereby he increased the per cent of milk-fat by feeding the cows oil emulsified in the drinking water, has been repeated many times by other experimenters, but none of them, so far as we know, have reached a similar result. The protein foods which increased the per cent of fat were palm-nut meal and sugar meal. The molasses preparations may owe their power to increase the fat content of milk to their rather abnormal character.

ORIGINAL EXPERIMENTS.

These experiments were conducted for the purpose of determining the comparative effect of rations having different nutritive ratios upon milk production. This question has been the subject of experimentation at various times and places as has been already noticed, but further investigation along possibly different lines may throw more light upon the problem. Much discussion has occurred over the matter of the length of time during which a particular food should be tested and as to the accuracy of conclusions drawn from feeding trials where two or more foods were given during brief alternating periods. Some contend that four or five weeks is sufficient time in which to secure the true effect of a food, some think that a shorter time, even ten days, is enough, while others hold that the longer the period the more accurate and conclusive the result. It is well known that, when a radical change is made in the food of a cow, the secretion of milk is greatly affected. This is most apparent in the fat content, which may either rise or fall, but is more apt to rise. How long the fluctuation may continue depends upon the ability of the cow to accustom herself to the new feed, which time may be only a few days or it may be weeks. And when the cow has become accustomed to the changed feed, her milk falls back to its normal average composition. However, if the experiment is concluded before this time, or if the feed is again changed, then conclusions drawn therefrom must be more or less warped.

In order that these sources of error might be obviated, we not only continued the experiments for a long period, but also made no changes in the kinds of foods given during the whole time. The feeding trials lasted through two successive winters and for a period of twenty-two weeks during each winter. The effect of the different rations was studied by comparing the influence of each upon the average milk production of the cows used. We think this method to be satisfactory because, in the first place, the cows were so selected as to make the different lots fairly equal as to age, breed and general characteristics; and in the second place, if a given ration will produce any particular effect upon milk production, then this ration will show its influence on the average composition of the milk from the lot of cows to which it is fed when compared with the average composition of milk from other cows on other rations.

Our study is confined to the yield of milk and its quality so far as represented by the percentage of butter-fat. The determinations of fat were made by the Babcock test from samples of milk taken from each cow during the last three days of each week. These daily samples were tested separately and their average taken for the average per cent of fat in the week's milk. Each cow's milk was weighed as soon as drawn and the weekly yield of milk multiplied by the average per cent of fat gives the total fat produced during the week.

The rations fed were of three kinds, one with a narrow, one with a medium, and the third with a wide nutritive ratio. No analyses of foods were made except of the oat chop which was fed during the first year. The amount of dry substance and the nutritive ratio were calculated largely from the average composition of feeding stuffs given in Bulletin No. 11 of the office of Experiment Stations.

With one exception the same cows were used throughout the two years of experiment. Moreover the same cows were fed rations having practically the same nutritive ratio, though made up of different foods during both years, *i. e.* the cows receiving a narrow ration the first year also received a narrow ration the second year and likewise with the cows on other rations. None of the rations are what would be called unusual for similar ones may be found in use on dairy farms in various parts of the country. During the whole length of both experiments it was the aim to give the cows all the food they could readily consume.

The records as published contain only the average data obtained from each lot of cows. In work of this kind, the average record of several cows is of more value than individual records taken singly, and it is from the average record that conclusions must be drawn. For this reason and in order to eliminate many long tables from these pages, the individual records are not published.

THE FIRST EXPERIMENT 1895–6.

This feeding trial began November 6, 1895, and continued for twenty-two weeks until April 7, 1896. It was conducted by James M. Johnson then a graduate student in the college of agriculture. The names of the cows used are given below together with their breed, age, number of days in milk and weight.

Name and breed.	Age.	Number of days in milk.	Weig't, beginning.	Weig't, end.	Gain.
LOT A:					
Garnet Valentine, A. J. C. C., 73873..	4	67	873	992	119
Belva 2d, $\frac{15}{16}$ Holstein...............	2	49	891	1088	197
Julia, ⅞ Holstein....................	4	25	1196	1370	174
LOT B:					
Cherry, grade Jersey................	2	49	721	849	128
Dora, $\frac{15}{16}$ Holstein...................	4	62	1146	1213	67
Glista 4th, H. F. H. B., 31408.......	3	65	1064	1239	175
LOT C:					
Clara, grade Jersey..................	3	65	922	1063	141
Glista Netherland, H. F. H. B., 32442	3	16	1038	1127	89
May 2d, ⅞ Holstein..................	3	54	1017	1223	206

The daily rations of the cows in each lot were made up as follows :

LOT A :

Grain mixture	8 to 13 pounds.
Gluten feed	3 parts.
Oat chop	2 parts.
Cotton-seed meal	2 parts.
Linseed oil meal	1 part.
Corn silage	40 to 45 pounds.
Clover hay	8 to 10 pounds.
Nutritive ratio	1:4.5

LOT B :

Grain mixture	8 to 10 pounds.
Gluten feed	2 parts.
Oat chop	3 parts.
Corn meal	1 part.
Linseed oil meal	1 part.
Corn silage	35 to 45 pounds.
Clover hay	4 to 10 pounds.
Nutritive ratio	1:6

LOT C :

Grain mixture	8 to 10 pounds.
Oat chop	4 parts.
Corn meal	4 parts.
Linseed oil meal	1 part.
Corn silage	35 to 40 pounds.
Timothy hay	4 to 8 pounds.
Nutritive ratio	1:9

Calculating each of these rations on the basis of 8 pounds of grain, 8 pounds of hay and 40 pounds of silage, each cow would receive the following number of pounds of digestible nutrients per day :

	Protein.	Carbohydrates.	Fat.	Nutritive ratio.
Lot A. narrow ration	2.90	10.78	1.09	1:4.5
Lot B. medium ration	2.25	11.61	.91	1:6.0
Lot C. wide ration	1.60	12.68	.75	1:9.0

Beginning with December 14, each cow received 5 pounds of mangel-wurtzels per day in addition to the above rations.

Table I contains the average record of consumption of food and production of milk and fat for each of the three lots of cows named above. The data given includes the weekly average consumption of dry matter per head, the average daily consumption per 1000 pounds live weight, the nutritive ratio, the average weekly yield of milk and fat and the average per cent of fat.

TABLE I—1895-6.

AVERAGE RECORD OF LOT A. (NARROW RATION).

Week.	Dry matter consumed.			Weekly product of milk and fat. Average per head.		
	Per head weekly.	Per 1000 lbs daily.	Nutritive Ratio.	Pounds of milk.	Per cent fat.	Pounds of fat.
1	159.46	23.34	1:4.53	219.50	3.64	7.98
2	164.01	23.59	1:4.50	221.33	3.20	7.08
3	164.71	23.66	1:4.50	220.92	3.35	7.41
4	166.27	23.24	1:4.51	208.67	3.55	7.41
5	170.55	23.46	1:4.43	202.42	3.52	7.13
6	171.19	23.26	1:4.38	200.33	3.42	6.85
7	175.05	23.65	1:4.35	196.33	3.22	6.36
8	177.32	23.72	1:4.32	199.00	3.39	6.75
9	170.55	22.61	1:4.28	191.00	3.31	6.32
10	171.11	22.64	1:4.29	195.67	3.23	6.32
11	171.96	22.74	1:4.29	197.08	3.39	6.68
12	174.19	22.92	1:4.24	191.25	3.26	6.24
13	173.20	22.74	1:4.20	191.08	3.47	6.63
14	178.43	23.48	1:4.26	183.75	3.60	6.62
15	180.12	23.58	1:4.27	184.42	3.61	6.67
16	180.97	23.55	1:4.28	191.33	3.50	6.74
17	180.69	23.37	1:4.28	186.42	3.53	6.59
18	176.73	22.68	1:4.25	169.50	3.53	5.98
19	177.44	22.57	1:4.26	176.83	3.86	6.83
20	178.71	22.56	1:4.23	177.17	3.63	6.44
21	179.13	22.45	1:4.27	166.83	3.60	6.01
22	179.16	22.26	1:4.27	166.67	3.62	6.04

TABLE I—(*Continued*).

AVERAGE RECORD OF LOT B. (MEDIUM RATION.)

Week.	Dry matter consumed.			Weekly product of milk and fat. Average per head.		
	Per head weekly.	Per 1000 lbs. daily.	Nutritive ratio.	Pounds of milk.	Per cent fat.	Pounds of fat.
1	162.25	24.03	1:6.12	187.50	3.35	6.27
2	161.42	23.70	1:6.11	191.42	3.33	6.37
3	161.55	23.56	1:6.11	182.50	3.38	6.17
4	162.26	23.57	1:6.12	180.75	3.58	6.47
5	165.52	23.77	1:6.05	175.75	3.19	5.61
6	167.28	23.81	1:6.03	166.50	3.44	5.73
7	171.70	24.25	1:5.97	177.75	3.28	5.82
8	173.29	24.16	1:5.94	167.58	3.16	5.30
9	167.81	23.53	1:5.89	164.75	3.05	5.02
10	163.72	22.66	1:5.89	167.33	3.07	5.14
11	171.23	23.51	1:5.96	169.25	3.45	5.84
12	168.72	23.14	1:5.96	164.92	3.32	5.48
13	170.11	23.29	1:5.95	165.67	3.32	5.49
14	168.18	23.05	1:5.88	152.83	3.40	5.20
15	169.63	23.47	1:5.93	154.08	3.60	5.55
16	173.43	23.44	1:5.95	162.83	3.50	5.70
17	174.34	23.49	1:5.96	159.17	3.52	5.60
18	173.46	23.21	1:5.96	156.50	3.59	5.61
19	173.21	23.00	1:5.96	152.67	3.73	5.69
20	173.77	22.91	1:5.96	154.67	3.53	5.46
21	174.48	22.86	1:5.96	146.42	3.51	5.14
22	173.35	22.50	1:5.96	125.33	3.84	4.81

TABLE I—(*Continued*).

AVERAGE RECORD OF LOT C. (WIDE RATION).

Week.	Dry matter consumed.			Weekly product of milk and fat. Average per head.		
	Per head weekly.	Per 1000 lbs. daily.	Nutritive ratio.	Pounds of milk.	Per cent fat.	Pounds of fat.
1	150.20	21.56	1:8.79	180.83	3.31	5.99
2	149.62	21.28	1:8.78	177.92	3.20	5.69
3	145.43	20.52	1:8.73	173.83	3.54	6.16
4	146.73	20.49	1:8.73	166.75	3.55	5.92
5	151 28	20.95	1:8.65	162.00	3.37	5.46
6	147.63	20.35	1.8.43	152.67	3 43	5.24
7	150.14	20.50	1:8.30	164.25	3.08	5.06
8	147.16	19.93	1:8.19	164.92	3.22	5.31
9	148.75	20.07	1:8.22	145.25	3.74	5.43
10	146.44	19.62	1:8.18	154.92	3.25	5.03
11	151.65	20.17	1:8.27	154.25	3.30	5.08
12	146.15	19.33	1:8.16	153.42	3.31	5.08
13	147.62	19.45	1:8.21	153.67	3.37	5.18
14	146.49	19.21	1:8.19	147.75	3.21	4.75
15	147.31	19.27	1:8.19	143.17	3.60	5.15
16	154.39	20.16	1.8.33	146.83	3.45	5.07
17	156.13	20.33	1:8.36	146.33	3.29	4.82
18	156.13	20.29	1:8.36	142.75	3.52	5.02
19	157.72	20.33	1:8.39	139.92	3.87	5.42
20	158.73	20.26	1:8.41	141.67	3.58	5.07
21	160.76	20.32	1:8.45	136.50	3.65	4.98
22	161.01	20.56	1:8.46	135.33	3.63	4.91

THE SECOND EXPERIMENT, 1896-7.

This feeding trial continued for twenty-two weeks from November 11, 1896 to April 13, 1897 and was conducted by the writer. The names of the cows used are given below together with their breed, age, number of days in milk and weight. It will be noticed that these cows are the same that were in the first experiment with the exception of Jennie 2d, in lot C who took the place of Glista Netherland.

Name and breed.	Age.	Number of days in milk.	Weig't, beginning.	Weig't, end.	Gain.
LOT A:					
Garnet Valentine, A. J. C. C. 73873..	5	74	920	1020	100
Belva 2d, $\frac{15}{16}$ Holstein........	3	50	1012	1200	188
Julia, ⅞ Holstein..................	5	62	1247	1333	106
LOT B:					
Cherry, grade Jersey................	3	54	809	928	119
Dora, $\frac{15}{16}$ Holstein.....	5	Calved Nov. 20.	1181	1213	32
Glista 4th, H. F. H. B. 31408........	4	60	1137	1289	152
LOT C:					
Clara, grade Jersey.................	4	68	1030	1062	32
Jennie 2d, Jersey-Holstein..........	3	Calved Nov. 8.	857	952	95
May 2d, ⅞ Holstein................	4	44	1124	1191	67

The daily ratious of the cows in each lot were made up as follows:

LOT A:
- Grain mixture....................................8 to 12 pounds.
  - Gluten feed........ .. ..3 parts.
  - Cotton seed meal............... ....2 parts.
  - Wheat bran...................... ....1 part.
- Corn silage.............................. .....35 to 45 pounds.
- Clover hay............................... .6 to 12 pounds.
- Nutritive ratio................................ ....1:4.3

LOT B:
- Grain mixture...................................8 to 12 pounds.
  - Gluten feed...2 parts.
  - Corn meal..2 parts.
  - Wheat bran............... ....2 parts.
  - Linseed oil meal....................................1 part.
- Corn silage............................ ....35 to 45 pounds.
- Clover hay......................... ....6 to 12 pounds.
- Nutritive ratio.................... ....1:5.7

LOT C:
- Grain mixture...... ....8 to 11 pounds.
  - Corn meal..................... ....2 parts.
  - Wheat bran ....1 part.
- Corn silage..................................35 to 40 pounds.
- Timothy hay....................................4 to 8 pounds.
- Nutritive ratio........................ ....1:9.3

Calculating each of these rations on the basis of eight pounds of grain, eight pounds of hay, aud 40 pounds of silage, each cow would receive the following number of pounds of digestible nutrients per day.

	Protein.	Carbo-hydrates.	Fat.	Nutritive Ratio.
Lot A, narrow ration........	3.08	10.63	1.13	1:4.3
Lot B, medium ration.......	2.37	11.67	.87	1:5.7
Lot C, wide ration..........	1.56	12.96	.67	1:9.3

Beginning with January 6, each cow was fed five pounds of mangel-wurtzels per day, which amount was increased to 10 pounds in a few days and so continued until the close of the experiment.

Table II contains the average record of consumption of food and production of milk and fat for each of the three lots of cows named above. The data given includes the weekly average consumption of dry matter per head, the average daily consumption per 1000 pounds live weight, the nutritive ratio, the average weekly yield of milk and fat and average per cent of fat.

TABLE II.

AVERAGE RECORD OF LOT A. (NARROW RATION.)

Week.	Dry matter consumed.			Weekly product of milk and fat. Average per head.		
	Per head weekly.	Per 1000 lbs. daily.	Nutritive ratio.	Pounds of milk.	Per cent fat.	Pounds of fat.
1	167.19	22.63	1:4.15	184.42	3.37	6.21
2	169.34	22.53	1:4.11	188.33	3.31	6.24
3	172.81	22.67	1:4.11	187.75	3.27	6.14
4	172.98	22.32	1:4.00	178.25	3.44	6.13
5	169.36	21.82	1:3.94	177.08	3.21	5.64
6	175.30	22.48	1:4.01	176.17	3.20	5.64
7	176.12	22.47	1:4.03	166.50	3.25	5.41
8	178.18	22.61	1:4.04	169.92	3.08	5.24
9	163.61	20.50	1:3.98	153.33	3.26	5.00
10	142.36	18.59	1:4.12	150.58	3.37	5.08
11	169.11	21.52	1:4.03	161.75	3.27	5.28
12	163.36	20.74	1:3.96	152.08	3.17	4.82
13	169.52	21.56	1:3.95	147.92	3.15	4.66
14	171.13	21.55	1:3.90	156.83	3.34	5.23
15	173.60	21.76	1:3.93	155.67	3.26	5.08
16	178.23	22.07	1:3.92	150.58	3.22	4.85
17	182.63	22.51	1:3.94	152.25	3.21	4.88
18	179.27	21.93	1:3.93	151.17	3.41	5.15
19	176.46	21.52	1:3.92	148.83	3.32	4.94
20	174.74	21.16	1:3.91	148.58	3.31	4.92
21	175.69	21.20	1:3.91	150.75	3.37	5.09
22	174.61	20.87	1:3.90	143.50	3.36	4.83

TABLE II—(*Continued*).

AVERAGE RECORD OF LOT B. (MEDIUM RATION.)

Week.	Dry matter consumed.			Weekly product of milk and fat. Average per head.		
	Per head weekly.	Per 1000 lbs. daily.	Nutritive ratio.	Pounds of milk.	Per cent fat.	Pounds of fat.
1	*162.22	23.96	1:5.58	*182.75	3.67	6.72
2	*164.89	23.76	1:5.54	*189.25	4.04	7.64
3	*166.15	23.44	1:5.54	*181.75	3.83	6.97
4	164.90	21.87	1:5.59	221.08	3.84	8.50
5	169.20	22.42	1:5.53	227.33	3.43	7.79
6	164.48	21.80	1:5.54	195.17	3.98	7.77
7	170.53	22.53	1:5.56	204.25	3.63	7.42
8	175.99	23.20	1:5.59	214.92	3.34	7.19
9	177.14	23.37	1:5.94	217.42	3.42	7.42
10	180.81	23.87	1:5.93	216.16	3.36	7.26
11	176.58	23.32	1:5.46	210.33	3.51	7.38
12	166.01	21.85	1:5.42	201.50	3.40	6.89
13	175.91	23.27	1:5.47	204.58	3.47	7.09
14	178.59	23.14	1:5.46	207.08	3.51	7.27
15	184.10	23.92	1:5.47	215.92	3.50	7.55
16	186.78	24.03	1:5.47	205.17	3.57	7.33
17	186.35	23.75	1:5.47	208.42	3.43	7.16
18	186.92	23.73	1:5.47	214.42	3.45	7.39
19	182.40	23.09	1:5.46	209.00	3.65	7.63
20	181.98	22.94	1:5.46	208.33	3.41	7.11
21	181.27	22.76	1:5.46	202.25	3.62	7.33
22	181.55	22.65	1:5.46	199.83	3.55	7.09

* Average for two cows.

TABLE II—(*Continued*).

AVERAGE RECORD OF LOT C. (WIDE RATION).

Week.	Dry matter consumed.			Weekly product of milk and fat. Average per head.		
	Per head weekly.	Per 1000 lbs. daily.	Nutritive ratio.	Pounds of milk.	Per cent fat.	Pounds of fat.
1	*129.38	17.37	1:8.87	* 179.75	3.63	6.53
2	141.92	20.56	1:9.02	189.08	3.96	7.49
3	147.75	21.21	1:8.99	186.25	3.95	7.36
4	144.32	20.71	1:8.95	174.17	4.09	7.12
5	135.80	19.52	1:8.79	169.92	3.89	6.61
6	149.93	21.48	1:9.08	169.33	3.78	6.39
7	153.89	21.97	1:9.12	156.75	3.63	6.18
8	156.10	22.23	1:9.15	169.42	3.73	6.32
9	155.15	22.12	1:8.90	167.50	3.99	6.68
10	158.99	22.56	1:8.76	161.42	4.05	6.54
11	158.09	22.37	1:8.75	160.92	4.06	6.53
12	152.95	21.53	1:8.75	157.08	4.10	6.44
13	159.51	22.42	1:8.80	155.83	4.06	6.32
14	158.27	22.04	1:8.69	157.42	4.06	6.39
15	159.68	22.44	1:8.69	158.33	3.99	6.32
16	152.38	20.90	1:8.55	147.92	4.18	6.18
17	154.93	21.04	1:8.56	153.42	4.06	6.23
18	157.59	21.37	1:8.61	151.67	4.06	6.16
19	151.51	20.40	1:8.51	146.25	4.16	6.08
20	* 160.50	21.62	1:8.53	* 161.38	3.64	5.88

*Average for two cows.

Before entering upon any discussion of these records it is necessary to make a few explanations in order that a clear understanding of them may be obtained. The first experiment went through without any irregularities, or illness of the cows, sufficient to cause variations that should be noticed when drawing conclusions. But during the second experiment there were some irregularities that need to be noticed.

In lot A, Table II, Julia was taken sick during the ninth week of the test and for a few days her milk yield fell off nearly one-half. Her illness and slow recovery considerably reduced the average milk and fat yield as may be seen by a glance at the table.

In lot B, Dora did not enter the experiment until the fourth week and was then fresh in milk. She was giving from 40 to 50 pounds of milk daily, which amount increased the average yield, as is seen in table II. During the sixth week she was "off feed" and her milk fell from 325 pounds, during the fifth week to 232 pounds. At the same time her average per cent of fat was over one per cent higher than during the week previous, as well as during the following week. This explains the high average of 3.98 per cent during the sixth week. She quickly regained nearly her former flow and at the close of the experiment was averaging 42 pounds per day.

In lot C, Jennie calved November 8 and entered the experiment the second week, fresh in milk. Her coming into this lot increased both the average yield of milk and the per cent of fat for the second and succeeding weeks. During the twentieth week, Clara, of lot C, was taken suddenly ill with a high fever and died. Upon examination, she was found to have accumulations of fatty tissue in close proximity to the vital organs. During the twenty-first week, May, of lot C, was taken ill in a similar manner to Clara, but her life was saved. It will be remembered that the cows in this lot received a highly carbonaceous ration. The grain consisted of two parts, by weight, of corn meal and one part of wheat bran, while the silage was rich in corn and had been increased five pounds each about a month before the cows became sick. It may be that so highly carbonaceous a ration has a heating tendency upon the animal body. If this be the case, feeding the ration for so long a period, might, in its cumulative effects, result as disastrously as mentioned above. Although Jennie 2d came through the experiment safely on the same ration, still, when the effect upon Clara and May is considered, we cannot help concluding that the ration is not a good one for long, continuous feeding.

To return to the study of the comparative effect of the three rations upon the yield and quality of milk, the results show that there is practically no difference between them so far as their effect on the percentage of fat is concerned. In general there is a gradual increase in the richness of the milk from the beginning of each experiment until the end, regardless of the kind of food. An average of the per cents of fat for periods of four weeks each will present the fact more clearly, and such an average is given in tabular form below. The first two weeks are omitted in striking the average in all cases.

	1895-6. Lot and kind of ration.			1896-7. Lot and kind of ration.		
	A Narrow. per cent fat.	B Medium. per cent fat.	C Wide per cent fat.	A Narrow per cent fat,	B Medium per cent fat.	C Wide. per cent fat.
1st four weeks.........	3.46	3.40	3.47	3.29	3.77	3.93
2nd four weeks.........	3.29	3.14	3.32	3.24	3.44	3.85
3d four weeks..........	3.44	3.37	3.27	3.23	3.47	4.07
4th four weeks.........	3.54	3.55	3.47	3.28	3.49	4.07
5th four weeks.........	3.68	3.65	3.68	3.34	3.56	——

An average of this kind balances the variations from week to week, and places the per cents of fat in a light where conclusions can be more readily drawn therefrom. The reason for the high average during the first four weeks in lot B, year 1896-7, has already been indicated in the discussion concerning Dora's entering the experiment when fresh in milk, and later becoming reduced in flow and increased in fat by forced feeding. Omitting this period, it will be noticed that the average for the remaining periods bear the same relation to each other as those for lot A. In the first experiment there was an increase from the beginning to the end with each lot of about two-tenths of one per cent of fat. In the second experiment this increase was about one-tenth of one per cent.

When we examine the yield of milk and of fat we do not find the same uniformity as is observed in the per cent of fat. If an average be taken of the yield of milk and fat for the first four weeks after the first two, and for the last four weeks of the experiments we find the following per cent of decrease from beginning to end :

	1895-6. Lot and kind of ration.			1896-7. Lot and kind of ration.		
	A Narrow.	B Medium.	C Wide.	A Narrow.	B Medium.	C Wide.
Per cent decrease in milk	17.5	18.0	15.5	17.8	3.0	14.4
Per cent decrease in fat	12.0	12.0	12.0	15.6	6.0	10.3

The decrease for 1895-6 was the same with all rations except for a slight difference in favor of the cows receiving the wide ration. During the year 1896–7 the yields are not so uniform, but lot B shows a much smaller decrease than either of the other lots. Taking both experiments into account it would seem that the medium ration had a more favorable influence upon the continued production of milk and total butter-fat than either the wide or narrow rations. Yet, if individual cases are considered, we find Belva 2d, on the narrow ration, holding out in her milk flow during both years as well as, or better than, any of the cows on the medium ration.

NUMBER OF POUNDS OF DRY MATTER REQUIRED IN EACH RATION TO PRODUCE 100 POUNDS OF MILK AND ONE POUND OF FAT.

	LOT A. Narrow ration.		LOT B. Medium ration.		LOT C. Wide ration.	
	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.
1895–6......	90.2	26.0	102.8	30.1	98.3	28.7
1896–7......	106.6	32.3	85.2	23.9	92.8	23.4
Average...	97.5	28.8	93.0	26.6	95.7	25.9

WEIGHT OF COWS.

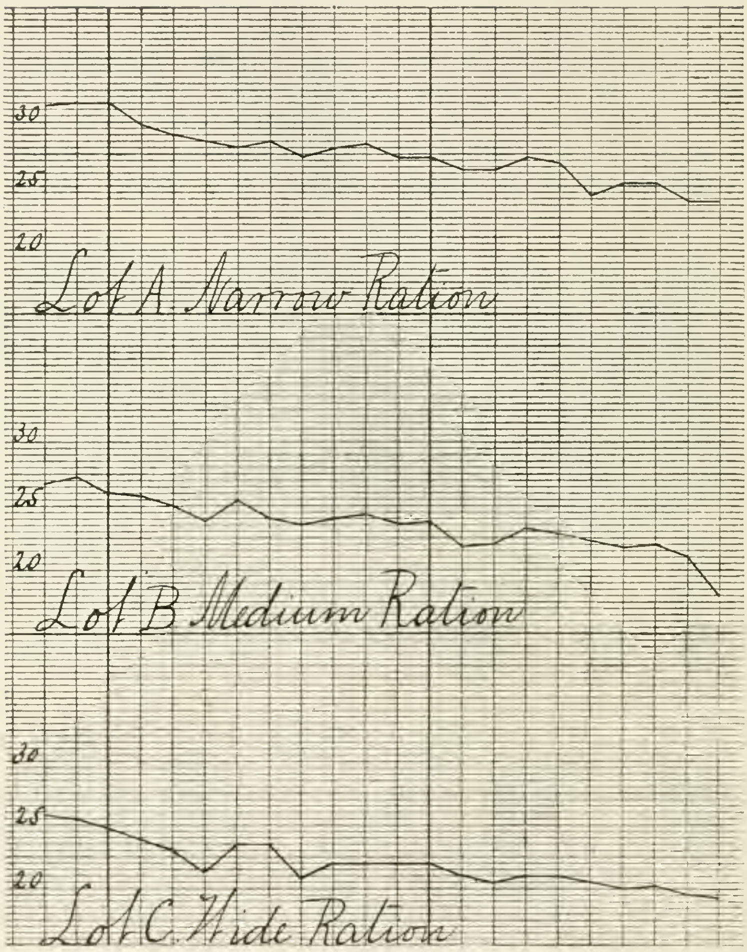
Whether or not the different rations had any particular effect upon the live weight of the cows may be studied by recourse to data already given, but an average of the gain of each lot during the twenty-two weeks together with their average age is tabulated here, for more ready reference. During the first year none

	LOT A. Narrow ration.		LOT B. Medium ration.		LOT C. Wide ration.	
	Age.	Gain per head.	Age.	Gain per head.	Age.	Gain per head.
1895–6......	3⅓	163	3	123	3	145
1896–7......	4⅓	131	4	101	3⅔	65

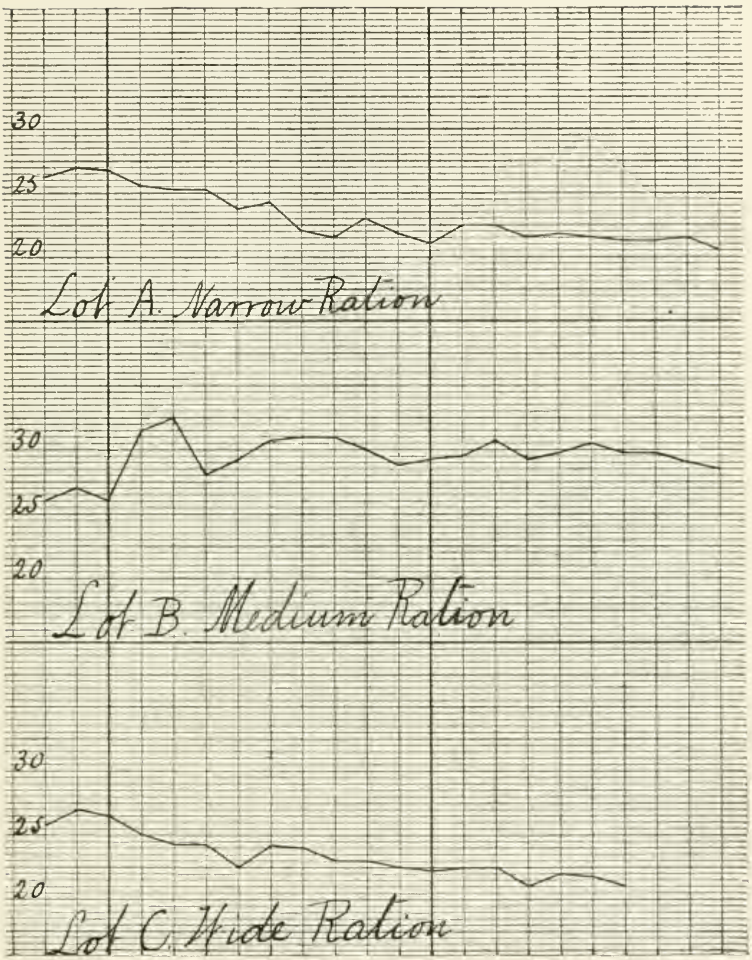
of the cows had reached full age and during the second year two of lot A and one of lot B were five years old. Since the cows in lot A were older than the others, it might seem that the narrow ration had a tendency to fatten the animals more than the other rations. However, the differences are so slight that it is safe to say that the gains in weight are due more to growth than to any particular effect of the food.

CHARTS.

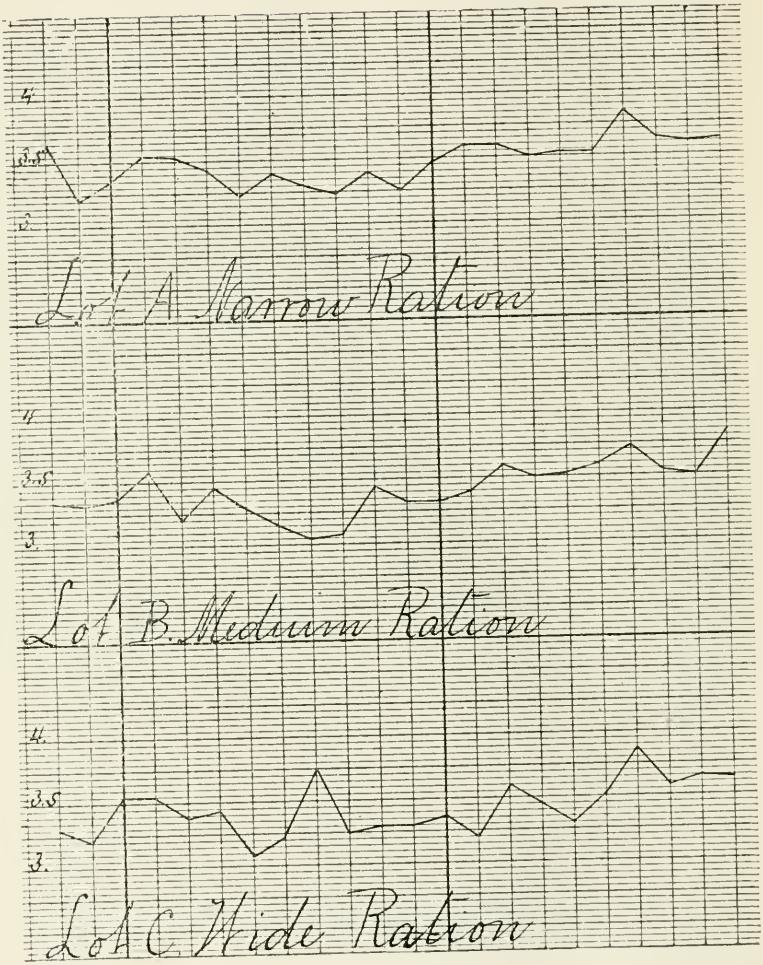
In order to place the records for milk and fat presented in tables I and II more vividly before the reader's eye the following six charts have been prepared. They show the average daily yield of milk, average per cent of fat and average weekly yield of fat for both experiments. Passing from left to right in the charts each division represents one week. Counting upward, each of the small spaces represents one-half pound of milk, five-one hundredths of one per cent fat, or one-tenth of a pound of fat as the case may be.



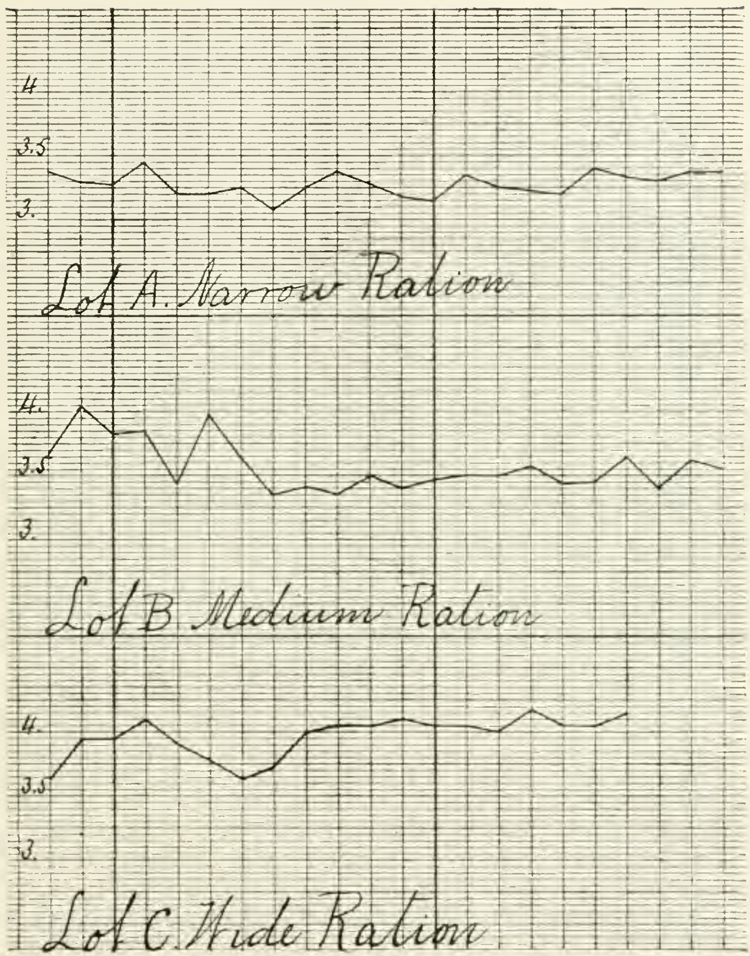
16.—*Diagram showing the average daily yield of milk for each week during the experiment of 1895–6. Each space between the perpendicular lines represents one week. Each space between the horizontal lines represents one-half pound of milk.*



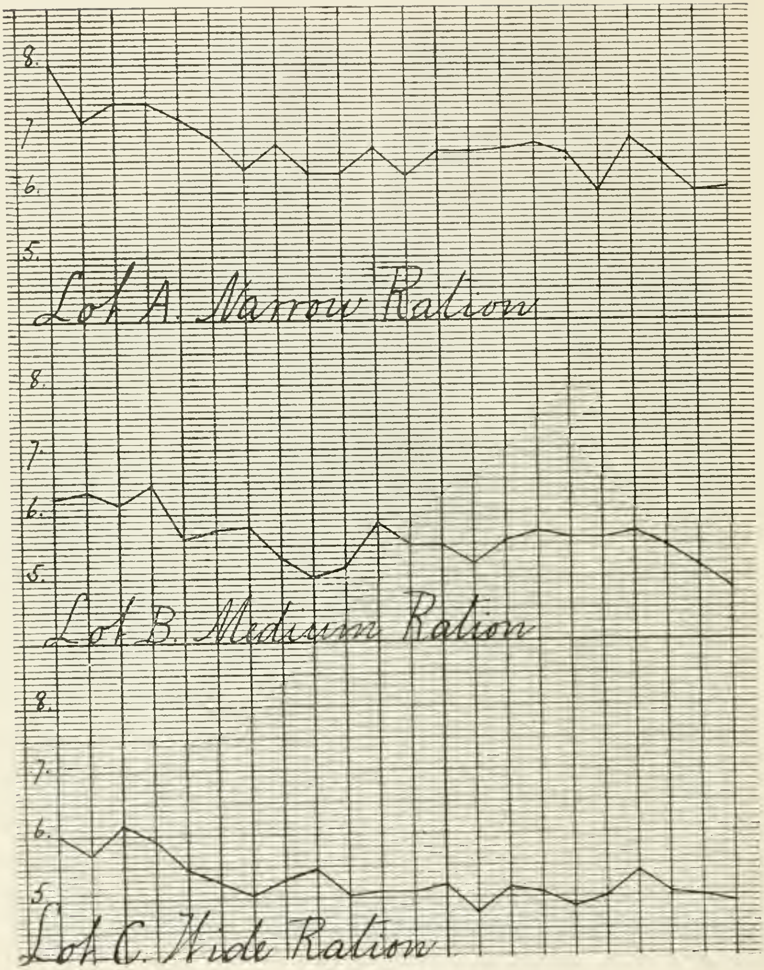
17.—*Diagram showing the average daily yield of milk for each week during the experiment of 1896–7. Each space between the perpendicular lines represents one week Each space between the horizontal lines represents one-half pound of milk.*



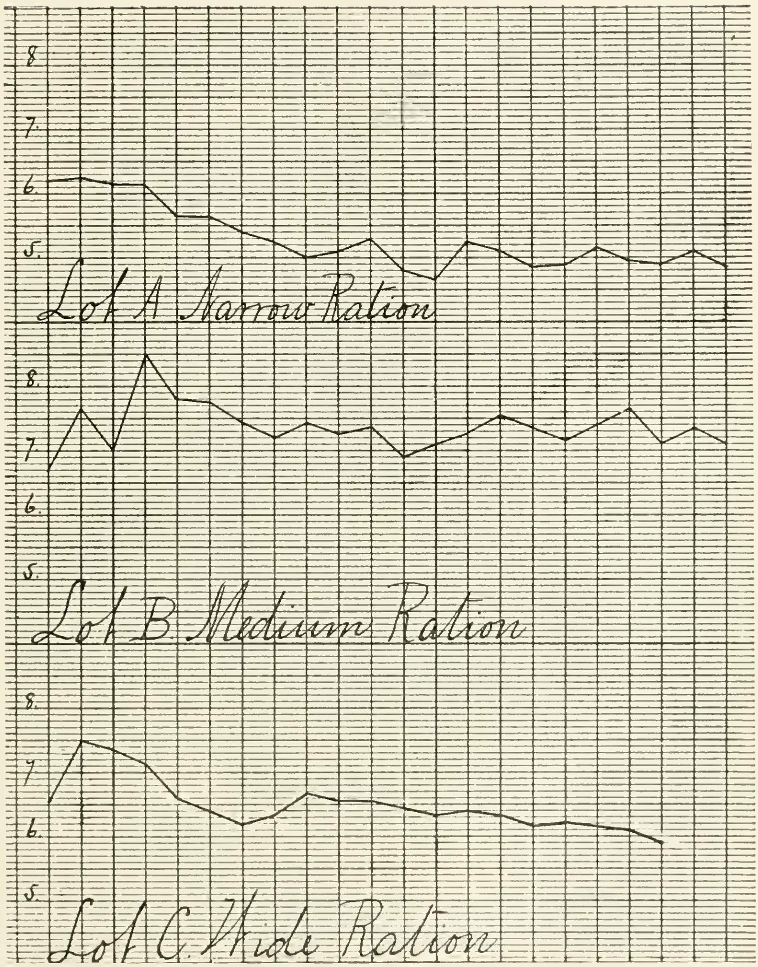
18.—*Diagram showing the average per cent of fat for each week during the experiment of 1895–6. Each space between the perpendicular lines represents one week. Each space between the horizontal lines represents five one-hundredths of one per cent of fat.*



19.—*Diagram showing the average per cent of fat for each week during the experiment of 1896–7. Each space between the perpendicular lines represents one week. Each space between the horizontal lines represents five one-hundredths of one per cent of fat.*



20.—*Diagram showing the average weekly yield of butter fat during the experiment of 1895–6. Each space between the perpendicular lines represents one week. Each space between the horizontal lines represents one-tenth of one pound of fat.*



21.—*Diagram showing the average weekly yield of butter fat during the experiment of 1896-7. Each space between the perpendicular lines represents one week. Each space between the horizontal lines represents one-tenth of one pound of fat.*

FEEDING PALM NUT MEAL.

To carry still further the study of the effect of food upon milk production a trial was made with palm nut meal. This work was carried on during the winter of 1897 by George N. Lauman, then a Senior in the College of Agriculture. An experiment with this food has a double interest because it is the one that Kühn found would increase the per cent of fat in the milk as has been seen in the summary of his work on page 52.

Palm nut meal is the by-product resulting from the extraction of the oil from the fruit of a species of palms which are native to the west coast of Africa. It is a highly nitrogenous product, its percentage of digestible composition being protein 16.6, fiber 16.6, nitrogen free extract 41.4 and fat 3.6. In Europe, and especially Germany, it has long been a popular dairy food because of its stimulative effect upon milk production, although not all feeders and experimenters have found it to increase the fat content of the milk as was reported by Kühn.

The meal used in this experiment was imported from Germany. Six of the University cows were chosen for the test and divided into two lots of three each. Before giving them the palm nut meal, their regular daily ration had consisted of from 8 to 10 pounds of a grain mixture composed of three parts gluten feed, two parts cotton-seed meal, and one part wheat bran, together with what silage and mixed hay they would eat.

The names of the cows in each lot, together with their age, date of calving and weights are given below:

Name of breed.	Age.	Date of calving	Weight beginning.	Weight end.	Loss.
LOT NO. 1.					
Glista Netherland, H. F. H. B. 32442	5	Oct. 21, 1895.	1339	1289	50
Gem Valentine, A. J. C. C. 57881 ...	8	Sept. 6, 1896.	1071	973	98
Mollie, $\frac{15}{16}$ Holstein	7	Oct. 24, 1896.	1348	1267	81
LOT NO. 2.					
Mabel 2d, Jersey-Holstein	2	Oct. 15, 1896.	902	832	70
Ruby, ¾ Holstein	8	Dec. 26, 1896.	1369	1191	178
Sadie, $\frac{15}{16}$ Holstein	5	May 1, 1896.	1407	1386	21

The feeding of the palm nut meal began January 20, 1897, and continued for six weeks. During this time the ration of lot No. 1 remained constant, while that of lot No. 2 was increased as indicated below. The daily rations were made up as follows :

LOT NO. 1:

Grain mixture	10 to 13 pounds.
Palm nut meal	2 parts.
Gluten feed	2 parts.
Wheat bran	1 part.
Corn silage	35 to 45 pounds.
Mixed hay	10 to 13 pounds.
Nutritive ratio	1:6.

Calculating this ration on the basis of 10 pounds of grain, 10 pounds of hay and 40 pounds of silage it would contain the following number of pounds of digestible nutrients: protein 2.7, carbohydrates 14.1, fat .96 and 26 pounds of dry substance.

LOT NO. 2:

Grain mixture.	
Palm nut meal	4 parts.
Gluten feed	3 parts.
Cotton-seed meal	2 parts.
Wheat bran	1 part.
Corn silage	35 to 45 pounds.
Mixed hay	7 to 10 pounds.

The amount of coarse fodder given this lot did not vary materially during the whole experiment. The quantity of the grain mixture fed was increased as follows :

	January 20-31.	February. 1-6.	February. 7-28.
Mabel	7	8.5	10
Ruby	10	12	14
Sadie	10	12	14

Calculating this ration according to the quantities eaten by Ruby and Sadie and considering the amount of silage and hay consumed as 40 and 10 pounds respectively, we have the following amounts of dry matter and the number of pounds of digestible nutrients consumed daily during the different periods :

	Dry matter.		Protein.	Carbo-hydrates.	Fat.	Nutritive ratio
	Per head.	Per 1000 lbs.				
January 20-31..	26.06	20.00	3.09	13.52	1.08	1:5.16
February 1-6...	27.87	21.51	3.52	14 42	1.22	1:4.84
February 7-28..	29.68	22.83	3.96	15.32	1.35	1:4.64

On February 24 the proportion of palm nut meal was increased from four to six parts in the grain mixture so that it made up one-half of the grain ration. On the first of March the meal was discontinued and all the cows returned to the same ration which they received before the trial.

Table III contains the yield of milk and butter-fat of each cow under experiment for six weeks before and six weeks after the palm nut meal was fed as well during the period of feeding the meal.

TABLE III.

WEEKLY PRODUCT OF MILK AND FAT OF LOT NO. 1.

Ration for each period of six weeks.	Glista Netherland.			Gem Valentine.			Mollie.		
	Pounds of milk.	Per cent fat.	Pounds of fat.	Pounds of milk.	Per cent fat.	Pounds of fat.	Pounds of milk.	Per cent fat.	Pounds of fat.
Usual	204.25	3.00	6.13	157.00	5.20	8.16	334.25	2.60	8.69
ration of	217.50	3.15	6.85	176.50	5.30	9.35	347.50	2.95	10.25
silage,	207.50	3.00	6.23	145.50	5.35	7.78	321.50	3.40	10.93
hay and	211.00	3.25	6.86	116.00	4.85	5.63	313.50	3.00	9.41
grain.	202.75	3.25	6.59	118.50	4.85	5.75	305.50	2.65	8.10
	201.50	3.50	7.05	131 25	5.50	7.22	299.50	3.10	9.28
Total.	1244.50	3.19	39.71	844 75	5.20	43.89	1921.75	2.95	56.66
Palm nut	206.50	3.20	6.61	127.75	5.52	7.05	311.00	3.17	9.86
meal	196.50	3.38	6,64	123.25	5.88	7.25	293.50	3.26	9.57
ration.	182.25	3.41	6.21	122.75	6.00	7.37	295.25	3.38	9.98
	187.00	3.75	7.01	117.75	5.98	7.04	296.75	3.48	10.33
	184.00	3.48	6.40	117.50	5.57	6.54	298.75	3.35	10.01
	164.75	3.75	6.18	105.50	5.85	6.17	295.00	3.53	10.41
Total.	1121.00	3.48	39.05	714.50	5.80	41.42	1790.25	3.36	60.16
Usual	139.50	3.42	4.77	111.50	5.73	6.39	285.50	3.07	8.76
ration.	* 62.00	3.60	2.23	114.75	6.00	6.89	315.50	3.30	10.41
				108.00	5.65	6.10	304.00	3.55	10.79
				83.75	5.95	4.98	307.75	3.25	10.00
				93.25	5.75	5.36	294.00	3.40	10.00
				93.75	5.85	5.48	290.75	3.25	9.45
Total.	201.50	3.47	7.00	605.00	5.82	35.20	1797.50	3.31	59.41

* Went dry.

TABLE III—(*Continued*).

WEEKLY PRODUCT OF MILK AND FAT OF LOT NO. 2.

Ration for each period of six weeks.	Mabel 2d.			Ruby.			Sadie.		
	Pounds of milk.	Per cent fat.	Pounds of fat.	Pounds of milk.	Per cent fat.	Pounds of fat.	Pounds of milk.	Per cent fat.	Pounds of fat.
Usual ration of silage, hay and grain.	183.75	3.90	7.17				169.75	3.20	5.43
	186.25	4.10	7.64				163.50	3.05	4.99
	163.25	3.80	6.20				147.00	3.40	5.00
	167.50	3.95	6.62	336.25	3.75	12.61	141.25	3.60	5.09
	176.00	3.90	6.86	385.25	3.80	14.64	148.00	3.45	5.11
	171.00	3.45	5.90	408.00	3.50	14.28	144.50	3.90	5.64
Total	1047.75	3.85	40.39	1129.50	3.67	41.53	914.00	3.42	31.26
Palm nut meal ration.	160.25	4.07	6.52	434.25	3.26	14.16	132.25	3.22	4.26
	148.75	4.58	6.81	439.00	3.28	14.40	119.75	3.28	3.93
	150.75	4.33	6.53	418.75	3.25	13.61	119.50	3.33	3.98
	152.00	4.53	6.89	423.25	3.26	13.80	122.50	4.06	4.97
	148.75	4.35	6.47	422.25	3.21	13.55	122.75	3.23	3.96
	149.50	4.18	6.25	415.75	3.35	13.93	113.75	3.46	3.94
Total	910.00	4.34	39.47	2553.25	3.27	83.45	730.50	3.43	25.04
Usual ration.	162.25	3.69	5.99	409.50	3.00	12.29	104.25	3.12	3.25
	169.75	3.80	6.45	389.50	3.20	12.75	104.75	2.30	2.41
	170.50	3 85	6.56	422.75	2.80	11.84	97.75	3.40	3.32
	171.00	4.00	6.84	397.50	3.25	12.92	86.75	3.30	2.86
	173.25	4.35	7.54	374.25	3.25	12.16	77.50	3.70	2.87
	174.00	3.75	6.53	345.50	2.90	10.02	67.25	3.45	2.32
Total	1020.75	3.91	39.91	2348.00	3.07	71.98	538.25	3.16	17.03

A clearer understanding of the variations in the per cent of fat during the eighteen weeks may be obtained by finding the average per cent in periods of three weeks each. A table of such averages is given below. In order to make the study more complete, there is placed in the same table the average per cents of fat found in the records of three cows which were in the second experiment described on page 65. The per cents are the averages for the periods of three weeks each which are coincident with those in which palm nut meal was fed. It will be remembered that the rations of the three cows were unaltered during a term of twenty-two weeks.

TABLE IV.

AVERAGE PER CENT OF FAT IN PERIODS OF THREE WEEKS EACH.

		Lot No. 1.			Lot No. 2.		
		Glista Netherland.	Gem Valentine.	Mollie.	Mabel 2d.	Ruby.	Sadie.
Usual ration (Dec. 9-Jan. 19)..	1st three weeks.	3.06	5:28	2.98	3.94	——	3.21
	2d three weeks.	3.39	5:09	2.92	3.77	3.67	3.63
Palm nut meal ration .... (Jan. 20-Mch. 2).	1st three weeks.	3.32	5:80	3.27	4.32	3.26	3.28
	2d three weeks.	3.64	5:80	3.45	4.35	3.27	3.58
Usual ration.... (Mch. 3-April 13).	1st three weeks.	3.47	5:80	3.31	3.78	3.00	2.92
	2d three weeks.	——	5:84	3.30	4.03	3.14	3.48
Ration unchanged.		Belva 2d. Narrow ration.	Cherry. Medium ration.	Clara. Wide ration.			
December 9–29................		3.02	5.37	5.11			
December 30–Jan. 19...........		2.92	5.58	5.30			
January 20–Feb. 9.............		2.94	5.75	5.68			
February 10–Mar. 2............		3.14	5.52	5.44			
March 3–23....................		3.23	5.55	5.45			
March 24–April 13.............		3.23	5.47	——			

Among the cows that were fed palm nut meal it is seen that all in lot No. 1 show in general a higher per cent of fat while the meal was fed than before, but this higher average is kept up for six weeks after the meal was discontinued. Mabel 2d of lot No. 2, is the only cow that shows a lower average both before and after feeding the palm nut meal than during that period, but her total yield of fat was less on the palm nut ration than on the usual ration. Ruby and Sadie each had a higher average before the meal was fed and nearly as high after as during the period of feeding the meal. Ruby's high average at the beginning is probably due to her being fresh in milk. A comparison of the records of all the cows in table IV shows that with one exception (Gem Valentine) there are no greater variations among the cows which alternated from the usual ration to palm nut meal than among those which were fed an unchanging ration. Thus, taking everything into consideration we do not feel warranted in saying that the feeding of palm nut meal increased the per cent of fat in the milk.

Conclusions.

For two terms of twenty-two weeks, nine cows were fed in lots of three each on different rations, the nutritive ratios of which were about 1:4, 1:6 and 1:9 respectively. During this time the percentage of fat in the milk of each lot increased slightly and gradually without regard to the kind of ration.

For continuous feeding, the medium ration appeared to give better results as to yield of milk than either the narrow or wide rations.

When the food of the cows was changed from the usual ration to one containing from four to seven pounds of palm nut meal and then to the usual ration again, there were variations in the fat content of the milk, but no more nor greater than when the food of the cows was unchanged.

The Following Bulletins are Available for Distribution to Those Who may Desire Them.

40 Removing Tassels from Corn, 9 pp.
55 Greenhouse Notes, 31 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
74 Impressions of the Peach Industry in N. Y., 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western N. Y., 116 pp
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
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96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to Care of Fruit Trees, 21 pp.
104 Climbing Cutworms in Western, N. Y., 51 pp.
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp.
114 Spraying Calendar.
116 Dwarf Apples, 31 pp.
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119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp.
121 Suggestions for Planting Shrubbery.
122 Second Report upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol-Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and the Raspberry-Cane Maggot, 22 pp.
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128 A Talk about Dahlias, 40 pp.
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138 Studies and Illustrations of Mushrooms; I, 32 pp.
139 Third Report upon Japanese Plums.
140 Second Report on Potato Culture, 24 pp.
141 Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142 The Codling-Moth.
143 Sugar Beet Investigations, 88 pp.
144 Suggestions on Spraying and on the San Josè Scale.
145 Some Important Pear Diseases.
146 Fourth Report of Progress on Extension Work, 26 pp.
147 Fourth Report upon Chrysanthemums, 36 pp.
148 Quince Curculio, 26 pp.
149 Some Spraying Mixtures.
150 Tuberculosis in Cattle and its Control.
151 Gravity or Dilution Separators.
152 Studies in Milk Secretion.
153 Impressions of Fruit-Growing Industries.
154 Table for Computing Rations for Farm Animals.
155 Second Report on the San Jose Scale.
156 Third Report on Potato Culture.
157 Grape-vine Flee-beetle.
158 Source of Gas and Taint Producing Bacteria in Cheese Curd.
159 An Effort to Help the Farmer.
160 Hints on Rural School Grounds.
161 Annual Flowers.
162 The Period of Gestation in Cows.
163 Three Important Fungous Diseases of the Sugar Beet
164 Peach Leaf-Curl.
165 Ropiness in Milk and Cream.
166 Sugar Beet Investigations for 1898.
167 The Construction of the Stave Silo.
168 Studies and Illustrations of Mushrooms: II.
169 Studies in Milk Secretion.
170 Tent Caterpillars.
171 Concerning Patents on Gravity or Dilution Separators.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1899.

171. Gravity or Dilution Separators.

172. The Cherry Fruit-Fly: A New Cherry Pest.

173. The Relation of Food to Milk-Fat.

Bulletin 174. **November, 1899.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

THE PROBLEM OF Impoverished Lands.

Being Suggestions for Investigation and Experiment.

COMPILED BY

L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899.

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CORNELL UNIVERSITY, ITHACA, N. Y., Nov. 1, 1899.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The one perennial inquiry at an Experiment Station is how to restore land to its original producing power. We have made many experiments and investigations to determine the problems at issue. A popular summary of these studies is given herewith. The chemical part of the subject has been prepared by G W Cavanaugh, under the supervision of Professor Caldwell. Full reports of three years' experimenting with fertilizers are now being compiled for publication in bulletin form.

This bulletin comprises the following subjects:

Part I. *How to Understand the Problem.*

- A. Some reasons why lands become impoverished.
- B. How to reclaim depleted lands.

Part II. *A Crusade with the Farmers.*

- A. Reading-Lessons Nos. 1 and 2.
  - No. 1. The Soil: What it is.
  - No. 2. Tillage and under-drainage: Reasons why.
- B. Answers to the Questions on Five Reading-Lessons.
  - No. 1. The Soil: What it is.
  - No. 2. Tillage and under-drainage: Reasons why.
  - No. 3. Fertility of the land: What it is.
  - No. 4. How the plant gets its food from the Soil.
  - No. 5. How the plant gets its food from the Air.

I. P. ROBERTS, Director.

Plan of a set of plats upon which the farmer may ask the soil and the plant what fertilizers are needed (See p. 95) :

1	S plat.	
2	K plat.	20 lbs. muriate of potash.
3	N plat.	20 lbs. nitrate of soda, or 40 lbs. tankage or dried blood.
4	K N plat.	{ 20 lbs muriate of potash. 20 lbs. nitrate of soda. } or { 20 lbs. muriate of potash. 40 lbs. tankage, etc. }
5	O plat.	No fertilizer.
6	P plat.	40 lbs. plain superphosphate with 15% phosphoric acid.
7	K P plat.	{ 20 lbs. muriate of potash. 40 lbs. superphosphate. }
8	N K P plat.	{ 20 lbs. nitrate of soda, 20 lbs. muriate of potash, 40 lbs. superphosphate. } or { 40 lbs. tankage, etc. 20 lbs. muriate of potash. 40 lbs. superphosphate. }
9	N P plat.	{ 20 lbs. nitrate of soda, 40 lbs. superphosphate. } or { 40 lbs. tankage, etc. 40 lbs. superphosphate. }

Size of plats 1-10 acre. Upon each plat the same crop is to be grown, care being taken that the seed is pure and that each plat receives exactly the same amount of seed.

S, means stable manure ; K, potash ; N, nitrogen ; P, phosphoric acid ; O. no fertilizer.

The best arrangement is to have plats as narrow as they can be and still carry a reasonable number of rows of the crop, and, unless the field is too large, extending from one side to the other, and across all unlike strips. Such an arrangement would reduce the labor of planting and tillage to a minimum, besides securing the probable advantage of greater evenness in results.

A set of plats seventeen and one-half feet wide would carry five rows of corn or potatoes, with three and one-half feet between the rows; there would then be three rows to harvest for the measurement of the crop, the two outside rows being rejected. For cereals, as wheat, rye, barley and oats, plats as wide as could be sown with the drill, with two or three feet vacant spaces between the plats, would answer. For small fruits, plats carrying three rows should be taken, the fruit of the inner row only being harvested for the measurement of the crop.

THE PROBLEM OF IMPOVERISHED LANDS.

Part I. HOW TO UNDERSTAND THE PROBLEM.

"Some of my land will not produce a crop, although my father raised good crops on it. What shall I do to make it productive?"

This is a common type of question. It is easily asked, but very difficult to answer. The first thing to do is to find out why the land is unproductive. The remedy then follows as a natural consequence. The disease must be diagnosed, as the physicians say, before it can be cured.

If the cause of the unproductiveness is to be discovered, the land itself must be studied carefully, and the history of the field should be known. The man who is on the spot—the farmer himself—has the best opportunity to determine the cause of the trouble. One value of an education and of experiment station teachings is to help the farmer to work out his problems for himself. He can not only solve many of his problems better than the experimenters can, but he derives pleasure from the quest, and great comfort in being able to master his difficulties.

The farmer who has worn-out land must study and experiment for himself. It is the object of this bulletin to suggest how this may be done. We will specify some of the leading causes of unproductiveness, and then suggest inquiries

A. Some Reasons Why Lands Become Impoverished.

1. *They may lack tillage and good care.* It is significant that impoverised lands are usually those which have been neglected. From insufficient or improper tillage, lands become cloddy, hard, unresponsive and foul. In such cases, it may be necessary to resort to summer fallow to correct the errors,—to bring the land

back into prime condition ; but it is rare that well farmed fields need fallowing. See part II, paragraphs 7, 8, 9, 14, 16, 25.

2. *They may lack humus or vegetable mold*—When in native conditions, in regions of sufficient rainfall, lands are covered with vegetation. As this vegetation dies it becomes incorporated with the soil as humus, making the soil mellow, dark-colored and rich. It enables the soil to hold moisture, lessens extremes of temperature, hastens chemical activities, and itself supplies plant-food. When vegetable matter is withheld from the soil, the humus is not replenished, and it is gradually used up. The soil then becomes hard, "dead," very dry in dry weather and very muddy in wet weather, and is subject to great extremes of temperature. If the original basis of the soil is clay, the land bakes and becomes lumpy when plowed; if sand, it becomes loose and leachy. See Part II,, paragraphs 5, 6.

One great value of stable manure is to supply humus. Green cropping is also exceedingly useful. A rotation of crops in which sod is one factor tends to maintain the supply of humus. Catch-crops (sown between other crops) may be used to replenish the humus ; also cover-crops (those sown in fall for a winter cover). Long continued cropping with one or with similar crops tends to deprive the soil of humus. When the farmer does not properly care for the land, nature tries to force him into another rotation. This is well illustrated in pastures and meadows, in which daisies and wild carrot force out the poor stand of grass. Most of the depleted lands in New York are suffering more for humus than for plant-food.

To determine by experiment whether a soil has sufficient humus is difficult because the forms of available humus-producing materials also contain plant-food. Humus may be supplied by muck, stable manure, leaves or green-crops. All these contain the different plant-food, and also a large amount of vegetable matter. To test whether a soil needs humus, apply these materials to several plats of ground, leaving one or more without them for checks. Stable-manure might be applied to one plat, muck to another, a green-crop of clover, barley, buckwheat, etc., turned under on another. Nature uses leaves for making humus in the woods.

3. *They may need draining.*—Under-draining lowers the water-table (or the zone of standing water), causing the soil to become deeper and mellower. Well-drained soil is drier in wet weather and moister in dry weather than soil which is underlaid with a high and hard subsoil. Most of the cold, wet and so-called "sour" lands need draining to make them productive. Even though they are not too wet for tillage, they may need the drainage for the purpose of deepening the soil and causing it to hold more air and moisture. Deep-rooting plants, as clover, tend to make soils deeper. Subsoiling has a similar tendency, but its effect usually is not permanent. Consult Part II., paragraphs 9, page 99.

4. *The soil may become acid.*—There are some cases in which the soil becomes sour to a degree that is injurious to many plants. This is true of some sandy uplands and sometimes is indicated by growths of sorrel, daisies and golden rod. The acid in soil can be detected by its reddening blue litmus paper (to be had at drug stores or at this Station). This over-acid condition often acccompanies a lack of humus, and sometimes may be corrected by adding humus. It is also relieved by the use of ashes or lime, which have the power of neutralizing or sweetening acids. The ashes or lime should not be plowed in, but harrowed in after plowing, as lime tends to work downward. When experimenting with humus (see next page,) an application of ashes on an adjoining plat may help solve the problem.

5. *The soil may lack in useful plant-food.*—Some of the leading plant-food elements may be nearly or quite exhausted; or, as is more usually the case, they may be in an unavailable condition or locked up. The chemist can tell if the soil which he analyzes lacks plant-food; but another sample of soil from the same field may be very different in composition. There is very little uniform soil in New York, for nearly all of it is mixed glacial soil. But the chemist cannot tell how much of the plant-food is available to plants. Food which is nearly unavailable when he analyzes it, may be made available by a change in conditions or by better tillage; and that which is clearly available may become unavailable the same season. In certain very pronounced cases of depleted lands, the chemist may render much direct aid; but in

general he can only suggest and advise, not prescribe. The only sure way to find out whether more plant-food is needed is to experiment on the land in question.

B. How to Reclaim Depleted Lands.

1. *If you think that they lack humus, apply stable manure or turn under a green-crop.* The best general green-crop is red clover, but it does not catch well on very sandy and very hard soils. Then begin with any crop which will grow—rye, buckwheat, corn, beans, anything to get a start. If the land produces weeds when left to itself, it is good enough to produce something else. Turn the weeds under, sow something, turn it under, sow again; in two or three years the results will be seen.

2. *Till frequently and wisely.*—Many depleted lands need tillage more than humus or plant-food. Usually, they need both. Prepare the land thoroughly for the green-crop. Plow when the land is most fit. In very hard clays, try fall-plowing.

3. *If the land is so poor that it is wholly bare, determine whether it is very acid. If it is, apply lime or ashes.*—Apply some fertilizer to enable you to get a start of plants. The start once made, the future is yours. Plow under herbage; add plant-food as your experiments suggest.

We have lands which are now so completely run out that the sand drifts and no plants can obtain a foothold. It is probable that they can be reclaimed, although it is a question if the reclamation will always pay. Analyses have been made of samples of some of these lands, and it is found that they contain liberal supplies of potash and phosphoric acid, but almost no nitrogen. They are also almost wholly lacking in humus. The soils are so leachy that an application of nitrate of soda or other very soluble materials would probably be of little avail. Probably the best means of recuperating these lands is to make applications of stable manure and then to sow rye or some other cover-crop for the purpose of making a body of humus in the soil. If stable manure cannot be had, tankage will be found to be a good substitute since it contains nitrogen in a more or less insoluble form. We advise persons who have such lands to experiment with a small piece and when the experiments prove successful to extend them to a larger area. In the Old World, spurry is used to begin the reclamation of such lands. Seed can be had of the leading seedsmen.

4. *Experiment with the land to determine what plant-food it needs.*—To test the need of fertilizers, a trial of five plats may be helpful :

On the first, apply nitrate of soda at the rate of 200 lbs. per acre.

On the second, 200 lbs. superphosphate.

On the third, apply nothing.

On the fourth, 200 lbs. muriate of potash.

On the fifth, 1000 lbs. lime.

The results will in some measure indicate which of the elements of plant-food is needed.

For a more complete and conclusive method of testing fertilizers, the reader is referred to Bulletin 129. The plan of experiment, as outlined by that publication, is reprinted at the beginning of this bulletin.

Part II. A CRUSADE WITH THE FARMERS.

In the winter of 1898–9 this Station discussed a series of soil and fertility questions with the members of the Reading-Course (8605 persons). Five Reading-Lessons were issued, two of which pertained directly to soil problems ; and these two Lessons are reprinted here. With each Lesson there was issued a series of questions designed to bring out the points in the Lesson. The replies which were received to these questions afford an excellent index to the state of the popular mind on subjects connected with the fertility of the land. The questions were designed to elucidate underlying truths or principles, and correct answers to them will do much towards spreading sound ideas of maintaining and increasing the productive power of the land. We therefore reprint the questions and give answers to them. These questions and answers cover all the five Lessons : "The Soil : What it is ;" "Tillage and Under-Drainage : Reasons Why ;" "Fertility of the Soil : What it Is ;" "How the Plant Gets its Food from the Soil ;" "How the Plant Gets its Food from the Air." These answers are written by H. P. Gould, but have been approved by specialists in the various subjects.

A. Reading-Lessons Nos. 1 and 2.

LESSON NO. 1. THE SOIL: WHAT IT IS.

1. *The basis of soil is fragments of rock.*—As the earth cooled, the surface solidified into rock. The processes of nature have been constantly at work breaking up this rock and making it into soil.

2. *Weathering is the great agency in making rocks into soil.*—Rain, snow, ice, frost have worn away the mountains and deposited the fragments as soil. Probably as much material has been worn away from the Alps as still remains and this material now forms much of the soil of Italy, Germany, France, Holland. Our own mountains and hills have worn away in like manner.

3. *Weathering is still active.*—All exposed rocks are wearing away. Stones are growing smaller. The soil is pulverized by fall plowing.

4. *The particles of soil are worn and transported by water.*—Every stream carries away great quantities of soil and deposits it in the shallows and the bays. After every rain, the streams and ponds are muddy and roily. Observe the sediment or fine mud which remains when a "mud puddle" dries up. The rivulet may carry away tons of earth every year; and this earth is deposited somewhere, and sometimes it may perhaps, come into use again for the growing of plants. Many of our best and richest farm lands are the deposits of former streams and lakes. Such lands are fine and silk-like. Most lowlands belong to this category; and even some of our higher lands are formed from deposits from water. The mixed and varied character of soils is largely due to the fact that they are the results of transportation from different places.

Observe the flat lands about lakes. These flats are formed by the deposition of material from the surrounding highlands; but they are often exposed before their natural time by the lowering of the water level in the lakes. All lakes and ponds are filling up. Nearly every stream makes a delta at its mouth; but if the stream into which it empties is swift, the delta may be carried away.

Observe, also, the broad rounded hillocks and knolls in valleys and ravines. Many of them have attained their present form from the action of moving water.

Every farmer knows that overflowed lands are rich. He has heard of the wonderful fertility of the Nile. He should explain these facts.

5. *All productive soils also contain organic matter.*—Most organic matter is the remains of plants and animals. As found in soils in a decaying condition, it is called humus. It is the humus which gives the soil its dark or "rich" look. It also tends to make soils loose warm and mellow. It holds moisture. The addition of humus makes soils loamy. A sandy loam may be defined as a soil of which the original mineral matter is sand, and a clayey loam is one of which the basis is clay. Soils which have no humus are hard, "dead" and unproductive.

6. *Humus is supplied by means of roots and stubble, green-crops and barn manures.*—If the farmer practices a rotation of which meadow and pasture are a part, the supply of humus will be maintained. In such cases, green-manuring is unnecessary except now and then upon lands which are very hard or poor. The roots and stubble, with the droppings of the animals on the pasture, and manure applied with one of the crops in the rotation, keep the land well supplied with vegetable matter. Whenever possible, it is better to feed the crop to stock and return the manure to the land, than to plow the crop under; for one will get back the greater part of the fertilizing value of the crops and maintain the animal at the same time. In western New York, there are hundreds of acres of refuse cabbage lands, and at this day there are thousands of tons of herbage on the ground, and no stock to eat it. It is wasteful.

Many soils which are said to be worn out are robbed of their humus rather than of their plant-food; others have been injured in their texture by careless or faulty management. In supplying humus, it is better to add small quantities often. Lands which are under constant tillage, in corn, wheat, oats, potatoes, may be supplied with humus if catch-crops are sown with the crop, now and then, late in the season. Rye, Canada peas, crimson clover, and the like may be used for this purpose. Plow them under as soon as the land is ready in the spring, even if the plants are not large.

Observe how the forest supplies its humus. Year by year the leaves add to the soil cover, which slowly passes into vegetable mold or humus. The trunks finally decay and pass into the soil. The work is effectively done, but it consumes time ; and man is in a hurry. When the forest is removed, the land is usually productive. It is called "virgin soil," notwithstanding the fact that an enormous crop of trees has just been taken from it, and that it may have grown hundreds of such crops. The real virgin soil is the barren soil. But however rich this forest soil may be when the timber is first removed, it generally soon loses its exuberant fertility. The pigmy crops of the farmer seem to be harder on the soil than the gigantic crops of Nature. Some of this loss of productivity is due to the loss of humus.

A rotation diminishes the exhaustion of plant-food, supplies nitrogen in leguminous crops, one crop leaves the land in better condition for another, the roots and stubble improve the texture of the soil, it keeps weeds in check, provides for continuous labor because stock is kept.

The rotation should differ with the kind of soil and general style of farming. The Cornell rotation is :

Wheat,
Clover and timothy, 1 year,
Maize (corn),
Oats.

A good rotation for weed-infested land is :

Sod, 1 year,
Maize,
Potatoes, or some other tilled crop,
Oats or barley.

On fruit farms, rotations are not so practicable as on grain farms ; but the fields which are not in fruit can often be worked in rotation to great advantage. The general tendency of fruit-farmers is to keep too little stock. If stock cannot be kept, the humus can be maintained by catch-crops and cover crops.

7. *The fertility of the land is its power to produce crops. It is*

determined by three things : the texture of the soil, its richness in plant-food, and its available moisture.—The texture of the soil is its physical condition,—as to whether it is mellow, loose, leachy, cloddy, hard, and the like. A rock or a board will not raise corn, and yet it may contain an abundance of plant-food. The plant cannot get a foothold : and it would do no good to apply fertilizers. Spreading potash on a lump of clay is not farming : it is the wasting of potash. A cow will not appreciate the fanciest ration if she is uncomfortable ; neither will a plant. It is only on land which is in good tilth that fertilizers pay. The better the farming, the more it will pay, as a rule, to buy plant-food : but poor farming cannot make it pay.

8. *Nature secures good texture in soil by growing plants in it.*—Roots make the soil finer, and plants supply it with humus. Plants break down the soil by sending their roots into the crevices of the particles, and the root acids dissolve some of it. Observe Nature working at this problem. First the "moss" or lichen attacks the rock ; the weather cracks it and wears it away ; a little soil is gathered here and there in the hollows ; a fern or some other lowly plant gains a foothold ; year by year, and century by century, the pocket of soil grows deeper and larger ; and finally, the rock is worn away and crumbled, and is ready to support potatoes and smart-weed. Or, the rock may be hard and bare, and you cannot see any such process going on. Yet, even then, every rain washes something away from it, and the soil beneath it is constantly receiving additions. Some soils may be said to be completed : the rock is all broken down and fined. Other soils are still in process of manufacture : they are full of stones and pebbles which are slowly disintegrating and adding their substance to the soil. Did you ever see a "rotten stone"?

The longer plants are grown on any soil, and returned to it, the richer the soil becomes. But Nature has centuries at her disposal ; man has but a few short years and must work rapidly, and he cannot afford to make mistakes.

9. *The texture of the soil may be improved* (1) *by underdraining*, (2) *by tilling*, (3) *by adding vegetable matter*, (4) *by adding certain materials, as lime, which tend to change the size of the soil particles.*—The reader will say that Nature does not practice tile-drain-

ing. Perhaps not ; but then, she has more kinds of crops to grow than the farmer has, and if she cannot raise oaks on a certain piece of land she can put in water-lilies. We have an entire lesson devoted to drainage and tillage, and also one to manures and fertilizers. It is enough for the present to say that the roots which are left in the ground after the crop is harvested are very valuable in improving the soil. This is particularly true if they are tap-roots,—if they run deep into the soil. Clover bores holes into the soil, letting in air, draining it, warming it and bringing up its plant-food. Roberts reports ("Fertility of the Land," p. 345) that a second growth of clover, two years from seeding, gave a yield of air-dried tops of 5,417 lbs. per acre, and of air-dried roots 2,368 lbs. in the first eight inches of soil. Add to this latter figure the weight of roots below eight inches and the stubble and waste, and it is seen that the amount of herbage left on the clover field is not greatly less than that taken off. In this instance, the roots contained a greater percentage of nitrogen and phosphoric acid than the tops, and about the same percentage of potash.

Make an estimate of what proportion of the plant growth you raise is actually taken off the field. Figure up, as accurately as you can, the part left in roots, stubble, leaves and refuse. Even of maize, you do not remove all from the field. This calculation will bring up the whole question of the kind of root-system which each sort of plant has. Have you ever made a close examination of the roots of potatoes, maize, wheat, clover, cabbages, buckwheat, strawberries, Canada thistles, or other crops? From what part of the soil do these plants secure their nourishment? What power have they of going deep for water? What proportion of them is root? Because the roots are hidden, we have neglected to examine them.

10. *The soil is plant-food ; but this food becomes usable or available slowly.*—Roberts has compiled the analyses of 49 representative soils, made by American chemists, and the following is the result : "The tables reveal the fact that even the poorer soils have an abundance of plant-food for several crops ; while the richer soils in some cases have sufficient for two hundred to three hundred crops of wheat or maize. The average of 34 analyses

gives to each acre of land, eight inches deep, 3,217 pounds of nitrogen, 3,936 pounds of phosphoric acid, and 17,597 pounds of potash, and this does not include that which is contained in the stones, gravel and sand of the soil which will not pass through meshes of one-fiftieth of an inch, which, by weathering and tillage, slowly give up their valuable constituents."—*Roberts*, "*Fertility of the Land*," p. 16.

Fortunately, this great store of plant-food is largely locked up, else it would have leached from the soil or have been used up long ago. By careful husbandry, a little of it is made usable year by year; and the better the management of the land the more of this food is available to the plant. When the farmer has done his best to get out of the land all that it will give him, then he may add fertilizers for bigger results.

Plant-food is available when it is in such condition that the plant can use it. It must be both soluble and in such chemical form that the plant likes it. Plant-food which is not soluble in rain water, may still be soluble in soil water (which contains acids derived from the humus); and the acid excretions from the roots may render it soluble. But solubility is not necessarily availability, for, as we have said, the materials must be in such combination that the plant will take them. Thus, nitrate of soda ($Na\ N\ O_3$) is available because it is both soluble and in the form in which the plant wants it. But nitrite of soda ($Na\ NO_2$) is not available although it is soluble,—the plant does not like nitrites.

11. *Nitrogen must probably be in the form of nitrates before it can be used by most plants.*—Nitrogen is abundant. It is approximately four-fifths of the atmosphere, and it is an important content of every plant and animal. Yet, it is the element which is most difficult to secure and to keep, and the most expensive to buy. This is because the greater part of it is not in a form to be available, and because, when it is available, it tends to leach from the soil. It is available when it is in the form of a nitrate—one part of nitrogen, three parts of oxygen, united with one part of some other element ($Na\ NO_3$, nitrate of soda; $K\ NO_3$, nitrate of potash or saltpetre; $H\ NO_3$, nitric acid, etc). The process of changing nitrogen into nitrates is called nitrification. This pro-

cess is the work of germs or microbes in the soil : and these germs work most efficiently when the soil is not water-logged, and when it is well tilled. The farmer should make his available nitrogen supply as he goes along ; and he makes it with tile drains, plows, harrows and cultivators.

But there are some plants which have the power of using the nitrogen which is in the air in the soil. These are leguminous plants,—clovers, peas, beans, vetch, alfalfa. If, therefore, the farmer cannot secure sufficient nitrogen by other means, he may use these plants as green-manures. If his system of farming will not allow him to use these plants, or if he does not secure sufficient nitrogen when he does use them, then he can go to the warehouse and buy nitrogen.

12. *The soil is not a mere inert mass : it is a scene of life and activity.*—This is the new and the true teaching. Soil which is wholly inactive is unproductive. Movements of air and water, actions of heat and evaporation, life-rounds of countless microscopic organisms, decay and disintegration of plants and soil particles,—these are some of the activities of the fertile soil. If our ears were delicate enough, we could hear the shuffle of the workers, the beating of the hammers, and the roll of the tiny machinery. All things begin with the soil and at last all things come back to it. The soil is the cemetery of all the ages, and the resurrection of all life. If the soil is not idle, neither should the farmer be.

LESSON NO. 2. TILLAGE AND UNDER-DRAINAGE: REASONS WHY.

By John W. Spencer.

13. *The difference between black and white.*—Two farmers are neighbors. Mr. White has made a study of potato culture for a number of years, and, as a result, now has an average yield, one year with another, of about 200 bushels per acre from a field of three to five acres. Mr. Black is considered a fairly good farmer. as farmers go, but has given potato culture no special study. He manages his crop as his neighbors do. His methods are those which have been a tradition for several generations, and they had their origin when the country was new and high cultivation was impossible on account of the stumps and lack of tools, and also because the virgin soil made it unnecessary. His annual yield is not far from 60 bushels per acre. In other words, Mr. Black has to plow, harrow, furnish seed, plant and cultivate about ten acres to secure as many potatoes as Mr. White does from three acres. Both men sell their product to the same dealer, and we will assume that they receive the same price per bushel. The cost of producing a bushel of potatoes must be very much more with Mr. Black than it is with Mr. White. No manufacturer or merchant could withstand the keen competition in trade if handicapped as Mr. Black is. When the respective farms were reclaimed from the forest, they were considered to be alike in character of soil, and the rain falls impartially on each.

Why the difference in cost of production between Black and White? There are many points of difference in their methods, but we are free to say that one of the essential differences is in tillage.

14. *The plant needs water.*—When Mr. White contemplates a crop of potatoes, he proceeds to make an estimate of what the crop will require and how he can provide for that demand. Perhaps the greatest of all needs is water. By turning to Cor-

nell Experiment Station Bulletin 120, page 419, it will be seen that in a dry season a bushel of potatoes requires about three tons of water for its production. If Mr. White expects 200 bushels of potatoes per acre, he must somehow manage to provide 600 tons of water for each acre. He has no facilities for irrigation, and his only resource is to make the soil a reservoir. He must store the supply left by winter snows and spring rains, and also the irregular rainfall that comes during the season's growth. Speaking in broad averages, in soils most commonly met with, this storage possibility amounts to about 300 tons of water per acre in the first eight inches of the soil. It must be understood that this amount is not in the form of standing water, for water standing in the soil for any length of time injures both soil and plant.

15. *The most useful form of water for plants is film moisture.*— Water is capable of assuming many forms, such as steam, vapor, ice, or free-moving liquid. The condition most valuable in the soil is none of these, but is in the form of film moisture. This film moisture can be shown by dipping a marble into water and observing the film of water surrounding it on all sides. When each soil-grain is covered with film moisture, as the marble is, the ideal conditions of soil moisture exist. This form of water is largely independent of gravitation and travels readily in all directions, as can be seen by dipping a cube of sugar into a spoonful of coffee. It is capable of transporting plant-food to the roots of plants from remote corners, where the roots do not reach.

It will be observed that film moisture is held only on the surface of soil-grains. The more the soil is pulverized, the more soil-grains there will be, and therefore the greater amount of surface to hold film moisture.

The difference in the capacity of lumpy and fine soils to hold film moisture is surprising to one who has not given the question study. George W. Cavanaugh, assistant chemist at the Cornell Experiment Station, has very graphically shown this by the following experiment: He put small marbles in a tumbler, as shown by Fig. 22, and the total amount of film moisture that the marbles would carry is represented in the tube placed beside the tumbler. The soil in the other tumbler (Fig. 23) is of the same weight as the marbles in Fig. 22, and it represents the marbles reduced to the fineness of common sand. Its capacity for holding film moisture is represented by the water in the standing tube (Fig. 23). The weight of material is the same in each tumbler, and the reason why one holds three times more film moisture than the other is due to the increase of surface that comes by dividing a coarse lump into fine particles.

The marbles represent the careless tillage of Mr. Black, and the finer particles the thorough tillage of Mr. White. Mr. White plows about one-third deeper than Mr. Black, and thereby makes another addition to the capacity of his reservoir.

The coarse soil, as represented by the marbles, will lose its film moisture by evaporation much more readily than the soil represented by Fig. 23, particularly if the surface of the latter is covered by fine particles representing an earth-mulch.

16. *Tillage makes plant-food available.*—Another difference in the culture given by Black and White is that the better tillage enables the plant to realize more food than all fertilizers which may be applied. There is also a benefit in making available some of the plant-food that nature has put in the soil. Broadly stated, the native plant-food amounts to as much as can be bought in $2,000 worth of commercial fertilizers. The finer soil has another advantage in affording a greater area for root pasturage. It is not uncommon for farmers to think of plant-food in the soil as in the condition of salt or sugar which is capable of being immediately dissolved by water and at once appropriated by

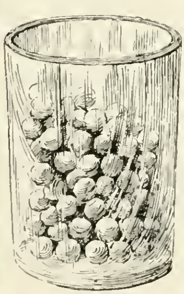



Fig. 22.—*Water held by a coarse soil.*


Fig. 23.—*Water held by a fine soil.*

the plant, or like potash in ashes that can be soaked out. Plant-food exists in this form only to a limited extent. A man might famish if locked in a granary filled with wheat; yet a chemist would say that there was enough food near him to feed a hundred men. This illustrates how nature has stored much of the plant-food in the soil. It has to go through many changes before it can be appropriated by the plant. The soil is a factory in which the work of preparation is carried on.

17. *The soil is a laboratory.*—Some of the agents employed in this factory are film moisture, air and heat; and if these are not furnished in the proper extent and condition, the factory runs in a sluggish way, if it does not stop altogether. Good tillage does much to hasten the activities of this factory by allowing free ingress to the soil of film moisture, air and heat. Air is necessary for a supply of oxygen, and heat to facilitate fermentation and other vital processes.

The importance of air and heat in the soil brings us to the question of drainage. Air cannot enter a soil freely which is filled with standing water, and growth of micro-organisms is hindered.

18. *Wet soils are cold.*—Standing water is a great absorbent of heat. If no provision is made to drain it away, it must be evaporated away. Thereby heat is lost. The soil is cold. A great many barrels of water can be standing on an acre of ground and not attract much attention.

To appreciate the amount of heat necessary to evaporate water, one has only to chop, split and burn beneath a caldron kettle enough wood to evaporate a barrel of water. Every barrel that is evaporated from the soil by the sun absorbs as much heat as is expended by the wood used under the kettle. The soil and plants are perhaps chilled for want of that heat. This is the reason that a wet soil is said to be cold.

19. *Drained soils resist drought.*—Some farmers have the notion that well drained soil will not withstand a drought as well as an undrained soil. The contrary is true. Everyone who has tilled the soil is familiar with places that are wettest in a wet time and driest in a dry time. When these places dry at all, they dry like a brick. A wet soil can never be tilled so as to present

the greatest amount of surface for film moisture and give it a mellow texture to receive a gentle saturation of air ; and standing water robs it of much heat required by the soil and plants.

20. *Drainage makes a soil reservoir.*—There is a place in every soil at which the free water stands. This place is called the water-table. It may be three inches down, or a hundred feet. It is the bottom of the soil reservoir, the bottom of our dish-pan. This dish-pan, or the upper and tillable soil, is the reservoir. It is the part in which the water is held as films on the soil particles. These films travel from particle to particle, the general tendency being upward because the moisture is passing off near the top of the soil by means of evaporation and appropriation by plants. Moisture is constantly supplied from the water-table below. We speak of this movement as capillary attraction.

Under-drainage lowers the water-table. It lowers the bottom of the dish-pan ; and thereby there is a deeper reservoir above it for the holding of film moisture and the distribution of roots.

But, the reader says, if the water-table supplies moisture to the upper soil, then it must be useful and necessary. Certainly ; but it must not be too high, for roots of farm plants do not thrive in standing water. If the upper soil is well tilled, capillary attraction will bring the moisture up.

21. *Do not let the moisture get away.*—We want this film moisture in the upper soil in order that roots may use it. The plants do not use it, to any extent, after it has passed off into the atmosphere. Therefore, stop this water before it reaches the atmosphere.

How ? Put a layer of loose dry earth between the moist soil and the atmosphere. This layer will stop the upward capillary flow. This layer is the earth-mulch. It conserves, or saves, moisture.

22. *Dry and hard soils may be benefitted by under-drainage.*—The water-table is lowered. Air is admitted. The soil does not puddle. It becomes fine. Under-drainage makes wet soils dry by removing the free water ; it tends to make dry soils moist by deepening the reservoir and fining the particles of soil.

23. *What tillage tools are for.*—Some tools, as plows, are to mellow up the soil and to deepen the moisture reservoir.

Others, as cultivators, are to tear up and to pulverize the soil to greater or less depths. Cultivators lift and turn the soil. The spring-tooth harrow is really a cultivator. Other tools, as harrows, prepare the surface of the soil. They make the seed-bed and put on the earth-mulch. The true harrows stir the soil, but do not lift or invert it.

24. *Weeds do not presist in well-tilled lands.*—The first and greatest value of tillage is to put the soil in such condition that plants can grow, and then to keep it so. Incidentally, it prevents those plants from growing which we do not want,—the weeds. Usually, the process is reversed: weeds make us till, and we get the other benefits without knowing it. The best tillage prevents weeds rather than kills them.

25. *Summer-fallowing is a means of cleaning land and of correcting mistakes.*—It may be necessary to fallow the land in order to clear it of stones, stumps and brush. But after the land is once thoroughly subdued, summer-fallowing is very rarely necessary if the land has been well handled. If the land has been plowed when too wet and thereby has become lumpy, if it has been allowed to become foul with weeds, or if it has lost heart by too continuous cropping with one kind of crop, summer-fallowing is a good means of bringing it back into condition. The better the farming, the less the necessity of summer-fallowing. In the old days, the poor tillage tools rendered fallowing more necessary than it is to-day.

Fallowing is tillage; and tillage liberates plant-food. Some of this plant-food may leach away and be lost, although the small rainfall of the summer months,—during which time fallowing is practiced,—makes this loss slight.

26. *The kind of tillage should vary with the soil, the time of year, the kind of crop.*—Too many farmers seem to think that tillage is tillage, no matter how it is performed. The same tool is used for clay or sand or muck, and for fitting the land for wheat or corn or apple trees. A harrow that is best for one field may be worst for the adjoining field. A man would not think of using a buggy for carrying grain to market, but he will use one tool for many kinds of work. The work is not only poorly done, but it is not economical. It costs too much. Persons who will

economize to the smallest degree in expenditures of money may be very wasteful in expenditures of labor and muscle.

Persons are always asking if deep plowing is best. The question cannot be answered on general principles. Deep plowing may be best for one field and one crop, and shallow plowing best for another field and another crop. The same remarks will apply to fall-plowing and spring plowing. One must first learn principles, or the why; then the practice, or the how, will come easy.

NOTE. The reader should have other sources of information than this Lesson. He may read our Bulletins 119, "Texture of the Soil;" 120, "The Moisture in the Soil;" 72, "The Cultivation of Orchards;" and the three bulletins on potato culture (Nos. 130, 140, 156). His library should also have King's "Soil" and Robert's "Fertility of the Land."

B. Answers to the Questions on the Five Lessons.

NO. 1. THE SOIL: WHAT IT IS.

Many of the questions in this lesson are intended merely to call attention to certain fundamental facts and to promote thought and discussion.

1. *Have you ever observed the influence of weather upon soft slaty rock jutting out on embankments and in railroad cuts?*

2. *Have you ever taken a glass of muddy water from a flowing stream and allowed it to stand until the sediment had settled? What is this sediment?*

These questions are intended merely to call attention to this process of soil formation and transformation.

3. *Imagine a branch of this stream bringing rotted slate rock and another bringing fine sand. When mixed in the main stream and deposited on some bar or overflowed field, what kind of soil would the mixture make?*

A sandy or clayey soil, the exact nature of which would be governed by the relative proportion of the different ingredients. Such a mixture might also contain much decaying vegetable or organic matter, and this would make the physical condition of the soil such that it would be very fertile.

4. *What is inorganic matter?*

All matter which is not a part or product of a living organism is inorganic or mineral matter, as a stone or a piece of iron. The bulk of the soil is made up of finely pulverized stone and is therefore inorganic matter.

5. *What is organic matter?*

Matter which has life or has been produced by living organisms. An animal or a tree, either living or dead, is organic matter. The humus of the soil is decaying organic matter.

6. *Why are soils from which a thrifty forest growth has been removed capable at once of producing good farm crops?*

Largely because of their good physical condition, due chiefly to the presence of large quantities of humus.

7. *Have you ever observed lichen (sometimes called "moss") growing on bare rock or on a tombstone?*

This question is intended to call attention to the fact that low forms of plant life are important in the early stages of soil formation.

8. *If any great amount of lichen should become mixed with the disintegrated rock, would it be humus and form a weak soil that might produce an order of plants a little larger and stronger than lichen?*

This mixing of the moss with the pulverized rock would be the first step toward making a soil of good physical qualities.

9. *As the higher orders of plants come in and die down and mix with the soil, would the process increase the productive power of the soil?*

Yes, within certain limits. The more decaying vegetable matter the soil contains, generally the more productive it is.

10. *In instances in which soil has been removed by grading, could a new soil be well made by adding commercial fertilizer alone? What would you apply first to such land?*

The addition of humus would be of first importance. Commercial fertilizers would do little good applied to a soil in which there is no decaying vegetable matter. This would propably be the condition in the case assumed in the question.

11. *If humus in soil under cultivation is perishable, ought it not to be the farmer's first care to keep good the quantity first found in the virgin soil?*

Yes; and this can be done only by adding humus from time to time in the shape of barn-yard manure and other forms of organic matter.

12. *In addition to the humus returned to the soil in manure, from forage fed to stock, and by plowing under stubble and roots, do you think it a good plan to sow some cover-crop in corn rows at last cultivation, and on oat and wheat stubble as soon as the crop is off, for plowing under the following spring?*

Usually a cover-crop is desirable, and especially so if the soil is lacking in humus.

13. *What are good crops for this purpose?*

Crimson clover, vetch, peas, rye, rape, barley, oats.

14. *Which of these are leguminous plants? Name all the kinds of leguminous plants you know?*

The first three named. All the clovers, alfalfa, vetch, peas, beans, lupines.

15. *Why is it advised to plow under the green-crops as soon as the land can be worked in the spring?*

These crops, if allowed to grow, would give off into the air much moisture needed by the permanent crop; and besides this, if left until they had made a large growth, there might not be enough moisture in the soil to cause them to decay.

16. *Do you think a rotation of crops helps the soil to bear the strain of successive cropping? If so, why?*

Yes: this practice admits of supplying humus by means of cover-crops; it admits of tillage which sets free plant-food; and as different kinds of plants require different proportions of the various plant-foods a rotation prevents an unequal depletion of plant-food, as might be the case if one kind of crop was grown continuously for a long time.

17. *Are you aware that plant-food exists in the soil in both available and unavailable forms, and that when plants have used up most of the available portion we call the soil worn out?*

Most soils, even though unproductive, contain plant-food in large quantities, but it is in such condition or chemical form that plants cannot get it.

18. *Is it true that your soil is capable of being made an active laboratory in which changes will take place and some of this unavailable plant-food be made usable?*

It is only when the soil is in such condition that certain changes can take place, that the unavailable plant-food becomes available to the plant.

19. *Are you aware that when the texture of your soil is poor, or in other words, your laboratory is out of order, the best commercial fertilizers or stable manures will not give the best results?*

The texture or physical condition of the soil is of first importance. A stone contains plant-food, but it will not grow crops because of its physical and chemical condition.

20. *Do you know that heat and air are important agencies in the changes going on in the soil, as they also are in the changes in a barrel of cider or in yeast in a pan of dough?*

Chemical changes in the soil cannot take place to the best advantage when the air is excluded, or when certain definite temperature cannot be maintained.

21. *Does standing water on soil have a detrimental or beneficial effect on the heat and air? Why?*

Detrimental, because it keeps the temperature too low and excludes the air; and soil texture is impaired.

22. *How can you make the soil laboratory do the best work?*

By making and preserving the best physical condition possible.

NO. 2. TILLAGE AND UNDER-DRAINAGE: REASONS WHY.

1. *What proportion of farmers in your neighborhood farm it like Mr. Black?*

Apply the test to yourself, and see if you are using good, economical business methods in carrying on your farm.

2. *How is farming to be made to pay,—by getting higher prices or by cheapening cost of production?*

Prices are largely beyond our control; the cost of production very largely rests with us. At least, this is true within certain limits.

3. *Do you expect permanently higher prices for farm produce?*

The past may be taken as a reasonably fair indication of the future.

4. *Do you set a certain yield before your mind when you are preparing for a crop? Or do you expect to be content with what comes?*

In the first case, you are farming with your head as well as with your hands, and the aim is to control circumstances as much as possible: the work is done on a good business basis. In the latter case, you are allowing yourself to be ruled entirely by circumstances and your work is not conducted in a good business-like manner. The same careful, judicious business management is necessary in farming that is needful in a successful commercial enterprise.

5. *An inch of rainfull weighs about 113 tons to the acre. About 300 tons of water is required to produce one ton of dry matter. Do you have rainfall enough in June, July and August to maintain a heavy crop of Indian corn or cabbage?*

In considering this question one must keep in mind the fact that much of the rain-fall drains off into streams, especially on hilly land; also that large quantities are evaporated before the plants can take it up. On account of these losses only a part of the rain is available for the plants. Usually the rainfall in midsummer is not sufficient to maintain a heavy crop, and so we must try to save, by thorough cultivation, what fell earlier in the season.

6. *Does surface tillage make soil moist, or keep it moist?*

It keeps it moist by preventing the soil from drying out. When soil is left undisturbed for a long time, and it becomes packed down, the moisture in the soil works toward the surface and is evaporated, passing off into the air. Tillage makes a surface mulch which the soil moisture cannot readily pass through. It is equivalent to covering the soil with a layer of straw or a board. Every farmer knows how moist it is under a pile of straw which has remained in the same place for some time, or under a board. This straw or board does not make the soil moist but prevents it from becoming dry. This is what tillage does.

7. *Why does deep fall plowing make soils "warm" or "early" in spring?*

Land so treated tends to dry out earlier in the spring than unplowed soils; and soils which dry out early in the spring are "warm" and consequently "early."

8. *What proportion of farmers in your vicinity practice under-drainage?*

The important point to be considered is, Does your farm need under-draining?

9. *How many of the farms need under-drainage?*

There is comparatively little land which will not be improved by under-draining.

10. *How deep and how far apart would you lay under-drains?*

The distance apart should be governed in a measure by the depth: the deeper the drains, the farther apart they may be placed. The contour of the land and the nature of the soil will also influence very materially in the matter. In a general way we may say that in moderately porous soils drains three feet deep should be from 30 to 40 feet apart.

11. *Do the farmers of your neighborhood have enough different kinds of tools to enable them to till their land cheaply and efficiently?*

This will depend upon the nature of the soil and the kind of crops grown. It is a good question to think about.

12. *How many different kinds of tillage tools should a man have to farm it properly if he has 100 acres devoted to general farming, of which half is clay and half sandy soil?*

This question is too general to admit of any one fixed answer. Each farm differs in some respects from every other, and the tools used on the one farm probably would not be exactly suitable in all details for another farm. Let each man answer.

13. *How often would you till a field of corn or potatoes?*

Often enough to keep the soil-mulch in good condition,—that is, light and loose. Study this question.

14. *Why do you till your corn or potatoes? Are weeds the leading problem in your mind?*

The keeping of the soil-mulch light and loose should be the leading idea. When this is done, few if any weeds can grow.

NO. 3. FERTILITY OF THE SOIL: WHAT IT IS.

1. *Do plants obtain all their food from the soil?*

A part comes from the soil and a part from the air.

2. *What do you mean when you say that soil is exhausted,—that it has no more plant-food in it, or merely that it fails to produce crops?*

When a soil merely fails to produce a crop, it is usually said to be exhausted, regardless of the amount of plant-food which it may contain.

3. *May a soil fail to produce crops and yet not be exhausted of plant-food?*

Yes; the plant-food must not only be present but it must be in such a form that the plants can use it. The physical condition of the soil also has much to do with the size of the crop. A soil which is hard and lumpy, containing an insufficient amount of humus, will not produce a good crop, even though it contains an abundance of plant-food.

4. *If there are 13 plant-foods which are positively essential, why do we commonly speak of only 3 of them as plant-foods—of nitrogen, potash, phosphoric acid?*

All the other plant-foods are sufficiently abundant in an available form in most soils, so that they do not have to be considered in maintaining the fertility of the land.

5. *Do you know if there is any difference between phosphorus and phosphoric acid? Write the chemical symbol for each.*

Phosphoric acid is a certain amount of phosphorus plus a certain quantity of oxygen. The symbol for phosphorus is P; for phosphoric acid, P_2O_5.

6. *Is there any difference between potassium and potash? Write chemical symbols for each.*

Potash is potassium plus oxygen, combined in a certain definite proportion. K stands for potassium; K_2O for potash.

7. *Write the chemical symbols for calcium and lime.*

Ca is the symbol foi calcium; CaO stands for lime.

8. *Where do phosphorus, potassium and calcium come from,—from the ground or from the air? Are they gases or solids?*

They come from the ground. They are solids.

9. *Where does oxygen come from?*

It comes from the air; about one-fifth of the air is oxygen and four-fifths nitrogen.

10. *Do you know if phosphorus, potassium and calcium exist in nature in their pure state?*

In nature they exist only as compounds with other substances.

11. *Does oxygen exist anywhere in a pure or uncombined state?*

Yes; oxygen exists in the free or uncombined state in the atmosphere. About one-fifth of the atmosphere is oxygen.

12. *Of what is water composed? Write its chemical formula.*

Of hydrogen and oxygen; the symbol or formula is H_2O.

13. *Of what is ammonia composed? Is it a gas or liquid? Can you buy pure ammonia at the drug store?*

It is composed of nitrogen and hydrogen (NH_3). It is a gas. Ammonia of the drug stores is water which has absorbed some of the ammonia gas.

14. *Does the plant feed on ammonia directly?*

Very little if at all. It must first be changed to a nitrate.

15. *What is the composition of a nitrate? Write the formula for nitrate of potash and nitrate of lime.*

Nitrates are the result of treating substances with nitric acid. For nitrate of potash it is KNO_3; for nitrate of lime, $Ca(NO_3)_2$.

16. *In what kind of materials does nitrogen occur? Name some common things which you think contain nitrogen.*

Nitrogen occurs in organic materials, as in plants and animals. In meat, leather, hair, milk, humus of the soil, cotton-seed meal, etc.

17 *Is nitrogen a solid or a gas?*

It is a gas.

18. *Are nitrates of potash and soda solids, liquids or gases?*

They are solids.

19. *Are nitrates soluble? Is there danger of their being lost from the soil?*

Yes. Loss is likely to occur, especially on land which remains for a long time with no crop on it.

20. *What is an amendment?*

A substance which, while it has little or no value as a plant-food itself, acts in such a manner as to make plant-food already in the soil more available, or which improves its texture.

21. *Is the soil in your garden sour? Try it.*

See Reading-Lesson No. 3, page 7.

22. *In what materials can you buy phosphoric acid for fertilizer purposes?*

The most common materials are forms of bone. South Carolina rock and Florida rock are ancient deposits of fossilized bone. Ground fresh bones are sometimes used as a source of phosphoric acid.

23. *In what can you buy potash?*

The common commercial forms of potash are sulfate of potash and muriate of potash. Wood ashes is also a source of this plant-food.

24. *In what can you buy nitrogen?*

Sulfate of ammonia and nitrate of soda are common forms. Cotton-seed meal, dried blood and tankage are some of the organic sources.

25. *Are there any home fertilizers, or common farm materials (aside from barn manure), in which you can get these elements?*

The plowing under of green-crops, like clover, peas, vetch and the like will furnish nitrogen; wood ashes furnish the only "home supply" of potash; phosphoric acid must usually be purchased from the dealers.

NO. 4. HOW THE PLANT GETS ITS FOOD FROM THE SOIL.

1. *Do the root-hairs finally become roots, or do they stay on as the main root grows?*

The root-hairs never become roots. As the young rootlets which bear the root-hairs enlarge and their tissues become hard, the root-hairs perish.

2. *Are there root-hairs on old roots?*

No.

3. *On what part of the roots are the root-hairs?*

On the young, tender rootlets.

4. *Where does the radish plant, which you grew in moss or cloth, get nourishment for making the first root-hairs?*

This nourishment probably comes from the food-material stored up in the seed.

5. *Why do particles of soil adhere to a young plant of wheat or cabbage when it is pulled up?*

Because the root hairs and rootlets are so numerous and in such close contact with the soil. The finer the soil, the closer and more extensive this contact is.

6. *What do you understand by a solution?*

A substance dissolved in a liquid.

7. *Give an example of a substance which will dissolve in water, and one which will not.*

Sugar will dissolve; sand will not.

8. *May materials which are insoluble in rain water be soluble in soil water? Why? (Consult Less. 3.)*

Yes. Because the soil water contains carbonic acid gas in solution and this increases the dissolving power of water.

9. *Does warming the water increase its power to make substances soluble?*

Yes.

10. *Write a definition of osmosis. (Consult dictionary or some school book on physics or natural philosophy.)*

It is the tendency of two liquids of different density to pass through a membrane or porous wall which separates them.

11. *Why does the soil water go into the root-hair?*

It is largely on account of this osmotic tendency or action. The outer walls of the little root-hairs constitute the membrane; the sap or moisture in the cells of the root-hairs and the soil-moisture represent the two liquids separated by the membrane. (See Reading-Lesson 4, fig. 3.)

12 *Why does not the liquid in the root hair flow out into the soil?*

Because the sap in the hairs is denser than the water or moisture in the soil; that is, it contains a larger percentage of solid matter in solution. When two liquids of different density are separated by a membrane, the passage of the liquid through the membrane is in the direction from the less dense to the more dense.

13. *What would happen if the liquid in the root-hair and that in the surrounding soil were of equal density?*

There would be little or no movement of the water from the soil into the root hairs and the plants would die.

14. *Must all food materials in the soil be in solution before the plant can use them?*

Yes.

15. *Does the plant ever utilize materials which are insoluble in the soil water? How?*

Yes; the roots of plants are slightly acid and this increases the dissolving power of the moisture in contact with the roots.

16. *How is it that plants can live and grow in a soil which is dust dry?*

Even the soil which seems to us dust dry really contains very minute amounts of water; and so long as this is the case osmotic action goes on though, of course, very slowly when the soil is "dust dry."

17. *Can your soil be so loose as to have too much air for the good of the plants?*

Yes. This is sometimes the case in very light sandy or gravelly soils.

18. *Do you understand that you can smother the root as well as the top of the plant? How?*

Yes. The roots need air as well as the top. Soil which is constantly soaked with water prevents the air from coming in contact with the roots; smothering results as one of the effects of too wet land.

19. *At what season do you suppose that corn roots absorb the most moisture?*

When the corn is making its most rapid growth.

20. *At what season do you have the least rainfall?*

During the summer season when plants are growing most rapidly.

21. *If you knew that you would not have sufficient rainfall in August to maintain your potato crop, how would you plan to secure the moisture?*

Prevent evaporation so far as possible by means of a surface mulch. This means thorough tillage.

22. *Name one way in which plants are injured by too strong dressings of potash or nitrogen.*

If applied in such large quantities that the soil moisture dissolved larger proportions than were contained in the sap—that is, if the density of the soil moisture became greater than of the sap—osmotic action would be from the plants to the soil and the plants thus giving up their moisture to the soil, would wilt.

23. *If all the potash in your cornfield were to become suddenly available, what would happen?*

The corn would be killed and heavy rains might leach much of the potash from the soil.

24. *How might you apply muriate of potash so that strawberry plants would be injured?*

By applying in large quantities too close to the plants.

25. *Would it be an easy matter to injure old apple trees by muriate of potash? Why?*

If applied in very large amounts directly over the roots, injury might follow; but such injury is rare.

26. *If you put the fertilizer in the hill, will not the roots grow beyond and away from it, as the plant grows?*

Yes, to a large degree.

NO. 5. HOW THE PLANT GETS ITS FOOD FROM THE AIR.

1. *What portion of its dry substance does the plant secure from the soil?*

The amount is variable, but on an average about 3 per cent. Some varieties of plants take up much more and others less than 3 per cent.

2. *What one substance or compound is taken in most profusely by the plant?*

Water.

3. *How does the plant get its water,—through roots or leaves?*

Through the roots.

4. *In what part of the plant does the water ascend—through the young wood, or between the bark and wood?*

It ascends through the young wood.

5. *Where does the plant get its carbon?*

From the air.

6. *How does it take in its nitrogen,—by roots or leaves?*

By the roots.

7. *Where is the starch manufactured?*

In the leaves and other green parts.

8. *From what substances is the starch made?*

From carbon dioxide and water.

9. *Of what elements is starch composed?*

Of carbon, hydrogen and oxygen.

10. *Into what is the starch changed before it is transported?*

It is changed into sugar.

11. *What use is made of the material after it is transported?*

It is used in the growth of the plant.

12. *Through what part of the plant does the starch-like material (or "elaborated sap") pass?*

It diffuses through the layers of the inner bark.

13. *The root takes in water containing food: Can it use this food material directly in making root-growth? Why?*

No. This food material is taken into the plant in a crude condition, and it must be transported to the leaves where it unites with other materials before it can be used in the growth of the plant.

14. *Why is starch stored in seeds and tubers?*

To be used by the seedlings or new plants when growth first begins, and before the plants are sufficiently developed to take their food from the soil and air.

15. *Is starch stored in twigs in the fall?*

Yes.

16. *Are the flowers of peaches, and other early blooming plants, fed from food taken in at the root at the time, or from materials stored in the twig? (Think how the potatoes sprout in the bin.)*

From materials stored in the twig the year before. It is for this reason that the condition and health of the trees this year influence so largely the crop of next year.

17. *Will mulching the roots of a peach tree with straw when the ground is frozen delay the blooming in the spring?*

No; because there is food enough in the twigs to feed the blossoms, and as soon as the weather is warm enough this food is available.

18. *Soil water holds very little food for plants; the roots must take in enormous quantities of water; what becomes of some of this water?*

It passes off through the leaves.

19. *Is the water which evaporates from the soil of any direct use to the plant?*

No, not of itself.

20. *The plant needs water,—it sweats it out; how shall we manage so that the plant can have all the water it needs?*

An abundance of water goes into the soil (in New York) every year, but it is not equally distributed. When the plants need it most is the time when there is usually the least rain. The only way we can help the plants (unless we irrigate) is to preserve the moisture so that it becomes available when it is most needed. This may be done by draining the land, and in this way increase the storage capacity of the soil (See Lesson No 2); and by keeping a good earth-mulch on the surface so as to prevent, as much as possible, the evaporation of the water from the soil.

21. *Write down all the substances (or materials) you know which the plant must have in order to live and grow.*

Nitrogen, phosphorus, potash, lime, iron and sulfur were given in Lesson No. 3 as some of the necessary plant-foods. Carbon, hydrogen and oxygen are also necessary.

22. *Which one of these does nature supply in sufficient abundance, without any thought on your part?*

Carbon.

23. *What ones can you help nature to supply?*

Nitrogen, potash, phosphoric acid, lime and water.

24. *Name all the congenial conditions (or agencies) which the plant must have in order to be comfortable and to grow.*

A certain temperature; a certain water supply; a certain amount of humus; good texture; and a sufficient supply of plant-food.

25. *What ones of these can you help nature to supply or maintain?*

We can influence the water supply, add plant-food and humus, and maintain good texture.

Bulletin 175. November, 1899.

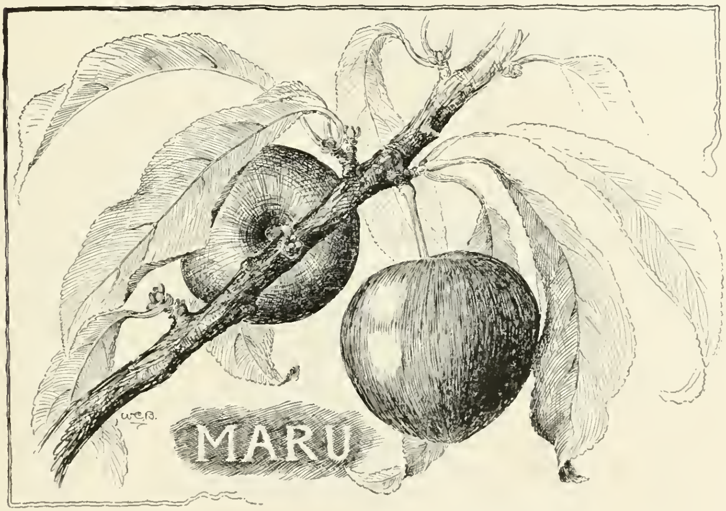
Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

HORTICULTURAL DIVISION.

FOURTH REPORT ON

JAPANESE PLUMS.



By L. H. BAILEY.

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CORNELL UNIVERSITY, ITHACA, N. Y., Nov. 1, 1899.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The Japanese plums have come to stay, but they have come without accurate descriptions and with confused nomenclature. The merits of the older varieties are now fairly well known, but the greater number of the varieties are very imperfectly understood. In order to elucidate these perplexities and to spread accurate knowledge of this new class of fruits, the Cornell Station has made a special effort to study all the varieties from bearing trees. This bulletin is the fourth report of this investigation.

I. P. ROBERTS, Director.

24.—*Earliest of All* (on left) and *Engre*. The earliest Japanese plums.

FOURTH REPORT ON JAPANESE PLUMS.

In January, 1894, this Station issued a bulletin (No. 62) on the Japanese plums. Subsequent issues were made in January, 1896, and in October, 1897 (Bulletins 106, 139). For five years and more, the Japanese plums have been the subject of careful study at Cornell, and an effort has been made to secure all the varieties. During the past season the crop of these plums has been large and excellent, and the following notes are made directly from the fruits. We are still convinced that the Japanese plums are a very important addition to our orchard fruits. They will not drive other plums from the field, but they have attributes which make them an excellent supplement to the European and native sorts. The particular merits of the Japanese plums are their great productiveness, adaptation to a wide range of territory, beauty, earliness of many of the varieties, comparative freedom from diseases and insects, and long-keeping qualities of fruit. Most of the varieties tend to overbear, and good fruits can be secured only by very heavy thinning. This is especially true of the Burbank, the Abundance and the Red June. There is great range in quality of the Japanese plums. The poorest of them are inferior to any of the European varieties. The best of them are nearly equal to the best of the European kinds, and all of the leading sorts are better in quality than the Lombard if they are properly thinned and ripened.

A great merit of the Japanese plum is the fact that it is adapted to an exceedingly wide range of territory, in this respect excelling both the Domestica and native types. There are varieties which thrive from Canada to the southern States, and apparently from ocean to ocean. There has been some complaint in the Middle states and the South of loss of blossoms from late spring frosts, but we have never experienced this difficulty. The buds start early; but in New York State, at least, the winter climate holds so late that there is practically no danger from the early swelling of the buds.

The Japanese plums are less seriously attacked by insects and fungi than the common European or Domestica type is. They are not entirely free from the shot-hole fungus, black-knot, curculio and other difficulties ; but in our experience these troubles have been so infrequent or of such minor importance as not to attract serious attention. The fruit-rot is often serious on the Japanese plums ; but in our experience, it is equally or even more serious on the Lombard. If the Japanese plums are properly thinned, there seems to be no unusual susceptibility to the fruit-rot fungus.

The larger part of the Japanese plum stock which is sold by nurserymen is on peach roots ; and on these roots they seem to thrive. However, we find that they do remarkably well when top-worked on Lombard stocks. Theoretically, we are to expect the best results when they are worked on their own roots ; and these plums are now so extensively planted that the time cannot be far distant when seed can be obtained cheaply enough to warrant the raising of Japanese plum stocks. It remains to be demonstrated, however, whether the Japanese plum roots are actually better than the peach or the Domestica plum roots.

In former reports, we have spoken of the great variation of Japanese plums in respect to the period of ripening. We find that the same trees often do not ripen their fruit in the same sequence in different years. In some years there may be a difference of two weeks in ripening between the Abundance and Burbank, whereas in other years the very same trees may ripen their fruit almost simultaneously. The period and sequence of all fruits are greatly modified by the particular season, but the Japanese plums seem to be particularly unstable in these respects.

Ever since we began the study of these Japanese plums, we have been puzzled to account for the great differences in opinion respecting the merits of individual varieties and the wide discrepancies in descriptions of them. Some of these discrepancies are traceable to a confused nomenclature ; but we now believe that many of them are due to the fact that the same tree may bear unlike fruit in different years. Some of the trees which we have had under the closest observation during two or three crops seem to have behaved in this way. For example, in our last report (Bulletin 139) we thought that the Chase is identical with the Chabot. This year, however, the fruit of the same trees of Chase was indistinguishable from Abundance ; and yet, between Abundance and Chabot there is normally a difference of two to three weeks in the period of ripening, and there was this difference on our own grounds this year. From this year's study, therefore, we are obliged to say that the Chase is the Abundance.

Some objection has been raised to the supplanting of Japanese names with new names. We are convinced, however, that the dropping of the Japanese class-names and adjectives is legitimate in the interest of perspicuity. Most of the Japanese names have been loosely applied, and it is impossible, in many cases, to determine any one variety to which the name may be said to belong. To use the old name of Botan, for example, would result in perpetuating a confusion, since any person who had a plum under the name of Botan, no matter what it was, would feel justified in sending it out. When, however, the different kinds of Botans are given specific names, the person must distinguish his variety before it can be put upon the market. The same remarks may be made for the Japanese names, Hattankio, Yosobe, Sumomo and Wassu. (Wassu is probably a misspelling of Wasse, or Wase, meaning *early*). There are two or three Japanese names, of which Maru and Satsuma are examples, which have been applied to one particular variety ; and in these cases we have held to the Japanese vernacular.

It is usually unsafe to make a general recommendation of varieties of any fruit. The value of a variety lies not only in its intrinsic merits, but in its adaptation to the personal likes of the grower and to markets, soils, and other extrinsic conditions. However, as a guide in the choice of varieties, I will mention those kinds which now seem to me to be most valuable for general uses and conditions. In the first list I place those which seem to be worthy of general planting ; in the other list are those of secondary value and those which must be further tested before they can be confidently recommended. The varieties are named in the order in which they ripened at Ithaca in 1899:

First list.	*Second list.*
Engre	Berger
Lutts	Kerr
Red June	Ogon
Abundance	Georgeson
Burbank	Hunn
Chabot	Hale
Satsuma	Wickson

In the following account of varieties, we record the notes which have been taken on the Cornell grounds during the present season. The varieties are arranged in the order of their ripening at Ithaca in 1899. (An index to the names will be found at the end of the bulletin.) As already indicated, this order of ripening is not uniform year by year. By season of ripening, we mean the date at which the first considerable numbers of fruits are fit to be eaten from the hand. Ordinarily, the varieties should be picked for market three or four days, or even a week, earlier than the dates here given. It is characteristic of most Japanese plums that even though they are uncolored when picked, they ripen up well if kept in a cool and dry place. All the pictures in this bulletin, except that on the title-page, are natural size. They are made from fruits of medium and average size. It should be remembered, however, that pictures of fruits, even though they are full size, look smaller than the fruits themselves. The histories of the varieties are recorded in previous bulletins.

1. EARLIEST OF ALL.—Fig. 24, left.

Yosebe of Bulletin 106. *Wasse-Sumomo.*

Small, round-oblong, with an indication of a pointed apex in some specimens; suture not prominent; color when fully ripe almost uniformly pink-red, with light bloom; flesh light yellow and soft, clinging to the pit, sour, with a decided almond or bitterish flavor, skin tough; first specimens picked July 10, but the larger part of the fruits ripe on July 14. The fruit drops from the stem as soon as ripe. Straw or hay should be spread under the tree to catch it. The tree is a decidedly upright grower, with small and yellowish green deeply serrate leaves, prominent stipules and reddish twigs. After having tested four or five crops of this plum, we are convinced that its chief merit is earliness and that it is too poor in quality to be recommended, particularly since the Engre is of better quality and practically of the same season.

25.—*Lutts. The largest of the very early Japanese plums.*

2. ENGRE.—Fig. 24, right.

About one-third larger than Earliest of All, not round but somewhat flattened endwise, the suture usually rather prominent; color a very little darker than Earliest of All; flesh soft and yellow, cling, sour but with almost no almond flavor, and the skin tough. Engre is practically of the same season as Earliest of All, although this year it was about one day later.

It is a distinctly better plum. We recommend it for being very early. With us it has been a prolific bearer, and the fruits are attractive. Its quality is not as good as that of Burbank and Abundance, but its great earliness commends it.

3. LUTTS.—Fig. 25.

Wasse-Botankio.

Under the name Wasse-Botankio, we have fruited an excellent early plum for two seasons. It seems to have such distinct merit that we think it worthy general introduction, and I therefore take pleasure in naming it for Mr. Henry Lutts, of Youngstown, N. Y., who has been one of the pioneers in the culture of Japanese plums in this State. Fruit round-oblate with a tendency to a pointed apex, in general form and appearance very like the Burbank, but running smaller ; color dark red, marked with many very fine golden dots and covered with a heavy bloom ; flesh light yellow and soft, cling when thoroughly ripe, with only a tinge of almond flavor, but not sour nor bitter, the skin rather tough. Ripe enough for eating in the present season on the 14th of July, being four or five days later than Earliest of All and Engre. This is the largest and best very early Japanese plum which we have tested. The tree is a good grower and with us has been productive.

4. BERGER.—Fig. 26.

Strawberry. Ura-Beni. Uchi-Beni. Honsmomo, at least of some nurserymen.

Small and cherry-like, flattened endwise, with a distinct suture ; color bright light red, with prominent bloom ; flesh firm and meaty, yellow, free from the very small pit and with no astringency or almond flavor, the skin not tough nor sour ; ripe this year on the 17th and 18th of July. This is one of the most distinct of all the Japanese plums. It has the flavor of some of the Domestica varieties. The handsome little fruits fall when ripe and should be caught on straw or hay spread underneath the

26.—*Berger. A cherry-like and attractive variety; desirable for the home garden.*

tree. The plums are not much larger than very large cherries, and, coming after the sweet cherries are gone, they seem to piece out the cherry season. The tree is a distinct and upright grower, with rather narrow and light colored leaves, and the fruits

27.—*Willard. One of the early plums, but quality very poor.*

are borne well down on the older wood. We believe that the Berger is well worth growing in every home garden.

5. WILLARD.—Fig. 27.

Fruit medium to small in size, oblong, slightly angular, never pointed, the sinus slight or scarcely any, the stem cavity rather

28.—Kerr. The earliest clear yellow variety deep ; color bright red with a heavy bloom and many minute yellow dots ; flesh soft to firm, yellow, somewhat cling, with a decidedly mawkish or almond flavor, skin sour : ripened this year July 23–25. The fruit falls easily. The quality is very poor, and we believe that the variety is not worth growing, particularly since there are earlier varieties of better quality. The leaves are also very badly attacked with the shot-hole fungus, being the worst in this respect of any of the Japanese plums which we have grown. The branches have a straight, upright tendency. The leaves turn red and fall very early.

6. KERR.—Fig. 28.

Hattonkin of some nurserymen. *Hattankio Oblong.*

Of medium size, tending to become fairly large when well thinned, tapering a very distinct long point, the suture usually well marked, stem comparatively short and stout ; color orange yellow, overlaid with a thick creamy bloom ; flesh firm and rather meaty and yellow, cling, sweet and of fair to good quality when well ripened ; ripe this year from the 28th to 30th of July. Tree is of moderate spreading habit, much like the Georgeson ; foliage strong, large and good. The Kerr is an exceedingly productive variety, and needs to be well thinned in order to produce the best results. It is one of the best of the yellow varieties. Its chief fault is that it tends to fall before it is fully colored, but the fruits ripen and color on the ground. If they are picked just before they begin to loosen from the stem and are stored or shipped, they will ripen up well.

7. RED JUNE.—Fig. 29.

Nagate no Botankyo

Medium to large in size, cordate-oblong and distinctly pointed, with a very strong suture, often lop-sided ; color deep vermilion red, with a thick and handsome bloom ; flesh light yellow or yellowish white, cling or partially cling, firm and moderately juicy, slightly acid to sweetish, of good quality, though not very rich, the skin slightly sour. We still believe that the Red June is one of the very best of the Japanese plums, because it is very

29.—*Red June.—A valuable second-early market plum.*

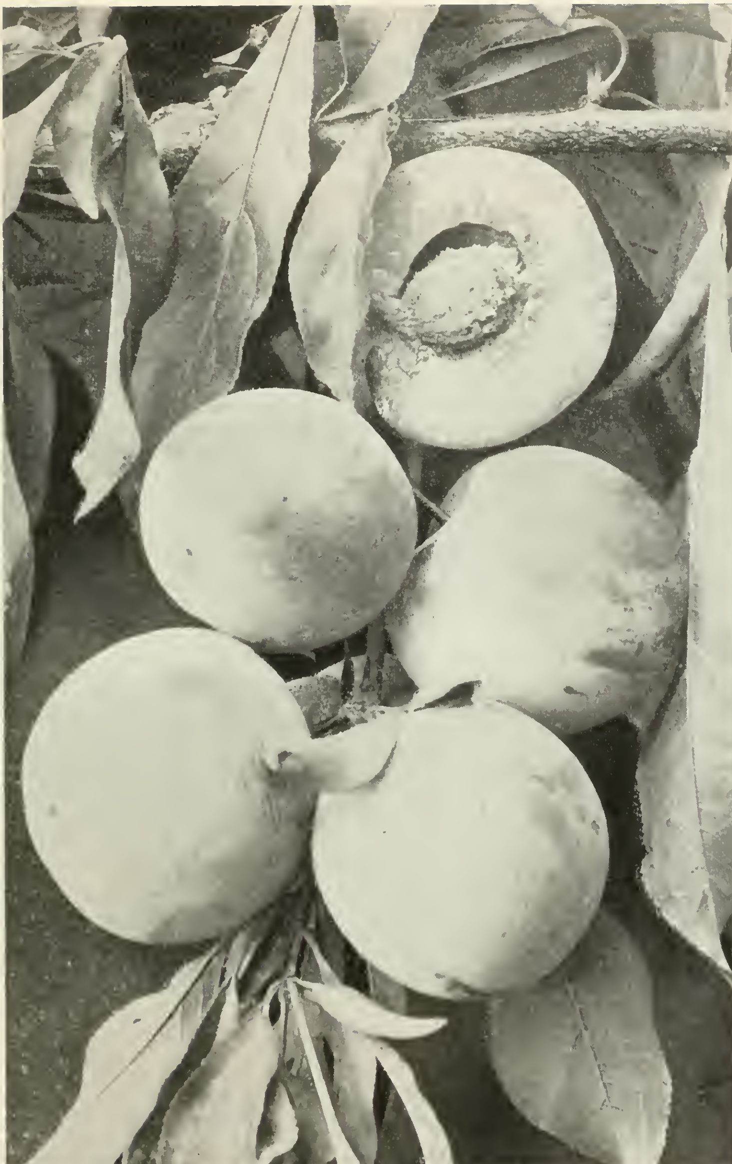
handsome and productive. It ordinarily needs heavy thinning to bring it to perfection. It varies considerably in season of ripening. This year the earliest fruits were ready for eating on July 30 and for marketing three or four days before that time. At the time that the Red June was coming into condition for eating, the Kerr was in a similar condition, Earliest of All and Lutts were all gone, Georgeson showed no sign of coloring, and the Abundance on some of the earlier trees was beginning to turn red. The Red June and Kerr are practically of the same season, although the Kerr begins to to fall from the tree a few days before the Red June is ripe. The Red June is a bushy-topped, upright grower, with yellowish green foliage and redish brown twigs. It is a well marked type. We are fruiting it on both peach and Lombard stocks.

8. OGON.—Fig. 30.

Fruits medium in size or becoming large when heavily thinned, globular or flatened endwise, not at all conical or pointed, the suture prominent; color a clear lemon yellow, with a heavy whitish bloom, rarely with the faintest indication of a blush cheek; flesh thick and very meaty, comparatively hard, free from pit, with a very peculiar musky almond flavor. Ready to eat this year August 1, although they were ready to ship, and a very few were edible, some three or four days before this time. It is practically the season of the Red June, although tending to be a trifle later. The tree is a strong, upright grower with heavy thick foliage. It does not seem to be so uniformly productive as some other varieties, although it tends to bear very heavily at times. It is readily distinguished from other early varieties by its globular or flatened shape, by the cavity around the pit and by its peculiar flavor. Its quality is indifferent—not so good as that of the Red June nor so bad as that of the Willard. It is said to be one of the best for canning.

9. BERCKMANS.—Fig. 31.

Fruit of medium size, round-oblong with a tendency to have a blunt point, more or less angular in cross-section, the suture not prominent; color deep bright red, especially when exposed



30.—*Ogon. A second-early yellow variety.*

to the sun, more or less yellow-splashed on the shaded side; flesh firm and sweet, cling or semi-cling, becoming dry and insipid when fully ripe. Ripe this year on the 4th to 6th of August with the earliest trees of Abundance. In 1896, it also ripened with Abundance or just ahead of it. In 1897, the same trees ripened two weeks later than Abundance. It is an upright grower, with

31.—*Berckmans. Distinguished, when fully ripe, by its dry flesh.*

yellowish green, rather small, foliage. It is readily distinguished from all other Japanese plums which I know by the dry and mealy character of the ripe fruit.

We doubt if the Berckmans is of sufficiently high quality to recommend it for general planting, since the Abundance occupies the same season. Some of the trees which have passed for Berckmans are Abundance. The true Berckmans is distinguished by its dry flesh.

10. ABUNDANCE.—Figs. 32 and 33.

Yellow-Fleshed Botan.

Fruit medium size or varying to nearly large when vigorously thinned, round-oblong with a distinct point, the suture usually more or less prominent; color pink-coppery-red, marked with

32.—*Abundance. A good type. Perhaps the best Japanese plum.*

many minute dots and a thin bloom; flesh firm but juicy, sweet, with no trace of mawkish or almond flavor when well thinned or well ripened, clinging to the pit. The Abundance is a variable plum. We have stock from various sources, amongst others from some of the original trees sent out as Abundance by Lovett. The trees vary in time of ripening, the period ranging over a week or ten days, but they all seem to be indistinguishable. This year the first fruits were ripe on the 5th and 6th of August. The ordinary, and what I take to be typical Abundance, is shown in Fig. 32; also in Fig. 1, Bulletin 106. Some trees, however, produce an inferior grade of fruit, as shown in Fig. 33, but I cannot distinguish that this small fruit is a different variety.

33.—*Abundance. Small or inferior type.*

This small-fruited type of Abundance is the one which I distinguished in our Bulletin 62 as the Babcock. When the Abundance is well thinned, it is certainly an excellent plum and one which most people delight to eat. Its great fault is to overbear, and in that case it is very liable to the fruit-rot fungus. With us the Abundance has been less injured with this fungus than the Lombard. The light pink-red color of the Abundance will clearly distinguish the variety from all other Japanese plums which we have fruited. The tree is an upright grower, not so spreading as the Berckmans, with larger and better foliage. I believe that the Abundance is the best single variety of Japanese plum.

The Chase which we have heretofore regarded as identical with Chabot was this year perfectly indistinguishable from Abundance.

We now believe that the Douglas is Abundance; or, if different, it is very difficult to distinguish. It seems to have a somewhat drier flesh than Abundance; but Abundance varies in juiciness.

11. MARU.—See illustration on title-page.

Written also *Masu* and *Massu*.

Fruit medium in size, globular or slightly flattened endwise, usually tending to have an obtuse point, the suture slight; color dark dull red or maroon red, uniform or nearly so over the whole surface, marked with numberless minute golden yellow dots; flesh rather soft and deep yellow, with a decidedly musky almond flavor, cling or semi-cling, the skin sour; ripens with the later trees of Abundance. It is a vigorous, upright grower and productive, but the quality is poor, and the variety cannot compete with Abundance.

12. BURBANK.—Fig. 34.

Fruit medium in size, becoming large upon vigorous and well-thinned trees, round-oblong to oblong, the point not well marked, and the suture usually somewhat prominent; color orange-yellow overlaid with splashes, streaks and dots of red, giving a more or less marble appearance, but becoming more or less uniformly dense red on the cheek; flesh firm and meaty, yellow, sweet and rich, cling, the skin not sour nor unusually tough. The Burbank ripened very unevenly with us this year, some of the trees maturing their fruit only three or four days later than Abundance, whilst others were ten to eighteen days later. In 1895, as compared with Abundance on our grounds, it was a week later; in 1896, it was from one to two weeks later; in 1897, it was from two to three weeks later. The tree is an exceedingly spreading flat-topped grower and needs strong heading-in to keep it in shape. When well thinned, the fruit is large and of excellent quality, perhaps as good as any of the Japanese plums. It is also a good keeper. It usually colors up on the tree some days before it is ripe. Occasional trees ripen their fruit before the main crop of

34.—*Burbank. A standard mid-season variety.*

Abundance is ripe. In many cases, the fruit does not become soft and edible, even when apparently full ripe. Heretofore, we have regarded Burbank as the best all-around Japanese plum, but we are now inclined to give that place to Abundance.

The Wassu, from Normand, was indistinguishable from Burbank in habit of tree and character of fruit in 1897 and 1898. This year a part of the fruit on our tree of Wassu ripened a week ahead of the main crop of Burbank, but some of the fruits were as late as the main crop of Burbank. We believe that it is the same thing as the Burbank.

13. GEORGESON.—Fig. 35.

White Kelsey. Yeddo Mikado.

Fruit medium or becoming medium to large when well thinned,

35.—*Georgeson. A yellow plum of long-keeping qualities.*

round or round-flattened in form, usually without a point, the suture distinct; color deep bright yellow with a heavy whitish bloom; flesh firm and solid, golden yellow, of fairly good quality, cling. Ripe this year the middle of August and nearly all gone by the time the latest trees of Burbank were ready for eating. In 1897, the same trees ripened their fruit from the middle to the 20 of September. The tree is a sprawling and forking grower, intermediate in character between the Abundance and Burbank. The fruit is a long keeper and, if picked before it is thoroughly ripe, will ordinarily shrivel before it decays. The quality is medium; it has a little of the mawkish almond flavor, and is usually not prized for eating from the hand. I doubt if it is destined to be a very popular variety. It is one of the commonest varieties.

36.—*Hunn. A small red medium-late variety.*

We refer the White Kelsey of Normand to the Georgeson from specimens which we grew this year upon grafts set on Lombard stocks. We have not fruited Mikado. One party exhibited specimens of Mikado and Yeddo at the State Fair this year, and these were the Georgeson. Mr. Normand, however, in a trade circular says that the Mikado ripens fifteen days earlier than the Yeddo. The Yeddo, as we have fruited it, seems to be Georgeson.

14. Hunn.—Fig. 36.

Burbank No. 1.

Fruit small to medium, globular, sometimes with a distinct short point, the suture more or less prominent; color something like that of Abundance but less pink, and usually a deep claret red with many minute, golden dots; flesh soft, deep yellow, cling, of fair to good quality, aromatic. Ripened this year as the Georgeson was passing out, that is, from the 20th to the 24th of August. In 1897, it ripened also at this season, but since the Red June ripened with us very late that year, we compared it in season with that variety, and therefore called it an early plum. We should now call it a mid-season to late plum. It has a slight musky flavor, but usually not sufficiently pronounced to make it disagreeable. We are more favorably impressed with it this year than we have been in the last two years. It is possible that it may deserve a place in the Japanese plums of second importance. We are fruiting it on the Lombard.

15. Hale.—Fig. 37.

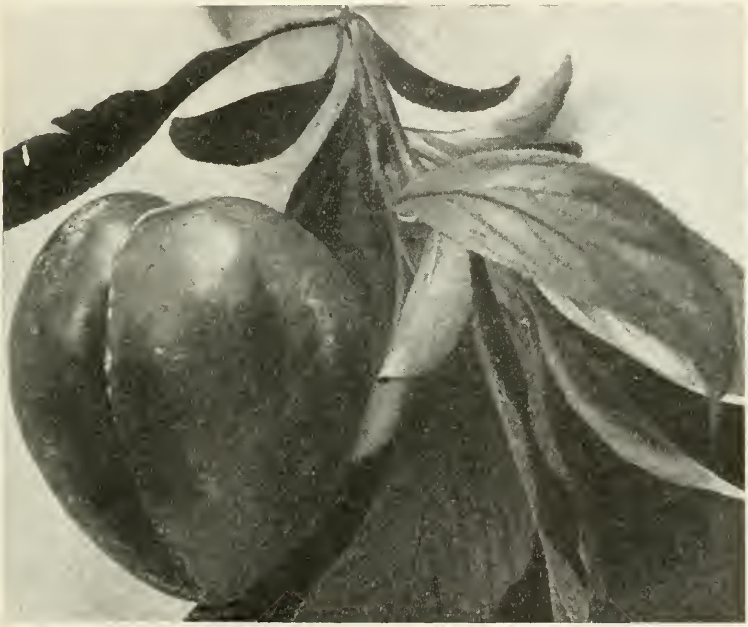
Fruit medium to large, globular or somewhat globular-oblong, not pointed, the suture usually distinctly marked; color deep yellow or orange, thinly overlaid with mottled and speckled red giving the appearance of a yellow-red fruit, bearing a thin bloom and having many yellow specks; flesh soft and juicy, yellow, cling, of good quality, but the skin sour; ripened with us this year on the 24th of August. The fruit has a very slender stem and drops easily from the tree. The tree is a moderately spreading grower, being intermediate in habit between the Georgeson and Abundance. The fruit is of good quality, but for the last two seasons it has failed to color well and has dropped prematurely. The trees have not been very productive, although they have borne for three consecutive years. From its behavior thus far, we are of the opinion that the Hale should not be put in the first or leading list of Japanese plums for western New York. It follows the Georgeson, being in condition for eating when the last specimens of the Georgeson are passing.

16. WICKSON.—Fig. 38.

Fruit very large, tapering from toward the base, and long heart-shaped with a deep strong suture ; color usually a deep

37.—*Hale. Of excellent quality ; medium-late.*

maroon red, but sometimes tending to yellowish red ; flesh very firm and meaty, dull yellow, rich but with an aromatic almond-like flavor, cling, the pit small. The tree is a very narrow upright grower with narrow yellowish green leaves. The fruit is borne far down on the old wood and not in clusters. Although it is said by Mr. Burbank that this plum was grown from Burbank seed fertilized by Kelsey pollen, I believe that it has Simonii blood. The character of the foliage and bloom, the habit of the tree and its method of fruit-bearing, together with the



38.—*Wickson. The largest of the hardy varieties.*

texture of the flesh, all point to Simonii as one of its parents.* The tree is perfectly hardy with us. It impresses us as being a shy bearer, although our trees are not yet of sufficient age to enable us to have tested this point. It certainly does not come into full bearing as early as other varieties of Japanese plums. From its habit of bearing far down on the old wood and the comparatively small amount of wood surface which it makes,

* An opinion shared by Professor Waugh. See "Hybrid Plums," Bull. 67, Vt. Exp. Sta.

it promises not to be a very prolific variety. Prunus Simonii itself has been a shy bearer with us, except one year when the trees bore exceedingly full and the branches needed to be propped. It is possible, therefore, that when the Wickson trees arrive at a greater age, they may bear full crops. Most of our Wickson fruits—of which we had few— were ripe

39.—*Chabot. An excellent late variety.*

on the 8th of September; some of them were ripe five days before that time.

17. CHABOT.—Fig. 39.

Bailey. Yellow Japan. Furugiya. O-Hatankyo. Uchi Beni of some.

Fruit medium to large, oblong-conical, lacking the point, the suture usually pronounced, the the stem thick and strong; color deep orange, heavily overlaid with light cherry red or the sunny side becoming deep dark red, with a whitish bloom and many minute golden yellow dots; flesh soft to firm, yellow, with no almond flavor, sweet, of excellent quality, cling; ripe with us this year, fit for eating, from the 7th to the 10th of September, and ready for shipping a week before that time. The Chabot is a strong, upright grower, prolific, the fruit handsome, good and long keeping. It is one of the best of the Japanese plums.

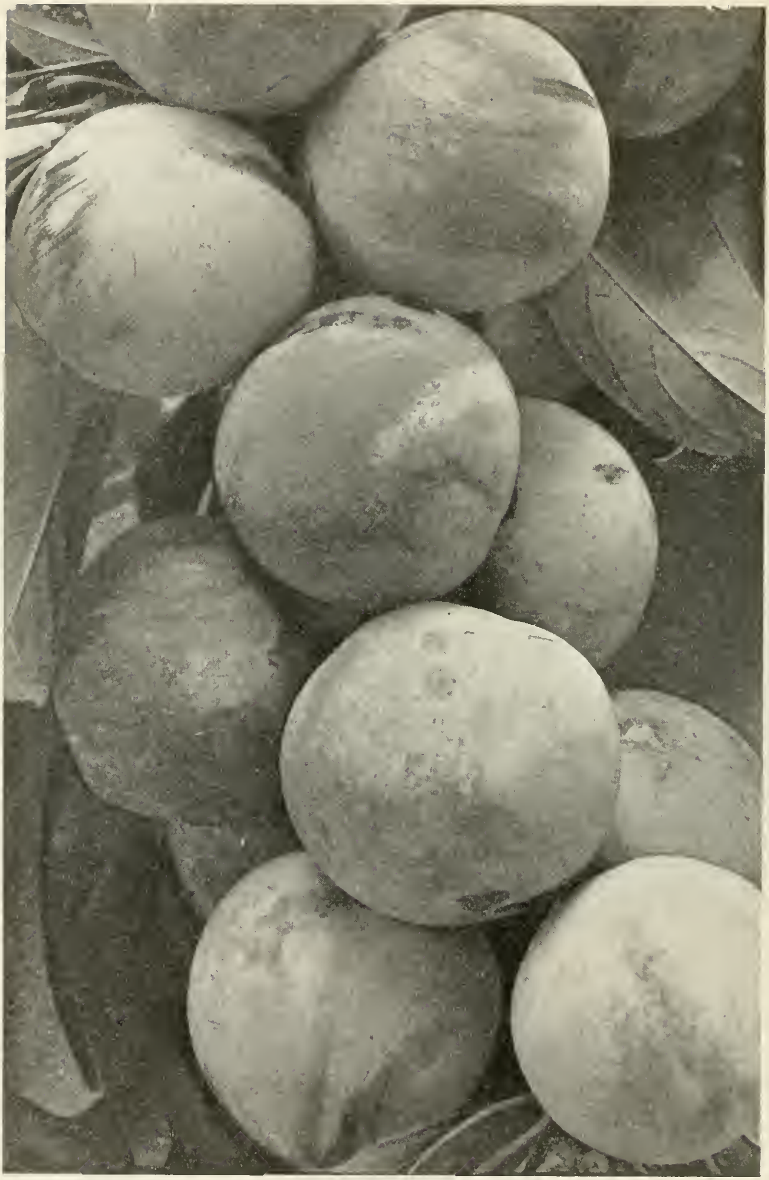
18. SATSUMA.— Fig. 40.

Blood. Yonemomo.

Fruit medium to large, round-oblong or round-conical, with a short blunt point and deep suture; color very dull dark brown-red with a heavy bloom, mottled with greenish dots; flesh hard and blood-red, very tenaciously clinging to the small pit, acerb but becoming rich and pleasant when fully ripe. This season the Satsuma was edible and also fit for market, but still hard, on the 8th and 10th of September. For the last three years the Satsuma has been a very prolific plum with us. When the trees were young they bore sparingly. Some growers complain that even when the trees are nearly mature they do not bear. It is a very long keeper. We believe that it is one of the coming Japanese plums. The red flesh may be against it in many markets. It seems to be an excellent plum for culinary purposes. The tree is a moderately spreading, but strong grower, and is distinguished from most varieties of Japanese plums by its habit of bearing spurs and short branches all along the main forks or branches of the top.

19. THE NORMAND HYBRID PLUMS.

J. L. Normand, Marksville, La., has distributed a number of so called Japanese plums under numbers ranging fom one to twenty. They are hybrids of apparently unrecorded parentage. Mr. Normand advertizes (1899): "Out of over 30,000 seedling Japan plums we have fruited the past three years, we have selected 20 varieties. * * * Most of these



40. —*Satsuma. The latest of the Japanese plums in New York.*

plums are a cross between the Japan and our native plums." One of these (No 15) we named Louisiana in our Bulletin 139, giving a picture thereof. In naming this plum, we did not recommend it; but since these numbered plums are offered to the trade, it seems to be necessary to name them. This

41.—*Georgia* (*Normand No. 20*). *An evident hybrid.*

year we have fruited two others of these numbered plums, and, with Mr. Normand's consent, we have given them names.

Georgia (Normand No. 20). Fig. 41. Fruit of medium size but variable, oblong, very blunt or sometimes with a cavity at the apex; color green or light greenish yellow when first ripe but becoming pinkish, with a very thin nearly white bloom; flesh soft, watery, sweet, cling, with a peculiar breaking skin ; ripe Aug. 24, some days in advance of the Louisiana. The tree has the habit and fruit of the Louisiana, but that plum is more distinctly heart-shaped. In common with others of these hybrids, Georgia drops when it is still green in color, although it is edible at that time, and a pinkish color appears if it is allowed to lie on the ground. The tree is a spreading, twiggy grower, with slender, glossy, half-zigzag branchlets and foliage suggestive of some of the native plums.

Alabama (Normand No. 5).— Fruit of medium size, round-conical or heart-shaped ; color light bright yellow when ripe, with perhaps a faint pinkish cheek, covered with a very thin bloom ; flesh soft, sweet and juicy, cling; ripe the 14th of September. The latest of the plums reported in this bulletin. The fruits drop before fully ripe, but develop an excellent quality after they have fallen. On account of its lateness, it is possible that this plum may have commercial value. The habit of the tree is like that of the Georgia.

INDEX TO VARIETIES.

L. H. BAILEY.

Bulletin 176. **December, 1899.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

ENTOMOLOGICAL DIVISION.

THE

PEACH-TREE BORER.

"June 15, 1749. Peach trees have often been planted here (Albany, N. Y.), and never would succeed well. This was attributed to a worm which lives in the ground, and eats through the root, so that the tree dies."—*Peter Kalm, in his Travels into North America, Translation by Forster, vol. II., p. 244.*

An abridged edition of this bulletin is published for general distribution.

By M. V. SLINGERLAND.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1899.

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THE PEACH-TREE BORER.

Sanninoidea exitiosa Say.

Order LEPIDOPTERA ; family SESIIDAE.

AFTER having made a careful study of the horticulture of New York State, I am convinced that the peach industry suffers more from careless and unscientific methods than any other pomological interest. The greatest fault lies in the cultivation, or, I might have said, in the lack of cultivation. *The second fault is inattention to borers and yellows.*'' Since 1894, when Professor Bailey expressed the above opinion, the peach industry in New York has increased until now there are probably 13,000 acres of peach orchards in the State, and many of them are receiving better care and cultivation. But every commercial grower of this luscious fruit realizes that his success oftentimes largely depends upon his ability to prevent the weakening or destruction of the trees by that king of all peach insect pests—the peach tree borer.

One of America's most noted peach-growers, J. H. Hale, has said that ''the peach-borer has killed more trees than all other causes combined.'' We suppose that but comparatively few of the peach-trees, which have been planted east of the Mississippi River during the last quarter of a century, have lived to produce a crop of fruit without suffering more or less from this dreaded borer.

The peach-tree borer has ranked as one of the standard and serious insect pests of the United States for nearly a century, hence, naturally it has been much discussed in our literature ; the bibliography of more important writings concerning it, which is appended to this bulletin, will serve to show how voluminous is the literature regarding it. By far the larger proportion of this literature deals with methods of preventing or controlling the pest. Thus, this exercise of the ingenuity of American peach-growers for a century or more has resulted in perhaps as many, if not of more, different schemes to circumvent the ravages of the peach-tree borer than has been devised for any other of our insect pests.

And yet there are recorded but few thorough, scientific, extensive, and conclusive experiments with any of the methods recommended. This fact led Professor Comstock to plan, several years ago, an extensive series of experiments with many of the so-called "remedies." A peach orchard of nearly 400 trees was set near the insectary in 1893 for the sole purpose of experimenting against the insect. Portions of this orchard are shown in figures 52 and 53. These experiments have cost much in time and labor, but no effort has been spared to render the results reliable and as conclusive as possible.

The principal aim of this bulletin is to record the results of these careful and extensive experiments which cannot fail to be of direct practical value to every peach-grower. But to fight an insect the most successfully one should know the details of the story of its life, hence we have also aimed to make this bulletin a complete and up-to-date compendium of information on all phases of the peach-tree borer.

ITS HISTORY AND DISTRIBUTION.

The peach-tree borer is an American insect, and has been found only in the United States and Canada. The peach-tree, a foreign plant, had doubtless been in cultivation for a century or more, before we find any definite record of its being attacked by the borer. The note quoted on the title-page is the first reference to this insect we have been able to find in the literature. This testimony of Kalm (in 1749) would indicate that the insect must have attained a liking for the peach-tree about two hundred or more years ago; and before the middle of the last century, or a hundred and fifty years ago, it had become a serious menace to the growing of this fruit in New York State. Twenty years later the insect was recorded (Cooper, 1771) as "prejudicial to the peach-trees" in New Jersey. During the first decade of the present century (1800-1812) it became a serious menace to peach growing in New Jersey, Pennsylvania and Virginia, and many methods of preventing its ravages were tried. In 1823, it was common and destructive in Massachusetts and North Carolina, and northern and eastern nurseries were accused of sending many infested trees into Maryland. Fifteen years later, the peach-growers of Tennessee were suffering from its ravages. By 1850 it had become a serious menace to peach growing from the Atlantic ocean to the Mississippi river, and by 1871 it had attained a similar reputation in Canada. It is said to have been recognized in Kansas as early as 1873. During the past ten years it has been sent into New Mexico and California on nursery stock from Alabama and Missouri, and has obtained a foothold in New Mexico. Aside from these two instances, there is no definite evidence that the peach-tree borer of the Atlantic States occurs west of the Rocky Mountains except in Colorado. The peach-tree borer of the Pacific coast is a different but very closely allied species (*Sanninoidea opalescens*).*

In brief, this native American insect found the imported peach tree to its liking, perhaps two centuries or more ago, and before the middle of the last century it had attained the rank of a serious pest of this fruit-tree. For more than a hundred years it has been recognized as a serious menance to peach growing in the north-eastern portion of the United States, and since 1850 it has sustained this reputation in most of the peach growing sections of the country east of the Mississippi river. At present it has to be fought by every successful peach-grower in nearly every State in the United States east of the Rocky Mountains, from Maine to Texas, and also in Canada. Apparently it has not yet established itself on the Pacific coast, and occurs west of the Rocky Mountains only in Colorado and possibly in New Mexico.

It seems to have first attracted attention as a peach pest in New York, and thence soon assumed a similar role to the southward, eastward and westward.

ITS NAME.

The destructive or "borer" stage of this insect was doubtless known to peach-growers in the first half of the last century. The adult or moth stage of the pest seems to have been known since about 1770. By 1800, some peach-growers had obtained a fairly accurate knowledge of its life, but it apparently received no scientific name until 1804 or 1805. In 1804 Dr. Barton received the Magellanic premium from the American Philosophical Society for an essay on "A Number of the Pernicious Insects of the United States." Harris recorded in 1826 that Dr. Barton named and described the insect as *Zygæna persicæ* in this essay, of which Dr. Mease had published

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*In 1897, Cordley published an account of the Atlantic or eastern peach-tree borer (*S. exitiosa*) as THE peach-tree borer of Oregon, which had been introduced nearly twenty years before. Dr. L. O. Howard has recently carefully investigated the distribution of this pest and he writes us, after an examination of Oregon specimens, that he has "no evidence that *Sanninoidea exitiosa* now occurs on the Pacific coast. Those introduced into California on nursery stock in 1891 do not seem to have established themselves." Mr. Cordley also tells us that all the moths he reared were *opalescens*.

an extract ;* we have been unable to discover if this essay was ever published. Dr. Barton used the name of *persicae* for this insect in 1805, but if he published a description in connection with this name, it has not yet been found ; hence the peach-tree borer's first and very appropriate scientific name of *persicæ* has been supplanted by another. It is of interest to note that the name *persicæ* or *persica* was also independently proposed for the insect by Harris in 1823 and Thomas in 1824.

In 1823, specimens of the moth of the peach-tree borer were submitted to Say, and he named and described them as *exitiosa ;* and the insect is now known by this specific name the world over.†

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* Harris says: "Barton having first described this insect, the name which he has imposed has the priority, and must be retained." He then describes the male and female, using Barton's name ; he refers to Say's name in a preceding paragraph. And yet four years later we find Harris using only Say's name, and never referring to Barton's name in any of his subsequent writings. We can find no explanation by Harris for his rejection of Barton's name.

† Bibliographical references showing the different scientific names which have been applied to the peach-tree borer and the different genera in which it has been placed, arranged by Mr. Beutenmüller.

Zygæna persicæ. 1805. Barton, B. S., Phil. Med. and Phys. Journal I., pt. ii, p. 29. No description of moth.

Aegeria exitiosa. 1823. Say, Jour. Acad. Nat. Sci., III., 216. Original description.

Apis persica. 1824. Thomas, American Farmer, VI., 37.

Paranthrene pepsidiformis. 1825. Hübner, Zut. Exot. Schmett., p. 32, figs. 533–534. Good figures of female.

Aegeria persicæ Barton. 1826. Harris, New England Farmer, V., 33.

Sphinx exitiosa Say. 1832. Brown, Book of Butt. and Moths, p. 17, fig. 63.

Trochilium exitiosum Say. 1856. Fitch, Third Rept., 356.

Trochilium exitiosa Say. 1862. Morris, Synop. Lep. N. Am., p. 140.

Sesia xiphiaeformis. 1874. Boisduval, Suites a Buffon, Nat. Hist. Lepidop., Het. I., p. 409. Description of female.

Sannina exitiosa Say. 1874. Butler, Ann. and Mag. Nat. Hist., p. 408.

Sanninoidea exitiosa Say. 1896. Beutenmüller, Bull. Am. Mus. Nat. Hist., VIII., 126; and Vol. XII., 1899, p. 160.

FEMALE VARIETY *fitchii*.

Aegeria exitiosa var. *fitchii*, 1882. Edwards. Papilio, II., 55.

MALE VARIETY *luminosa*.

Sannina exitiosa var. *luminosa*. 1894. Neumoegen, Ent. News, V., 331.

FEMALE VARIETY *edwardsii*.

Sanninoidea exitiosa var. *edwardsii*. 1899. Beutenmüller, Bull. Am. Mus. Nat. Hist., XII., 160.

This bibliographical foot-note shows that the insect has received two other specific names (*pepsidiformis* by Hübner in 1825, and *xiphiaeformis* by Boisduval in 1874) in Europe, and it has also been placed in several different genera, being once described as a wasp (*Apis persica*). The latest student of this kind of insects, Mr. Beutenmüller, has formed a new genus, *Sanninoidea*, for this insect and a few closely allied forms. Hence the peach-tree borer now bears the scientific name of *Sanninoidea exitiosa* Say.

The insect was popularly known as the "peach worm" or "the peach-tree insect" in earlier writings.[*] Sometime before 1850 it had received the name of "peach-tree borer," and usually under this popular name it has since been discussed. Almost every peach-grower east of the Rocky Mountains understands what insect is referred to as the "peach-tree borer". However, the peach-tree borer of the Pacific coast States is a different kind of an insect, bearing the scientific name of *Sanninoidea opalescens*. Hence, when *exitiosa* obtains a foot-hold in these States, which is liable to occur at any time, it will doubtless be designated as the Eastern peach-tree borer to distinguish it from the Pacific species.

The specific name *exitiosa* means "destructive," hence it is aptly applied to such a pest as the peach-tree borer. Emmons (1854), doubtless freely translating this name, called the insect the "Mischievous Egery," the latter part of this being a popularization of its first generic name of *Aegeria*.

As the bibliographical foot-note, referred to above, indicates, three variations of the adult forms of this insect have been described as distinct varieties. Thus we have the female varieties, *fitchii* and *edwardsii*, and the male variety, *luminosa*. These will be discussed when the appearance of the insect is being considered.

ITS CHARACTERISTICS.

Most peach-growers have seen this insect in its destructive or "borer" stage, and doubtless but few have ever seen it in any other form. However, the peach-tree borer, like all the butterflies, the moths, the beetles, and flies and some other insects, passes through four different stages (see figure 57 on last page) during its life. It begins life as an *egg*, from which hatches the *larva* or "*borer*," which has to pass through a *pupa* stage, from which the *adult* or *moth* form of the insect emerges. The egg and pupa stage will be described in telling the story of the life of the insect.

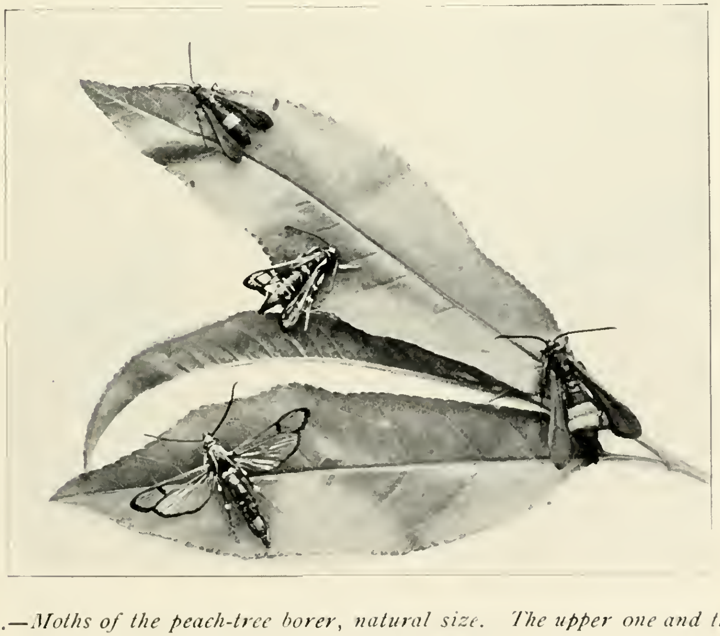
The "borer"—When full-grown, the larva or caterpillar of the peach-tree borer a is very light yellow, worm-like creature whose general characteristics are well shown in figure 42. It measures about an inch in length, and in addition to its six well developed thoracic or "true" legs, it has five pairs of "false" or pro-legs on the third, fourth, fifth, sixth and last abdominal segments. The true jointed legs are of a light brown color, and terminate in a sharp, dark brown claw ; all of the pro-legs are furnished with two rows of recurved brown hooklets, except the last pair which has but one row. The body is sparsely clothed with brownish hairs arising from smooth, slightly elevated tubercles, and arranged according to a definite plan. The "borer's" head is of a shiny, dark reddish brown color with its strong mandibles or jaws nearly black. The dorsal portions of the first thoracic and the last abdominal segments bear a very light brown, shiny, chitinous shield. The spiracles or breathing holes along each side of the body are nearly circular, dark brown with a black border, the first and last ones being considerably larger. The "borer" is well illustrated, both natural size and enlarged in figure 42, and is also represented natural size in its burrow in figure 47.

The younger larvae or "borers" present practically the same characteristics as the full-grown one just described, except that the hairs on the body are comparatively longer. We have seen no indications that young peach-tree-borers present such striking differences from the older ones as do those of the closely allied squash-vine borer. (See Bull. 19, U. S. Div. Ent., p. 35-36.)

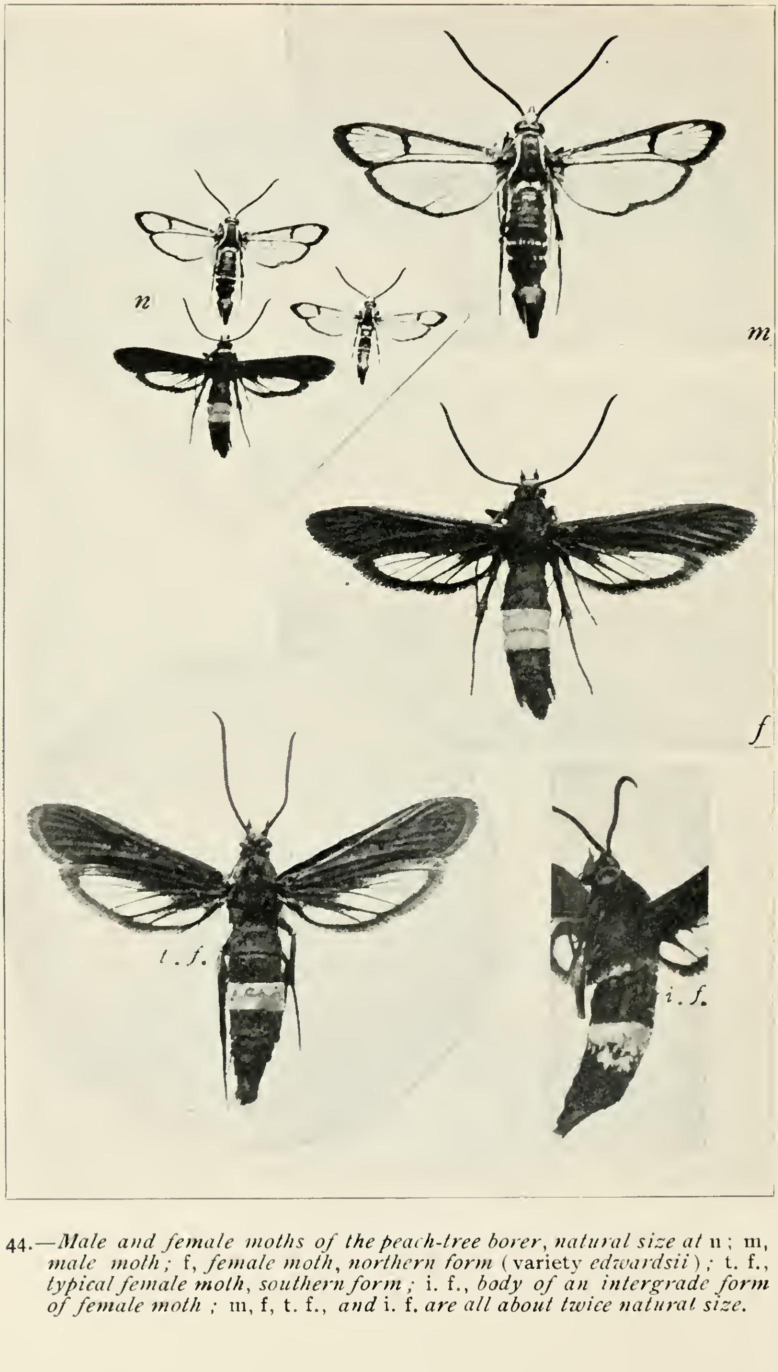
The adult insect.—The adult form or the parent of the peach-tree borer is a moth. The moth belongs to a remarkable family of insects known as the Clear-winged Moths, many of the members of which resemble bees or wasps in appearance more than they do ordinary moths, a resemblance due to their clear or unscaled wings and in some cases to their bright colors. DeGeer, writing more than a century and a quarter ago, says of one of these wasp-like moths: "When I saw the moth for the first time, I dared not take it with the naked hand, so sure was I that it was a wasp." (DeGeer's Abh. zur Gesch. der Insekten, German Translation, Vol. II., p. 163.) A glance at figure 43 will show how easily one might mistake the moth, especially a male, for a wasp, so striking is the resemblance. It is not strange that the adult insect was regarded as a wasp by some of the early writers and was once so described and named (*Apis persica*, by Thomas in 1824).

In figure 43 it will be noticed that two of the moths there illustrated have a very different appearance, resembling wasps much less than do the other two moths. All of the moths in the figure are peach-tree borer moths, and simply represent the two sexes, the male and female which differ so strikingly in appearance that one may well wonder if they can belong to the same species of insect. Could the figures have been colored true to life, the remarkable unlikeness of the two sexes and the

42.—*The larva of the peach-tree borer, natural size and enlarged.*



43.—*Moths of the peach-tree borer, natural size. The upper one and the one at the right are females.*



44.—*Male and female moths of the peach-tree borer, natural size at* n ; m, *male moth ;* f, *female moth, northern form* (variety *edwardsii*) ; t. f., *typical female moth, southern form ;* i. f., *body of an intergrade form of female moth ;* m, f, t. f., *and* i. f. *are all about twice natural size.*

striking resemblance of the male to a wasp would have been more vivid.

The male moth is represented, twice natural size, at *m* in figure 44, and natural size, by a large and a small specimen, at *n* in the same figure. Its general color is a deep steel-blue with a glossy lustre like satin ; all the dark portions of the figures are of this blue color. The four wings are transparent and glass-like, with a light tinge of smoky yellow ; their veins, margins and fringes are steel-blue, the margins sometimes scaled more or less with yellow. The lower sides of the palpi are light yellow ; there is a paler yellow spot on the vertex of the head and a deeper yellow, transverse stripe at the base of the head both above and beneath. The thorax has a similar light yellow stripe on each side of the dorsum, a transverse one at its base which is slightly interrupted in the middle, and a short, broader one on each side beneath the bases of the wings. The caudal borders of the dorsal and lateral portions of the second, fourth, fifth and sixth abdominal segments are light yellow ; sometimes one or more of these narrow yellow bands are absent or become indistinct, especially where the specimen has become greasy, as it often does in a collection. The anal tuft is wedge-shaped and tipped with white laterally. The legs are light yellow at the joints. Most of these light colored markings are represented by white in the figures of the moths. The males vary in size from three-fourths of an inch to an inch and a quarter from tip to tip of their expanded wings ; the two males at *n* in figure 44 differ considerably in size.

Fitch described seven varieties of the male moth based entirely upon variations in the light colored markings. Neumoegen (1894) has described a beautiful variety of the male which has the borders of the wings heavily scaled with yellow ; it bears the varietal name of *luminosa*.

The female moth of the peach-tree borer is shown twice natural size with wings spread at *f* and *t. f.*, and natural size by one specimen at *n* in figure 44 ; two females are also shown natural size and at rest in figure 43, one at the base of the leaves and the other at the tip of the upper leaf. They are a little larger than the male moths, their wings expanding from one inch to an inch and a half. The female is wholly of a deep steel-blue color with a satiny lustre, except a broad, orange-colored band extending nearly around the abdomen on the fourth, or on both the fourth and fifth segments. The front wings are opaque, being entirely covered with the deep blue scales, while the hind wings are transparent over about half of their area, being heavily scaled with deep blue at the base and along the costal margin, and sometimes also between the two veins nearest the inner margin.

A glance at *f* and *t. f.* in figure 44 will show that the female presents a striking variation in the width of the orange band on the abdomen. In the typical form (*t. f.*) this orange band occurs only on the fourth segment, while the female at *f* has both the fourth and fifth segments thus banded. Rarely a specimen is found with the fourth segment and a few scales on the sides of the fifth segment of an orange color, as shown at *i. f.* in figure, thus forming a "connecting link" or intergrade between the typical female (*t. f.*) and the one shown at *f* in the same figure. In his original description of the female, Say stated that the *fifth* segment bore this orange band, but his figure shows the *fourth* segment orange; no specimen with only the fifth segment orange has ever been found. We have been unable to find any structural differences between the form with only one segment orange and the one with the orange band on two segments, and the fact that an intergrade (*i. f.* in figure 44) exists, is quite conclusive evidence that they are simply striking variations of the same species. A similar variation occurs in the male of *Sannina uroceriformis*, the persimmon-root borer.

The fact that all of the scores of females of the peach-tree borer moth which we bred here at Ithaca, N. Y., with the exception of one intergrade form, were like *f* in figure 44, while all those which were bred on Long Island and New Jersey by Professor Smith, were like *t. f.* in this figure, led us to make inquiries regarding the geographical distribution of these two forms of the female. The results indicate that the females with only the fourth segment orange are a southern form or geopraphical race occurring south of latitude 40 to 42 degrees, while north of this latitude only the variety or race with the orange band covering the fourth and fifth segments occurs; the intergrade form (*i. f.* in figure 44) has been found at Ithaca, N. Y., and near New York City. Mr. Beutenmüller (1899) has recently given the name of *edwardsii* to this northern form of the female moth. Another variety of the female with only the fourth abdominal segment orange and "the space between the two inner veins of the hind wings is nearly, or quite, covered with blue-black scales, forming a stripe which divides the transparent disc into two parts" was named *fitchii* by Edwards (1882).

Prof. J. B. Smith (1898) has illustrated some interesting structural characteristics of the moth of the peach-tree borer. The scaly vestiture on different parts of the body and wings present striking differences in size and character. "At the base of the last segment in the female there is a brush of hair ordinarily lying close to the body like a pencil, but capable of being expanded at the will of the insect. Giving this the usual interpretation we may take it to be a scent organ. The virgin female soon after emergence from the pupa fixes herself at rest, elevates the abdomen, projects the ovipositor with the genital organs directed downward, the tufts expanded, and awaits the male. The antennae show considerable differences between the sexes. In the female the joints are not furnished with tufts of hair on the inner side as is the case of the male. At the base of the antenna the differences between the male and female are yet more marked, and yet here the greatest modification is found in the female." On the basal segment of the antenna occurs a sensory fovea "in the form of a considerable opening covered by a tight, drum-like disc. A series of sensory punctures is found at the base of the second segment, and just above the sensory fovea there is an excavation which leaves that structure entirely free. In the male the large sensory fovea is present, but hardly as well developed as in the female, and there are no sensory punctures on the second segment. It is probable that this fovea is auditory in function. The maxillæ of the mouth-parts differ quite strongly in the sexes at the base."

Mr. Beutenmüller writes us that only two others species of these clear-winged moths might be easily mistaken for the moths of the peach-tree borer. Both the males and females of *Sesia pictipes** look much like the males of the peach-tree borer, but are readily distinguished by the presence of a narrow yellow band across the venter of the fourth abdominal segment, which is not present in the peach-tree borer. Both sexes of *Sannina uroceriformis*, the persimmon-root borer, resemble the female peach-tree borer, but the hind wings of the former are entirely opaque, except a small transparent area at the extreme base.

FOOD-PLANTS.

The peach-tree borer apparently has a decided preference for the peach-tree, as no other plant is so often and so destructively attacked. The borer does not seem to discriminate in favor of any particular variety of the peach, all, whether "old relics" or young nursery trees, apparently suffering alike under similar circumstances. But the insect does not confine itself to the peach. As early as 1823, Harris reared it from the cultivated cherry in Massachusetts.† In 1854, Fitch found it working in his cultivated plum-trees in New York, and Glover recorded that "nectarines and apricots are as liable to be attacked by these worms as the peach." In 1880, Fuller discovered that the cause of the death of several of his dwarf flowering almond shrubs was this peach-tree borer working in the roots. The preceding year it was recorded by Milton as working in the roots of azaleas which had been grown during the summer out doors in pots near badly infested peach-trees. In 1882, Edwards described the female variety *fitchii* from a specimen apparently reared from the roots of wild cherry in West Virginia, and Devereaux (Clyde, N. Y.) has recorded (1890) in Packard's Forest Insects seeing this borer "in the trunk near the ground and in the bark of the

* Its larva lives under the bark of plum, wild cherry, June berry, and beach plum. We have also bred it from peach-trees.

† In 1826, Harris records frequently seeing the borers in "those tubercles which deform the limbs of the cherry-tree." And in 1841, he states he has "repeatedly obtained both sexes of the moths from borers inhabiting these excrescences." Whether these excresences were the well-known Black Knot fungus or not is not quite clear from the context. Webster bred the moths from cultivated cherry in Indiana in 1891.

roots of young wild cherry-trees." Townsend states (1891) that the insect works in apricot as well as peach in New Mexico, and New York plum and prune-growers suffer from the pest, but not to such a serious extent as those who grow peaches.

In brief then, the peach-tree borer is *par excellence* a peach pest, but may also attack both the wild and cultivated varieties of the cherry, the cultivated varieties of the plums or prunes, nectarines, apricots, flowering almond shrubs, and azaleas.

As the peach-tree borer is a native of America it must have lived upon some native plant previous to the introduction of the peach into this country. The fact that he found the borer working in his plum-trees, led Dr. Fitch to think it quite probable that our indigenous species of plums were its original food-plants. Marlatt (1896) and other writers have accepted this suggestion, but Devereaux's observations of the insect working in wild cherry led Packard (1890) to suggest that "this was undoubtedly the native food-plant of the insect before the importation of peach-trees." In 1896, "G. E. M." of Virginia recorded that his Japan plum-trees on Myrobolan or Marianna plum stocks were as badly infested as his peach-trees, whereas when budded on Chickasaw or other native varieties, they were entirely exempt. This evidence, in connection with the fact that we have found no record of the peach-tree borer having been found in our native wild plums, would indicate that the wild cherry is more likely to have been its original food-plant than the wild plum; perhaps it originally fed upon both these plants. Whatever may have been its original food-plant, it has evidently almost entirely forsaken it for the peach.

HOW IT SPREADS.

The "borer" or caterpillar probably never leaves the tree upon which it is born from the egg laid on the bark, and the insect spends nearly eleven months of its yearly life-cycle on or in the tree. It thus can be easily transported for long distances on infested trees, and this is doubtless the way in which it usually reaches new localities. In the spring and fall, when trees are usually transported, many of the "borers" are quite small and easily escape casual observation. As large peach-trees are rarely moved, the growers of nursery stock are most responsible for the introduction of the insect into new localities. As early as 1806, Peters had "discovered the worms in or near the roots of the smallest stocks taken from the nursery." In 1824, Thomas states that he believed the pest was introduced into the neighborhood of Baltimore on nursery stock from Northern and Eastern nurseries, for many of the trees received from there were infested. It has been found on nursery stock sent into California from Southern nurseries, and it doubtless reached New Mexico and Colorado in a similar manner. Mr. Lowe (1897), states that "it is a too common occurrence in our own State (N. Y.), to find many young peach-trees in the packing shed, waiting to be shipped, which are infested by borers. Within the past few months hundreds of such trees have been found which were about to be packed and shipped to some distant State." It is doubtful if there is a peach nursery to-day east of the Rocky mountains that is not more or less infested with the peach-tree borer. It is one of the most serious of the insect pests that are now being sent out by nurserymen.

When the pest once gets a foot-hold in an orchard or locality, it may be slowly spread from orchard to orchard by the adult insects or moths, which fly readily, but apparently not for very long distances.

Peach, plum, prune, apricot or cherry-trees from a nursery should always be carefully examined for "borers" before setting them.

APPEARANCE OF INFESTED TREES.

Peach-tree borers often kill young trees by girdling them with their burrows just beneath the bark underground and thus rendering their destructive work very conspicuous. Many infested trees, even young trees, survive the attacks of the borer, but thev are usually easily recognized by their weakened, sickly appearance when compared with perfectly healthy trees. The recuperative powers of a peach-tree from the ravages of borers are sometimes wonderful. We have seen a peach-tree, only one and a half inches in diamater, support nine borers nearly to maturity in a single season and yet survive. And some of the trees in the older peach orchards of the country, and some of the "old relics" in door-yards or gardens, have furnished sustenance to hundreds of borers and are yet producing fair crops of fruit. But every borer weakens the tree more or less, the damage done depending much on the age of the tree, and whether it is well fed and cultivated. We have yet to learn of a successful and progressive fruit-grower who thinks he can afford to let the peach-tree borer have its own way in his peach or plum orchards.

One can usually quickly determine if a peach-tree is infested with borers. The work of the borer always causes the tree to exude a large amount of a mucilaginous matter which forms a gummy mass around the infested portion. We have seen at least two tablespoonfulls of this gum result from the work of a single borer in a peach-tree. This gummy mass mixed with particles of bark and the excrement of the borers is frequently visible on the surface of the soil close around the base of the tree. In figure 45 is shown a small peach-tree surrounded by a ring of this gum resulting from the work of borers. By this tell-tale evidence, the presence of this gum at the base, one can usually determine at a glance if a peach-tree is suffering from borers.

45.—*Base of an infested peach-tree, showing the gummy mass surrounding the tree.*

Where the peach-tree borer attacks plum or prune trees, however, there is but a slight, if any exudation of this gummy substance, hence one cannot so readily detect its presence on these trees. It is thus more difficult to find the borers in plum or prune trees, and this makes it harder to combat them in these trees.

THE STORY OF THE PEACH-TREE BORER'S LIFE.

Not many creatures pass through such varied, complicated and interesting experiences in their life-time as do the insects. The most common of them, those that we meet almost every day, could unfold to us many a wierd and fascinating tale of their haps and mishaps in life could we but patiently watch their daily life. It is a curious fact, however, that when most of us see an insect of any kind, our first impulse is to devise some method of taking its life, or literally of committing an insecticide. And especially is this true when the insect happens to be one which injures our plants, as does the peach-tree borer. But few peach-growers stop to marvel over the wonderful transformations exhibited by this insect in passing through the four stages—the egg, the "borer" or larva, the pupa and the adult moth—of its life-cycle. These four stages are illustrated in figure 57, used as a tail-piece on the last page; and how few peach-growers ever saw the insect in any except the "borer" or second stage of its life. And yet, our more successful fruit-growers are fast realizing that they must know more, and, in fact, cannot know too much, about the lives and habits of their insect foes in order to fight them the most successfully.

The peach-tree borer, like most other insects begins life as an egg, and logically we should begin the story of its life with this stage, but for various reasons, we prefer to start with the insect in its winter quarters.

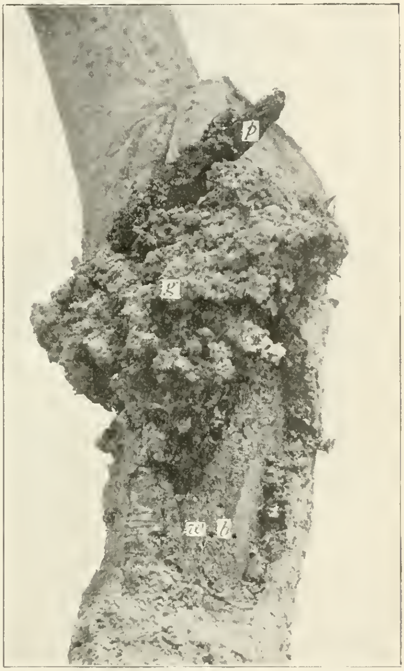
How and where the winter is spent.—The peach-tree borer always passes the winter in the larva or "borer" stage; this seems to be true wherever the insect occurs, even in the extreme South. In most of the Southern States the borers apparently get most of their growth before winter, and thus the hibernating larvæ are mostly large or nearly full-grown. In the Northern States and Canada, however, most of the hibernating borers are usually less than half-grown. Sometimes, during a long and favorable season in the North, many of the borers will attain one-half or more of their growth before winter; this happened in New York in 1898, so that many of the borers we found in hibernation at Ithaca on January 5, 1899 were large, some of them three-fourths grown. In most localities, however, both North and South, borers of all sizes, from those only one-eighth grown to those nearly full-grown, may be found in the trees during the winter.

Our observations indicate that in New York State most of the larger borers hibernate in their burrows just beneath the bark and below the surface of the soil. While most of those which are less than half-grown pass the winter curled up in a thin, half cocoon-like structure built over themselves on the outside of the bark in the exuded gum, usually at the upper end of their burrows and at or near the surface of the ground. This winter home or *hibernaculum* of the peach-tree borer is a thin affair, with a smooth interior, and is made of bits of frass or particles of bark fastened together with silken threads, which simply covers the borer as it rests curled up on the bark. As these hibernaculums are usually surrounded by the sticky gum which exudes from infested trees, their principal use may be to protect the borers from the gummy mass, thus giving them a more comfortable home during the winter. In exceptional cases we have seen nearly full-grown borers in winter curled up in a hibernaculum on the outside of the bark, just at the head of their burrow which had become filled with the gummy mass. But usually in New York the larger borers hibernate in their burrows beneath the bark and the smaller ones, those less than half-grown, pass the winter in hibernaculums on the outside of the bark in the gummy mass; there are exceptions, however, in both cases, as just noted in the case of the larger borers, and some of the small ones apparently hibernate on the bark or in the gummy mass without any hibernaculum. This peculiar method of hibernation of the smaller borers is of considerable importance economically, as several northern peach-growers have discovered that they can quickly remove most of the borers a safe distance from the trees during a warm spell in winter by simply hoeing away the exuded gum from around the base of the trees.

The peach-tree borer apparently eats nothing during the winter, at least in the Northern States.

Habits of the borers in the spring.—In the latter part of April, 1895, we found that some of the borers had already awakened from their long winter's nap, and had broken the winter's fast by beginning to feed on the bark. Yet some of them had not awakened or begun feeding by May 1st, but still lay curled up in their hibernaculums. Climatic conditions in the spring will doubtless vary these dates somewhat, but usually the borers cease hibernation and begin feeding earlier than this in the spring, possibly feeding nearly all winter in the extreme South.

As the borers usually hibernate, either in hibernaculums at the upper ends of their burrows, made the preceding summer and fall, or in their burrows, they oftentimes simply begin work in the spring where they left off to go into hibernation. The smaller borers often feed over an irregular area in the outer bark, but soon burrow into the inner bark and gradually excavate a burrow from one-half to an inch or more wide and two or more inches long, just under the outer bark in the inner bark and sapwood.* At *w b*, in figure 46 is shown the work of a single borer, with part of the resulting gummy mass, *g*, just above.



46.—*Work of a single borer in a peach-tree, natural size;* w b, *burrow of borer;* g, *gummy mass;* p, *pupa projecting from cocoon.*

Usually the borers confine their destructive work to the trunk or roots of the tree a short distance below the surface of the soil; sometimes one is found in a root six or eight inches underground. Occasionally, however, a borer is found in the trunk above ground. We found one borer working in a large root-gall on a peach tree.

Our observations indicate that in most years the peach-tree borer does more feeding, and is thus more destructive, in the spring than in the preceding autumn in New York; this is

*Smith (1898) states that the borers "travel little and simply keep a clear chamber about them, mostly cut out of the bark, and in this they lie, subsisting largely upon the plant juices." It may be that the borers do get much of their food from the juices which exude from the wounds they make with their jaws, thus necessitating their making a comparatively small burrow, but from what we have seen of their work we do not reach such a conclusion.

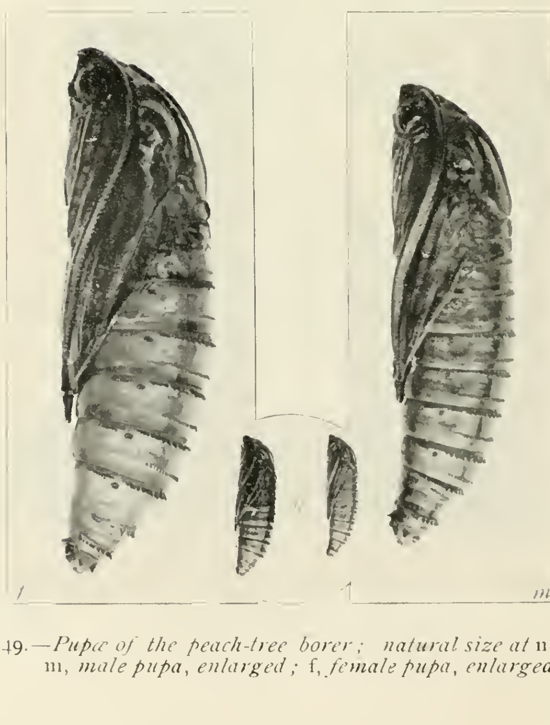
doubtless also true in most Northern States and in Canada. As the borers begin feeding about May 1st, it is during May and June that the peach-tree borer gets in its most destructive work in the North ; in Canada apparently much feeding is also done in the first half of July. The above statements are based somewhat upon data furnished by the following table which has been compiled from our "digging-out" records and those of Mr. Burrell in Canada.

SOME DATA OBTAINED FROM "DIGGING-OUT" RECORDS.

Year.	Dates of "digging-out."	No. of borers ⅛ to ¼ grown.	No. of borers about ⅓ grown.	No. of borers ½ to ⅔ grown.	No. of borers ¾ to full grown.	No. of borers in cocoons	No. of pupæ.	No. of adults emerged.
1894	21 March	40	28	25	5			
	7 May	2	4	9				
	1 to 5 June		5	12				
	13 "			3				
	26–27 "		1	10	4			
1895	25–29 April	110	13	12	2			
	1 May	37	13					
	23–25 May	12	21	16	1			
	12 June			14	9	2		
	17–18 June			6	21	6	1	
	27 June to 3 July	3		4	25	1		
	16 July				2	4		
1896	5–6 June			46	15			
	10–11 June	2	5	121	55	1		
	12 "			40			1	
	15 "			41	18	1		
	17 "			28	27	3		
	8–13 July			2		2		
1897	22 June	1	4	30	33	6		
	25 "		1	41	29	8	8	
	29 "			3	6	1	1	
	1 July			5	5	1		
1898	27–29 June	3	32	71	45	3	1	
1899	26–27 May		1	24	7		2	
	30 June			7	19	12	21	11
Similar data by Burrell in Canada.								
1897	19 July		63	63	48		22	1
	16 August		19	18	23		9	several
	29 Sept.		6	15	9		1	

47.—*Work of the peach-tree borer, natural size;* b, b, *borers in their burrows;* c, c, *cocoons in the place where they were made by the borers;* p, *empty pupa skin from which the moth emerged.*

48.—*Cocoons of the peach-tree borer, natural size.*



49.—*Pupæ of the peach-tree borer; natural size at* n; m, *male pupa, enlarged;* f, *female pupa, enlarged.*

The above table indicates that usually by far the larger proportion of the borers get less than half their growth before going into hibernation in New York and northward. They are naturally hungry after their long winter's fast and their strong jaws are kept busy during the spring in satisfying this hunger and providing for the rapid growth of their body. It is surprising how rapidly the smaller borers grow in the spring. Some of the borers we dug out on April 19th, 1895 were so small, only one-fourth of an inch long, that we were loath to believe that they would get their growth and develop into the perfect or adult insect that season. We transplanted some of these small borers onto trees in cages in the insectary on the same day they were found, April 19th. They soon got to work and grew so rapidly that in the next ninety days, or by July 20th, they had not only grown into caterpillars an inch long, but these had spun cocoons, transformed to pupæ, and the adult insect or moth had emerged.

This question of when the peach-tree borer does most of its damage has a very important bearing on one of the most successful methods of combating it. In the South, the borers apparently get most of their growth or do most of their damage in the summer and fall, as most of them pass the winter as nearly full-grown borers.

The Cocoon.—In New York, and probably in most Northern States some of the peach-tree borers attain their full growth in most years by June 5th, while others do not reach this stage until a month or more later; in 1899, however, some of them must have become full-grown by May 15th, for we found pupæ on May 26th. When full-grown the borer leaves its burrow under the bark and proceeds to make around itself what is known as a *cocoon*. This is a rough, brown, elongate-oval capsule with slightly pointed ends and is about an inch in length. It is constructed by the borer of its excrements and particles of bark, these being bound together with gum and a thin smooth inner lining of silk. A cocoon is shown natural size, where it was made by the borer, at *c* in figure 47, and two others are also shown in figure 48; the one in the right of this figure is of unusual length. It takes the borer from two to three days to complete its cocoon.

The cocoons are usually attached to the outside of the bark of the tree at or near the surface of the soil, but occasionally one is found two or three inches below the surface or lying loosely in the soil.*

Within this cocoon the larva or borer soon sheds its skin and is transformed into an entirely different looking creature known as a *pupa*. We have not determined just how much time is spent in the cocoon by the borer before it changes to a pupa, but it is at least from three to five days. Usually we have not found the the cocoons earlier than June 5th at Ithaca, N. Y., but in 1899, some must have been made by May 20th, as they contained pupæ six days later. They are made much earlier, in April, at Washington D. C., or even in March in the extreme South. They may be found, containing borers or pupæ in most parts of the country, from these dates until September, even into October in Canada.

The pupa.—The third or pupa stage into which the peach-tree borer transforms is shown natural size at *m* and enlarged at *f* and *m* in figure 49. These well illustrate the size, form and general features of the pupa. It is of a dark brown color, considerably lighter when first formed, and measures about three-fourths of an inch in length. The male and female pupæ are readily distinguished. The female pupa is larger and more robust, and it has but one row of spines across the back of the seventh abdominal segment (the segment bearing the last or caudal spiracle) while there are two rows of these spines on this segment in the male pupa. These sexual differences in the pupæ of the peach-tree borer are clearly shown in figure 49, the male pupa at *m* and the female at *f*. When nearly mature, the female pupæ are also readily distinguished from the males by the fact that the fourth or the fourth and fifth abdominal segments assume a dark orange color; the orange-colored segments of the female moth developing inside, simply show through the skin of the pupa.

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*In one case on a tree we had protected with tarred paper, the borer had first eaten a round hole, through the paper, and had then capped the hole with silk and particles of bark, before spinning its cocoon beneath the paper near the hole. This is an interesting case of instinctive foresight in the borer in thus providing for the sure exit of the adult or moth.

Usually the peach-tree borer does not transform to a pupa in New York much before June 15th (May 26th is the earliest date we have found one), and pupæ may be found from this date until September, probably the most in July. Add about two weeks to these dates for Canada, but at Washington, D. C. and southward, some pupæ must occur as early as April, or even in March in the extreme South.

In the pupa stage most of the tissues of the borer or larva are built over into the moth. No food is taken, the pupa spending its whole life quietly within the protecting cocoon ; it can move its abdomen slightly when disturbed. The statements regarding the duration of the pupa stage are quite at variance. They vary from "a few days" (Marlatt, 1896), or "eight to ten days" (Cocke, 1813) to from three to four weeks. Most writers who have recorded definite data from breeding experiments agree that the pupa stage of the peach-tree borer lasts about three weeks ; Ashmead (1888) says eighteen to twenty-four days for Florida, Smith (1897) records about twenty days for New Jersey, and Fitch (1855) found it to be at least three weeks in New York, while Burrell reports it as twenty-eight days for Canada. Our breeding experiments indicate that at Ithaca, N. Y., the insect is in its cocoon from twenty-five to thirty days, from three to five of these being spent as a larva, thus making the pupal period about three weeks. Possibly it is shorter in the South, but Ashmead's record would indicate that it is but little shorter even in Florida.

The emergence and habits of the adult or moth.—When the pupa is fully mature, or when the adult insect is ready to emerge, the pupa uses the hard, sharp, beak-like prominence on its head to break through the end of the cocoon, and then by means of the rows of spines on its back, it moves or hitches itself forward until it projects for half its length or more out of the cocoon, as is well shown at *p* in figures 46 and 47. This movement of the pupa out of the cocoon, and the wise precaution of the borer to build its cocoon near the surface of the soil, usually results in bringing the projecting pupa out of the soil. Thus the adult insect or moth, which is delicate and soft when it first emerges, finds itself at once in its favorite element, the open air.

At *p* in figure 46 is shown a pupa projecting from its cocoon ready for the emergence of the moth. And at *p* in figure 47 the moth has emerged, leaving the empty pupa skin still sticking in the cocoon ; the same thing is also seen in figure 48. The moth bursts through the pupa skin, which splits down the center of the back for a short distance. After carefully drawing out its wings, legs, antennae, and tongue from their pupal sheaths, it may crawl a short distance, where it rests for from twenty minutes to half an hour to let its wings expand and dry. It is then ready for active flight.

All records agree that the moths of the peach-tree borer emerge in the day-time, usually early in the day about 8 A. M., and they are also most active during the day, doubtless flying but little, if any, at night. Most moths in other families emerge and fly mostly at night. One familiar with the moths of the peach-tree borer can usually find them flitting about from tree to tree in a peach orchard during the month of June or July. Those we have seen were rather easily disturbed and always flew rapidly and close to the ground, usually to the base of another tree not far distant. They visit flowers, Fyles (1898) having captured one on the blossoms of *Spirea salicifolia* in Canada. Unlike most moths, they are not attracted to lights.

The dates of emergence of the moths vary much in different parts of the country, and somewhat in different years. As all sizes of the borers occur in the trees in the spring, and as all of these get their full growth before fall, it naturally follows that the resulting moths must continue to emerge over quite a long period, or from two to four months.

The records from our breeding-cage experiments and other observations at Ithaca, N. Y., are given in the following table :

SOME RECORDS OF THE EMERGENCE OF THE MOTHS AT ITHACA, N. Y.

1895.			1896.			1898.	
Date.	Male.	Female.	Date.	Male.	Female.	Date.	Number.
15 July..	1		9 July	1		27 July	3
17 " ..		2	10 "	1			
18 " ..		1	11 "	3	2		
29 " ..	1	2	13 "	9	4	1899.	
5 Aug..	5	2	14 "	1	4		
6 " ..	2	1	15 "	6	3		
8 " ..		1	16 "	4	8	30 June	11
			17 "	1	2	6 Aug.	2
			18 "	3	4		
			19 "	2	8		
			20 "	6	5		
			21 "	2	3		
	9	9		39	43		

Most of the moths in the above table, except for June 30th, 1899, were reared from borers dug out of peach trees in June. In examining our trees on June 30, 1899, we found that eleven moths had already emerged, some of them possibly a week or more before, so that in exceptional years the moth may appear as early as June 15th in New York. But our records for the four years preceding 1899, indicate that usually no moths emerge in New York before July 1st, while most of them appear from July 15th to August 15th. We have no data as to the emergence of the last stragglers in autumn; Kellicott (1881) has recorded rearing the moths late in September near Buffalo, N. Y. Thus the time of the emergence of the moths in New York may range from June 15th to nearly Oct. 1st, or over three months.

We have endeavored to compile, in the following table, all of the records which seem to be based on definite knowledge of the time of flight of the moths in different localities or States :

TABLE SHOWING RECORDED TIMES OF FLIGHT OF THE MOTHS IN DIFFERENT STATES.

Authority and Date of Record.	State or Locality.	Time of Flight.
Ashmead (1888).	Florida.	Appears early in April.
Weed (1891).	Mississippi.	April and Sept.
Crossman (1888).	Arkansas.	June to Sept.
Lancaster (1839).	Tennessee.	None June 1, but few cocoons 18 July.
McCarthy (1893).	N. Carolina (Central)	Moths disappear by 15 July.
Cocke (1813).	Virginia.	15 July, through Aug. and Sept
"G. E. M." (1896).	"	First pupa July 1, moths about 15 July.
"H. F. H." (1888).	Kentucky.	6 June to Oct., mostly 15 July to 15 Aug.
Riley (1869).	Missouri.	20 July, possibly last of May.
Stedman (1898).	"	May until well into July.
Kellogg (1892).	Kansas (Southern).	May and June.
Faville (1898).	" (Northern).	16 June to Sept.
Thomas (1877).	Illinois.	Usually July, but May or June in S. Ill.
Comstock (1880).	Washington, D. C.	May 10.
Fulton (1870).	Delaware.	15 June to Oct.
Cooper (1808).	New Jersey.	About July 15.
Smith (1897).	" "	Last of June to Sept. 1.
Worth (1823).	Pennsylvania.	15 July through Aug. and Sept.
Bateman (1876).	Ohio.	Not before 15 June.
Smith (1897).	Long Island N. Y.	20 June to Sept.
Harris (1841).	Masssachusetts.	June to Oct., mostly July.
Fitch (1855).	New York (Albany).	14 July to 15 Aug.
Lintner (1888).	" "	Earliest moth on 27 June.
Glover (1855).	" (Hudson R.).	About June or July.
Kellicott (1881).	" (Buffalo).	As late as late in Sept.
Lowe (1897).	" (Geneva).	Not before July 1, usually.
Cook (1875).	Michigan.	July, Aug., and Sept.
Burrell (1898).	Canada.	19 July to Nov., mostly 15 Aug. to 15 Sept.

It will be seen from the above table that the moths of the peach-tree borer may be found flying in some part of the country from early April (Florida) to November (Canada). Most writers previous to 1880 had recorded that the moths fly from about June 15th to October in most parts of the country. But Comstock's observations of the moths laying eggs as early as May 10th, in 1880, at Washington, D. C., created an impression, which was quite general for many years, that the moths emerged in most localities much earlier than the early writers had led us to suppose. It also led to the recommendation to apply remedial measures much earlier in most parts of the country.

There is need of more definite data from many localities, especially in the South, before one can make a general statement that will apply to all parts of the country. Marlatt (1896) has given the best generalization of this kind, which we would change but little, as follows: The moths begin to appear early in May in the latitude of Washington, D. C., and southward, over what approximates the lower austral region; in the Gulf Strip of this region they are recorded as appearing a month earlier. In the upper austral region roughly comprising the States above the cotton belt and below the northern tier, the moths do not usually appear until after the middle of June; in the southern portions of some of the States in this region they are recorded as appearing in May. In the transition region, which comprises the northern tier of States, together with most of New York and New England, and also including Southern Canada, the moths appear chiefly in July and later, rarely emerging however, as early as June 15th, and belated individuals as late as October, or even November in Canada. June and July are therefore the worst months for the moths over the principal peach districts south of the fortieth degree of latitude, while north of this the moths are the most numerous during July and August, and in Canada from August 15th to September 15th.

Our breeding experiments indicate that the two sexes of the moths are produced in about equal numbers, but we have no conclusive evidence that the males emerge "a few days earlier than the females" as some record. Smith (1898) states that "the adult life is short, perhaps no more than a day or two." We have had them live for three or four days in cages before we killed them, but there seems to be no definite data as to how long they live, probably it is not more than a week.

Oviposition, and description of the egg.—The moths may copulate very soon after they emerge from the pupa; copulation may last for half an hour or more, and we have seen a mated pair fly from tree to tree meanwhile. Our experience, like that of others, indicates that the sexes will not mate when confined in cages. Egg-laying may begin in three or four hours after the females emerge. Smith (1897) states that if the eggs are not fertilized by the male within twenty-four hours, the females lay them unfertilized to get rid of them; these eggs do not hatch, however. The eggs are laid in the day-time, usually, it is said, from 11 A. M. to 1 P. M.

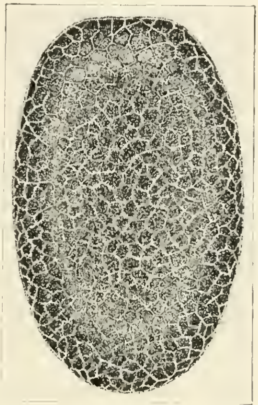
Most of the eggs in the body of the female when she emerges are full size, and have a hard, brown shell, hence it is not a difficult matter to dissect them out and count them. This has been done by some, and the results show how many eggs may be laid by a female of the peach-tree borer. In 1820 "W. T.," of Washington, D. C., counted 678 eggs in one female; this is the largest number thus far recorded. In 1897, Smith dissected from a female, only two hours old, 500 eggs with a hard, brown shell, and fully 100 more white or less mature ones; and in another female he counted 625 eggs, "all but very few of them brown and of full size." In a small female we found the 244 eggs shown natural size at *m* in figure 50. Thus one female is capable of laying from 200 to over 600 eggs. As Smith (1898) states: "Evidently there in an enormous discrepancy between the reproductive power of the female and the actual number of larvæ or borers produced," else our peach orchards would suffer much more severely from borers than they do. No plausible cause for this apparent discrepancy has yet been suggested. Smith found that many eggs had been broken into after they were laid, but could not discover the agent. Possibly many unfertile eggs are laid, or the females may often die before laying their full quota.

50.—*Eggs of peach-tree borer, natural size at* n; *one egg, enlarged at* l; *micropyle end of egg, greatly enlarged at* m.

Worth published a very brief description of the egg of the peach-tree borer in 1823, but it was first characterized in detail by Comstock in 1880. An egg is shown enlarged at *l* in figure 50 (from a photograph), and in figure 51 is shown an egg greatly enlarged (from a drawing). The eggs average .02 of an inch in length and are a little more than half as wide; many are shown natural size at *m* in figure 50. They are of a light chestnut or mars brown color and are subellipsoidal in form, slightly flattened with an oval-shaped depression, as shown in figure 51 and at *l* in figure 50. One end of the egg is either squarely or somewhat obliquely truncate, with a slight depression in the middle where the micropyle is located, as shown in figure 50 at *m*, which gives a much enlarged view of this end of the egg.

The whole surface of the egg is so sculptured as to have the appearance of being laid with irregularly shaped paving stones, the stones being separated by slight ridges; this peculiar sculpturing of the shell is well shown at *l* in figure 50, or in figure 51, and still better at *m* in figure 50.

Several persons have seen the female moth depositing her eggs. Comstock (1880) saw one female "deposit upwards of twenty eggs upon different parts of the trunk of one tree, usually about one or two feet from the surface of the ground, in the space of about one hour. The eggs were deposited singly, and were stuck to the surface of the bark on their sides by a gummy secretion." Smith (1898) records that Walker, at Jamaica, Long Island, saw a female begin laying eggs immediately after mating. She "moved about actively over every portion of the trunk, and even on the lower branches, touching her abdomen constantly to the surface. She was engaged in that way two hours and more. On examination, he found the eggs laid in all sorts of places, without special selection, singly or in groups, the greatest number found together being ten, while in several places three or four were observed together." Smith then states that in his own examinations he found that "as a rule the eggs were laid singly, and most of them within six inches of the soil. None were found at the immediate surface, although this point was particularly examined. They were found more scattered higher up the trunk, and, as a rule, few above from twelve to eighteen inches. Groups of three or four were occasionally observed, and in one instance I found nine within a space of half a square inch. A few eggs were scattered up to a height five feet, and on one tree I found some on the main branches. It may be justly said, however, that above eighteen inches from the surface the eggs were "scattering." They were laid apparently without selection of locality; some on the perfectly smooth bark, some among the lichens covering the trees in parts and some among the bark scales. No one locality seemed to be especially selected, and it seemed rather a haphazard seeding down, the moth depending rather upon the number of eggs laid than any method of protection. As to the number on a single tree, I cut out twenty that were most convenient, observed at least as many more without close examination, and feel safe in asserting that more than fifty were then present within eighteen inches of the surface."



51.—*Egg of peach-tree borer greatly enlarged.*

Smith further states that "the length of time during which the insect remains in the egg state is not yet accurately determined. Mr. Walker has found larvæ just hatched beneath the empty egg-shells about ten days after observing the moths ovipositing, and believes that to be near the actual period. Dr. L. O. Howard informs me that their records indicate seven to eight days."

How long it takes a female to lay her quota of eggs, if she does lay all of them, is not known. Probably most of the eggs are laid in July and August in New York.

Habits of the newly-hatched borer.—Comstock (1880) states that "the young larvæ when first hatched are very active and have many long, stiff bristles on their bodies. Instead of boring through the bark they seek a crack, and an almost incredibly small one will suffice." This last statement, as we shall see later, has a very important bearing on the question of preventive applications for this pest. Smith (1898) records on this point that "Mr. Walker states from his observations, and my own agree in this point, that the young larvæ may enter the bark at almost any point on the trunk, and that they will try to work in very close to the egg, if possible. I found several cases during the summer of burrows almost immediately below the egg, well up on the trunk. But in such cases the larva does not remain long and soon migrates toward the base. Mr. Walker says that he has actually seen such a migration and found the young larva crawling down the trunk. It is possible that in this way many are killed in the very early stages by unfavorable surroundings before they get to the base of the tree."

Habits of the borers in the fall.—The young borers continue to feed on the inner bark from the time of hatching in summer or early fall until they go into hibernation for the winter. We have no data on the time when the borers cease feeding in the autumn and prepare for hibernating. Perhaps the freezing of the soil is the signal for them to begin their winter's nap.

Number of broods yearly.—As we began the story of the peach-borer's life with it in hibernation, we have now finished its yearly life-cycle. One early observer (Thomas, 1824) thought there were two broods of the insect in a year, but it is the unanimous experience of all others that it always takes the insect a year to go through its life-cycle, even in the extreme south.

Its life-story briefly told.—In New York the moths (figures 43 and 44) begin to appear in the latter part of June and continue to emerge until September. A few hours after emerging the females lay their small, oval, brown eggs (figures 50 and 51) on the bark of the trunks of the trees from six to eighteen inches from the ground. From these eggs there hatches, in a week or ten days, a minute larva—the young borer—which at once works its way into a crevice of the bark, and soon begins feeding on the inner layers of the bark. It continues to feed in this manner, gradually enlarging its burrow under the bark, until winter sets in, when it stops feeding and hibernates during the winter, either in its burrow or in a thin hibernaculum made over itself on the bark near the surface of the soil. The winter is always spent as a larva or borer, a few of them being nearly full-grown, but most of them being considerably less than one-half grown. In the spring, usually about May 1st in New York, they break their winter's fast and grow rapidly for a month or more, most of them getting their full growth in June. They then leave their burrows and spin about themselves a brown cocoon (figure 48 and *c* in figure in 47) at the base of the tree, usually at the surface of the soil. A few days after its cocoon is made, the borer changes to a pupa (figure 49) in which stage it remains for about three weeks, usually in June in New York. From the pupa the moth emerges, thus completing its life-cycle in a year, fully ten months of which are usually spent as a borer in the tree, the remainder or a little more than a month being spent in the egg, pupa and adult stages. About the middle of July all stages of the insect may be found in some orchards. The above brief sketch of the life of the peach-tree borer will apply in general to most localities in the United States north of Washington, D. C. In Canada the moths do not begin to fly until about a month later, while in the South they appear a month or more earlier, so that the dates in the above sketch will not apply to these regions.

ITS NATURAL ENEMIES.

As the peach-tree borer spends most of its life under the bark beneath the surface of the soil, it is not readily accessible to enemies. But it does not entirely escape, for several insects have discovered a way to include this serious peach pest in every course served to their growing progeny. At least eight different enemies of the peach-tree borer have been found, and all of them are parasitic Hymenoptera. In 1872, the Ichneumon, *Phaeogenes ater* Cresson, and a Braconid, *Bracon* n.sp., were reared from the peach-tree borer in Missouri (Insect Life, II, p. 349 and III, 152). In 1880 Comstock recorded that "four species of parasites have been bred from the peach-tree borer the past season—two chalcids and two small Ichneumonids, the one belonging to the genus *Microgaster* and the other to the genus *Bracon*." Dr. L. O. Howard writes us that the Braconid mentioned is undoubtedly *Bracon nigropictus* Riley, but that the *Microgaster* cannot be found.

In 1889, Popenoe recorded (The Industrialist, June 8, 1889, XIV, 153) that "specimens of the pupæ and larvæ of the peach-tree borer collected in the College orchard, were enclosed in a breeding-jar which now, a few days after the collection, is alive with specimens of the two sexes of a honey-yellow Braconid fly, measuring in the female about one inch, in the male about one-half as large. From the abundance of this parasite in the jar where the dozen larvæ and pupæ were confined, it may be inferred to be a common insect in this locality."

We have reared two other kinds of these little parasitic enemies. On June 11th, 1896, we found in its cocoon a dead peach-tree borer. A minute insect was seen to dart away from the cocoon, and we found many long, narrow, white eggs laid near one end of the dead borer.

By June 16th, there had hatched from these eggs small, white, maggot-like creatures which had evidently been feeding *on* the dead body of the borer for a day or two. Three days later the maggots or grubs had entirely devoured the dead borer and had spun cocoons around themselves both on the inside and on the outside of the borers' cocoon. On June 29th and July 4th, the adult parasites issued from these little cocoons. Dr. L. O. Howard kindly determined them as *Bracon mellitor* Say. We bred these little Braconids from two different specimens of the peach-tree borer, both of which were dead when found. Is it possible that the Braconid fly kills its victim before laying its eggs near the body, or does it attack only those borers which have died from other causes? It is apparently not an internal parasite of the peach-tree borer as we saw its grubs feed only externally upon the dead bodies of the borers. In July, 1898, we also bred the same Braconid from the cocoon of a peach-tree borer which we found packed full of the cocoons of this little enemy.

About August 1st, 1899, we examined some plum trees at Geneva, N. Y., and found four cocoons of the peach-tree borer. From two of these there emerged a male and a female moth of the borer, but from the other two cocoons we reared two large parasitic flies. One of these emerged August 17th and was determined by Mr. Ashmead, through the kindness of Dr. L. O. Howard, as *Ephialtes irritator* Fab. This Ichneumon fly has not been before recorded as a parasite of the peach-tree borer. From the remaining cocoon, there emerged on August 21st, the same Ichneumon parasite—*Phaeogenes ater*—which was found at work on the pest in Missouri in 1872, as noted above.

The following insects are thus known to be enemies of the peach-tree borer: *Phæogenes ater*, *Ephialtes irritator*, *Bracon* n. sp., *Bracon nigropictus*, *Bracon mellitor*, *Microgaster* sp., and two Chalcids; whether the Kansas Braconid is a species distinct from any of the above, we do not know. The grubs of the first species devours, or is parasitic upon the pupa, while all the others apparently feed upon the larvæ of the peach-tree borer.

The fact that, from two of the four cocoons collected from plum trees at Geneva, N. Y., parasites emerged, would indicate that in some localities the enemies of the peach-tree borer may play quite an important part in checking the normal increase of the pest.*

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*Sometimes minute white larvæ are found in the gummy mass exuded from peach-trees infested by borers. These white "worms" are not enemies of the borer, and they develop into a Fungous-gnat (Mycetophila persicæ). See Am. Ent. I., 223 (1869); Glover's Rept. of U. S. Ent. for 1872, p. 114; Lintner's 2nd Rept., p. 6 (1885). The worms probably feed upon the gum or some decaying matter in it.

HOW TO FIGHT THE INSECT, Including a Discussion of Previous Recommendations and a Detailed Account of our Extensive Experiments Against it.

For nearly a century and a half American peach-growers have been fighting the peach-tree borer and the proverbial Yankee ingenuity has been freely exercised to devise methods to circumvent the pest. The result has been that more than a hundred different remedial measures have been recommended. We doubt if any other American insect pest has had its life threatened with so many different kinds of machinations. And yet peach-tree borers are now, after being besieged for more than a century by such an army of man's devices, apparently as numerous and destructive in most peach orchards as in the days of our forefathers.

We shall not attempt to discuss all of the methods which have been recommended, for, although we have made a critical and extended search through our American insect literature, doubtless some suggestions have escaped our notice ; and again such a discussion would require too much space, and much of it would be of no practical value to peach-growers. Many methods will only be mentioned in connection with some similar methods used in our extensive experiments.

Some early recommendations and experiments.—In 1771 a paper was submitted to the American Philosophical Society "On the Nature of the Worms so Prejudicial to the Peach Trees for Some Years Past and a Method for preventing the damage in Future" (see the Bibliography, Cooper, 1771). We have found no methods recommended for combating this pest earlier than this, and not having access to this article, we are not sure of the nature of the method then proposed. But apparently the same author stated in 1806 that he had successfully used for many years a combination of the "digging out" and "mounding" methods, and that he had tested the "freezing" method in 1779, injuring his trees and not the worms ; hence it is probable that the "digging-out" and "mounding" methods were among the first to be used against the insect.

About the year 1800, John Ellis received a prize of $30.00 offered by the American Philosophical Society for an essay on the best methods of preserving peach-trees. Ellis' method consisted in putting a band of straw, three feet long and an inch thick around the tree from the roots upward when the tree was in blossom, then removing the band in autumn.

In February, 1806, Mr. Peters read a paper before the Philadelphia Society for the Promotion of Agriculture in which he gave some remarkable experiences in combating the insect. The remedial measures employed against the peach-tree borer in the early part of this century are so well brought out in Mr. Peters' article that we quote from it as follows :

"I have failed in many things, in which others are said to have succeeded. *Straw* and *bass*, or *paper*, surrounding the trees, from the root, at all distances, from 6 inches, to 3 or 4 feet—*whitewashing, painting, urinous applications, brine, soot, lime, frames filled with sand, oil, tar, turpentine, sulphuric acid* or *oil of vitriol, nitrous mixtures, and almost every kind of coating*. Teguments of straw or bass make the bark tender ; the more dense coating stopped the perspiration. The oil invited mice and other vermin, who ate the bark thus prepared for their repast and thus killed the tree. I planted in *hedge rows* and *near woods*, I *paved, raised hillocks* of *stone*—I have suffered them to *grow from the pit only, grafted* on *various stocks* and *budded, hilled up the earth in the spring* and exposed the butt in the fall—I have *scrubbed the stocks or trunks with hard brushes, soap suds and sand*, scraped them with proper instruments : I have, for a season or two under various experiments, amused myself with the persuasion, that I had discovered an infallible *panacea*. I had temporary success, but final disappointment.

I remove the earth a few inches around the tree in August or September. I pour around the butt of the tree, beginning about one foot above the ground, a quart or more (not being nice about the quantity) of boiling hot soap suds or water. This kills the egg or worm lodged in the tender bark ; and of course prevents its ravages the next season. I frequently plunge nursery stock into boiling water, before planting. I lose very few, and do not attribute the losses to the hot water. I have the trees bared at the roots, exposed to the winter. I have lost some in this way, but still continue the practice."

It will be seen from the above that a hundred years ago quite an arsenal of insecticidal devices had been brought to bear upon the peach-tree borer. And the methods most frequently recommended to-day are the same or but slight modifications of these methods which our great grandfathers devised and used. Furthermore, although it is anticipating a little, it is a curious and interesting fact that the results recorded by Mr. Peters in 1806 are not strikingly unlike those we have recently obtained in our extensive experiments against the pest.

Cultural methods. – It is doubtful if any of the cultural methods practiced by peach-growers exerts a great influence in keeping their trees free from borers.

In our extensive experiments, budded stocks and trees grown from pits were used. Naturally there was no noticeable difference in the number of borers attacking each, for the borers usually worked below the inserted bud on the stock grown from the pit. However, in the case of plum-trees, it is stated by "G. E. M." (1896) that in his experience, Japan plum-trees on Myrobolan or Marianna stocks were as badly infested as peach, but when budded on Chickasaw or other native varieties they were entirely exempt. Has anyone had a similar experience with plums? Apparently the insect does not discriminate between the different varieties of peaches, attacking all with equal relish.

In New Mexico and neighboring States, *irrigation* is an important factor in the growing of fruit, but Townsend (1892) reports that the "peach-tree borer does not seem to be affected by irrigation, even though the water be allowed to stand for a considerable time and be given thorough access to the roots."

Those peach-growers who thoroughly cultivate and feed their orchards, scarcely allowing a weed to grow in them during the summer, still have to exercise eternal vigilance to keep the numbers of borers below the danger limit. We feel quite sure that it would not lessen the numbers of borers to allow such cultivated orchards to grow up to weeds or grass, but we have found no conclusive data on this point. Both cultivated and uncultivated peach orchards may suffer severely from the peach-tree borer, but the one who cultivates has several advantages; his orchard is always an advertisement to his thrift; it usually pays the best; and it is much easier to fight the borers in a cultivated orchard.

Some general details regarding our experiments.—Realizing the lack of definite experimental information regarding the so-called "remedies" for borers, Professor Comstock planned in 1892 the most extensive and detailed experiments against the peach-tree borer * ever attempted. In the fall of 1892 an orchard of nearly 400 peach-trees of five different, leading varieties was set near the insectary. As the sole purpose of the orchard was

* The plans also included experiments against the apple-tree borer (*Saperda candida*) and the experimental orchard was started, but owing largely to lack of the borers, and also to the fact that the peach-tree borer experiment took so much of our time, we have not yet tested any remedial measures for the apple-tree borer.

52.—*View in the experimental orchard in May, 1897, looking east down the rows. Note the different applications on the bases of the trees.*

53.—*View in the experimental orchard in May, 1897, looking south.*

for experiments against the borers, and as the space was limited, the trees were set in seven long rows six feet apart and only three feet from each other in the row. The location proved to be well adapted to our purpose. The trees grew well and several badly infested, "old relics" of peach-trees adjoining the experimental orchard insured a good crop of borers in the orchard each year. This last condition was a very important factor in the success and relative value of our experiments. The trees were budded stocks from the nursery, and about one third died during the winter of 1892–1893, while about one half of the remaining buds failed to start in the spring. The dead trees were replaced by more budded stock in the spring of 1894, thus the experimental orchard consisted of 275 budded stocks (about half of which had just been set) of five of the leading varieties, and about 125 trees of natural varieties grown from the pits, when our experiments with remedial measures were begun in the summer of 1894. The experiments were carried on during 1894, 1895, 1896 and 1898, no applications being made in 1897. The make-up of the orchard remained practically the same during these years, except that a few young trees were set in each year to replace those which were killed by certain applications, and in 1897 the trees being so large, every other one in the rows was removed, thus reducing the number of trees one half. Figure 52 is a view of this experimental orchard looking east down the rows in May, 1897; some of the different applications put on the trees in July, 1896, are well illustrated here. Figure 53 is a view of the same orchard looking south across it in May, 1897.

The literature of the insect was critically searched and the different methods which have been recommended for combating it were carefully considered. As many of the methods were simply slight variations of others, only representative ones were selected to be thoroughly tested in our experiments. To these were added a few new ones which occurred to us. We thoroughly tested about twenty-five methods for from one to three years each.

In treating the trees each method would be applied to a row of seven trees across the orchard, as shown in figure 52, where the first row is treated with tarred paper, the third row with some white substance, and so on. Beginning at the west end of the orchard we would usually treat each of the first four rows of seven trees each by a different method, and then leave the next two, or the 5th and 6th, rows untreated for a check experiment. The next four rows, or the 7th, 8th, 9th, and 10th rows, would then be treated, usually each by a different method, and the next two, or the 11th and 12th rows, left untreated as checks. This method was continued on through the orchard, duplicating each method at some other portion of the orchard in order to give each as fair and complete a trial as possible. All applications were made about the same time, usually during the latter part of June, and everything was kept cultivated during the growing season. The following spring every tree, treated or untreated, would be carefully examined, and a note made of the numbers and sizes of the borers found in each tree. All this involved a great deal of time and labor each year, but nothing was spared to give each method a thorough and scientific test. Most of the work has been done by the writer, and every detail of it under his direct observation and supervision. We had no favorites among the methods tested; we tried to make each do all it was recommended to do; and we confidently excepted to find one or more sure methods for controlling the ravages of the pest. We doubt if so extensive and thorough a series of experiments were ever made against borers of any kind in any country, and surely not against the peach-tree borer, hence our results should furnish much data for future recommendations of methods for fighting borers of all kinds.

Sometimes results are rendered inconclusive or uncertain on account of the non-appearance of the insect in sufficient numbers to enable one to draw definite conclusions, regarding the effectiveness of any method. As the following table indicates, the "old relics" of peach-trees located near our experimental orchard have furnished us a goodly supply of borers to combat:

TABLE SHOWING THE NUMBER OF BORERS FOUND IN THE WHOLE ORCHARD EACH YEAR.

Year.	Number of infested trees.	Number of uninfested trees.	Number of borers found.
1894	123	144	176
1895	165	210	342
1896	171	210	376
1897	106	167	177
1898	83	65	171
1899	72	90	116
SIMILAR RECORD FOR THE UNTREATED OR CHECK TREES ONLY.			
1895	60	68	128
1896	72	57	176
1897	75	50	137
1899	27	29	47

From the above table we learn that, in spite of the fact that two-thirds of the trees were treated during four of the years to protect them from the attacks of the borer, the average for the whole period of six years is almost a borer (.9 is the exact number) to each tree each year ; the average for the check or untreated trees for four years is over one (or 1.1) borer in each tree. Usually over one-half of the check trees were infested each year, and nearly one-half of all the trees, whether treated or not, every year since the orchard was set.

The methods which have been devised for fighting the peach-tree borer may be classed as *destructive methods*, which aim to kill the insect, and *preventive methods*, which do not intend to let the borer get into the tree.

I. DESTRUCTIVE METHODS FOR FIGHTING THE INSECT.

It is against the larva or borer and the pupa stages only of the pest that a destructive warfare can be successfully waged. The eggs have too hard a shell and are scattered about over the bark too much to enable one to effectively reach them with an insecticide that would not injure the tree. One method has been suggested for killing the adults or moths. Neal (1889) recommends that "small fires at sunset in the orchard during April (in Florida) will destroy many of the moths." As the moths are rarely, if ever, attracted to lights and are most active during the early part of the day, we do not believe they can be lured to their death by fires. And it is doubtful if the insect can be successfully fought at all in the adult or moth stage.

The "freezing" method.—This method was much in vogue among peach-growers a century and more ago. It was one of the first methods employed against the insect, and consisted in removing the earth from around the base of the tree down to the roots in the fall and leaving this portion, in which the borers usually work, bared to the frosts of winter. Many found it did not kill the borers, and as trees often died from the winter exposure, the method was discarded early in the present century.

Boiling water or similar applications.—As early as 1823 it was suggested to remove the earth and gum from around the base of infested trees and pour boiling water on and around the base. There is no question but what the water will kill every borer it reaches. Several have had fairly good success with this method (Crossman, 1888; Smith, 1890) and one (Peticolas, 1860) killed his trees as well as the borers. Smith suggested the use of kerosene emulsion instead, and some have used boiling soapsuds. Coquillett (1891) dipped the lower portion and roots of infested nursery trees for two minutes into a solution of one pound of whale oil soap to the gallon of water, the temperature of the solution being maintained at from 120° to 130°F. The trees were examined five days later and all the borers found "as lively and vigorous as ever."

Thus it would seem that very hot (scalding or boiling temperature) liquids may sometimes be successfully used in killing peach-tree borers in the tree, but there is danger of injuring or killing the tree, and the method is not so practicable as others on a large scale.

Bisulphide of carbon.—This is a liquid which evaporates very rapidly and the fumes of which are sure death to animal life. Cook suggested its use against the peach-tree borer in 1880. No one seemed to have tested the liquid, however, until we treated a few trees in 1895. On April 17th, several small trees were selected which were so badly infested that there was a complete ring of the characteristic gum around the base of each. With a sharpened stick four holes were made around one tree, beginning about four inches from the trunk, and extending in a slanting direction toward the roots for a distance of six to eight inches; seven teaspoonfuls of the liquid were poured into these four holes, and then the holes were quickly stopped up. An hour later, we found three half-grown live borers in the tree and several living angleworms in the soil near the tree. The soil all around the tree smelled very strongly of the fumes. Around another similar tree, we introduced six teaspoonfuls in the same manner, and three hours later, found five live borers in the tree. Around a third tree, we injected with the McGowen injector four tablespoonfuls of the bisulphide. The injector was forced into the ground as near the tree as practicable, and straight downward. After twenty-four hours we found two living borers in the tree and live angleworms in the soil. These experiments satisfied us that this was not a practicable or effective method for killing the insect.

About two years ago the liquid was extensively used in the San José region of California for the Pacific coast peach-tree borer. One of our correspondents there wrote that "they could not get the liquid fast enough." Thousands of trees were killed, and the craze apparently soon subsided It must be used with great care around the roots of trees, as has been demonstrated on apple-trees in Missouri (Bull. 35 of the Mo. Exp. Station), and in some Ohio experiments (Bull. 106 of the O. Exp. Station) peach-trees were killed by injecting it around them.

Carbon bisulphide is too expensive and too dangerous to use against the peach-tree borer, and we have no evidence that it is an effective way of fighting the insect.

The "digging out" method.—This method was one of the first to be used by peach-growers, and it is to-day more universally practiced than any other method. Its name well describes the method. After removing a little of the soil from around the base of the tree, the presence and usually the location of a borer is readily determined in a peach-tree by the gummy mass exuded from the wound made by the borer. Sometimes it is a little difficult to locate and reach a borer which is working far down on a root. When once their burrow is located it is usually an easy matter to kill them with the knife or a wire. With a little experience one can often locate and kill the borers with but little injury to the tree from the "digging-out" process. The peach-tree so quickly repairs such wounds that one should not hesitate to use this method for fear of doing more injury with the knife than the borers would do.

Some of the most extensive peach-growers first have a man hoe the soil and gum away from around the base of the trees and leave it thus exposed for a few days. In the meantime, the fresh excrement and gum resulting from the borers' work renders it easier for one to locate them then, than to do so when the soil is first removed.

When is the best time to dig them out? In the peach-growing districts north of Washington, D. C., the ideal time would be in the fall in September or later, or in April the next spring. By September most of the borers have hatched from the eggs but have not done much damage. And usually most of them do not get half their growth before it is time for them to stop eating and go into hibernation; and they usually do not begin feeding in the spring before the latter part of April; thus they get most of their growth and do much more damage in May and June. Therefore, by digging them out in September or April one can catch the rascals before they have done much damage in northern localities. But the borers are then so small that many will be missed, enough to develop into a sufficient number of the moths to often re-stock the orchard with as many borers as were dug out the preceding fall or spring. In April, 1895, we went over our experimental orchard thoroughly and got about 240 borers, and yet in June a second "digging out" revealed nearly 100 more large ones. This has been our experience every year that we have done the work early in the spring, and we should expect similar results from fall work, although we have had no experience in digging them out then. If the "digging out" method is to be practiced but once a year, we would do it in June in New York or northern localities. It is true that the borers have usually done most of their destructive work by June; yet most of them are then so large that one can locate and kill them quicker and will miss but very few of them. This also means a greater reduction of the crop of borers for the next year than if the "digging out" was done only in September or April. We believe if the borers are thoroughly dug out in June in northern peach-growing districts, if one has equally as enterprising neighbors, and if all "old relics" of peach-trees in the neighborhood are destroyed or thoroughly "wormed," that, under these almost millennial conditions, one could reduce the numbers of the pest in an orchard below the danger limit in a few years so that the process would become less and less arduous each year. But if the method were neglected for a year or two, the pest would soon regain its former prestige and destructive powers. We doubt if the insect could ever be exterminated in a locality by the "digging out" or any other method yet devised. To reduce the damage done and the number of borers to the minimum, the digging out should be done twice a year, once in September or later or in April and again in June in northern localities. In the South, apparently the best time to dig them out would be in March or April as it is reported that the moths begin to fly in April and May. Baker (1898) states that in Alabama "it should be done during late fall or winter; *surely* before the middle of April." Perhaps July or August would be the proper time to get at the smaller borers before they had done much damage. There is need of more knowledge of the life-history of the insect in the South before one can make definite recommendations regarding the best time to apply remedial measures there.

As little or no gum is exuded from infested plum or prune trees, the peach-tree borer is not so easily located in these trees, thus often making the "digging-out" process a more laborious one in such orchards.

The "digging-out" method is, when thoroughly done, the surest way of getting at and controlling the peach-tree borer yet devised, and it is practically the only way to get at the pupæ in the cocoon. It involves much time and labor, but most other methods are equally as laborious and expensive. From our experience of six years we believe that one can dig out the borers from young peach-trees in a cultivated orchard with no more expense and labor than it requires to apply most of the other methods recommended; on old trees or on trees in uncultivated orchards we have had no experience, but doubt if such conditions would much affect our belief. To properly apply almost any other method, one must first remove the soil from around the base of the tree down to the roots, then usually clean the dirt from the bark, and then incur the expense of making and applying the material used. While the latter is being done one can usually, with no more expense, locate and kill all the borers in the tree.

It is an interesting and curious fact that most peach-growers first dig out the borers and then follow some other method, but they never attribute any of the success which may follow their efforts to the "digging" process where it usually rightfully belongs. Our experiments have demonstrated to us the wisdom of certain combinations, however, for the trees from which the borers were removed and killed each year usually contain more borers the next year than those trees from which they were first dug out and then certain other methods applied.* Thus the use of certain methods to supplement the "digging out" process is not a waste of energy and is to be recommended. We will discuss such combinations in our general conclusions to follow this detailed account of remedial measures.

II. PREVENTIVE MEASURES.

(*a*) *By the use of other plants.*

The theory that the odor, or some other quality, of certain plants would keep insects away has led some to recommend that such plants be set beside peach-trees to preserve them from attack by borers. We find tomatoes, tansy, red cedar and wormwood thus recommended. How tomatoes could afford any protection, it is difficult to conceive, hence the suggestion of their use seems to have scarcely survived its birth. Practically the same results followed the recommendation, as early as 1841, to plant red cedar or wormwood in the same hole with the peach-tree, although the odor of these plants afforded a slight hold on which to pin one's faith that it might possibly have some preventive effect.

Tansy.— It was recommended to grow this weed around peach-trees, as early as 1841. Although many people were equally as skeptical about its protective properties as they were of red cedar, yet the fact that so eminent an entomologist as Dr. Fitch thought it merited a trial, led several to test it. Peticolas (1860) and "T.V. P." (Count.Gent. for 1862, p. 357) reported that it had no effect on the number of borers.

The following tabular statement tells the story of our experience with tansy :

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* We had to practice the "digging-out" method in connection with all the others tested. We would not have been able to make any comparison between the methods without the knowledge of the actual number of borers in each tree, which could be gained only by digging them out. In this process one ordinarily kills many of the borers accidently, but it might be possible by taking great pains to locate and count the borers without injuring them. But we doubt if our experiments would have given any more conclusive results had we done this, for we never lacked for a goodly supply of borers.

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree.	Effect of application on tree.
16 May, 1894,	7	April, 1895...	2 (29%).	4	3	None
	7	10 June, 1896.	3 (43%).	5	2	"
Untreated trees.						
	128	April, 1895...	60 (47%)	128	8	
	128	June, 1896....	68 (53%)	176	8	

The above results afford some evidence that tansy exercised a slight preventive effect upon the number of borers. We do not believe any other odorous plant would give results more encouraging to the peach-grower, besides it would not be advisable to use them in orchards for several reasons.

(*b*) *By materials piled or scattered around the base of the tree.*

In 1806, Peters "*paved*," made *piles of stones*, and used *soot* around the base of peach-trees without result against the borers. This verdict seems to have been accepted, and with good reason, for the preventive qualities of the methods are not apparent.

Salt scattered in a circle around the base, *slacked lime* in a trough in the soil, and *flowers of sulphur* were found of no value and were discarded in the early half of the century. L'Hommedieu (1846) tried a mixture of *salt* and *salt petre* for three years without success, but reports good results from use of *air-slacked lime;* this has not been the usual experience, however, with lime. A safe quantity of *kainit* around the base of the tree offers no encouraging features so far as effecting the numbers of borers is concerned (*Rural New-Yorker* for 1896, p. 533). *Tanbark* and *screenings of anthracite coal* have been recommended, but they are not always available, and would afford no more protection than so much soil. *Ashes* piled around the tree have been often recommended since 1823, but all who have reported their results offer no encouraging evidence.

Tobacco.—In 1813, Cocke recorded successful results for several years from binding cured tobacco around the tree at the surface of the soil. Dey (1839) gives corroborative results, and tobacco has since been frequently recommended. This evidence induced us to test it. We wound "tobacco stems," obtained cheaply at a cigar factory, thickly and close around the base of the tree from the roots to a little above the surface of the soil. Our results are graphically represented in the following table :

1894–1895.

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree.	Effect of application on tree.
4 June, 1894.	20	29 April, 1895. 1 May, 1895. 24 May, 1895.	8 (40%)	15	3	None
1895–1896.						
25 June, 1895.	13	10 June, 1896. 17 June, 1896.	2 (15%)	5	2	None
1896–1897.						
13 July, 1896.	27	22–23, 28–29 June, 1897...	3 (11%)	5	2	None
Years.	Untreated trees.					
1894–1895....	128	Same date....	60 (47%)	128	8	
1895–1896....	128	" "	68 (53%)	176	8	
1896–1897....	128	" "	75 (58%)	137	6	

The tobacco was applied about a month too early in 1894, which may explain much of the difference in the results for that year from the two following years. Note that the percentage of untreated trees which were infested during the last two years is from four to five times larger than the percentage of infested treated trees. This indicates that tobacco kept out from two-thirds to five-sixth of the borers during 1895 and 1896, which is decidedly a good showing for the method. In fact, but very few other applications gave us as good results. Tobacco stems can usually be obtained very cheaply from cigar manufacturers, and when thus available, the evidence indicates that they can be depended upon to greatly aid the peach-grower in his fight against this insect.

We are not sure just how the tobacco stems act on the insect. It is doubtful if they act as a mechanical barrier, and we are also loath to believe that their odor is offensive to the insect. Perhaps the liquid leached out of the stems by rains may kill the young borers.

The mounding method.—This consists in simply hilling up the soil around the base of the tree. It was one of the first methods devised and has been extensively practiced by peach-growers for a hundred years. Perhaps no other method has been so extensively discussed in the literature. In 1869, Walsh, Rily, Dean, and Wells submitted much evidence both for and against the mounding method. So much was said in its favor that most writers have strongly recommended it, but it seems to have been little used in recent years by our most extensive peach-growers. Usually the soil is mounded to a height of from 6 to 10 inches, but some have made mounds 3 feet high around their trees.

We tested the method for three years, making mounds from 6 to 8 inches high around the trees by simply hoeing up the surrounding soil. We never hoed the mounds away in the fall. The following table succinctly states our results :

1894–1895.

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree	Effect of application on tree.
13 June, 1894.	21	April, 1895 ... 1 May, 1895.. 24 May, 1895.	9 (43%)	13	4	None
		1895–1896.				
17 June, 1895.	21	10 June, 1896. 11 June, 1896. 17 June, 1896.	8 (38%)	10	2	None
		1896–1897				
13 June, 1896.	27	23, 25, 29, June, 1897....	7 (26%)	9	2	None
Years.		Untreated trees.				
1894–1895....	128	Same dates...	60 (47%)	128	8	
1895–1896....	128	" " ...	68 (53%)	176	8	
1896–1897....	128	" " ..	75 (58%)	137	6	

The table shows that the number of treated trees which were infested was considerably less than the infested ones among the untreated trees. A comparison of the number of borers found in the treated and untreated or check trees brings out the significant fact that the mounds kept out from $\frac{1}{2}$ to $\frac{7}{10}$ of the borers. Had we made the mounds a few inches higher or hoed them away late in the fall, the results might have beeu still more favorable to the method. It must be remembered that we mounded the trees in connection with the "digging out" process, and that there were untreated trees nearby. If one should mound all of the trees in an orchard and dig out none of the borers, it is doubtful if the mounds would keep out quite ½of the borers. From the evidence, we are forced to conclude that mounds of earth around the base of peach-trees exercise a decided influence in keeping out borers, but we are not sure just how it is done. Mounding is probably the simplest and least expensive method yet devised for fighting the peach-tree borer, and, when practiced in connection with the "digging out" process, we believe it will give good results, but not as good as some other combinations. The mounding should be done between June 15th and July 1st in northern peach-growing districts, and the mounds should remain at least until October or November.

(c) *By wrapping with paper or similar substances.*

It has been often recommended to bind *straw* around the base of peach-trees to prevent their being attacked by borers. Ellis practiced this a hundred years ago, and in 1800 he communicated his results, certified to by thirteen of his neighbors, to the American Philosophical Society and gained a premium of $30 offered by the society for the best method of preserving peach-trees. Peters (1808) soon recorded unsuccessful results with straw, and it seems to have been used only spasmodically since. In 1880, Comstock reported that the same method was being advised as a "new remedy" for the peach-tree borer in many agricultural journals. It could act only as a mechanical barrier to the borers, and one would naturally expect that its numerous crevices would allow the minute, newly-hatched borer to readily work its way through to the bark. For this reason and the fact that there was little evidence of the effectiveness of the *straw bandage* we did not test it. Theoretically, we would not expect it to keep out many borers, but, as we shall see later, our theories are not to be depended upon in fighting the peach-tree borer.

About 1825, it was recommended to use bandages of *cotton cloth*, *canton matting*, *tow string* ; some one suggested *smearing* the *cotton cloth* with *tar* but it is doubtful if this would sufficiently increase its effectiveness to warrant the expense. In 1826, Harris recommended a *sheathing paper bandage*, and the more expensive cloth bandages have since received little attention ; paper had been used without success as early as 1806 by Peters. Various kinds of paper bandages have been suggested, such as *old newspapers*, *heavy Manilla or roofing paper*, and *tarred paper;* Bateman used the latter quite successfully in 1871.

Tarred paper. — We tested the ordinary tarred siding paper for three years with the following results :

1894–1895.

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers found in one tree.	Effect of application on tree.
18 May, 1894	21	April, 1895... 23 May, 1895..	8 (40%)	10	2	None
1895–1896.						
8 June, 1895	21	5 June, 1896. 11 June, 1896. 12 June, 1896.	3 (14%)	3	1	None
1896–1897.						
11 July, 1896. 13 July, 1896.	33	22, 23, 25, 28 June, 1897...	10 (30%)	12	3	None
Years.	Untreated or Check Trees.					
1894–1895....	128	Same dates...	60 (47%)	128	8	
1895–1896....	128	" " ...	68 (53%)	176	8	
1895–1897....	128	" " ...	75 (58%)	137	6	

From this tabular statement we learn that while from 14 to 40 per cent of the treated trees were infested, yet the paper evidently kept out from ½ to ⅞ of the borers, as compared with the untreated trees. This is a very good showing for the tarred paper bandage.

We used pieces of paper large enough so that they usually went around the tree twice and extended from the roots to about a foot above the surface of the soil. Several of the treated trees are to be seen in the first row of trees in figure 52 ; and in figure 54 is shown a nearer view of one of the trees. As the figure shows, the paper was carefully and closely applied to the tree, especially at the top, and going around the tree twice made two thicknesses of the paper, thus apparently eliminating all chances for the little borers to get in. And yet some of the borers got in in spite of the tarred paper bandage.

We believe the tarred paper acted only as a mechanical barrier, and that its odor did not add to its effectiveness. Hence we should expect ordinary newspaper or any other paper bandage to be equally as effective a preventive if carefully applied. The tarred paper did not injure our young trees in the least, although it was applied to the same trees for three years in succession and remained on the trees nearly the whole time. But others (Smith, 1898) have injured trees with it. Old newspapers or any wrapping papers are much cheaper, a little easier to apply and probably just as effective, but they will not remain intact nearly so long in northern peach districts on account of rains and winds. Smith (1898) records some fairly successful experiments with newspaper bandages; and Cordley tells us that in Oregon where the rains do not interfere with it so much as in the East, it is one of the most successful methods in use against the Pacific coast peach-tree borer. Large or moderate sized trees were treated in New Jersey with newspapers for less than one cent per tree.

54. — *Peach-tree treated with tarred paper in the experimental orchard.*

The evidence thus indicates that paper bandages, when carefully applied, are one of the cheapest, and they are also quite an effective method of keeping out peach-tree borers. Apply the paper closely around the base of the tree from the roots to about a foot above the soil from June 15th to July 1st in New York, and it should remain intact until November. Do not use too large or strong a cord for tying on the paper as it is liable to interfere with the growth of the tree; never use wire for this purpose on young, growing trees.

(d) *By the use of wire-cages or similar mechanical devices.*

In 1806, Peters recorded that *frames filled with sand* were not effective against the borers, but in 1808 (Matlack) and 1825 (Haines) sand in mounds or cylinders or boxes around the trees was reported a success. In 1898, Smith boxed some trees "with half-inch stuff three inches wide and covering the trunk to the branches"; half of the boxes were closed at the top and the rest left open. Apparently the boxes were not filled with sand or anything else. He states that "the results on the boxed trees are only what we had a right to expect. So far from a shelter being an objection to the moth, it is rather an invitation, and a tile or box-protected tree, with an opening at the top, would rather tempt than repel. If the top be closed by a band tied tightly to the tree, the effect would propably be good, but this is by all odds the most expensive possible means of keeping out the borers and should be excluded from practical consideration altogether." Stedman (1898) says that "*thin wooden wrappers* are satisfactory and, as they can be purchased for about three dollars per thousand from box and basket makers, they are economical. "They should be pushed down into the ground so the adults cannot crawl under to deposit their eggs, and the tops should be stopped up with cotton wool in order to prevent them from entering there." Some one has conceived the scheme to protect the trees by tiles. Smith expected to test these *tile protectors* in 1897, but they were so heavy and clumsy that his experimenter refused to use them, but he tested the principle on which they were supposed to act with the wooden boxes, as mentioned above.

The evidence would hardly encourage a peach-grower to go to the expense of making any of the above applications, when there are others which are much cheaper and much more effectual.

Wire-cage.—In 1891, Lintner announced that a model for a "new tree-protector" had been shown him, "which promises to give complete protection for young trees from the attacks of the peach-tree borer. A cylinder of wire netting, fifteen inches high, mounted on a galvanized metal base, gathered in at the top so as to adjust itself closely to the tree, opens at one side for passing it around the trunk, and is then secured and fastened to the ground, and slightly into it, by a sliding pin. With this protection, the moth would be effectually prevented from depositing an egg upon or near the base of the tree. The cylinders could be quickly applied, and with proper care in housing them, they would last for many years. It is thought that they can be offered for sale at about twelve dollars the hundred." Dr. Lintner wrote us in 1894 that he had no record of the name of the person who showed him this wire device. Although it was at once pointed out by Snyder (1891) that this device was too expensive for extensive use, the idea seemed so good theoretically that most of those who have recently discussed this insect have given such a device a prominent place in their recommendations. But apparently no records of actual tests of the device appeared until 1898 (Smith). Smith wrapped pieces of ordinary wire mosquito netting, 12 by 18 inches in size, around the trees, letting it run about two inches below ground, and keeping it about half an inch away from the trunk by a band of newspaper at the top which filled the space between the wire and the tree; he found it to cost about five cents each for sixty young trees. His results were far from conclusive but seemed encouraging.

We thoroughly tested these wire-cages in 1894 and 1895. The netting was cut into pieces 14 by 16 inches in size, and the first year we unraveled or pulled out the cross threads on the upper end for a distance of about three inches, so that we could bring the strands together closely around the tree. The next year, we slit down the upper end for about three inches, making the slits about half an inch apart; we found this the quicker method, and it also served our purpose better. We dug out all the borers, placed the wire netting around the tree so that it extended from below ground where the roots were given off to about a foot above the surface. An inch or more of space was left between the cylinder and the tree, and at the top the slitted wire was carefully brought together around against the tree and tied. Great care was taken, especially the second year, to make and to keep this cage so tight at the top that by no possibility could one of the moths have gotten inside of it during the season. In figure 55 is shown one of our wire cages in position. Here we have a theoretically perfect protector from the attacks of this pest. We could apply such a cage at a cost of about five cents per tree, but each protector would doubtless last for two or three years, hence the final expense was really not greater than that of many other methods which must be renewed annually. We felt confident that this wire cage or protector would surely solve the question of perfect protection against the peach-tree borer.

55. — *Wire-cage protector in position on a peach-tree in the experimental orchard. Theoretically a perfect protector, but practically a useless device.*

The following results show what little regard the borers had for our theory:

1894–1895.

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree.	Effect of application on tree.
26 June, 1894	21	29 April, 1895. 23 May, 1895.	12 (47%)	21	3	None
			1895–1896.			
17 June, 1895	21	5 June, 1896. 11 June, 1896. 12 June, 1896.	14 (67%)	44	13	None
Years.			Untreated or Check Trees.			
1894–1895....	128	Same dates...	60 (47%)	128	8	
1895–1896....	128	" " ...	68 (53%)	176	8	

As the table shows, it was simply a case of misplaced confidence. More of the caged trees were infested by borers than there were of the untreated ones. And what is still more remarkable is the fact that the first year there were nearly as many borers in the caged trees as in those untreated, and the second year, when we took very great pains with the cages, nearly twice as many borers got into the caged trees as into the same number of untreated trees! The most borers we ever found (thirteen) in a single tree in our experimental orchard were found in one of these carefully caged or protected (?) trees! It is almost needless to say that we did not consider it necessary to test this theoretically perfect wire protector another year.

The cages apparently attracted rather than repelled the insect. We are not quite sure how the borers got in, but probably the moths laid their eggs on the trunk above the cage, and when the borers hatched they could easily have crawled through the meshes of the wire; perhaps when once inside the cage, it then afforded the borers a sure protection from their enemies so that every borer which got inside survived to do its destructive work.

We must conclude from our experiment that wire mosquito-netting protectors offer no protection against the attacks of the peach-tree borer, and the indications are that they are worse than no treatment, and also offer an attraction or protection to the insects rather than repel them.

(e) *By the use of washes.*

At least 50 different kinds of so-called "washes" have been suggested for preventing the attacks of the peach-tree borer. We have made careful and thorough tests of 18 different washes, and these include most of the representative mixtures. We will not attempt a classification of the washes but will discuss those we have treated, and will briefly mention under each of these, the others which seem to us to have similar protective properties.

In applying the different washes, we first dug out the borers, removed all soil from around the base of the tree down to and usually including an inch or more of the main roots, brushed clean the portion of the tree to be treated, then put on the wash so thoroughly as to completely cover all irregularities in the bark from the roots to about 12 to 18 inches above the ground; after allowing the wash to dry somewhat the soil would be returned around the base of the tree.

In 1806, Peters reported no success with washes of *sulphuric acid*, *turpentine*, *brine*, *urinous applications*, and *nitrous mixtures* and they have been scarcely mentioned since.

Asafetida and aloes wash.—This was used against the apple-tree borer by Wielandy in 1870 (American Entomologist, II, 147), and it seemed to us to afford a good test of the effect of odors and bitterness on the peach-tree borer. We used ¼ pound of each of the substances in 2 quarts of water, heating it to dissolve them. The wash was visible on the trees for a month and a half but retained its odor for a much shorter time. The following table gives our results from the use of this wash:

1894–1895.

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest Number of borers in one tree.	Effect of application on tree.
5 June, 1894.	21	30 Apr. 1895. 24 May, 1895.	9 (43%)	21	4	None
1895–1896.						
12 June, 1895. 16 July, 1895.	14	6 June, 1896. 14 " " .	8 (57%)	8	2	None
Years.	Untreated or Check Trees.					
1894–1895....	128	Same dates...	60(47%)	128	8	
1895–1896....	128	" " ...	68(53%)	176	8	

The first year the application was too early and it had no effect on the numbers of the borers. The second year the wash was applied twice, and the results were considerably better, although a larger percentage of trees were infested. The results offer no encouragement to use such a wash.

Tallow.—Finding that axle grease had been recommended for the apple-tree borer, it occured to us that tallow, melted and applied as a wash, might prove effective against the peach-tree borer. As the tallow formed a complete and very greasy coating, and remained so for several months, we expected good results from it. The following table shows the results we got :

1894–1895.

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers found in one tree.	Effect of application on tree.
4 June, 1894	21	30 April, 1895. 24 May, 1895.	8 (38%)	17	4	None
1895–1896.						
25 June, 1895	21	6 June, 1896. 11 June, 1896. 15 June, 1896.	11 (52%)	40	11	None
Years.	Untreated or Check Trees.					
1894–1895....	128	Same dates...	60 (47%)	128	8	
1895–1896....	128	" " ...	68 (53%)	176	8	

The tallow did not materially lesson the number of infested trees, and the second year it was tested, the treated trees contained more borers than those untreated. We cannot explain why such a greasy coating should not be more effective.

Soap washes.—A strong soap suds or a soap wash has been a standard recommendation for borers of all kinds for a century. As soft soap was not easily obtained, we tested a solution of *hard soap* for two years, using it at the rate of ½ pound in 1 gallon of water the first year, and twice as strong the next year. Our results are as follows:

1894–1895.

When applied.	Number of trees tested.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree.	Effect of application on tree.
1 June, 1894. 19 July, 1894.	14	April, 1895....	9 (64%)	42	9	None
1895–1896.						
12 June, 1895 16 uly, 1895	14	5 June, 1896. 11 June, 1896.	9 (64%)	21	7	None
Years.	Untreated or Check Trees.					
1894–1895.... 1895–1896....	128 128	Same dates... " " ...	60 (47%) 68 (53%)	128 176	8 8	

The table shows that, although the soap was applied twice each year, many more (over twice as many the first year) borers attacked the treated than the same number of untreated trees, and a larger percentage of the treated trees were infested. We doubt if soft soap would have given better results. We tested *whale oil soap* (½ pound in 1 gallon of water) for two years with the following results:

1894–1895.

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree.	Effect of application on tree.
13 June, 1894	9	25 May, 1895.	2 (22%)	6	3	None
1895–1896.						
26 June, 1895 16 July, 1895	9	17 June, 1896.	4 (44%)	9	4	None

Thus whale oil soap gave but little more encouraging results than hard soap. One application of soap will be washed off too soon in most eastern peach districts, and two applications are too expensive in labor. We must conclude that ordinary soap washes are valueless.

"*Glubo*," a soap refuse, was recommended by Morgan in 1893. In 1888, Ashmead recommended that *Paris green be added to the soap wash*, and since then many have added this poison to other washes. Such poisoned washes had been recommended for apple-tree borers nearly 15 years before. It is very doubtful if Paris green or similar poisons add anything to the value of washes, and such poisons may injure the trees, as pointed out by McCarthy in 1891, and as will be seen in our results from the use of such washes. Our experience with carbolic acid in other washes leads us to believe that the *carbolic acid soaps* sometimes recommended have little value as a preventive of the attacks of the peach-tree borer.

We doubt if the *Shaker wash* (Lintner, 1891) consisting of *fish oil*, *soft soap*, *whale oil soap*, and *pulverized sulphur* would effectually prevent many borers from getting into the trees.

Whitewash.—Lime is one of the principal ingredients of a great many washes. We first tested it for one year as ordinary whitewash, and although we made two applications, on May 31st and July 19th, no encouraging results were obtained. The whitewash scaled off quickly under the influence of rains and other ordinary climatic conditions.

Whitewash and Linseed oil.—This combination was suggested to us by a correspondent in 1895. To every gallon of thick whitewash we added one quart of linseed oil. The oil greatly increased the lasting qualities of the whitewash, and the mixture formed a good coating on the trees for two months. Linseed oil is reported as a dangerous ingredient in washes (Howard, Bull. 2, U. S. Div. of Ent., p. 34) but no injury resulted to our young trees from its use with whitewash. The following table gives our results from one year's test of this wash :

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree.	Effect of application on tree.
24 June, 1895.	14	6 June, 1896. 15 June, 1896. 17 June, 1896.	7 (50%)	13	5	None
Years.	Untreated or Check Trees.					
1895–1896....	128	Same dates...	68 (53%)	176	8	

The results afford no encouragement to the peach-grower.

It is doubtful if the *whitewash and glue* wash recommended by Marlatt (1896), or the *Bordeaux mixture* inconclusively tested by Baker (1898) would afford any more protection from the peach-tree borer than did our similar *whitewash* and *linseed oil* wash.

Hale's and similar washes.—Since 1888 Mr. J. H. Hale, one of America's most famous and most successful peach-growers, has strongly recommended a wash of potash or soap, lime, and carbolic acid, and sometimes Paris green; the real "meat" of the whole thing, he states "being the carbolic acid which makes such an offensive odor that the moth is driven to more congenial quarters to lay her eggs." This wash has doubtless been more extensively used during the past ten years than any other application. Some substituted *clay* for the lime, while Stedman (1898) advises adding common washing soda and a poison.

We dissolved ½ pound of hard soap in 1 pint of water and then added ¼ pint of crude carbolic acid ; to this enough freshly slacked lime was added to form a thick wash. We tested this wash thoroughly for two years with the following results.

1894–1895.

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest Number of borers in one tree.	Effect of application on tree.
1 June, 1894. 28 " "	35	April, 1895 . 24 May, 1895..	17 (48%)	26	5	None
		1895–1896.				
12 June, 1895. 16 July, 1895.	21	5 June, 1896 11 " " .. 17 " " ..	6 (29%)	11	4	None
Years.	Untreated or Check Trees.					
1894–1895 ... 1895–1896....	128 128	Same dates.. " " ..	60 (47%) 68 (53%)	128 176	8 8	

Apparently Hale's wash kept out from ⅓ to ½ of the borers, but it required two applications each year. In New York the wash began to scale off in two weeks, and thus lost its mechanical protective qualities ; and we do not believe the offensive carbolic acid has any repellant effect on the moths, and certainly the soap or whitewash is not protective, as our experiments, detailed above, show.

None of the washes we have used which contained lime as a principal ingredient, except the whitewash and linseed oil wash, remained intact on the bark as long as it is necessary to afford protection from the borers. The climatic conditions in New York soon cause the lime to scale off, and thus whatever mechanical protective quality (it has no other) it might have is rendered useless.

It is a significant fact that all those who report good results from the use of Hale's wash also practice "digging out" the borers, and then give all the credit to the wash. We do not believe that Hale's wash, and the other similar washes mentioned above, will afford nearly as much protection against the peach-tree borer, under northern climatic conditions, as will some ohter applications which it is necessary to make but once a year.

Lime, salt and sulphur wash.—A two years' test of this famous California insecticide gave us the following results :

1894–1895.

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree.	Effect of application on tree.
5 June, 1894.	14	1 May, 1895. 24 May, 1895.	5 (36%)	24	10	None
1895–1896.						
25 June, 1895. 16 July, 1895.	7	11 June, 1896.	5 (71%)	9	4	None
Years.	Untreated or Check Trees.					
1894–1895....	128	Same dates...	60 (47%)	128	8	
1895–1896....	128	" " ...	68 (53%)	176	8	

Even two applications of this wash had no effect upon the numbers of the borers, hence it is valueless.

Resin wash.—This is another insecticide which has been extensively used on the Pacific coast, and good results have been reported from Oregon when it was used as a wash for the native peach-tree borer. We used this resin wash, made according to the California formula, for two years. Although we used it of double strength and made two applications the second year, the results obtained, as given in the following table, show that such a wash has little to recommend it to peach-growers who are fighting the borers:

1894–1895.

When applied.	Number of trees treated	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree.	Effect of application on tree.
13 June, 1894.	10	24 May, 1895.	3 (30%)	5	3	None
1895–1896.						
26 June, 1895. 16 July, 1895.	7	15 June, 1896.	4 (57%)	6	2	None
Years.	Untreated or Check Trees.					
1894–1895....	128	Same dates...	60 (47%)	128	8	
1895–1896....	128	" " ...	68 (53%)	176	8	

A wash made of *resin*, *linseed oil*, and *beeswax* has been recommended. It would be rather expensive to use on a large scale, and it is very doubtful if it would be more effectual than the resin wash just discussed.

Paris green and glue wash.—This wash was apparently first suggested by Neal in 1889 (Bull. 4, Fla. Expt. Station), and a few years ago was strongly recommended in prominent entomological and horticultural books. We dissolved one pound of common glue in one-half gallon water, then added one ounce of Paris green, and diluted the whole to two gallons with water (Neal's formula). We used it at the above strength and later only half as strong. Within a week after this wash was applied the leaves on nearly every tree began to drop off and in three weeks most of the trees were dead. The wash had killed the bark where it was applied, and had thus practically girdled the tree at the base. Others have reported similar results from its use, so that it should never be used, at least on young trees.

Probably the addition of *whitewash*, as suggested by Smith (Insect Life, IV, 43), would render the wash less injurious to the trees, but we do not believe it would make an effective wash of it.

White or green paint.—Ordinary white paint, made of linseed oil and white lead, was strongly recommended about five years ago by the Virginia and Nebraska Experiment Stations as an effective application for borers.

We used white paint for two years with the following results :

1895–1896.

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree.	Effect of application on tree.
19 June, 1895.	14	16 June, 1896.	2 (14%)	3	2	None
1896–1897.						
14 July, 1896.	20	22–28 June, 1897.......	11 (55%)	12	3	Slight injury
Years.	Untreated or Check Trees.					
1895–1896....	128	Same dates...	68 (53%)	176	8	
1896–1897....	128	" "	75 (58%)	137	6	

The first year the paint was very effectual, keeping out nearly ⅚ of the borers, and doing little or no injury to the trees. The second year it did not keep out ½ of the borers, a large percentage of the treated trees were infested, and the trees were noticeably injured; possibly the application was made a little late in 1896. Our conclusion is that white paint makes a lasting wash and it will doubtless keep out ½ or more of the borers, but it may injure young trees; a young orchard is said to have been completely ruined in Alabama by its use (Baker, 1898). It would probably not injure old trees, but we doubt if it would usually be applied thoroughly enough on such trees to penetrate all the cracks and crevices which it must do to be a preventive. We doubt its effectiveness when applied on old trees, and would not recommend it for general use on young trees.

We made a light green paint by stirring ½ pound of Paris green into 1 gallon of white paint, made as described above. We thus had a poisoned wash. Our results from a two years' experience with this green paint is shown in the following table:

1895–1896.

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree.	Effect of application on tree.
19 June, 1895	14	11 June, 1896.	5 (36%)	7	2	Much injury
1896–1897.						
13 July, 1896	28	22, 23, 28 June, 1897	2 (7%)	2	1	Much injury

Apparently the paint was a very effectual preventive, but the fact that many of the trees were seriously injured and some of them died from its use, renders the results as to the number of infested trees and the number of borers found of no value. This experiment in connection with our Paris green and glue combinations is strong evidence that Paris green is a dangerous ingredient in washes, and we do not believe it increases their effectiveness.

Hydraulic cement wash.—In 1824, Shotwell recorded that he found a *lime mortar* or *bricklayer's mortar* to work perfectly as a wash to keep out peach-tree borers. In 1891, Woodward recommended a wash made of dirty soap, sweet skim milk and hydraulic cement (common water-lime) as "a sure and safe remedy for borers." Two years later McCarthy recommended a wash of sour or buttermilk and hydraulic cement, stating that "the weak-jawed grub is unable to break it, and hence soon dies of exhaustion;" but further stipulating that it must be applied every two or three weeks, as the growth of the tree causes it to crack. In 1898, Smith recorded some experiments with a wash of skim milk and the cement. He demonstrated that the milk made such a wash last much longer than if water were used, and that as a mechanical coating it left nothing to be desired. One application would last and remain in good condition as long as necessary, but it would not "prevent the exit of borers that were already working in the tree, but would keep out any young larvæ that attempted to get in." Smith's results from the use of this cement wash, so far as keeping out the borers is concerned, were inconclusive.

We made a wash of sweet skim milk (from a separator) and Portland cement, using about 6 pounds of cement in 3 or 4 quarts of water; this was sufficient to treat 48 young trees from 1½ to 4 inches in diameter. It is a very cheap wash, is easily applied, does not injure the trees, and lasts as long as desirable. Thus, theoretically it is an ideal, mechanical, preventive coating or wash.

We gave this wash a thorough test in 1898–1899 with the following results:

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree.	Effect of application on tree.
7 July, 1898.	47	26 May, 1899. 30 June, 1899.	26 (55%)	36	4	None
Years.	Untreated or Check Trees.					
1898-1899.	56	Same dates.	25 (44%)	41	3	

This table shatters another theoretical ideal, for there were more infested trees among the treated than among the untreated ones, and just as many borers got into the treated trees. We had expected much more encouraging results from the use of this cement wash, but it evidently has not the qualities which will make it of any value to the peach-grower.

Printer's Ink.—This seemed to us to have qualities which might make it a good wash for the peach-tree borer, hence we tested it with the following results :

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree.	Effect of application on tree.
7 July, 1898.	27	26 May, 1899. 30 June, 1899.	8 (30%)	9	2	Slight injury
Years.	Untreated or Check Trees.					
1898-1899.	56	Same dates.	25 (44%)	41	3	

Although the ink kept out about one-half of the borers, it caused gummy exudations where it was applied, indicating injury to the bark, hence it is not to be recommended.

Raupenleim.—This "Caterpillar glue" is a German product, resembling somewhat axle-grease mixed with tar. It has been extensively used in Europe, and in fighting the Gypsy Moth in Massachusetts. It is sticky and has a distinct tarry odor, and is applied to the bark of trees to prevent the ascent of caterpillars and other insects. When applied in a thick band, it retains its sticky properties for a considerable period. Apparently it had the necessary qualities to make it a good preventive wash to keep out peach-tree borers, hence we tried it for two years with the following results :

1895–1896.

When applied.	No. of trees treated.	When examined.	No. of trees infested.	No. of borers found.	Effect of application on tree.
18 June, 1895	21	11 June, 1896...	0	0	Killed 7 recently-set trees
1896–1897.					
10 July, 1896	42	22, 23, 25, 28, June, 1897....	0	0	Killed every tree

It is to be noted that the first year the raupenleim apparently injured only seven trees which had been set only two or three months and had not yet become thoroughly established. As a preventive against the peach-tree borer it was a perfect success on the 14 uninjured trees. Our hopes rose high, and we treated twice as many trees the second year, but we were doomed to bitter disappointment for, as the table shows, not a tree survived the treatment. In figure 56 is shown the effects of raupenleim and dendrolene. Perhaps old trees will stand the raupenleim better, but we believe it is not a safe, although apparently a sure, preventive wash.

We applied the raupenleim on the bark from the roots to about six or eight inches above the surface of the soil ; ½ pound sufficed to treat 21 trees (1½ to 2 inches in diameter), making a band of the substance from ⅛ to ¼ of an inch thick.

Dendrolene.—This is a crude petroleum product and an American imitation of the German raupenleim. The substance was first made for Professor Smith in New Jersey in 1895, and some preliminary experiments which he made with it that year, led him to strongly recommend it as a general application for borers and other insects. Soon a dendrolene was placed upon the market and it has been tested in several States, but practically all reports show that it either seriously injured or killed all fruit-trees on which it was applied. We treated 50 trees in the same manner as with the raupenleim, and the following table shows that our results agree with most other records :

56.—*The two rows of peach-trees in the centre of the picture show the results of applications of raupenleim and dendrolene to trees in the experimental orchard. Each substance was used on one row of trees,*

1896–1897.

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Effect of application on trees.
10 July, 1896.	50	22–30 June, 1897	0	0	Killed every tree

We must conclude that neither raupenleim nor its imitation, dendrolene (the kind now on the market) is a safe application for young peach-trees. In figure 56 is shown the effect of the application of these substances on our trees.

Pine Tar.— We used some "pure North Carolina pine tar" as a wash with the following results:

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree.	Effect of application on tree.
7 July, 1898.	34	26 May, 1899. 30 June, 1899.	13 (38%)	19	3	None
Years.	Untreated or Check Trees.					
1898–1899....	56	Same dates.	25 (44) %	41	3	

Apparently the pine tar kept out a few borers, but not enough to warrant its being recommended as a preventive of the peach-tree borer.

Gas Tar.—Tar was among the first washes to be used against the peach-tree borer, and several (Merriam and Meehan, 1859; "J. R. G." in Count. Gent., XXX, 14; and "R. H. S." in Rural New Yorker for 1893, p. 622) have recorded that it was a first-class preventive wash, and it did not injure their trees. Some, however, have found that the tar injured or killed young trees.

We used it as a wash for three years, heating it slightly so that it could be more easily painted on, and *applying it to the same trees each year*, with these results:

1894–1895.

When applied.	Number of trees treated.	When examined.	Number of trees infested.	Number of borers found.	Largest number of borers in one tree.	Effect of application on tree.
31 May, 1894.	21	April, 1895.... 1 May, 1895... 24 May, 1895.	2 (10%)	3	2	None
1895–1896.						
18 June, 1895.	21	6 June, 1896. 11 June, 1896. 15 June, 1896.	5 (24%)	6	2	None
1896–1897.						
14 July, 1896.	21	22 June, 1897. 23 June, 1897. 28 June, 1897.	0	0	0	None
Years.	Untreated or Check Trees.					
1894–1895....	128	Same dates...	60 (47%)	128	8	
1895–1896....	128	" " ...	68 (53%)	176	8	
1896–1897....	128	" " ...	75 (58%)	137	6	

The tar apparently kept out from four-fifths to all of the borers, only a small percentage of the trees became infested, and no injury resulted to the trees. These are the best results we obtained from the application of any wash which did not injure the trees. Our trees had been growing for a year, and hence were well established when the tar was applied; we suspect some of those who injured their trees applied the tar to unthrifty or recently-set trees. In our experience the tar did not interfere with the growth of the trees in the least. Tar is about as cheap as any wash, but it is disagreeable stuff to manipulate. The results of our experiments would lead us to believe that gas tar is the most effective application yet devised for preventing the attacks of the peach-tree borer, and as our trees suffered no injury from its use for three years on the same trees, we think it may often be used with safety. Let the young trees get thoroughly established and get to growing thriftily, and keep them in this condition, and try the gas tar wash sparingly at first on a few trees.

Some miscellaneous washes.—In 1824, a wash of *cow-dung*, *leached ashes*, and *plaster of Paris* was recommended, but we doubt if this would remain on the tree long enough and prove more effectual than Hale's or similar washes. The same must be said of *cow-dung* and *clay* which was recommended in 1827. In 1892, Brown recommended a wash made of *lime*, *gas tar* and *soap*; we have shown that soap and lime are not preventives, and we believe they would neutralize the preventive qualities of the tar in this combination. A wash of *soft soap*, *corrosive sublimate*, and *wood alcohol* was recommended in 1893; it would be an expensive wash and of very doubtful efficiency.

We are well aware that many other combinations have been recommended as washes for the peach-tree borer, but we think that they will be found to differ very little from some of those we have tested or discussed.

Some General Conclusions Regarding Methods of Fighting the Peach-Tree Borer.

Although American peach-growers have been fighting the peach-tree borer for a hundred and fifty years, the results from to-day's methods of warfare are not strikingly different from those recorded by Peters in 1806. Most of the applications now recommended were devised nearly a century ago.

Cultural methods.—Different cultural methods (p. 188) such as budding on various stocks, irrigation, and cultivation seem to have little or no effect upon the number of the borers. But to make a success of peach-growing it is usually necessary to thoroughly cultivate and feed the trees, and we believe the borers can be controlled more successfully and much easier in such an orchard.

Our experiments.—During the past five years we have conducted the most extensive and scientific series of experiments ever attempted. An experimental orchard of 400 peach-trees was set for the sole purpose of testing the so-called "remedies." The details of the plan and extent of these experiments are discussed on p. 188. We thoroughly tested about 25 representative methods for combating the peach-tree borer.

Vulnerable stage of the insect.—The insect is open to successful attack only in its larva or borer stage and in its pupa stage; the pupæ are reached only by searching for the cocoons and destroying them.

DESTRUCTIVE MEASURES.

Of the destructive or killing methods recommended, the "*freezing*" *method* (p. 192) and the use of *carbon bisulphide* (p. 192) are unsuccessful and unsafe. *Boiling water* and similar methods (p. 192) have been successfully employed, but they are impracticable on a large scale and may injure or kill the trees.

The "digging out" method.—The "digging out" method (p. 193) is the only thoroughly successful and safe way of killing the peach-tree borer. This method is expensive in time and labor, but our experience leads us to believe that any other equally as successful method will cost just as much. To make it a success, the "digging out" should be thoroughly done, not only on every tree in the orchard, but also on all "old relics" of peach-trees in the immediate neighborhood. A half-dozen such "old relics" left untreated near by served to thoroughly re-stock our orchard with borers every year, so that our "digging out" method, although practiced thoroughly each year, never reduced the numbers of the borers below the danger limit (p. 191). This is a very important factor in the success of the "digging out" method. Under certain millennial conditions, mentioned on p. 194, we believe the numbers of borers could be reduced to the minimum in an orchard by this method alone. Practically every peach-grower, who makes any pretensions of fighting the borers, digs them out at least once a year. Many then apply some wash or other device, but curiously enough, they usually attribute any success they may seem to have, not to the "digging out" process, where most of the credit usually belongs, but to the other preventive applications. As our experiments show, however, the application of certain preventive measures after the borers have been dug out, is not a waste of energy where several "old relics" are left untreated near by, or if a neighbor's peach orchard a few rods away is neglected. As these conditions usually prevail in the neighborhood of most peach orchards, we doubt if the "digging out" or any other method used alone, with a few possible exceptions, can be depended upon to reduce the number of borers to the minimum. But we believe there are several combinations of this destructive method with a preventive application which will give better results than either one alone in most orchards, and will keep the pest under control. The best time to dig out the borers is discussed in detail on p. 193.

PREVENTIVE MEASURES.

Plants.—There is little evidence to show that the odor of any plant, like red cedar or tansy, will have any influence on the numbers of the borers when such a plant is set with the tree (p. 195); such plants would not be desirable adjuncts to peach-growing for other reasons.

Tobacco.—It has been recommended to pile or scatter various substances around the base of the tree to keep out the borers (p. 196) but only two of these deserve serious consideration.

Nearly a century ago good results were reported from the use of tobacco wound around the base of peach-trees. We tested tobacco stems (midribs of the leaves) from a cigar factory, and the results, given on page 197, astonished us. Evidently the tobacco kept out from two-thirds to five-sixths of the borers. We are not sure how the stems acted on the insect, but our results indicate that, where tobacco stems are cheaply obtainable, they will prove a good preventive from the attacks of the peach-tree borer.

Mounding.—By this old and much-discussed method we apparently keep out from one-half to seven-tenths of the borers (p. 197). We do not understand just how the mounds of soil keep out the borers, and we doubt if it would give as good results if not practiced in connection with the "digging out" method. The mounding method evidently has considerable value as a preventive and is perhaps the cheapest method yet devised. It is perhaps the only method that is practicable in nurseries.

Paper protectors.—In the early days, *cloth* and similar protectors were used, but all were soon superceded by the less expensive and equally as effective *paper bandages* (p. 199). We kept out from one-half to seven-eighths of the borers with the tarred paper protector shown in figure 54. And doubtless where rains and winds are not too prevalent to interfere with an ordinary *newspaper protector*, it would give equally as good results as the tarred paper ; some report injury to the trees by the use of tarred paper, but our trees suffered no injury from its use. Paper protectors, when carefully put on and kept intact during the danger period, will prove a valuable and very cheap preventive measure, especially when combined with the "digging out" method.

Wire-cages.—Wooden boxes or tiles placed around the trees are too expensive and the evidence (p. 201) shows that they afford little protection. The device shown in figure 55, however, is strongly recommended by most recent writers, and, theoretically, it is an ideal protection from the ravages of this pest. We confidently believed that we had solved the problem of how to keep out the borer when we placed these wire mosquito-netting cages around some of our trees. But it was a case of misplaced confidence, for our theory was completely demolished when we examined the caged trees the next year. The cages apparently proved an attraction to the insect, for nearly twice as many borers got into the caged trees as into those untreated. Read the detailed account of this demolition of our pet theory or preventive device on p. 202.

Washes.—The favorite method of preventing the ravages of the peach-tree borer has been, for at least a century, by the use of a *wash* of some kind. More than 50 different washes have been concocted, most of which are valueless as preventives, and some of which will injure or kill the trees. We tested 18 washes.

An asafœtida and aloes wash (p.204) was not offensive enough.

Tallow (p. 205) should have given good results theoretically, but it proved wholly useless ; this was a great surprise to us.

Ordinary soap and whale oil soap (p.206), even two applications, offered little or no protection. The addition of *Paris green* to a soap wash will not increase its effectiveness, and it may injure the trees. *Carbolic acid soaps* or the *Shaker wash* (p. 207) would afford no more protection than ordinary soaps, we think.

Whitewash or whitewash and linseed oil washes (p. 207) were wholly ineffectual in our experiments. We doubt if *whitewash* and *glue*, or *Bordeaux mixture* have better preventive qualities.

By making two applications the same season of *Hale's celebrated wash* (p. 208) we succeeded in keeping out from one-third to one-half of the borers. This wash will not remain intact long enough in New York State, hence it is of little value unless applied twice, which makes it too expensive a process. We cannot see how *Stedman's* (p. 208) or other variations of Hale's wash could afford any greater protection from the borers.

Two applications the same season of a *lime, salt* and *sulphur wash* (p. 209) and a *resin wash* (p. 209) gave little encouraging results to peach-growers.

A Parisgreen and glue wash (p. 210) killed our trees in a few weeks.

White paint (p. 210) proves to be quite an effective wash, keeping out from one-half to five-sixths of the borers, but it may injure young trees, and we doubt its proving as effectual on old trees.

White paint and Paris green or green paint (p. 211) is quite an effectual wash but it seriously injured our young trees, and is therefore not to be generally recommended.

The Hydraulic cement wash (p. 212) which has recently attracted considerable attention, makes an ideal coating over the bark, but we did not succeed in keeping out any borers with it, thus shattering another theoretical ideal.

Printer's ink (p. 212), although it apparently kept out nearly one-half of the borers, it injured our trees, and thus cannot be recommended.

Raupenleim (p. 213) *dendrolene* (p. 214), kept out all of the borers, but killed all the trees. See figure 56.

Pine tar (p. 216) kept but a few borers out of our trees.

Gas tar (p. 216) proved to be the best application we tested. We used it freely on the same trees for three successive years without the slightest injury to the trees and it kept out nearly all the borers. We had been led to believe that tar was very injurious to young trees, and confidently expected to see our trees die each year after being treated with it. But the trees kept just as healthy and grew as thriftily as any others in the orchard. Let the trees become thoroughly established and get a year's growth, and it is our experience that tar can be used with safety on them. Go slow with it, by first testing it on a few trees in your orchard. We believe it will prove equally effective whether the borers are dug out or not, and from no other application yet devised would we expect to get such results when used independent of the "digging out" method.

A few miscellaneous washes of very doubtful value are discussed on p. 217.

Some general conclusions regarding washes.—*Lime* and some kind of *soap* are often the principal ingredients of washes. Our experience leads us to believe that neither of these substances exercise any preventive effect on the peach-tree borer. Furthermore, climatic conditions in New York and doubtless in most northern peach districts, will cause any wash containing much lime to scale off and thus render it ineffective, before the moths have stopped laying eggs. Thus *soap* and *lime* or *clay* are useless ingredients and lime may seriously interfere with the effectiveness of a wash in moist climates.

We do not believe a poison like *Paris green* adds anything to the effectiveness of a wash, and it may prove a dangerous ingredient, as with glue or white paint. The theory upon which the poison is supposed to work is a wrong one. The newly-hatched borer does not deliberately eat its way through the wash and thus get some of the poison, according to the theory, but it seeks a minute crack or crevice and works its way in below the surface bark, on which the wash is applied, before it begins to eat. We believe this last fact, regarding the entrance of the newly-hatched borer into the tree, will explain much of the ineffectiveness of washes. It is very difficult to so thoroughly cover the bark of even a young peach-tree that many minute cracks will not be left or soon be made through the wash by climatic conditions or by the growth of the tree.

Crude carbolic acid is another favorite ingredient in washes. Hale says it is the "meat" of his wash, on the theory that its odor is offensive to the moths. In our experience in combating the peach-tree borer or any other insect, we have seen little or no evidence that substances having offensive odors had any repellant effect in keeping the insect away from the food-plant of its progeny. *Asafoetida* did not in our experiments, and we do not believe that any of the effectiveness of *tarred paper* protectors was due to their odor, for others get just as good results from newspapers; they form a mechanical and not an odorous barrier to the insect. Hence, we do not believe that *carbolic acid* is a useful ingredient of washes.

Most, perhaps all, of the washes act simply as a preventive, mechanical coating over the bark to keep the newly-hatched borers out. Such substances as *raupenleim*, *dendrolene*, and *gas tar* seem to be ideal washes but the two first usually kill young trees, and the last also has a similar reputation in some localities, although we saw no evidence to indicate that tar was injurious to well-established young peach-trees. Perhaps some one can so modify these ideal washes as to retain their effectiveness as a preventive and yet eliminate their plant-injuring qualities. Future compounders of washes should work along this line.

We think that most of the above generalizations regarding washes may also apply to washes designed to prevent the work of the apple-tree borer.

When to apply washes or other preventive measures.—In New York the applications should be made between June 15th and July 1st, and they should remain in perfect working order until October 1st. In Canada, July 15th will usually be soon enough to make applications, and they should last until November. In the South, the applications should be made in April and they will apparently have to last for three or more months. Read the detailed discussions of the different methods for instructions how they are to be applied.

Final conclusions.—In our four years of warfare against the peach-tree borer we have been thoroughly convinced that it is a very difficult insect enemy to control. No method of fighting it has yet been devised by which the peach-grower can hope to get a single year's respite; the trees must be treated anew each year and thus the warfare is a perpetual one.

The following substances injured or killed our trees and are therefore classed as *dangerous*:

Paris green and glue,
Raupenleim,
Dendrolene,
White paint,
White paint and Paris green,
Printer's Ink.

The following is a list of the things we found to be practically *ineffectual* or *useless :*

Wire-cages,
Carbon bisulphide,
Asafoetida and aloes,
Lime, salt and sulphur,
Resin wash,
Hard soap,
Tallow,
Tansy,
Whale-oil soap,
Whitewash,
Lime and linseed oil,
Hydraulic cement wash,
Pine tar,
Hale's wash (1 application).

The following methods proved to be *quite effective*, that is most of them kept out over ½ of the borers.

Hale's wash (2 applications) kept out ⅓ to ½,
Mounding kept out ½ to $\frac{7}{10}$,
Tarred paper kept out ½ to ⅞,
Tobacco stems kept out ⅔ to $\frac{5}{6}$.

We would expect equally as good results from the "*digging out*" *method* applied under the conditions stated on pages 194 and 219.

Gas tar (p. 216) gave us the best results of anything we tried

We doubt if the applications listed as *quite effective* would prove as effective if used alone, hence we would recommend that they be combined with the "digging out" method, for the reasons mentioned on pages 195 and 219. Make whichever combination best suits your conditions.

If you find, after a preliminary test on a few trees that you can use gas tar without injuring your trees, we believe it will prove to be the most effective and cheapest method of fighting the peach-tree borer ; but use it carefully and intelligently, as trees have been injured by its use.

We began this investigation confident that some sure preventive of the entrance of the borers into the trees would be found. There was nothing lacking on our part to have the substances we tested do all that they were recommended or expected to do. We did not accomplish our ideal, but we have demonstrated that nine-tenths of the methods recommended are useless. Our experiments furnish much definite data for future workers, and form a definite basis on which to make suggestions regarding methods of fighting the apple-tree borer and other borers. Our experiments must lead to a much more rational and intelligent warfare against the peach-tree borer. Peach-growers will now *know what not to do*, which is often equally as valuable and important as to know *what to do*. Finally, our experiments have enabled us to point out with confidence certain methods by which the peach-grower may hope to control his worst insect enemy—the peach-tree borer.

BIBLIOGRAPHY OF THE MORE IMPORTANT CONTRIBUTIONS TO THE LITERATURE OF THE PEACH-TREE BORER.

1749. Kalm, P. Travels in North America, Trans. by Forster, II., 244. Apparently the first reference to the insect. See note below frontispiece.

1771. Cooper, J. Submitted a paper to Am. Phil.Soc.,"On the Nature of the Worms so Prejudicial to the Peach-Trees for Some Years Past, and a Method for Preventing the Damage in Future." The Society ordered the paper to be printed in the *Pennsylvania Gazette and Journal.* This paper has not been accessible to us.

1801. Ellis, J. Papers on Agr., Mass. Agr. Soc., p. 25, 26; same account in Mass. Agr. Soc. Papers for 1803, and in Trans. Am. Phil. Soc., V., 325. Brief and fairly correct account submitted as Prize Essay ($30 prize) sometime before 1800 to Am. Phil. Society. Recommends binding on straw when trees are in bloom, removing it in the fall.

1802. Barton, B. S. Philosophical Mag., XXII., 208 (pub. in 1805). Footnote as follows: "The insects most pernicious to this tree are two lepidopterous insects, of the genus *zygaena* of Fabricius. These while in the larva state, destroy the bark of the root." Partly quoted by Kirby and Spence in their Introduction to Entomology, I., 198 (1815).

1803. Mease, J. Domestic Encyclopedia, IV., 243–44. Brief account. Recommends mounding, soap-suds, and quotes Ellis.

1804. Barton, B. S. Essay on "A Number of the Pernicious Insects of the United States," submitted to the Am. Phil. Soc. It was partly read on Nov. 16, 1804, and received the Magellanic Premium on Dec. 21, 1804. The essay was returned for alterations in 1805, and we are unable to find that it was ever published. It is recorded (Harris in 1826) that the insect was described and given its first scientific name of *Zygaena persicae* in this apparently unpublished essay.

1805. Barton, B. S. *Phil. Med. and Physical Journal*, I, pt. II., p. 29. Brief notice as being destructive to roots of peach. No description of moth.

1808. Cooper, J. Mem. Phila. Soc. Prom. Agr., I., 11–14. (Paper read Jan 14, 1806). Brief, but very good account of the life-history and methods of controlling the insect. The "freezing-out" process unsuccessful. A combination of the "digging-out" and "mounding methods was very successful.

Peters, R. Mem. Phila. Soc. Prom. Agr., I., 15–19, (Paper read Feb. 11, 1806). Records failure to prevent the work of the borers by the use of 25 or more different "washes" and other methods. Recommends exposing roots in winter and using boiling hot soap-suds or water in August or September.

Matlack, T. Mem. Phila, Soc. Prom. Agr., I., 273–79. Supposed there were two broods of the borers. Detailed account of successful use of sand (not loam) in earthen cylinder or in a pile around base of tree

1813. Cocke, J. H. Mease's Archives of Useful Knowledge, III., 40–42. Same account in *American Farmer* (1820) I., 350. Good brief account of life-history. Failed with straw but was very successful with tobacco leaves.

1820. "W. T." (Wash., D. C.). *The Plough Boy*, I., 331. Brief account of life-history. Counted 678 eggs in one female.

1822. Thacher, J. *American Orchardist*, 198. Brief account quoted from Mease (1803).

1823. Say, T. Jour. Acad. Nat. Sci., III., 216. Original description of moth as *exitiosa*. Pupa and cocoon described.

Worth, J. Jour. Acad. Nat. Sci., III., 217–221. Very good account of the life-history of the insect; egg first described. A sensible discussion of methods then recommended. Recommends a bandage of tow followed by a soft soap or lime-wash. Same account in *American Farmer*, IV., 395; and also in Mem. Bd. of Agr. of New York, III., (1826), p 421.

"Agricola" (N. Car.). *American Farmer*, V., 118. Brief account of life-history, thought moths perforated bark to lay eggs. Quotes Tilton's experience with hot water, and also the recommendations of Peters, Coxe and Cocke.

Harris, T. W. Letters to Say and replies published in *Psyche*, VI, 58, 60, 122, 123–24 (1891) Brief notice; proposed to call it *persicæ*; bred from cherry also.

1824. Shotwell, W. *American Farmer*, VI., 14. Records the successful use of a lime mortar wash.

Thomas, E. *American Farmer*, VI., 37. Erroneous account of the life-history; thought there were two broods. Briefly described the female only as an Hymenopteron, *Apis persica*. Borers numerous on nursery stock. Same account in *New England Farmer*, III., p. 12.

Smith, J. *American Farmer*, VI. 324–25. Very good summary of methods then recommended. Moths bred and submitted to Mitchell and Say. Quotes Worth (1823) entire.

1825. Say, T. American Entomology, II.. pl. 19. Revision of original description of moths. Worth, Shotwell and Thomas freely quoted regarding habits and methods of preventing. Fairly good colored figures of the male and female moth, the cocoon and the pupa skin; these are the first pictures of the insect ever published.

In the LeConte edition of Say's writings, published in 1859, and in the Foote edition of 1891, this article is reprinted on pages 36–42, pl. 19. vol. I.

Haines, R. *American Farmer*, VI., 401. Records success with sand in mounds and in boxes or cases around trees.

1826. Harris, T. W. *New England Farmer*, V., 33 Perhaps the best of the earlier accounts. Many references and quotations from earlier writers. Insect described as *persicae*; and the statement made that this name of Barton has priority over Say's *exitiosa*. Recommendations of Worth, Shotwell and Thomas summarized. Finds there is but one brood of the insect in a year. Thought he found the larvæ in black-knot on plum trees.

1827. Stabler, T. P. *American Farmer*, IX., 29. Experiments showing that a mortar of cow-dung and clay was not always effectual.

1832. Brown, T. Book of Butt., Moths and Sphinges, p. 17, fig. 63. Quotes Worth (1823).

1835. "Senex" (Kinderhook, N. Y.). *The Cultivator*, II., 40. First saw it near Philadelphia in 1800, from whence it spread northward at the rate of 12 to 15 miles a year, reaching Kinderhook in 1807. Thought eggs were laid on leaves on which larvæ fed for a time. Mistook female for a parasitic wasp. Apparently the first account of the insect in New York literature.

1839. Lancaster, S. *The Cultivator*, VI., 133. Notes on development of insect in Tennessee ; no cocoons June 1st and a few found July 18th. Hens of no use. Mounding good and facilitates digging out.

Harris, T. W. Sillman's Jour. of Sci. and Art, XXXVI., 312. Adults described, with brief note referring to previous writings.

1841. *The Cultivator*, VIII., 90 Recommends planting a red cedar tree with thepeach ; the odor of the cedar thought to keep the insect away. P. 95 records that Dr. Anderson, of Virginia, haspracticed this method with success.

Harris, T. W. Rept. on Insects of Mass. Inj. to Veg., 232–34. Good general article, practically a recast of his 1826 article. In the 1842 edition, the 1852 edition (p. 253), and the Flint edition (p. 331) of Harris' Report there is no change from the 1841 article, except that figures of the larva, pupa and adults are added in the 1862, or Flint edition

1844. Gaylord, W. Trans. N. Y. State Agr. Soc. for 1843, p. 161–62. Brief general account compiled from Harris (1841). Rather crude figures of adults, cocoon and pupa skin, evidently adapted from Say's. Suggests salt around tree.

1845. Downing, C. Fruit and Fruit-trees, 460–61. Brief compiled account, not changed in subsequent editions. Recommends air-slacked lime or ashes.

1846. The Cultivator, III., N. ser., 217. Good general compilation, with illustration of work of borer in tree, and of a cocoon.

L'Hommedieu. Trans. Cincinnati Hort. Soc. for 1843–45, p. 17. Used salt and salt-petre without success, but slacked lime gave good results.

1854. Emmons, E. Nat. Hist. of New York, Agriculture, V. 222. Brief account compiled from Harris. Pl. 26, figs. 1–5, male and female, larva, pupa and cocoon. Fair, colored figures.

1855. Fitch, A. First Rept. on Insects of New York, 108–117. One of the best accounts in the literature, by far the best up to that time. Detailed descriptions of all the stages, including several varieties of the adults. Larva and its work poorly figured.

Glover, T. Rept. Com. of Patents for 1854, p. 83-84, pl. 7. Good brief account. Fairly good figures of male and female, larva and pupa in cocoon.

1856. Fitch, A. Third Report on Insects of New York, 356. Brief account, with fair figures of male and female.

1858. *The Northern Farmer* (Utica, N. Y.), V., 116. Record of successful use of tansy.

1859. Merriam, J. P. and Meehan, T. *Gard. Monthly*, I., 168. Record successful use of gas tar.

1860. Peticolas, T. V. *Country Gentleman*, XV., 226. Records negative or disastrous results with many of the methods then recommended. Good general discussion of methods.

Morris, Miss M. H. Horticulturist, XV., 118. Brief, popularly written account with crude original figures of male and female, a pupa and a cocoon.

1862. Harris, T. W. Insects Injurious to Vegetation (Flint edition), p. 331–32. Same as the 1841 account, with figures of the larva (Fig. 161), pupa (Fig. 162), male (pl. V., fig. 6), and pupa skin (pl. V., fig. 7); very good figure of the male.

1866. Walsh, B. D. Practical Entomologist, I., 27–28. Brief, general account, with a good discussion of various methods for combating it. Fair figures of male and female.

1869. Walsh, B. D. and Riley, C. V. American Entomologist, I., 180–81. Very full discussion of the "mounding system." The system is further discussed from experience by WELLS and DEAN on pp. 201 and 222.

Riley, C. V. First Rept. on Insects of Missouri, 47–50. Good general account; mounding system especially treated. Fair figures of male and female.

1870. Fulton, J. A. Peach Culture, 120–125. Brief account of life-history, with rather poor figures of male and female. Good sensible discussion of methods of combating.

1871. Saunders, W. Canadian Entomologist III., 22. Detailed description of the larva, the first and about the only one published. Poor figure of larva

Bateman, M. B. American Agriculturist, XXVIII., 141. Records successful expts. with coal tar, with a detailed account of use of Buchan's carbolic soap.

1872. Fitz, J. The Southern Apple and Peach Culturist, 254–60. Fairly accurate account of life-history. Excellent discussion of mounding, scalding, various washes, and other applications on soil around tree.

1873. Reed, E. B. Rept. Ont. Ent. Soc. for 1872, III., 44–47. Very good general article compiled from Say, Harris, Fitch and Riley. Fair figures of male and female and Saunders' poor figure of larva.

1875. Cook, A. J. Rept. Mich. Bd. of Agr. for 1874, p. 136. Brief, good account of life-history and methods for controlling the insect. Practically the same article in Rept. Mich. Pom. Soc. for 1874, p. 140–41.

1876. Bateman, M. B. *Country Gentleman*, p. 535. Records fairly successful expts. with tarred paper, and good results with a carbolic acid soap.

1877. Thomas, C. First Rept. on Insects of Ill., 38–39. Brief general account, compiled mostly from Fitch.

1878. French, G. H. Seventh Rept. of State Ent., of Ill., 169–70. Brief compiled account.

1879. Milton, M. *Country Gentleman*, XLIV., 119. Records the insect in azaleas.

1880. Comstock, J. H. Rept. of U. S. Ent. for 1879, p. 254–55. Detailed description of the egg, oviposition, and habits of the newly-hatched larva. Straw bandage recommended. Four parasites recorded.

Rutter, J. Culture and diseases of the Peach, p. 74–76. Brief account, with good discussion of methods of combating.

Fuller, A. *American Entomologist*, III., 11. Records insect working in dwarf flowering almond shrubs.

1881. Zimmerman, C. D. *Gard Monthly*, XXIII., 238. Discusses the borer in nursery stock. Mounding the best method in a nursery.

Kellicott, D. S. *Canadian Entomologist*, XIII., 7, Brief, but important note on emergence and habits.

1882. "Anti-borer." *Country Gentleman*, XLVII., 373. Decline in profitable peach culture due to borer and not to climate. Successful with clean culture and "digging-out" process.

Edwards, Hy. *Papilio*, II., 55. Describes Fitch's var. *d* as *fitchii*, in wild cherry from Fla. W. Va.

1883. Cooke, M. Injurious Insects, 126–27. Brief general account. Saunders' figures.

Lintner, J. A. *Psyche*, IV., 106 ; also in Second Report on Insects of New York, 213. Points out a distinguishing characteristic of the male pupa

Saunders, W. Fruit Insects, 191–195. One of the best general accounts of the insect.

1885. Lintner, J. A Second Rept. on Insects of New York, 5–6. Brief discussion of methods of combating ; pp 24–26, discussion of carbolic soap washes

1886. Wilcox. Peach Culture, 43–45. Brief account, with discussion of "mounding system."

1887. Treat, Mary. Injurious Insects, 183–85. Brief account.

1888. Hale, J. H. Trans. Mass. Hort. Soc. for 1888, Part I, p. 66. Hale's wash recommended.

Barry, P. Fruit Garden, p. 488. Good, brief account.

Lintner, J. A. *Country Gentleman*, LIII., 109. Full discussion of time of emergence and egg-laying.

"H. F. H ," Kentucky. *Country Gentleman*, LIII., 149. Time of flight in Kentucky from June 6 to October, mostly from July 15 to Aug. 15. Mounding most practical remedy.

Crossman, S. Ark. Expt. Sta., Bull. 3, pp. 3–5. Brief discussion of habits and "remedies."

Ashmead, W. H. Fla. Exp. Sta., Bull. 2, pp. 17–19. Brief discussion, with descriptions of all stages. Recommends a Paris green-soap wash.

1889. Lintner, J. H. *Country Gentleman*, LIV., 861. Good account of name, appearance (poor figures of male and female), life-history and remedies.

1890. Insect Life, II., p. 378, and III., p. 79. Successful expts. with hot water recorded.

Packard, A. J. Forest Insects, p. 521–22. Records it on wild cherry trees.

Kellicott, D. S. Jour. Columbus Hort. Soc., V., 16, pl. I., figs. 1 and 2. Brief note, with very good figures of male and female. This article is wrongly accredited to Coquillett by Lintner and others.

Smith, J. B. Rept. N. J. Expt. Sta., for 1889, pp. 299–303. Brief account of habits, with good discussion of "remedies." Recommends hot water or kerosene emulsion to kill, and newspaper wrapping to prevent.

1891. Weed, C. M. Insects and Insecticides, pp. 77–79. Good, brief account. Kellicott's figures.

McCarthy, G. N. C. Expt. Sta., Bull. 78, p. 27. Brief account. Dangerous to use Paris green washes.

Weed, H. E., Miss. Expt. Sta., Bull. 14, pp. 17–18. Brief, compiled acount, with Kellicott's figures.

Townsend, C. H. T. New Mex. Expt. Sta., Bull. 3, pp. 13–15. Brief account. Attacks apricots. Irrigation, allowing water to stand for sometime, has no effect.

Coquillett, D. and Riley, C. V. Insect Life, III., 392–93. Records *exitiosa* on Eastern nursery stock in Calif. Compared with the native California peach borer.

Snyder, R. *Country Gentleman* LVI., 677. Very sensible article on washes and similar applications. Good "digging-out" method described.

Woodward, J. S. *Rural New Yorker*, p. 736. Formula for soap, milk, and cement wash. Ashes are dangerous.

Lintner, J. A. *Country Gentleman*, LVI., 457. One of the best discussions of methods of controlling this insect in the literature. Same account occurs in his Eighth Rept. on Insects of N. Y., p. 181–86 (1893). Uses Kellicott's (1890) fine figures, and reproduces Emmons' poor figures.

Little, S. A. *Rural New Yorker*, L., 593. Good, popular, compiled account.

1892. Barnes, W. D., Hale, J. H., Brown, N. and White, J. F. *Rural New Yorker*, LI., 186–87. Symposium on remedies. Hale's wash and others found ineffectual.

Kellogg, V. Common Injurious Insects of Kansas, pp. 91–92. Good, brief account. Records it as appearing as early as April in Kansas, and having been in the State as early as 1873.

1893. McCarthy, G. N. Car. Expt. Sta., Bull. 92, pp. 104–105. Brief account of habits, with good discussion of methods for combating.

1894. Neumoegen, B. *Ent. News*, V., 331 var. *luminosa* described.

Sempers, F. Injurious Insects, pp. 86–87. Brief account; Riley's figures.

Hale, J. H. *Rural New Yorker*, Mar. 10, 1894, p. 151. Describes his "wash" and its use.

1895. Comstock, J. H. Manual for the Study of Insects, p. 260. Brief account. Good figure of female.

Davis, G. C. and Howard, L. O. Bull. 2 (N. ser.), U. S. Division of Ent., pp. 33 and 34. Raupenleim recorded as ineffectual, and linseed oil applications dangerous.

Weed, C. M. Insects and Insecticides, Second Edition, p. 121–122. Nearly same as 1891 account, except white paint is recommended instead of Paris green and glue. Poor figures of adults.

McCarthy, G. N Car. Expt. Sta., Bull. 120, pp. 292–293. Brief account.

Davis, G. C. Mich. Expt. Sta., Bull. 212, pp. 31–32. Brief account.

Stinson, J. Ark. Expt. Sta., Bull. 33, pp. 72–74. Brief, compiled account.

Smith, J. B. N. J. Expt. Sta., Bull. 111, p 6. Records apparently successful expts. with Raupenleim and Dendrolene.

1896. Marlatt, C. L. Circular 17, N. ser. U. S Div. of Ent., 4 pp. Best brief, general discussion in the literature and illustrated by fine original figures of male and female pupæ and adults, larva and cocoon.

Smith, J. B. *Ent. News*, VII., 107–109. Good general account of life-history and remedies.

"G. E. M." *Rural New Yorker*, Aug. 22d, 1896, p. 560 Data on life-history in Virginia; finds difference in infestation of plums when budded on different stocks

Smith, J. B. Economic Entomology, pp. 261–262. Good, brief account, with Kellicott's figures.

Cole, R. D., Massey, W. F., Wright, C. and Kerr, J. W. *Rural New Yorker*, Aug. 8, 1896, p. 533. Symposium on probable effect of kainit on borer.

Slingerland, M. V. *Rural New Yorker*, Dec. 5th, 1896, p. 800. Brief account, based on original observations and experiments.

Slingerland, M. V. *Michigan Fruit Grower*, Dec. 11, 1896, Vol. V., p. 8. (Same in Rept. Mich, Hort. Soc. for 1896, pp. 342–343). Brief account of some of the results reached in our many expts. against the insect.

Beutenmüller, W. Bull. Am. Mus. Nat. Hist., VIII., 126. New genus *Sanninoidea* proposed for *exitiosa*, but not characterized. *S. exitiosa* and its varieties *fitchii* and *luminosa* described, the former incorrectly so.

1897. Smith, J. B. *Ent. News*, VIII., 208. Important notes on life-history; p 233–34. Detailed discussion of emergence and egg-laying habits. Pl. XI., good, enlarged, photo-reproduction of male and female.

Lowe, V. H. 15th Rept. N. Y. Expt. Station, pp. 559–69. Very good general account, with good photo-reproductions, its work, and poor illustrations of adults, larvæ, and cocoon.

Slingerland, M. V. *Rural New Yorker*, Dec. 11, 1897, p. 805. Brief account.

"E. T." *Rural New Yorker*, Jan. 2, 1897, p. 6. Records finding borers in the gum in winter.

Beutenmüller, W. Bull. Am. Mus. Nat. Hist., IX, 219 Food-plants.

Butz, G. Penn. Expt. Sta., Bull. 37, p. 23–25. Brief account. E. F. Smith's figures, and photo-reproduction of effect of borer on trees.

Lowe, V. H. Proc Western, N. Y. Hort. Soc. for 1897, p. 65–66. Brief account of life-history and habits; expts. with dendrolene.

Cordley, A. B. Oregon Expt. Sta. Bull. 45, pp. 100–107. Good discussion, with poor photographic figures, of the Oregon peach and prune borer, supposed to be *S. exitiosa.* Specimens submitted to Washington authorities, however, show that Oregon species is *opalescens*, thus there is yet no definite evidence that *exitiosa* occurs in Oregon.

1898. *Country Gentleman*, LXIII., p. 328. Good popular discussion compiled from recent bulletins.

Smith, J. B. *Ent. News*, IX., 79, 114–115. Detailed account of some peculiar structural characteristics of the adults, illustrated by a full-page plate.

Starnes. H. N. Ga. Expt. Sta., Bull. 42, p. 226. good brief account with E. F. Smith's figures.

Stedman, J. H. Missouri Expt. Sta., Bull. 44, pp. 12–14. Brief account of life-history, with Kellicott's figures. Good discussion of remedial measures based on experiments. Recommends a wash of soap, soda, lime, carbolic acid, and Paris green or arsenic; also recommends wire gauze or thin wooden wrappers as mechanical preventives.

Slingerland, M. V. *Rural New-Yorker*, Jan. 15, 1898, p. 34. Detailed discussion of use of carbon bisulphide against the insect, with record of some experiments.

Slingerland, M. V. Proc. Western N. Y. Hort. Soc. for 1898, p. 67. List of applications found non-effective, partially effective, and injurious when used against the peach-tree borer in our experiments.

Faville, E. and Parrott, P. Kans. Expt Sta., Bull. 77, pp. 44–47. Good account of the work of the borer, with good new illustrations.

Craig, J. Ottawa Expt. Farm. Bull. 1, Sec. Ser., p. 44. Brief note regarding some of the results of experiments against the insect at Cornell Exp. Sta.

Baker, C. F. Ala. Expt. Sta., Bull. 90. pp. 27–32. Very good general discussion of life-history and remedies. Experiments with Bordeaux mixture and dendrolene. Illustrated with the good figures of Kellicott and Marlatt.

Smith, J. B. N. J. Expt. Sta., Bull. 128, 28 pages. Being based on original observations and experiments, this is one of the best and most detailed accounts of the life-history and methods of combating the peach-tree borer in the literature. Records experiments with various

mechanical protectors, and with cement and other washes. Illustrated by many new pictures of the different stages of the insect, its structural characteristics, and its work.

1899. Lugger, O. Fourth Rept., p. 57–59. Brief general account, quoted mostly from Saunders (1883). Uses Kellicott's (1890) fine figures.

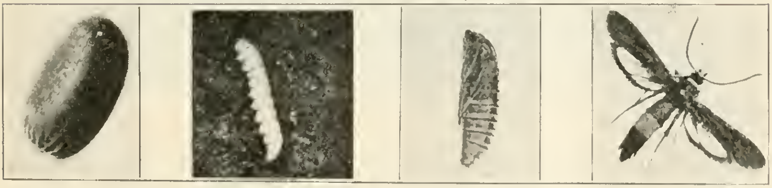
Fernald, H. T. Penn. Dept. of Agri., Bull. 47, pp. 14–15. Brief account, with Lowe's figures.

Slingerland, M. V. *Rural New-Yorker*, Mar. 25, 1899, p. 222. Results of experiments with tarred paper.

Slingerland, M. V. Trans. Mass. Hort. Soc.. Part I., for 1898, 5 pages. Brief account of life-history with somewhat detailed statement of results obtained with the various methods used in our extensive experiments against the insect.

Beutenmüller, W. Bull. Am. Mus. Nat. His., XII, 159. Genus *Sanninoidea* defined. Variations of *exitiosa* discussed; variety *fitchii* shown to have been incorrectly described; and the varietal name *edwardsii* proposed for the females, having both the fourth and fifth abdominal segments banded with orange; var. *luminosa* described.

MARK VERNON SLINGERLAND



57.—*The four stages—egg, larva or "borer," pupa, and adult or moth—of the peach-tree borer's life; all natural size except the egg, which is much enlarged.*

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158 Source of Gas and Taint Producing Bacteria in Cheese Curd.
159 An Effort to Help the Farmer.
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162 The Period of Gestation in Cows.
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167 The Construction of the Stave Silo.
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169 Studies in Milk Secretion.
170 Tent Caterpillars.
171 Concerning Patents on Gravity or Dilution Separators.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1899.

171. Gravity or Dilution Separators.
172. The Cherry Fruit-Fly: A New Cherry Pest.
173. The Relation of Food to Milk-Fat.
174. The Problem of Impoverished Lands.
175. Fourth Report on Japanese Plums.

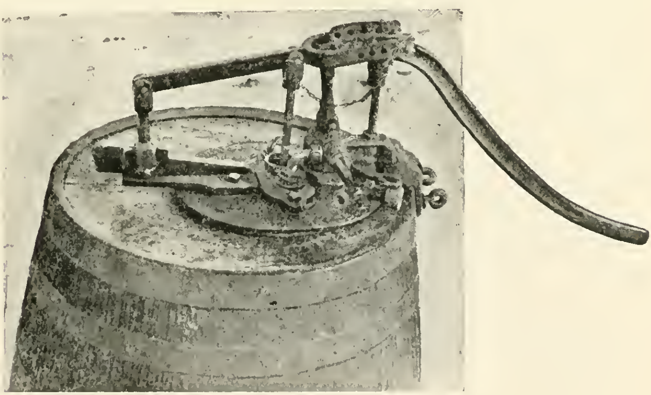
Bulletin 177. January, 1900.

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

HORTICULTURAL DEPARTMENT.

SPRAYING NOTES.



By L. H. BAILEY and Others.

PUBLISHED BY THE UNIVERSITY.

ITHACA, N. Y.

1900.

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Cornell University, Ithaca, N. Y., Jan 1, 1900.

Honorable Commissioner of Agriculture, Albany.

Sir :—The following account is a summary of the experiments of 1899 on the spraying of plants. These experiments were made under the direction of Professor Bailey. The work was begun by H. P. Gould, but after his withdrawal to the Maryland Agricultural College it was continued by S. W. Fletcher. The chemical work was done by G. W. Cavanaugh, assistant chemist to the Experiment Station. Other materials than those reported have been tried, but it seems unwise to make any discussion of them, since the results were not satisfactory.

Respectfully submitted,

I. P. Roberts,
Director.

FORMULAS.

Bordeaux Mixture.

Copper sulfate (blue vitriol)	6 pounds.
Stone or quick lime	4 "
Water	1 bbl. (45 to 50 gals.)

Dissolve the copper sulfate in 2 gallons of hot water; or put it in a coarse sack, as burlap, and hang this in 4 to 10 gallons of cold water. Use only an earthen or wooden vessel. Pour the copper solution into the spraying barrel and fill the barrel half full of water. Slack the lime, dilute it to 10 to 15 gallons, *never less*, and pour this milk of lime into the spraying barrel through a wire strainer of about 30 to 40 meshes per inch. Add water to fill the barrel and stir the mixture vigorously. Bordeaux should be well stirred every 4 to 5 minutes when spraying. Few agitators are satisfactory; a wooden paddle worked by hand power is good.

Bordeaux mixture itself should always be made fresh for each application, but stock solutions of copper sulfate and lime may be kept to advantage when the spraying operations are extensive. Copper sulfate may be dissolved in water at the rate of 1 pound per gallon; and quick lime slacked at the rate of 1 pound per gallon. For a barrel of Bordeaux, take 6 gallons of vitriol solution and 4 gallons of milk of lime. It is better, however, to use the ferro-cyanide test when the lime is taken from a stock solution. Both stock solutions should be kept covered to prevent evaporation.

Arsenite of Lime.

White arsenic	1 pound
Stone lime	2 "
Water	1 gallon

Boil together for forty-five minutes. This stock solution may be kept indefinitely in a closed vessel. Some green dye stuff may be mixed with it to prevent mistaking it for other material. One quart of the above per barrel will be sufficient for most insects.

The "Kedzie Mixture" is made by boiling together 2 lbs. of white arsenic and 8 lbs. of sal soda, in 2 gallons of water, until the arsenic dissolves. One pint of this stock solution and 2 lbs. of slacked lime are sufficient for 40 gallons of the spraying mixture.

Paris Green.

For most purposes 1 pound is used in 150 gallons of water. In some cases a more dilute mixture is made; and on potatoes some persons use a stronger one (1 pound to 100 gallons). The poison distributes better in the water if it is previously dampened and worked into a paste. To every 100 gallons of the mixture add 1 or 2 pounds of lime.

GENERAL ADVICE.

L. H. BAILEY.

Each succeeding year emphasizes the importance of spraying. There is no onger any doubt that the operation is based on rational principles and is demanded by the increasing incursions of insects and fungi. Yet a man says, "I sprayed this year, and it did no good. Shall I spray next year?" A man may insure his barn this year and it does no good; but he insures it again next year. My neighbor put in a tile drain last spring, but it did no good this year: I do not believe that he will dig it up. My neighbor believes in tilling to save moisture; yet two years ago he had too much moisture, but I notice that he did not abandon tillage last year. The wise man takes precautions.

Farming, like any other business, should be ruled by ideals. The good farmer sets a mark and tries to attain to it. He knows that the mark is right and the effort is right, even though incidental results now and then seem to contradict. The experiences of a single season do not prove nor disprove things which are true. We know that sprays kill insects and check the spread of fungi: and we know that the insects and fungi are with us. Lay out a course of action to accomplish a desired result: modify your practice as the case requires, but stick to the action.

* * *

What is new in spraying? Perhaps nothing which experimenters are ready to recommend; but we know some things better than we did last year. One of these things is the fact that the old kerosene and soap emulsion—the vilest of concoctions—seems to be doomed. The kerosene and water emulsion is to take its place. The insecticidal properties of this mixture have long been known, but it has needed a practicable mechanical device to mix them. There are two great difficulties in this mechanical problem—the difficulty of making a mathematically correct mixture of the water and oil, and the difficulty of securing power enough to mix the liquids and to throw the spray the required distance. It is scarcely to be expected that the automatic kerosene-and-water mixing pump can ever throw a spray so far as one which expends all its energies in throwing the spray. These automatic pumps are not yet perfect, but some of them are perfect enough to be useful and reliable; and they indicate that we may expect better things. I do not say that the kerosene-and-soap emulsion is already out of date—only that the indications are that it will become less and less important.

* * *

Shall white arsenic be used as a substitute for Paris green? This is not a new question. Experiments on this point were made by Kilgore as early as 1890. The arsenic is combined with lime to form arsenite of lime. There is no question as to the efficacy of the mixture, or its safety on foliage. Our tests show that it is less caustic than Paris green to foliage. We have not recommended it publicly because it is a dangerous thing to have the general run of farmers buying white arsenic and mixing and boiling it themselves. One has only to inspect the ordinary farmstead to see how careless the owner is about things which require careful handling and weighing. The refuse is thrown in the yard or into a stream. Utensils are left where they were used. There are farmers who are otherwise, and if they have much spraying to do, the white arsenic can be recommended confidently; but I believe that most people should buy their poisons ready prepared, even if the cost is somewhat greater.

* * *

The San José scale is still with us. It will stay. There is no hope of eradicating it. Then every man should be prepared to meet it. He should not rely on State control alone.

For three seasons now, we have experimented with the kerosene and water emulsion—as others have done—and have found that it is a specific for the scale. In the proportion of 1 part of oil to 5 of water in summer, and 1 to 4 in winter, it will kill the scale.

Can a man hope to annihilate the scale, then, by spraying? No. On plants which he can spray thoroughly and frequently, he can hope to eradicate it ; but I should not expect him to eradicate it from a large and badly infested plantation, any more than he can eradicate the apple-scab or the bark-louse. But I should expect him to keep it in check. Spraying for San José scale must come to be an accepted practice, as spraying for potato-blight is.

All this means that the farmer should not be frightened, but should be self-reliant and determined. But the State should help him. The law should not help him less, but more. Nursury stock should be fumigated with hydrocyanic acid gas, under strict control. It would be folly to attempt to burn every infested tree or bush wherever found; but the law should be so amended as to allow a properly qualified officer to destroy plants which, in the judgment of experts, are a menace to the general weal.

SUMMARY OF EXPERIMENTS OF 1899.

H. P. GOULD, S. W. FLETCHER AND G. W. CAVANAUGH.

I. The Season's Experience with the San José Scale.

The results of experiments in spraying for the San José scale were detailed in Bulletins 144 and 155. During the past year these experiments were continued more extensively. The former conclusions were fully confirmed. The infested stock was mainly apple, pear, plum, almond and willow trees, all of medium size or below. Some were very badly infested, but all had made a fairly vigorous growth in 1898. Experiments in 1898 had shown that a 20 per cent mechanical mixture of kerosene and water was the most efficient spray, so no other proportion was used this year. The first application in 1899 was made to one lot of trees on April 10 and 11, when the weather was favorable for rapid evaporation. This is a very important point in all spraying with un-emulsified kerosene. Another lot of trees was sprayed on June 6 and were, of course, in full leaf at the time of spraying. A few badly infested currant bushes were left as checks.

On June 23, the young scale insects were numerous on the unsprayed currants and a very few were found on the sprayed trees, indicating that the insecticide had killed most, but not all of the old scales. On one of the worst infested trees which had been sprayed, but a single live scale could be found. The trees sprayed in June showed more live scales than any of those sprayed in early spring.

All of the trees were sprayed a second time on June 24, and three with very dense heads again on June 29. At this date, Dec. 11, few live scales can be found on the sprayed trees—mostly on apples and pears, where some insects were protected from the spray by irregularities of the bark. On the smooth barked willows, every scale was killed. On the whole the results are encouraging. We feel sure that the San José scale can be held in check by spraying whenever the infested plants can be thoroughly treated. If the trees had been sprayed again in late summer, probably all the insects would have been eradicated; but it was desired to leave the trees for study.

While spraying for the San José scale in early spring has given excellent results, there is no reason why late fall spraying should not be equally effective, since the insect continues to multiply for some time after the leaves have fallen. Furthermore, it is often more convenient to spray in the fall than during the hurry of spring work. Summer spraying is rarely advisable, since the foliage prevents the insecticide from reaching all parts of the tree. We are now experimenting with early winter spraying for the scale.

Spraying vs. fumigating.—Most of the eastern fruit-growers and nurserymen who have adopted the fumigation method of combating the San José scale, report it efficient and practicable, when properly done. Fumigation is certainly more thorough than spraying. Hydrocyanic acid gas is very penetrating and can be depended upon to kill all the scales or other insects on the tree in one thorough fumigation, whereas several applications of the spray may be necessary to accomplish the same result. In spraying there is always a possibility that a few untouched insects may live and re-infest the tree. Nevertheless, there is no doubt but that the San José scale can be held in check by spraying.

The comparative cost of the two methods is a practical point. In spraying, a pump with a good kerosene attachment is the only equipment necessary besides the usual spraying appliances. In fumigation, tents are indespensible (if growing trees are treated) and are generally costly, especially those large enough to cover a full sized orchard tree. The choice between spraying and fumigation will therefore depend largely on the amount of work to be done and the first cost of the tents. Nurserymen will find fumigation the most effective and probably the most economical method of control, while those with growing plants will find kerosene spray an efficient, economical and simple method of checking the scale.

The San José scale situation is improving, not because the scale is less destructive but because it is better understood and methods of combating it are more generally known. In some respects it is undoubtedly the worst insect we have in the orchard. Every precaution should be taken to guard against infection ; yet there is no reason why infested trees may not be saved, provided they are not seriously weakened before remedial measures are taken. Herein lies the greatest danger,—not because the insect is hard to kill, but because it is hard to see, and it spreads with amazing rapidity. A slight infestation is not at all noticeable, and one must look sharp to see individual scales. The probability is that most farmers would not notice the San José scale on their trees till they are infested so badly as to be hardly worth the trouble of spraying. Taken at the right time, however, the pest can be dislodged. A faithful application of arsenical sprays will hardly save us 80 per cent of wormless apples; while the same amount of energy directed against the scale may be expected to hold it at bay.

II. FIELD TESTS OF NEW INSECTICIDES.

The burning of the foliage.—In order that an insecticide shall have practical value, it must not only check the insect or plant disease but must also work no injury to the plant itself. Many materials of great fungicidal value are worthless for practical purposes because they kill or injure the plant as well as the parasite. The standard insecticide is Paris green. As a poison it is very satisfactory; yet it is expensive, it does not remain long in suspension when applied with water, and it sometimes burns the foliage. These objections have induced several manufacturers to offer substitutes, a few of which this Station has tested in comparison with Paris green. Below is recorded the comparative injury to the foliage by four strengths of each insecticide. It is probable that much if not all of the injury noted could have been prevented by adding lime to the arsenical spray. The object of this test was merely to find out the physiological effect of the insecticides when used alone, and incidentally the danger limit of strength. Grades are recorded of injury ranging from doubtful (when the slight imperfections in the foliage may or may not have been produced by the spray), through slight, considerable, and severe to very severe (when a large proportion of the leaves had fallen and the young shoots were frequently killed). Most of the orchard applications were made June 10. The potatoes were sprayed July 10 and a duplicate lot on July 17. Final records on the fruit trees were taken July 1; on the potatoes, August 3. The spray barrel held 48 gallons.

TABLE I.—THE EFFECT OF INSECTICIDES ON FOLIAGE.

Insecticide.	Apple.	Pear.	Plum (domestic).	Peach.	Potato.
¼ lb. per bbl.					
Paris Green	none	none	none	doubtful	none
Paragrene	none	none	none	doubtful	none
Green Arsenite	none	none	none	slight	none
* XX	considerable	considerable	slight	very severe	severe
Pink Arsenoid	none	none	none	doubtful	none
Green Arsenoid	none	none	none	none	doubtful
Green Arsenoid, No. 53	slight	slight	doubtful	considerable	none
½ lb. per bbl.					
Paris Green	none	none	slight	slight	none
Paragrene	none	doubtful	slight	slight	none
Green Arsenite	none	none	doubtful	considerable	none
XX	severe	severe	considerable	very severe	very severe
Pink Arsenoid	none	none	considerable	considerable	none
Green Arsenoid	doubtful	doubtful	doubtful	severe	doubtful
Green Arsenoid, No. 53	slight	slight	severe	very severe	slight
† Arsenite of Lime	none	none	none	none	(no record)

* This insecticide was sent to us for trial under name; but since the manufacturers do not intend to place it upon the market in its present form, the name is suppressed. It is included in this report because it emphasizes certain undesirable features in the composition of an insecticide.

† One, two and three quarts of the material for the respective comparisons.

TABLE I.—*Continued.*

Insecticide.	Apple.	Pear.	Plum (domestic).	Peach.	Potato.
1 lb. per bbl.					
Paris Green	none	slight	slight	severe	
Paragrene	doubtful	doubtful	considerable	slight	
Green Arsenite	none	doubtful	doubtful	considerable	
* XX	severe	severe	very severe	very severe	
Pink Arsenoid	doubtful	doubtful	severe	severe	
Green Arsenoid	slight	doubtful	slight	severe	
Green Arsenoid No. 53	considerable	slight	very severe	very severe	
Arsenite of Lime	none	none	doubtful	doubtful	
1½ lbs. per bbl.					
Paris Green	none	slight	slight	very severe	
Paragrene	doubtful	slight	considerable	very severe	
Green Arsenite	none	slight	slight	severe	
* XX	severe	severe	very severe	very severe	
Pink Arsenoid	slight	slight	severe	very severe	
Green Arsenoid	severe	doubtful	considerable	very severe	
Green Arsenoid No. 53	severe	considerable	very severe	very severe	
Arsenite of Lime	none	none	doubtful	slight	

A bug-killing contest.—A test of the insecticidal value of these materials was made on potatoes. The results are fairly representative of their value as insecticides, for if the materials will kill potato slugs their poisonous properties are assured.

Two strengths of the materials were used : ¼ lb. per bbl., (48 gals.) the strength at which Paris green is usually applied for potato slugs, and ½ lb. per bbl. The spraying was done July 10 and 17, each strength covering about seventy-five rods of rows. The physiological effects of the arsenites are recorded in Table I. Slugs were not numerous, but were plentiful enough for a fair test. Both strengths of Paris green, Paragrene, XX, and Green Arsenoid killed all the slugs. A very few sick ones were found when both strengths of Pink Arsenoid, Green Arsenoid No. 53 and Green Arsenite had been sprayed, yet it would pass for a clean sweep.

III. THE COMPOSITION OF ARSENITES.

The analyses of the insecticides used in these experiments consisted chiefly in determining the amount of arsenic, the arsenic soluble in water, and the copper. The arsenic soluble in water was found by shaking the insecticide in water for one hour, at the rate of one pound to one-hundred gallons, and determining the amount of arsenic dissolved. Comparing Table II with Table I it will be seen that in proportion as the amount of soluble arsenic in an insecticide increases, its injury to foliage likewise becomes greater. At the rate arsenites are commonly used (¼ lb. per bbl.), the burning is not noticeable with insecticides having less than 3 ½ per cent of soluble arsenic.

Anybody but a chemist is likely to become confused over the nomenclature of poisons. *Arsenite* is a general term for all compounds of arsenious oxid ($As_2 O_3$), the active element in all these materials. *Arsenoid* is a trade name, not a chemical compound, and simply means arsenic-like. An *arsenate* is a compound of arsenic acid ($As_2 O_5$). None of the materials mentioned here is an arsenate. When the term arsenic is used in connection with insecticides, we mean what is ordinarily called white arsenic ($As_2 O_3$) and not the metal arsenic (As). In the table copper is given as copper oxid (Cu O), lead as lead oxid (Pb O) and lime as calcium oxid (Ca O). The sulfuric acid ($S O_3$) has no insecticidal effect.

TABLE II.

ANALYSES OF ARSENITES.

Insecticide.	As_2O_3 Arsenic, total.	As_2O_3 Arsenic, soluble.	CuO Copper oxid.	SO_3 Sulfuric acid.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Paris green	56.45	1.83	23.62	.71
Paragrene	55.57	3.21	27.68	1.34
Green arsenite	54.10	2.36	31.59	3.70
XX	33.71	32.23		
Pink arsenoid	49.17	1.93	49.09 (PbO)	
Green arsenoid	60.63	3.53	29.29	1.55
Green arsenoid No.53	53.71	8.33	29.43	3.70

In Bulletin 149, page 720, the following analysis of Laurel green was published:

Copper (Cu)	10.00	per cent.
Arsenic (As_2O_3)	7.75	"

This year an insecticide manufactured by the same firm and labeled Special Laurel green analyzed :

Arsenic (As_2O_3) total	42.69	per cent.
" " soluble	1.15	"
Copper oxid (CuO)	4.50	"
Lime (CaO)	35.39	"

With its present composition this material evidently has value as an insecticide, although no field tests have been made here. It is manufactured by the Nichols Chemical Company of New York, and retails for 12½ cents per pound.

Heretofore the ammonia test has been advised for detecting the purity of Paris green. The pure Paris green which has been on the market in the past does dissolve in ammonia completely ; but this year samples have been received for analysis which do not, although containing the 50 per cent of arsenic required by New York State law. The reason is that they contain lime as well as copper, and the lime compound with arsenic is insoluble in ammonia water. Although this material is a good insecticide, it is not Paris green.

The specific gravity of insecticides.—An important point in every insecticide applied with water is the time it will remain in suspension. If the arsenite sinks to the bottom of the barrel in a few minutes, as does Paris green, there is an unequal distribution of the poison and the concentrated mixture at the bottom is likely to burn the foliage. Frequent stirring is an inconvenience. Generally speaking, the lighter and more flocculent an insecticide is, the longer it will stay in suspension. Assuming the Paris green to be 10, the various insecticides compare with it in weight as follows: Green Arsenite, 10; Pink Arsenoid, 9; Paragrene, 7; Green Arsenoid, 7; XX, 4; Green Arsenoid No. 53, 4. Equal amounts of the above arsenites shaken in water followed approximately the same order in settling, Paris green and Green Arsenite settling first, and No. 53 last. The heavy specific gravity of Paris green is one of its weak points as an insecticide.

Summary on insecticides.—*Paragrene.*—Manufactured by Fred L. Lavenburg, New York. Price 14½ cents per pound in 14 pound pail. It has equal insecticidal value with Paris green, is about as likely to burn the foilage and remains longer in suspension. We consider it an excellent substitute.

Green arsenite. — (Arseniate of copper, Scheele's green.) This is practically the same as Paris green in composition, and has the same effect on foliage. Its fungicidal value is slightly greater than Paris green owing to the higher percentage of copper oxid. When it can be obtained as cheaply as Paris green, it may be given preference.

Pink arsenoid. — Manufactured by the Adler Color and Chemical Works, Brooklyn, N. Y. Retail price, 15 cents per pound at N. Y., f. o. b. It is slightly inferior to Paris green as an insecticide and has decidedly less fungicidal value, since the lead oxid it contains, corresponding to the copper oxid of Paris green, has little if any merit as a fungicide. The pink color may be objectionable. Paris green has been so long in common use that people instinctively associate an arsenical poison with a green color. This material is apparently not as valuable as the following, manufactured by the same firm.

Green arsenoid.—Retails for 15 cents per pound f. o. b. It is slightly superior to Paris green in composition and appears to be equally safe on foliage when applied at the ordinary strength. The powder is more flocculent than Paris green, about a third lighter and remains correspondingly longer in suspension. With its present composition and price we feel justified in recommending it for practical use.

Green arsenoid No. 53.—The most serious objection to this material is that its comparatively high percentage of soluble arsenic makes it liable to burn the foliage. It is about equal to Paris green in insecticidal value, superior to it as a fungicide and is remarkably slow in settling from a spraying mixture. Provided the soluble arsenic were neutralized with lime, No. 53 would make an efficient and economical substitute for Paris green.

Arsenite of lime.—This has the three-fold advantage of being cheap, the amount of arsenic is under perfect control, and it does not burn the foliage. It is made by boiling together for forty-five minutes

1 pound white arsenic.
2 pounds fresh lime.
1 gallon water.

This may be kept in a tight vessel and used as desired. Thoroughly stir the material before using. For most insects, one quart of the above per barrel will be sufficient. Arsenite of lime is insoluble in water and will not injure the foliage of any orchard fruit at this strength. This insecticide is growing in popularity. Some green dye stuff should be mixed with it to prevent the ever-present danger of mistaking it for some other material.

IV. THE BURNING OF FOLIAGE BY FUNGICIDES.

The effect on Japanese plums.—The foliage of the Japanese plums is so extremely sensitive to injury from fungicides and insecticides that one must always be cautious when spraying this class of fruit. The apparently increasing susceptibility of the Japanese plums to the fruit rot (Monilia) makes it essential to take some preventive measure. It cannot be said that spraying is always an absolute specific for the fruit rot. In a wet season, no advantage may be noted. Through a series of years, however, a faithful combination of spraying, thinning the fruit and destroying the diseased fruit can be depended upon to prevent serious injury.

The standard fungicide for the Japanese plums is Bordeaux mixture. Bulletin 164 contains an account of the shot-hole effect produced by Bordeaux on plums and peaches. This injury has been observed for several years as resulting from even the most carefully prepared Bordeaux. During the past season, experiments were made to determine the effect of copper carbonate and potassium sulfide on Japanese plum foliage. The copper carbonate was applied in an ammoniacal solution at the usual strength: the potassium sulfide at the rate of one ounce to a gallon of water. Both were slightly more injurious to the foliage than Bordeaux. Since it is not probable that either has a greater fungicidal value than Bordeaux, there can be no advantage in displacing the older fungicide.

The effect of copper sulfate on foliage.—It would be difficult to find a material of greater fungicidal value than Bordeaux mixture, yet it becomes a practical point to combine the same efficiency with greater ease in application and less danger of injury to the foliage. Those who have used a solution of copper sulfate find it to be an excellent fungicide. From laboratory studies we know that a very weak solution of blue vitriol will prevent the germination of fungi spores, but it is a question if it will have the same value under the conditions of orchard and field.

It is of importance to know whether the foliage will be injured by a solution strong enough to be an efficient fungicide. The spraying in our test of this point was done May 24, and the final records taken June 10. The barrel reported below holds 48 gallons.

TABLE III.

INJURY TO FOLIAGE FROM COPPER SULFATE SPRAYS.

Foliage.	4 oz. per bbl.	8 oz. per bbl.	1 lb. per bbl.	2 lb. per bbl.
Apple	doubtful	slight	considerable	considerable
Pear	doubtful	slight	severe	very severe
Peach	considerable	considerable	severe	very severe
Cherry	none	slight	slight	severe
Plum (domestic)	considerable	considerable	severe	very severe
Plum (native)	slight	slight	considerable	considerable
Plum (Japan)	considerable	considerable	severe	very severe

Although no severe injury to the native plums is recorded in the table, it was incidentally brought out that there is considerable variation between the different varieties of this group in their susceptibility to injury. The variety under experiment was Golden Beauty. Some spray accidentally reached the leaves of an adjacent Munson and there caused serious injury.

Most of the injury noted was in the spotting of the leaves. Wherever the fungicide clung, there the tissue was killed and ultimately fell out, producing a condition which might readily be mistaken for the effect of the shot-hole fungus. When copper sulfate was applied to peaches and domestic plums at the rate of 2 lbs. per bbl., these perforations were so numerous that many leaves dropped. The young fruits of the Japanese plums were injured by the two strongest sprays.

These tests do not throw any light on the value of copper sulfate for controlling plant diseases ; they simply indicate that unless careful discrimination is made between varieties, only a very weak solution can be used with safety to the foliage. Until the simple solution of copper sulfate has been tested further, there is no safer or surer orchard fungicide than well made Bordeaux mixture. On Japanese plums, apply it weak. It would be well to experiment in applying it only in bright weather.

VARIOUS POINTS.

1. The San José scale can be controlled in a plantation by a 20 per cent kerosene and water mixture when the plant is thoroughly sprayed. Early spring or late fall spraying is preferable, but the material may be applied when the plant is in full leaf if the day is sunshiny.

2. Only on sunshiny days should sprays of kerosene and water be used.

3. Compared with fumigation on growing trees, spraying is cheaper, simpler, and perhaps equally effective in the long run. Nurserymen will find fumigation better adapted to their needs than spraying. On growing plants, however, it is attended with difficulty because of the necessity of providing tents.

4. Paragrene, green arsenite, green arsenoid and arsenite of lime are equal if not superior to Paris green in insecticidal value. The reduced price of these substitutes will commend them. Arsenite of lime can be made at home.

5. Bordeaux mixture is liable to injure the foliage of the Japanese plums, but no better fungicide for spraying this class of fruit is now known. To avoid injury, use a very dilute mixture.

6. Varieties of fruit differ in their susceptibility to injury from sprays.

7. Unless lime is added, a simple solution of copper sulfate as strong as 4 ounces per barrel, cannot be used without injury to the foliage of many fruit trees.

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- 71 Apricot Growing in Western New York, 26 pp.
- 72 The Cultivation of Orchards, 22 pp.
- 74 Impressions of the Peach Industry in N. Y., 28 pp.
- 75 Peach Yellows, 20 pp.
- 76 Some Grape Troubles in Western N. Y., 116 pp
- 78 The Cabbage Root Maggot, 99 pp.
- 79 Varieties of Strawberry Leaf Blight, 26 pp.
- 80 The Quince in Western N. Y., 27 pp.
- 93 Cigar-Case-Bearer, 20 pp.
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- 170 Tent Caterpillars.
- 171 Concerning Patents on Gravity or Dilution Separators.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1899.

171. Gravity or Dilution Separators.
172. The Cherry Fruit-Fly: A New Cherry Pest.
173. The Relation of Food to Milk-Fat.
174. The Problem of Impoverished Lands.
175. Fourth Report on Japanese Plums.
176. The Peach-Tree Borer.
177. Spraying Notes.

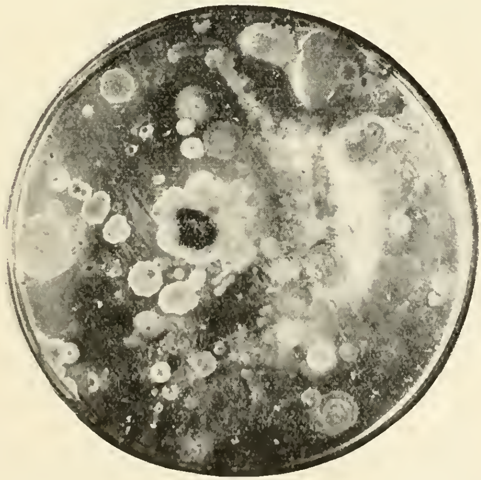
Bulletin 178. **January, 1900.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

DAIRY DIVISION.

The Invasion of the Udder by Bacteria.



COLONIES OF BACTERIA IN A GELATIN PLATE CULTURE FROM AN UDDER.

By ARCHIBALD R. WARD.

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ITHACA, N. Y.
1900.

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Cornell University, Ithaca, N. Y., Jan. 30, 1900.

The Honorable Commissioner of Agriculture,

Albany, N. Y.

Sir: This bulletin is submitted for publication under Chapter 430 of the Laws of 1899.

Whether or not, bacteria invade the milk channels of the normal udder further than the milk duct of the teat, is a problem which dairy bacteriologists have vainly sought to answer satisfactorily.

This bulletin contains a description of a unique method of throwing light upon this subject together with the facts determined by an application of the method to the study of the udders of nineteen cows. The fact that milk may become contaminated by bacteria before it leaves the small milk ducts of the cow's udder has a broad and direct application to the methods employed in the production of milk by the most progressive dairymen.

The conclusions embodied in this bulletin are general in nature but it is believed that future investigations will reveal more specific facts concerning this hitherto unrecognized source of the contamination of milk.

I. P. Roberts,
Director.

Description of Plate.

Photograph of a section of an udder injected through the teats with a mixture of lampblack and gelatin. The gelatin is removed from the teats and cisterns in order to show the lining mucous membranes of those cavities. The jet black areas throughout the whole section indicate the presence of the lactiferous ducts which communicate with the cisterns. The finest ramifications of those ducts, almost invisible to the naked eye, are manifest by the darkening of the cut surface exposed to view.

PLATE I.—SECTION OF AN UDDER.

THE INVASION OF THE UDDER BY BACTERIA.

BY ARCHIBALD R. WARD.

The designation of the sources from which bacteria gain access to milk is one of the important results of the application of bacteriology to the amelioration of the dairy industry. Among dairy bacteriologists there is a marked unanimity of opinion concerning the presence of micro-organisms in unclean utensils, the dust in the air of stables and in the first milk drawn from the teats at each milking. The necessity for the application of precautions to prevent the contamination of milk from those sources is well recognized and is exhaustively discussed in the more recent dairy literature.*

Concerning the place at which milk first becomes contaminated with bacteria is a controverted matter among bacteriologists at the present time. The more generally accepted views are expressed in the following quotations. Grotenfelt † says that "When the milk is first drawn from the udder of a healthy cow it is germ free or sterile. The original sterility of normal milk is due to the fact that the bacteria can not gain access to the milk glands from without as long as the udder is not injured in any way." The translator of Grotenfelt's work, adds in a footnote this statement made by Lehmann ‡: "The bacteria in the milk cistern will be largely washed out by the first milk drawn, but not all removed until milking has progressed some time."

v. Freudenreich § holds a somewhat similar view. In his

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* H. L. Russell, Dairy Bacteriology. Ed. v. Freudenreich, Dairy Bacteriology, translated by J. R. A. Davis. R. A. Pearson, Farmers' Bulletin No. 63, U. S. Department of Agriculture.

† Gösta Grotenfelt, The Principles of Modern Dairy Practice, translated by F. W. Woll, p. 23.

‡ Lehmann, 17te Versammlung d. deut. Ver. f. offent. Gesundheitspflege.

§ Dr. Ed. v. Freudenreich, Die Bakteriologie in der Milchwirthschaft, 2d edition p. 25.

dairy bacteriology the following is found: "In the udder, milk is germ free except when the milk glands are diseased, as with tuberculosis, or with mammitis. In such cases the tubercle bacilli or those causing the inflammation, are present in the milk when drawn. At other times, it is germ free as was shown by Pasteur by drawing the milk direct from the udder through a sterile cannula."

In discussing the sources of contamination of milk, v. Freudenreich mentions that the first milk drawn always contains bacteria. These he says, have invaded the teat since the previous milking and are all washed out, so that sterile milk can be obtained toward the latter part of each milking. This explanation of the presence of bacteria in the fore milk is apparently based upon the experiments in which sterile milk has been obtained from the udder. Schultz,[1] Gernhardt,[2] Lehmann,[3] Moore,[4] and Backhaus and Cronheim[5] have worked along this line, merely succeeding in demonstrating that sterile samples may be occasionally obtained from the strippings.

Moreover v. Freudenreich's results, with the milking tube experiment suggested by Pasteur, are diametrically opposed to those of Bolley and Hall.† These writers made a study of the bacteria present in the milk cistern of the normal udder, drawing their samples by means of a sterilized cannula inserted well into the cistern.

Bolley questions the accuracy of the dictum: "In the healthy udder, milk is germ free or sterile." He says, "Germs nearly always gain admission to the interior of the teats, and often per-

*[1] Schultz, Archiv. f. Hygiene, XIV (1892) p. 260.

[2] Gernhardt, Quant. Spaltpilzunters d. Milch, Inaug. Dissert, Univ. Jurjew.

[3] Lehmann, loc. cit.

[4] Moore, Preliminary Investigations Concerning the Number and Nature of Bacteria in Freshly Drawn Milk. Twelfth and Thirteenth Annual Report of the Bureau of Animal Industry, U. S. Dep't of Agr., p. 261.

[5] Backhaus and Cronheim, Ber. Landw. Inst. Univ. Königsberg, 2 (1897), pp. 12–32. Abstracted in the Experiment Station Record Vol. X, No. 1, p. 87.

† Bolley and Hall, Uber die Kontanz von Bacterien Arten in Normaler Erste Roh Milch. Centralblatt für Bakteriologie u. Parasitenkunde. II Abt., 1 Band No. 22–23.

haps, the milk cistern proper where some types may multiply in great numbers.''

The writer † has concluded, chiefly from a study of the bacterial flora of fore milk that (1) Certain species of bacteria normally persist in particular quarters of the udder for considerable periods of time. (2) It is possible for bacteria to remain in the normal udder and not be ejected along with the milk. These conclusions controvert the statement that the milk ducts are always sterile at the close of the milking, becoming tenanted from the outside alone by organisms which chance to come in contact with the end of the duct.

Moore pointed out the importance of a study of the bacterial flora of the normal udder and to that end suggested that bacteriologic examinations should be made of the udders of freshly killed milch cows. After making a fruitless effort to obtain udders for the purpose from sound cows, he deemed it expedient to avail himself of opportunities offered by the slaughter of tuberculous milch cows. In January, 1898, Dr. Moore and the writer, who was privileged to associate with him, were given opportunity to examine the udders of six cows, slaughtered after reacting to the tuberculin test. The animals were apparently in good condition, and the udders normal in appearance. The post mortem examinations showed the tubercular lesions to be restricted to a few small nodules in the bronchial and pharyngeal glands.‡ After the bacteriologic examination, the udders were carefully scrutinized for tubercular or other lesions without finding them. The results of those examinations briefly given in a former publication,§ opened up a broad and almost totally unexplored field of research for dairy bacteriologists.

The present publication contains a more extended account of

H. L. Bolley, North Dakota Agricultural Experiment Station, Bulletin No. 21, p. 164.

† A. R. Ward, The Persistence of Bacteria in the Milk Ducts of the Cow's Udder. Journal of Applied Microscopy, Vol. I, No 12, p. 205.

‡ The fact that the six animals were selected as the least diseased out of a herd of seventy-five condemned animals, explains the apparently remarkable restriction of the tubercular lesions.

§ V. A. Moore and A. R. Ward, Bulletin No. 158, Cornell University Agricultural Experiment Station.

the methods employed, and the results obtained from examinations made in coöperation with Dr. Moore and of subsequent ones conducted by the writer independently. The udders of nineteen milch cows from five different dairies have been examined. Six of these, Group I, were made at Elmira as already noted ; two, Group II, at Albany ; two, Group III, at Richfield Springs ; five, Group IV, were made at Syracuse ; and four, Group V, near Elmira.

METHODS.

The bacteriologic examinations of the udders have of necessity been confined to those of tuberculous milch cows. But in no case was the udder tuberculous or otherwise abnormal in appearance. Whether or not a few tubercular lesions in organs far distant from the udder bring about an abnormal invasion of the udder by bacteria, is a question which the writer, in the absence of evidence to the contrary, is inclined to answer negatively.

Just before slaughtering, samples of the fore milk were taken and the animals milked as thoroughly as possible, under the exciting conditions surrounding them. For convenience in noting results the gland was divided arbitrarily into three parts as follows : (A) The lower third including the teat and cistern ; (B) The middle third which includes the lower half of the gland proper, and (C) The upper third, which includes the remaining portion of the gland. After the cow was slaughtered, the udder was carefully removed. The skin was reflected and a flamed knife was used to make an incision extending from the upper part of the udder to the cistern, and of such depth as to expose tissues in the vicinity of the vertical axis of the gland. Alcohol lamp, scalpels, curved scissors, tenaculum, tweezers, and platinum loop were found useful in this and in the following proceedings. In making cultures from the glandular tissue, care was taken to prevent milk of the ventral region from coming in contact with the freshly exposed surfaces which normally lie above the cistern. Bits of tissue were detached with flamed scissors, and transferred to culture media by the use of a flamed platinum loop or tweezers. In some of the earlier examinations made, tubes of gelatin and slanted agar were inoculated in this manner from each of the three arbitrarily designated divisions of the quarter. Later, after it was recognized that bacteria are broadly distributed in the udder, the use of slanted agar was discontinued, as it did not permit of the isolation of species

Upon returning to the laboratory, the gelatin was liquefied at a temperature not exceeding 37°C. and poured into sterile Petri dishes, where it again became solid. Agar plate cultures were made from the milk samples, and, together with those slanted agar cultures already inoculated, were placed in the incubator. The agar plate cultures were designed to be used as a check upon the reliability of the conclusions reached from an examination of the other cultures. For instance, it might be possible that organisms which appeared to have been obtained from the interior of the udder may have lodged upon the bits of tissue during the transfer. The identity in cultural and morphologic characters of bacteria found in the fore milk and in the glandular tissue of the udder would largely eliminate a source for false conclusions.

The tubes of slanted agar, after standing in the incubator for several days, were examined particularly with reference to the presence or absence of growth. Note was taken of the color and character of the growth of the colonies, and sub-cultures were made.

The gelatin plate cultures * were in like manner examined, and furnished a more satisfactory method for obtaining pure cultures. With these, a direct comparison made it possible to trace the presence of the same organism in the three localities. In order to prove that these identities existed, sub-cultures were made for a more detailed comparison later. The plate cultures made from the milk were examined and sub-cultures were made from all of the apparently different colonies.

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* The gelatin plate pictured on the first cover page gives an idea of the number of colonies occurring in the cultures made from the glandular tissue of the udder. The culture was rather old when photographed. Hence the colonies are larger and have become more confluent than when first examined. The bit of glandular tissue may be seen as an irregular shaped black area near the center of the plate culture. The illustration is about one-half the diameter of the original plate.

In the examinations of udders 7 and 8, bits of tissue were brought to the laboratory in sterile test tubes. They were then placed in cool liquid agar and treated thereafter similar to gelatin. The results from this use of agar was less satisfactory than those from gelatin, since the growth of most species is less distinctive upon agar.

BACTERIOLOGIC EXAMINATION OF THE GLANDULAR TISSUE.

Group 1.—In this examination * a large number of sub-cultures were made. The growth of the cultures was studied on several kinds of media and each was examined microscopically. They were found to be nearly all micrococci and to belong to one of three species. A spore bearing bacillus belonging to the *Bacillus subtilis* group and another organism probably *B. fluorescens liquefaciens* were occasionally encountered in this and the following examinations. It is possible that they are contaminations, but our lack of knowledge of the bacteria in freshly drawn milk renders it unsafe to deny their presence within the udder. A number of other cultures, each found in but a single instance, were discarded. The writer does not wish to be understood as offering the following brief summaries of cultural characters as full descriptions. The loss of most of the cultures has rendered it impossible to present but little more information concerning their cultural characteristics than was considered in classifying them into the three groups of similar cultures.

MICROCOCCUS NO. 1.

Morphology.—A micrococcus about 1μ in diameter.

Staining.—Stained readily by the common anilin dyes.

Agar.—The growth † is white, shiny and viscid rather than friable.

Alkaline bouillon.—This medium becomes slightly clouded with the deposition of a white sediment easily disseminated by agitation. The reaction remains constantly alkaline.

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* The writer is indebted to Dr. Cooper Curtice for the privilege of examining the above group of udders.

† The temperature, except in the case of gelatin cultures is to be understood as 37.5 degrees centigrade.

Ten per cent gelatin, stab.—Colonies are white and are very slightly depressed, due apparently to a slight liquefaction. In a stab culture the needle's path is marked by a whitish growth. The surface exhibits a white colony of creamy consistency, but no general liquefaction occurs even after a month's growth.

Fermentation tube.—Growth in one per cent solutions of glucose and of lactose in bouillon occurs only in the open arm of the tube. The reaction remains alkaline.

Milk.—Litmus milk remains blue and is not visibly changed.

TABLE NO. I.

THE SOURCE OF PURE CULTURES OF MICROCOCCUS NO. 1.

Udder.	Quarter of udder.	Region.
No. 1	Right fore.	Fore milk and strippings.
" 1	Right hind.	B (see description of diagram).
" 1	Right fore.	A (" " ").
" 2	Right fore.	A, C, also fore milk.
" 3	Right fore.	Fore milk.

MICROCOCCUS NO. 2.

Morphology.—A micrococcus about 1μ in diameter.

Staining.—Stained readily by the common anilin dyes.

Agar.—Color * varies from cream white to ocher depending upon age and other undetermined conditions. During active growth the color assumes successively the tints lying between cream white and ocher. The color is the distinguishing feature of the growth upon agar. The color of old cultures fades.

Alkaline bouillon.—Growth renders the liquid clouded, with the deposition of a yellowish sediment. Reaction remains constantly alkaline.

Milk.—Milk is coagulated in from three to five days.

Ten per cent gelatin, stab.—This medium is gradually liquefied, the fluid becoming turbid, while a yellowish sediment is deposited.

* The writer employs Saccardo's color chart for the nomenclature of colors.

The liquefaction extends downward in a zone involving the whole area of the tube, but preceded slightly by a pit following the track of the inoculating needle.

Fermentation tube.—Growth in one per cent solutions of glucose and lactose in bouillon, occurs only in the open arm of the tube. The reaction remains alkaline.

TABLE NO. II.

THE SOURCE OF PURE CULTURES OF MICROCOCCUS NO. 2.

Udder.	Quarter of udder.	Region.
No. 1	Left hind.	A
" 1	Right hind.	B
" 1	Right fore.	A
" 3	Right fore.	B
" 4	Right fore.	A

MICROCOCCUS NO. 3.

Morphology.—A micrococcus about 1 μ. in diameter.

Staining.—Stained readily by the common anilin dyes employed in the laboratory.

Agar.—Growth is lemon yellow in color and somewhat viscid in consistency.

Alkaline bouillon.—The fluid becomes slightly clouded with the formation of a lemon yellow pellicile and deposition of a sediment of the same color. The reaction remains alkaline.

Milk.—The casein is precipitated in six days with an alkaline reaction. It is rapidly digested during the few following days, forming a yellowish liquid.

Ten per cent gelatin, stab.—This medium is gradually transormed by liquefaction into a fluid of yellow color.

Fermentation tube.—Fermentation tubes containing a one per cent solution of glucose or of lactose in bouillon, show a cloudiness in the open arm of the tube only. The reaction remains alkaline.

TABLE NO. III.

THE SOURCE OF PURE CULTURES OF MICROCOCCUS NO. 3.

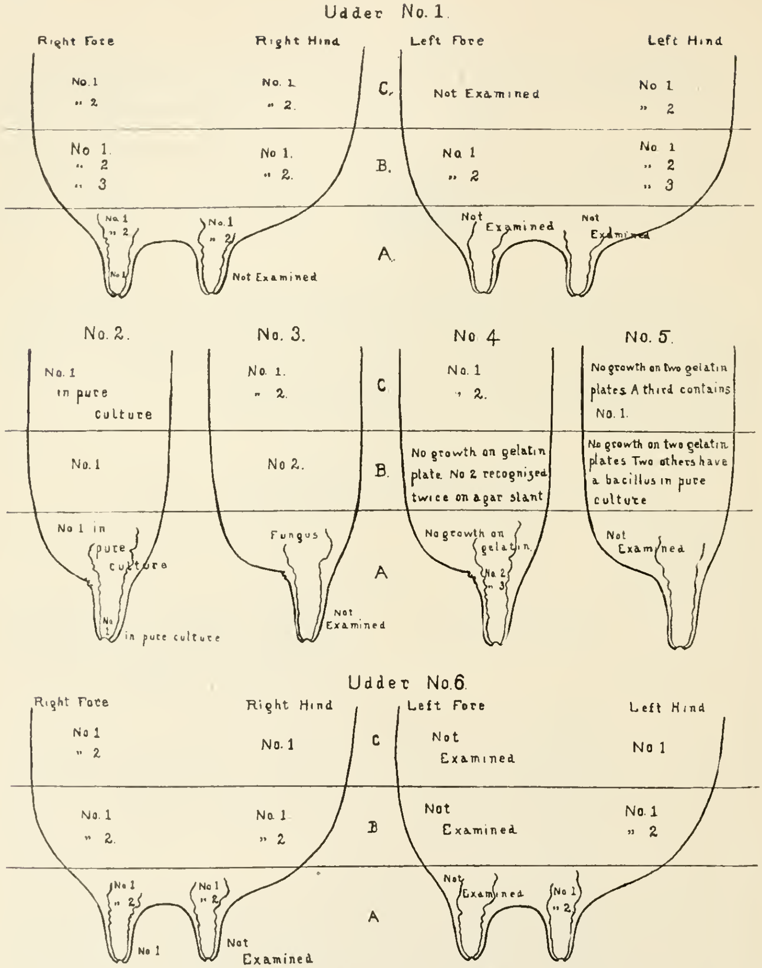
Cow.	Quarter of Udder.	Region.
No. 1	Right hind.	B
" 3	Right fore.	A
" 3	Right fore.	B
" 4	Right fore.	A

A considerable number of tubes of slanted agar were inoculated with bits of tissue, the size of a pea, taken from the several regions of the six udders comprising group 1. The results are summarized in the following table.

TABLE NO. IV.

AGAR SLANT CULTURES MADE FROM UDDERS, GROUP I.

Udder No.	No. Inoculated.	Source.	Resulting growth.
1	26	Regions A, B and C of four quarters.	In 22, a confused mass of white, ocher and lemon yellow colored colonies of micrococci Nos. 1, 2 and 3. In 4, *B. subtilis*(?) only.
2	5	Milk, right fore quarter.	Pure culture of micrococcus No. 1.
		Region A, right fore quarter.	Pure culture of micrococcus No. 2.
		Region B, right fore quarter.	Micrococcus No. 1 and spore bearer.
		Region C, right fore quarter.	Clear.
		Region C, right fore quarter.	Pure culture of mocrococcus No. 1.
3	15	5 each from A, B, C, right fore quarter.	3 remained sterile, 12 exhibited a confused mass of colonies of species 1, 2 and 3.
4	8	A, B and C of right fore quarter.	Confused mass of colonies of species 1, 2 and 3.
5	18	A, B and C of right fore quarter.	1 from A remained sterile. Remainder showed species 1, 2 and 3.
6	23	A, B and C of four quarters.	6 overgrown by a member of *B. subtilis* group. Remainder presented a confused mass of species 1, 2 and 3.



A Graphic Representation of the Bacterial Flora of Udders Nos. 1 to 6.

The areas designated by the letters A, B, C, indicate the three arbitrary divisions into which the gland was divided for purposes of examination. A figure (1, 2, or 3) in the canal of the teat indicates that a culture of the micrococcus bearing that number was isolated from a sample of the fore milk. Figures elsewhere indicate that either a pure culture of the species in question was obtained from the place indicated or that colonies of that species were recognized from peculiarities of growth. One quarter only of udders Nos. 2, 3, 4 and 5, three of No. 6 and four of No. 7 were examined.

TABLE V.

SUMMARY OF RESULTS OF THE BACTERIOLOGIC EXAMINATION OF UDDERS NOS. 1 TO 6.

Gelatin plate cultures.					Agar slant cultures.	
Udder No.	Quarter.	Region.	No. made.	Colonies.	No. made.	Colonies.
1	R. F.	A	1	Numerous.	2	1st. *B. subtilis* (?) only. 2d. Species No. 2 on tissue.
		B	0	No cultures made.	2	1st. *B. subtilis* (?) only. 2d. White, ocher and lemon colored cocci. (No. 1, 2, 3.)
		C	0	No cultures made.	1	White and ocher cocci. (No. 1 and 2).
	R. H.	A	1	16 colonies of two species.	1	*B. subtilis* (?) and species 1 and 2.
		B	2	1st. Liquefied *B. fluorescens liquefaciens* (?). 2d. Colonies like region A and *B. fluorescens liquefaciens* (?).	7	All show Nos. 1 and 2, and *B. subtilis*(?).
		C	2	1st. Liquefied by *B. fluorescens liquefaciens* (?). 2d. Same but shows colonies like region A.	6	All show species Nos. 1 and 2. 5 show *B. subtilis* (?), 1 shows *B fluorescens liquefaciens*(?).
	L. F.	A	1	Liquefied by *B. fluorescens liquefaciens* (?).	2	1st. Shows Species No. 1 and *B. subtilis* (?) 2d. White and ocher coccus. Nos. 1 and 2.
		B	0		0	
		C	0		0	
	L. H.	A		1st Shows 10 colonies of No. 1. 2d. Numerous.	2	*B. subtilis* only in both.
		B	0		2	Nos. 1, 2, 3 in both.
		C	0		1	Nos. 1, 2, 3.
2	R. F.	A	2	1st. No. 1 and 2 fungi. 2d. Fungous growth over plate.		See Table IV.
		B	0			See Table IV.
		C	2	1st. No. 2 on tissue. 2. Clear.		See Table IV.

TABLE V.— CONTINUED.

Gelatin plate cultures.					Agar slant cultures.	
Udder No.	Quarter.	Region.	No. made.	Colonies.	No. made.	Colonies.
3	R. F.	A	2	1st. Fungus on tissue. 2d. Clear.	6	These and the cultures from B and C with three exceptions contain Nos. 1 and 2.
		B	1	Fungus and B. *fluorescens liquefaciens* (?)	5	See above.
		C	1	Several colonies of white and of yellow cocci.	4	See above.
4	R. F.	A B C	1 1 0	Fungus over plate. Clear.	8	Eight agar slant cultures from regions A, B and C showed growth of Nos. 1, 2 and 3.
5	R. F.	A	4	2 clear, 2 contain 10 and 50 colonies respectively of a bacillus.	18	1 culture clear, 2 contain B *fluorescens liquefaciens* (?) 15 others from the various regions show colonies of Nos. 1 and 2. A few show *B. subtilis* (?) also
		C	4	2 clear, 1 contains 6 colonies of a bacillus, 1 contains 6 colonies of white coccus. (No. 1.)		
6	R. F.	A	1	Liquefied by a bacillus.	3	Nos. 1, 2, and *B. subtilis* (?) in each.
		B	1	Three or four colonies of No. 2.	3	All show *B. subtilis* (?) only.
		C	0		3	2 show Nos. 1 and 2, 1 *B. subtilis* (?) alone.
	R. H.	A	1	Four colonies of No. 2	1	*B. subtilis* (?) only.
		B	0		1	No. 2 and *B. subtilis* (?)
		C	0		1	*B. subtilis* (?) only.
	L. H.	A	1	Fifteen colonies of No. 2.	2	1st. No 2 and B subtilis (?) 2d. white coccus and *B. subtilis*. (?)
		B	0		2	1st. shows No. 1. 2d. No. 1 and 2.
		C	0		2	1st. No 1. 2d. *B. subtilis* (?)

Group II.—In January 1899, an opportunity was offered for the examination of two more udders in the manner already described. During the examination of the gelatin plate cultures two apparently different colonies were distinguished as predominating. Sub-cultures were made from these, but were lost before they were compared with the three cultures from the preceding examination. Nevertheless a tabulation of the results from an examination of the growth upon the gelatin plates will be of interest in its bearing on the subject of the general invasion of the normal udder by bacteria. Species No. 4 is a bacillus liquifying gelatin. Species No. 5 is probably identical with No. 2.

TABLE VI.

SUMMARY OF RESULTS OF THE BACTERIOLOGIC EXAMINATION OF UDDER NO. 7.

Quarter of udder.	Region.	No. of colonies.	Species.
Right fore	A	2	No. 4
" "	B	15	" 4
" "	B	10	" 5
" "	C	1	" 4
Right hind	A	None	—
" "	B	None	—
" "	C	None	—
Left fore	A	10	No. 5
" "	B	100 to 200	" 4
" "	C	50	" 4
		2	" 5
Left hind	Cistern milk	4	" 4
" "	A	3	" 5
" "	B	None	—
" "	C	22	" 4
" "	Cistern milk	5	" 5

TABLE NO. VII.

SUMMARY OF RESULTS OF THE EXAMINATION OF UDDER NO. 8.

Quarter of Udder.	Region.	No. of colonies.	Species.
Right fore..........	.........A........	......20......	.....No. 5
" "	.........B........	......50......	....." 5
" "	.........C........	......15......	....." 5
Right hind.........	.........A........	...... 2......	....." 4
" "	.........A........	...... 3......	....." 5
" "	.... B........	...... 8......	....." 4
" "	.........C........	...... 1......	....." 4
" "	.........C........	...... 3......	....." 5
Left fore..........	.........A........	...... 4......	....." ?*
" "	.........B........	... . ?......	.........?
" "	.........C........	...... ?......	.........?
Left hind..........	.........A........	... Clear ...	.........?
" "	.........B........	... .. 1......	...." 4
" "	.........C........	......18......	....." 4

* Notes incomplete.

The examination of the agar plate cultures confirmed the conclusions drawn from the examination of the gelatin plates. Owing to the fact that (1) the colony growth of species is never so distinctive on agar as upon gelatin, and (2) that micrococcus No. 2 assumes a diversity of shades on agar, the results obtained from the examination of the agar plates do not lend themselves to a concise tabulation.

Group III.—An examination of udders 9 and 10 confirmed the results of previous examinations. Every culture from the regions A, B, and C of each quarter of the two udders, showed growth. Neither sub-cultures, nor further study of the plates were made.

Group IV.—In the examination of these udders gelatin only was used, experience having demonstrated its superiority. As in the former examinations, the results indicated an extensive invasion of the udder. In practically every quarter, it was possible by comparison of the gelatin plates, to observe the similarity of the bacterial flora in each of the regions A, B, and C. Two species of micrococci were found in considerable numbers in all of the udders.

MICROCOCCUS NO. 6.

Morphology.—A micrococcus about 1μ in diameter.

Staining.—Stained readily by the common anilin dyes in use in the laboratory.

Agar.—The colonies are circular, viscid, white, but assume a cream color later. The growth on agar slant cultures is white, shiny, pasty, with an irregular border. The condensation water is clouded with flocculent sediment.

Alkaline bouillon.—The liquid becomes clouded with the deposition of a whitish sediment, easily disseminated by agitation.

Ten per cent gelatin.—Colonies are circular, varying in color from cream to ocher, and each occupying a slight indentation in the medium. Later, the area of liquefaction becomes larger and the colonies disintegrate into grandular masses floating in the liquid. In the stab cultures the needle's path is marked by a white dotted growth, more abundant near the surface. The liquefaction extends downwards in a few days forming a liquefied area involving the whole width of the medium. The center becomes liquefied somewhat in advance of the edges, forming a cone-shaped liquefaction.

Milk.—It remains fluid even after months, with the accumulation of a yellowish sediment in the bottom of the tube. Litmus milk is unchanged in color.

Fermentation tube.—Growth in one per cent solution of glucose, lactose and saccharose in bouillon occurs only in the open arm of the tube. The reaction remains alkaline.

TABLE NO. VIII.

THE SOURCES FROM WHICH PURE CULTURES OF MICROCOCCUS NO. 6 WERE OBTAINED.

Udder.	Quarter.	Region.
No 11	Right fore.	A
" 11	Left fore.	A
" 11	Left fore.	B
" 15	Right hind.	B
" 15	Right hind.	C
" 11	Right hind.	B
" 11	Left hind.	A
" 12	Left fore.	Fore milk

MICROCOCCUS No. 7.

Morphology.—A micrococcus about 1μ in diameter.

Staining.—Stained readily by the common anilin dyes used in the laboratory.

Agar.—Smooth, shiny, white growth upon agar slant cultures.

Bouillon.—The liquid becomes uniformly clouded with the deposition of a whitish sediment.

Gelatin.—The growth is similar to that of No. 6, except that the colonies of No. 7 are always white.

Milk.—It is coagulated with an amphoteric reaction in three days.

TABLE NO. IX.

THE SOURCES FROM WHICH PURE CULTURES OF MICROCOCCUS NO. 7 WERE OBTAINED.

Udder.	Quarter.	Region.
No. 11	Right hind.	Fore milk
" 11	Left hind.	A
" 12	Right fore.	B
" 12	Right fore.	C
" 13	Right fore.	B
" 14	Right hind.	A
" 15	Right hind.	A

TABLE NO. X.

SUMMARY OF RESULTS OF THE EXAMINATION OF GELATIN PLATE CULTURES FROM UDDER NO. 11.

Udder No.	Quarter.	Region.	No. made.	Observations.
11	R. F.	A	1	Numerous.
		B	1	Six colonies and mould.
		C	1	Exceedingly numerous.
	R. H.	A	1	Exceedingly numerous.
		B	1	Numerous.
		C	1	Numerous.
	L. F.	A	1	About twenty-five colonies.
		B	1	Numerous. Liquified *B. subtilis* (?)
		C	1	Very slight growth bordering tissue.
	L. H.	A	1	Numerous.
		B	1	Tissue ocher colored, 5 colonies.
		C	1	Numerous.

TABLE NO. XI.

SUMMARY OF RESULTS OF THE EXAMINATION OF GELATIN PLATE CULTURES OF UDDERS 12, 13, 14, 15.

Udder No.	Quarter.	Region.	No. made.	Observations.
12	R. F.	A	1	Entirely liquefied.
		B	1	Numerous.
		C	1	Numerous.
	L. F.	A	1	Entirely liquefied.
		B	1	Slight liquefaction near tissue. No colonies.
		C	1	About twelve colonies.
13	R. F.	A	1	Fungus.
		B	1	About twelve colonies.
		C	1	About eight colonies.
14	R. F.	A	1	100–200 colonies, many liquefiers.
		B	1	Completely liquefied.
		C	1	Completely liquefied.
	R. H.	A	1	100–200 colonies.
		B	1	Fungus, and numerous colonies.
		C	1	Few.
15	R. H.	A	1	Fungus, and about 100 colonies.
		B	1	About twenty-five.
		C	1	Few.

Group IV.—An examination of udders Nos. 16 to 19 inclusive is being made just as this publication goes to press. The results cannot be discussed in detail at present. A bacillus is found quite generally distributed in the fore milk and the four udders. This bacillus agrees with the micrococci, heretofore obtained, in its long deferred action upon milk. At 37.5° C., after five days the casein of milk is precipitated with an alkaline reaction. The coagulum is subsequently digested.

THE STRUCTURE OF THE UDDER.

A study of the relations of the milk channels and reservoirs of the udder tends to strengthen the conclusions that the udder may be normally invaded by bacteria. Figure 58 shows a plaster of Paris cast of the lower portion of one quarter of an udder. The duct of the teat, and the milk cistern (galactiferous sinus), are plainly shown. The plaster penetrated the fine lactiferous ducts of the udder, but owing to the fragile nature of the cast, it was impossible to dissect away the tough tissue without ruining the model.

There will be seen in figure 58 a slight constriction indicating the boundary between the duct of the teat and the milk cistern proper. In the examination of the udders incident to the bacteriologic work, care was taken to ascertain if there was present a distinct barrier separating the milk cistern from that of the teat. Such was not found. There was seen, however, a considerable variation in the size of the constriction in the different quarters of the several udders. The presence of circularly disposed plain muscle fibres in the constriction of the mucous membranes and in the mucosa throughout the whole length of the teat has been demonstrated by the writer by histologic methods. The point to be emphasized is that no obstruction capable of excluding bacteria from the milk cistern exists, except perhaps, the sphincter muscle at the lower end of the teat.*

Fig. 58.—*A plaster of Paris cast of the interior of the teat and milk cistern of one quarter of an udder.*

Plate 1 shows much better the system of milk channels in the udder. One-half of the udder of a cow was injected through the teats with a mass of hot gelatin containing lamp black in suspension. After cooling, which solidified the gelatin, a section was made and photographed. The gelatin was previously removed from the cavities of the teat,

* Dr. R. G. Freeman has observed that the milk of some cows when drawn from the udder with aseptic precautions shows a considerable bacterial content even after the milking period is more than half completed. He has also found that this invasion is much more marked in the udders in which the ends of the teats are imperfectly closed by weak sphincter muscles than in those possessing teats which are firmly closed at their lower extremities.—From unpublished data furnished by courtesy of Dr. Freeman.

milk cistern and its larger ramifications, in order to show the lining mucous membrane of those cavities. Since the udder was not secreting milk when the cow was killed, the glandular tissue occupied the minimun amount of space. This resulted in a general darkening of the udder by the lampblack without the contrast which would have shown more clearly the individual lactiferous ducts.

The free communication of the milk cistern with the more minute lactiferous ducts is at times interrupted by the sphincter muscles described by anatomists as present in those ducts. There is little ground, however, for considering them as serious barriers to the progress of micro-organisms one twenty-five thousandths ($\frac{1}{25000}$) of an inch in diameter.

That the milk ducts of the teat normally harbor bacteria is admitted by all. Some few, with whom the writer agrees, assert that the milk cistern normally harbors bacteria. Such being true, there is little reason to doubt that bacteria may find their way through the fine ramifications of the milk cistern (lactiferous ducts) to regions remote from the teat. Pathogenic organisms certainly do so when the udder is diseased and to conceive that harmless ones do so in health is not difficult.

THE IMPORTANCE OF THE PROBLEM.

It will be noted that none of the species of micrococci isolated from the udders are capable of rapidly souring milk. They are, on the contrary, inert as regards their immediate visible effect. A similar fact has been noted by Dinwiddie* in regard to the bacterial flora of the fore milk of two cows studied by him.

Bolley† likewise has expressed his belief, "that comparatively few forms may multiply within the normal udder, and that these are perhaps scarce to be considered as detrimental forms."

The writer has repeatedly isolated micrococci from the fore milk of the University herd, apparently identical with some of those found in the udders of the freshly slaughtered milch cows from the herds mentioned elsewhere in this bulletin.

*R. R. Dinwiddie, Arkansas Agricultural Experiment Station, Bulletin No. 45, p. 56.

†H. L. Bolley, North Dakota Experiment Station, Bulletin No. 21.

On the other hand, Moore* has isolated species from the fore milk which were capable of rapidly souring milk and hence of great importance to the dairyman.

The methods† employed by the present writer unfortunately were not such as would have permitted the recognition of *Bacillus acidi lactici* had it been present. Esten has found this organism in the fore milk of several cows and has shown that it grows best at the temperature of the cow's body. He has suggested that *Bacillus acidi lactici* in milk may come originally from the milk duct of the teat. A further examination of the lactiferous ducts of the udder employing methods adapted for the easy recognition of acid producing organisms would be of the greatest interest.

The principle at stake is an important one. If harmless species invade the udder, certainly there is a possibility that species capable of injuring milk, but harmless to the cow, may be present. Moore and the writer ‡ have studied a gaseous fermentation occurring in cheese curd, in which the gas producing bacteria appear to have been localized in the udders of the cows supplying the milk used in the factory.

The ineffectual attempts to obtain milk in commercial quantities uncontaminated by bacteria can be directly ascribed to the presence of bacteria within the depths of the udder. Since the dangers from the contamination of milk by fecal matter etc., have been recognized the advisability of Pasteurizing all milk and cream which are to be consumed raw, has been considered. The application of that suggestion causes some undesirable changes in the heated milk. Among these are: loss of property of creaming readily and of the most importance in milk for infants' food, the alleged lessening of the digestibility of heated milk. To obviate this difficulty, attempts have been made to bottle milk directly from the udder with the exercise of such precautions as to prevent contamination by bacteria. Milk drawn with rigid care, after rejecting the fore

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* Loc. cit.

† W M. Esten, Bacillus acidi laciti and other acid organisms found in American dairies. Ninth Annual Report of the Storrs Agricultural Experiment Station, p. 49.

‡ Loc. cit.

milk and hermetically sealed in the bottles many remain sweet during an ocean voyage to Europe and return. That milk drawn with such care is not sterile and that it ultimately teems with microorganisms although sweet to the taste, is a fact which the writer has been assured by unquestionable authority. Such behavior of milk might be expected from the character of the micrococci isolated from the udder, and is indicative of contamination from that source.

Judged from the standpoint of the dairyman, who considers that souring is the one and only harmful change in milk, the contamination of milk from the interior of the udder, so far as has been shown in this work, might be disregarded as unimportant. Until more is known of the ordinary and of the occasional bacterial inhabitants of the udder and of their ability to elaborate enzymes and toxic substances, the writer urges the recognition of that source of the contamination of milk.

CONCLUSIONS.

1. The lactiferous ducts of the nineteen udders examined, harbor bacteria throughout their whole extent.

2. Our present knowledge concerning the place at which bacteria first gain access to milk, should be expressed somewhat as follows: Milk when secreted by the glands of the healthy udder is sterile. It may, however, immediately become contaminated by the bacteria which are normally present in the smaller milk ducts of the udder.

3. The bacteria so far found in the interior of the udder, apparently do not affect milk seriously. This, however, does not preclude the probability that forms more injurious to milk may invade the udder.

4. The constant contamination of milk from the udder suggests an explanation for the frequent occurrence of certain "dairy bacteria" in milk.

5. A study of the anatomy of the udder fails to disclose structural features which could prevent the invasion by bacteria.

ACKNOWLEDGMENT.

The Dairy Division is indebted to Dr. James Law, Director of the New York State Veterinary College, and to Professor V. A. Moore, of the same college, for exceptional privileges in the Department of Comparative Pathology and Bacteriology where the major portion of this investigation was conducted. In addition, the writer is personally indebted to Dr. Moore for the fundamental methods employed in the investigation and for his personal assistance in several examinations. Instructor F. R. Wright of the same department has rendered aid in field work incident to the investigation.

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Dairy Bacteriology.

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158 Source of Gas and Taint Producing Bacteria in Cheese Curd.
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171 Concerning Patents on Gravity or Dilution Separators.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1899.

171. Gravity or Dilution Separators.
172. The Cherry Fruit-Fly: A New Cherry Pest.
173. The Relation of Food to Milk-Fat.
174. The Problem of Impoverished Lands.
175. Fourth Report on Japanese Plums.
176. The Peach-Tree Borer.
177. Spraying Notes.

Bulletin 179. **February, 1900.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

CHEMICAL DIVISION.

INTRODUCTION TO

Field Experiments with Fertilizers.

59.—*Results of thorough and hasty preparation—Buckwheat.*

By A. L. KNISELY.

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The regular bulletins of the Station are sent free to all who request them.
* Absent on leave.

Cornell University, Ithaca, N. Y., February 1, 1900.

Honorable Commissioner of Agriculture, Albany.

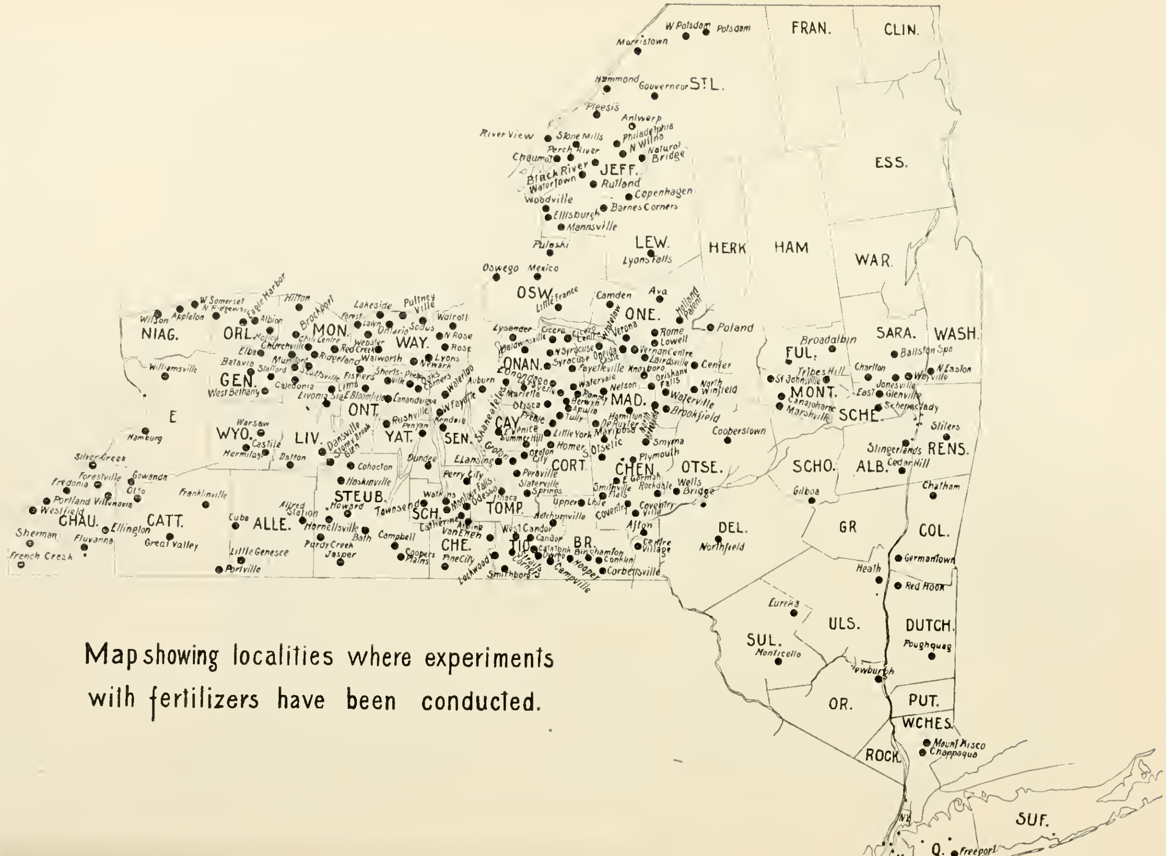
Sir: It cannot be denied that the use of commercial fertilizers is a source of profit for the farmer, when they are used in the right way. But the common way of using them is not the right way. The application of a complete fertilizer, without knowing whether the crop to be fertilized needs the three plant-foods, or whether the yield may not be just as large, if but one, or perhaps two of them are supplied, usually results in waste.

The purpose of the field experiments with commercial fertilizers, an account of which is given in part in this bulletin was to interest farmers in testing their soils in order that they might learn what plant-food is deficient for the crops that they wish to raise, and also whether the commercial fertilizers used are more or less profitable than good stable manure.

The results of these experiments have taught many farmers that they have not been using these fertilizers in the right way; this work has also taught them how to experiment. To Dr. G. C. Caldwell, Chemist of the Experiment Station, much credit is due for having inaugurated this plan of conducting field experiments. The work has been made especially effective by the zeal with which the author of this bulletin has superintended the experiments during the three years of their continuance. In his visits to a large number of the farms where experiments were being carried on he helped and encouraged the experimenters by his valuable criticisms and suggestions.

It is hoped that this work can be continued during the present year.

I. P. Roberts, Director.



Map showing localities where experiments with fertilizers have been conducted.

INTRODUCTION TO

FIELD EXPERIMENTS WITH FERTILIZERS.

A difficult problem.—Some of the questions most frequently asked by farmers are these: What fertilizer shall I use on my land? How can I tell just what combination or mixture of plant-foods is best adapted to my soils? What is the best all round fertilizer? Such questions are among the hardest that can be asked in the whole field of agriculture. They cannot be answered offhand in a day or a week; it may take months and in some cases years to answer them. Many a farmer spends his whole life on the farm without even trying to solve these problems, or without getting correct answers if he does try to solve them.

What regulates crop production.—A farmer grows an acre of corn and harvests a modest crop of 10 bushels. What is the cause of this very poor yield? Something must be wrong and it is for him to try and find out wherein the trouble lies. The poor yield may be due to one or more of several conditions. It may be a lack of moisture, or too much moisture; the soil may be too acid; it may be deficient in either nitrogen, phosphoric acid or potash; it may be too cold and heavy; it may not contain enough nitrifying organisms to maintain a good supply of nitrates or it may contain too many denitrifying organisms which destroy nitrates; it may be too compact and therefore may not leave enough air spaces between the soil particles; capillary action may be imperfect; there may be a lack of humus; the texture may not be suitable to the crop grown; and so on.

The law of the minimum.—This is most important with reference to plant growth. It means that the one essential condition which is at a minimum, or is at the lowest grade, during the growth of a crop, is the one condition that regulates the amount of crop grown.

For example, a field may have all the essential conditions favorable for producing a large crop, except one. Let that one be a lack of available phosphoric acid, then the amount of crop grown is regulated by the amount of available phosphoric acid present. If this quantity is increased, the crop will be increased. To apply nitrogen or potash to this soil would be unwise for it may be taken for granted that these plant-foods are already present in sufficient quantity for at least a fair crop. Again, suppose that the essential condition which is at a minimum is a lack of humus, or it may be an unsuitable texture. Then the total crop produced will be governed by the amount of humus or by the texture. If the amount of humus in the soil is increased or if the texture is improved then this soil becomes more productive. An application of commercial fertilizers to such a field would have little or no beneficial effect.

It sometimes happens that some essential condition is at such a low grade, and is of such a character that the farmer can recognize it at a glance; for instance, a soil may be a very stiff, hard, compact clay, similar to a brickyard. Such a soil must be loosened and made porous and friable or mellow. Its texture must be improved before one could expect to obtain profitable results from the use of fertilizers. But if the farmer wants to make the most that he can out of his farm he will not stop here; for just as soon as one low-grade condition has been improved and larger crops are thereby obtained, some other condition may be at a minimum and consequently regulates the amount of crop produced. This becomes the condition to be sought out and improved in order that the productivity of the soil may be raised to a higher standard.

These essential conditions may be likened to a lot of jack-screws and the productivity or fertility of the field to a large house. If we wish to raise this house, we distribute the jack-screws in various places under it. If the house is to be raised without damage, every one of these jackscrews must be carefully watched and that one which is the lowest must be screwed up; presently some other screw becomes the lowest and that one in turn must be attended to and so on with every one of the supports.

If all the screws are carefully watched the house rises properly; if only a part are watched and no attention is paid to the others, before long something is liable to be strained and the house may be badly injured. So it is with the fertility of a soil: each and every one of the many conditions essential for raising a large crop must be carefully watched: those which are constantly falling short in consequence of the improvement of the others must themselves be likewise improved in order to keep the fertility up to its maximum. If only a few of the essential conditions are looked after, the soil will in time become less productive and the farmer becomes discouraged and sums up the whole difficulty by saying, "Farming don't pay." On the other hand, a successful, wide-awake farmer is constantly trying to find out, and does detect and improve those conditions of his soil which are at the lowest ebb, and to him farming *does* pay.

Take for another illustration an actual case in which an important condition, namely capillary action, was at a low grade. Two adjacent fields were prepared for buckwheat; the same seed was used on each field, it was sown at the same rate per acre and with the same drill. Similar fertilizers were applied to each field; the amount applied and the manner of applying them were the same. For the results see the frontispiece.

The only known difference between the two fields was this; one was thoroughly prepared, the other was prepared in a hurry. The thoroughly prepared field was plowed in advance of planting-time and the soil had settled somewhat, so that its capillary action had time to re-adjust itself and was able to pump up moisture from below to keep the seed-bed damp; consequently the buckwheat sprouted promptly and grew luxuriantly thereafter.

The hastily prepared field was plowed just before the buckwheat was sown. The capillary action was broken up and did not have time to re-adjust itself, consequently the moisture from below could not rise to the seed-bed. The surface soil soon became dry and the buckwheat grew very slowly owing to the lack of moisture in the uppermost few inches of the arable layer.

This season the author's attention was called to another interesting case. A farmer planning to sow buckwheat started an early preparation of the soil. The headlands were plowed and also a narrow strip across the field, before night came on. Plowing could not be finished, however, until planting-time. Then the work was done hastily on the remainder of the field and the seed was sown. The results were that the headlands and the narrow strip across the field that were plowed early, and had re-adjusted the capillary action before planting-time, yielded a large crop that even lodged considerably. The rest of the field was scarcely worth harvesting.

The object of the experimental work.—This work was undertaken for the purpose of helping the farmers of the State to detect and improve some of the low-grade conditions of their fields. Experimental work with fertilizers, which is the subject of this bulletin, was taken up. It was the plan of the Station to send to such farmers as would agree to do the work, a sufficient quantity of the three plant-foods, nitrogen, phosphoric acid and potash, separately and in combination, with directions for a series of experiments for the purpose of determining whether any separate plant-food or any combination of them would increase the crops to which they were applied. The results of such experiments, carried out according to directions, should assist the farmer to decide what plant-foods his soils need, if any, for the production of satisfactory crops.

If the series of experiments proves to be a failure, that is, if it gives no marked or definite results, it is still valuable. It at least shows the farmer that his soil is not in a condition to respond to the use of fertilizers, which means either that it is already well stocked with available food or that some one or more of the essential conditions other than plant-food conditions need looking after and improving before much money or time is spent on fertilizers.

Extent of the experimental work and the results in general.—During the past three years 371 sets of fertilizers have been sent to farmers in various parts of the State. (See map, page 286.) The time at which the appropriation for this work became available in the spring was so far advanced, that in some cases the fertilizers were received by the farmers much later than they should have been applied to the soil; the results may therefore have been less satisfactory than might otherwise have been the case.

A majority of the experimenters have been visited by a Station representative ; in some cases photographs of the crops have been taken ; in other cases samples of soil have been sent to the Station for analysis. In general the farmers manifested much interest in the work and most of them took great pains with it. A few were disappointed because it required so much "time and fussing." Of all the experimenters only one failed entirely to catch the spirit of the work ; owing to some misunderstanding he dumped the small sacks of fertilizers into a tub, mixed them together, and applied the mixture on a small plat of land. He reported that he thought the fertilizer increased the crop somewhat—a report of no use to him or to us.

A number of the experimenters made the mistake of measuring off too small plats and consequently the fertilizers in some cases injured the crop. A large number did the work well and kept good records, but many of them unfortunately omitted the check plat without fertilizers. This plat was absolutely necessary as a standard for the measuring of the crops grown on the several fertilized plats. Without it the results obtained on the fertilized plats were almost worthless for the experimenter ; he could not decide whether or not any of the fertilizers had inceased the yields, or whether any one gave a profitable crop. However, notwithstanding all these unfortunate drawbacks there were many experimenters who followed all the directions and felt that they had profited by the work.

In 1897 and again in 1898, fertilizers were used at the rate of 200 lbs. of nitrate of soda, 400 lbs. of superphosphate and 200 lbs. of muriate of potash per acre. Owing to the prevalence of acid soils, in 1898 it was advised to use lime when convenient, on half of each plat at the rate of two tons per acre. In 1899 the application of fertilizers was increased to 300 lbs. of nitrate of soda, 600 lbs. of superphosphate and 300 lbs. of muriate of potash per acre.

Acid soils.—Within the last few years the subject of acid soils has been brought to the attention of farmers and questions are requently asked about this acidity or sourness of soils. While traveling about the State, the Station representative had exceptional opportunity for testing various soils for acidity ; the tests were made by leaving blue litmus-paper in contact with the moist soil for five minutes. The presence of acid in the soil would be indicated by a reddening of the paper. One hundred and eighty-six tests were made in different parts of the State ; of these, 160 indicated the presence of considerable acidity. Generally, the most acid soils were found to be uplands, usually sandy or light clay loams and especially soils underlaid with hardpan. In several cases low-lying, wet, muck soils were tested and were found to be free from acid.

Acid soils must not always be associated with poor crops. Some acid soils produce very poor crops, others luxuriant crops. The most thrifty cornfield seen during the season was growing on very acid or sour soil. The same was also true with potatoes. Experiments show that both corn and potatoes are not affected by acid in the soil. Potatoes grown on acid soil were better, smoother, less scabby and diseased than those grown on soil not acid. Many clover fields were tested and most of them showed acid, but usually the best fields would have the least acidity. Generally, common plantain and sorrel would be sure indications of free acid in the soil.

Was the use of lime beneficial?—Since the presence of acid in the soil was found to be so common, it was thought best to try the use of lime for correcting this acidity ; it was applied at the rate of two tons per acre, in some cases quicklime slaked on the field, in others air-slaked lime. Thirty-one field tests were thus made. Several months after this application these soils were found to be just about as acid, producing the same change of the litmus-paper as the adjacent soils which had not been limed. The use of lime by itself gave very good results in seven cases, injurious results in three cases, and indifferent results in twenty-one cases. When used in connection with fertilizers, the results were in five cases very good, in four injurious, and in twenty-two indifferent. In two cases the use of lime was followed by an injurious effect upon the physical condition of the soil, consisting of clay loams, tending to make them hard and lumpy, rather than loose and friable.

That the use of lime was not more often followed by marked favorable results may be due to the fact that the application was not large enough, or that it had not in that short time become thoroughly mixed in the soil. Its use is worth further trial and more serious study.

Circular of instructions.—In 1898 and '99 a special circular of instruction was sent to each farmer who was carrying on experimental work with fertilizers.

The following is one of the circulars which was sent out in the spring of '99 and returned in the fall. Spaces were left for recording the summer's work and these were filled out by the experimenter according to the directions. That part of the circular printed in italics constitutes the actual report of the experimenter.

CIRCULAR OF INSTRUCTIONS

CONCERNING

FIELD EXPERIMENTS

WITH

FERTILIZERS

No. 14.

CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION.
I. P. ROBERTS, DIRECTOR.

ITHACA, N. Y., April, 1899.

DEAR SIR:

We have ordered one set of fertilizers to be sent to you by freight. This set consists of two large sacks containing four 15 lb. sacks of nitrate of soda; two 15 lb. sacks of muriate of potash; two 30 lb. sacks of superphosphate, and two 45 lb. sacks containing a mixture of 30 lbs. of superphosphate and 15 lbs. of muriate of potash.

We have also sent you a revised copy of Bulletin 129 of this Station. It contains many valuable suggestions about conducting field experiments with fertilizers.

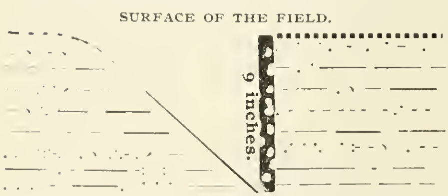
Circular No. 14 explains how to apply the fertilizers and how to keep a record of the season's work.

KEEP THIS CIRCULAR IN A HANDY PLACE AND FROM TIME TO TIME JOT DOWN NOTES UNDER THEIR PROPER HEADINGS. FINALLY IN THE FALL RECORD THE WEIGHTS OF CROP GROWN ON EACH PLAT AND THEN RETURN THIS SAME CIRCULAR TO G. C. CALDWELL, ITHACA, N. Y.

Do not get this experimental work confused with another line of investigations with sugar beets which the Station is planning.

SAMPLING THE SOIL.

The first thing to do before applying the fertilizer is to get a good average sample of soil from that portion of the field on which the plats are laid out.



Proceed as follows: with a spade with a square end dig a hole, the width of the spade and nine inches deep, leaving one side of the hole vertical and the other side sloping just as in the cut. Clean out all the loose soil at the bottom of the hole; cut off from the vertical side a slice about two inches thick from top to bottom, the full width of the spade; this slice represents one of the partial samples; in precisely the same manner take 10 to 15 other samples from different parts of the field.

Put all the samples together, after having picked out of each one all pebbles over ¼ to ½ inch in diameter. In a clean box large enough to hold them all, or on some clean boards, mix the samples together as thoroughly as possible, by stirring and shoveling over and over many times; then put four or five pecks of this mixture into a strong sack, or into a box about large enough to hold it, and tie the sack, or cover the box tightly. The sack in which the fertilizers were sent must not be used for this purpose. Too much care cannot be taken in preparing this sample so that it shall represent the soil of the whole larger plat to be divided up into smaller ones for the experiments.

Make a record of the field, as complete as possible, according to the following plan:

I—Location of Field.
  a—Upland.
  b—Lowland. (If lowland, do sidehills wash down upon it?)
  c—Hillside, etc.

Write answer here—*The field was valley land and laid up towards the hills. The sidehill did not wash down on it.*

II—Character of Soil.
a—Sandy.
b—Gravelly.
c—Clayey.
d—Loamy, etc.
e—How deep is surface soil?
f—Is there a hardpan; if so how deep is it?
g—Does soil hold moisture, or dry out rapidly?

Write answer here—*The soil was dark loam and a little gravelly. The surface was from 10 to 12 inches deep with no hardpan and rather inclined to hold the moisture.*

III—Fertility of Soil.
a—Does the soil possess the required amount of plant-food, or does it "run down" quickly and need enriching?
b—Have manures or fertilizers been applied in past years? If so, how often, what kinds and how much per acre?

Write answer here—*The soil possessed a good amount of plant-food and does not run down easily. It has been manured about once in 4 years, generally 20 tons per acre previous to raising a crop of corn in rotation.*

IV—History of Crops Previous to 1899.
What crops have been grown and how much yield per acre, in past years? In case of cereals give the number of bushels of grain and tons of straw or stalks per acre.

Write answer here—*Had raised in past years a rotation of hay, two years yielding from 2 to 4 tons per acre; then manured for corn or potatoes, either yielding good crops—corn 125 bu. ears per acre, or potatoes 100 to 200 bu. per acre. This followed with oats, yielding from 40 to 60 bu. per acre with a large growth of straw; this completed the rotation. This year the potatoes were raised after corn which had been manured.*

The field should be plowed before the plats are laid out. Then use good, substantial stakes at the corners of the plats, and mark them in such a way that the plats will not become mixed, thus leading to confusion. It would be well to leave a space of 4 ft. between each two plats in order to be sure that the plants on one plat cannot feed on the fertilizer each side of it.

Do not lay out the plats on land that has been manured within one year. If you carried on fertilizer experiments last year do not use the same set of plats again this season.

The following diagram shows the arrangement of the plats, with the spaces between. Each plat contains $\frac{1}{20}$ of an acre.

Each plat one rod wide.

1.	Plat K.	15 lbs. Muriate Potash	100 lbs. lime on this half
2.	Plat N.	15 lbs. Nitrate Soda	100 lbs. lime on this half
3.	Plat P.	30 lbs. Superphosphate	100 lbs. lime on this half
4.	Plat Blank.	No Fertilizer	100 lbs. lime on this half
5.	Plat KN.	15 lbs. Muriate Potash 15 lbs. Nitrate Soda	100 lbs. lime on this half
6.	Plat KP. MIXED	15 lbs. Muriate Potash 30 lbs. Superphosphate	100 lbs. lime on this half
7.	Plat NP.	15 lbs. Nitrate Soda 30 lbs. Superphosphate	100 lbs. lime on this half
8.	Plat NPK.	15 lbs. Nitrate Soda MIXED 15 lbs. Muriate Potash 30 lbs. Superphosphate	100 lbs. lime on this half
9.	Plat S.	Stable Manure	100 lbs. lime on this half

Eight rods long.

THE USE OF LIME.

Some recent investigations that have been carried on under the direction of Mr. Wheeler of the Rhode Island Experiment Station, at Kingston, R. I., have shown that acidity or sourness of the soil is much more common than has hitherto been supposed to be the case. It was proved by these experiments that this acidity of the soil lessens the effect of fertilizers on very many crops; in most cases the effect of nitrate of soda was very much lessened.

It is for this reason that the use of lime is recommended in the experiments of this year, when it can be obtained without too much cost, on half of each one of the small plats of the set, in the manner directed below.

If the soil is acid or sour, the lime corrects the acidity, and makes success with fertilizers much more certain ; besides this it loosens a heavy clay loam, so that it can be more easily cultivated ; it helps in the conversion of the slow action of the nitrogen of the soil into more rapid action ; it may set free and make immediately efficient some of the tightly locked potash of the soil.

The experiments of last year indicated that the failures to get good crops with the fertilizers applied was not due to a ack of plant-food in some of the soils tested ; it is quite possible that if lime had been used with the fertilizers better results would have been obtained.

One application of lime will last for some years. Therefore, since its use may prove to be profitable in many cases, a trial of it seems to us advisable.

APPLICATION OF THE LIME AND FERTILIZERS.

Each half plat is to receive 100 lbs. of lime.* (One heaping bushel of fresh stone lime weighs 75 lbs.; one heaping bushel of air-slaked lime weighs 50 lbs.—Roberts' Fertility of the Land, page 305.)

The plats having been laid out, make two piles of fresh stone lime of 50 lbs. each (⅔ bushel in each pile) upon that half of each plat which is to be limed. This quantity represents two tons of lime per acre. Pour from ¼ to ½ of an ordinary pailful of water on each pile of lime, or less water if the soil is pretty damp, and immediately cover the lime with soil. In three or four days the lime will be completely slaked. It is then in the form of a fine, white powder, and it can be easily spread. With a shovel scatter the lime in the two piles as evenly as possible over that half of the plat to be limed ; care should be taken not to leave an excessive amount of lime on the ground under the piles. If fresh stone lime cannot be obtained, use air-slaked lime if that can be had. The air-slaked lime is already in the form of a fine powder and should be spread broadcast immediately without further treatment ; (2 bushels to each half plat if air-slaked lime is used.)

Apply the lime as early in the spring as possible on the PLOWED GROUND and immediately drag it into the soil most thoroughly.

As soon as this work has been done, apply broadcast the muriate of potash and superphosphate to the whole of each plat which is to be manured with one or the other, or with a mixture of the two, and drag into the soil as thoroughly as possible. Drag the plats lengthwise because particular care must be taken that none of the fertilizer for one plat is sown on or is dragged on another plat adjoining it. In many cases muriate of potash injures the plant if applied just previous to putting in a crop ; so that the earlier this fertilizer is applied in the spring the less will be the danger of injury.

*If potatoes are to be grown on the plats, omit the use of lime.

Apply half the nitrate of soda broadcast on the whole of each plat requiring it just before the seed is planted and drag into the soil. Three weeks later apply the rest and cultivate in.

Care should be taken to keep the nitrate off the foliage of plants, as it may cause some damage; in the case of sown crops, such as oats, it will be impossible to prevent this altogether.

BE SURE NOT TO OMIT THE BLANK OR CHECK PLAT WITH NO FERTILIZER. This is the most important of any single plat because all of the others must be compared with the blank in order to learn how much benefit the fertilizers have been to the crop.

You are to grow any crop you wish on these plats.

The same kind and same amount of seed is to be sown on each of the series of nine plats in the set. It must be remembered that these experiments are to be tried upon the crop planted and not upon an accidental crop of weeds. In no case will the experiments be of value if the weeds are allowed to grow on the plats. Thorough cultivation is one of the most important features of the field test.

RECORDS FOR 1899—TO BE FILLED OUT.

1—Date of plowing field. *May 2.*

2—Date of applying lime. *No lime used.*

Was the lime fresh slaked, or air-slaked?

Date when dragged into soil.

Dragged how many times?

3—Date of applying muriate and superphosphate. *May 15.*

Date when dragged into soil. *May 15.*

Dragged how many times? *Three times.*

Date of applying first half nitrate of soda. *May 15.*

Date of applying second half nitrate of soda.

4—Kind of crop grown. *Rural New Yorker Potatoes.*

5—Date of planting crop. *May 15.*

Dates when crops came up on each plat. *June 5—Could see no difference in the plats as to time they came up.*

6—Dates of rain storms and general remarks on weather. *Very dry from June 1st to 15th. Good rain June 15th and June 24th. Showers June 28th then very dry up to July 6th. Plenty of rain from July 6th to July 20th, then very dry. No more rain to speak of till after the potatoes were matured and dug.*

7—Dates of cultivating plats. *With a Hallock Weeder—May 20th, 23d, 25th, 28th, 31st, June 3d and 10th. With cultivator—June 16th and 23d and hand hoed. With cultivator June 29th and July 5th. With hiller July 12th. With hiller July 24th and hand hoed.*

8—Injury by crows, insect pests, etc. *Old beetles ate them a considerable when first came up. The summer hatch of beetles did little damage. Used Paris green on them but once.*

9—Keep record of general appearance of plats during summer. Which plats are most thrifty? Which least thrifty, etc. *July 18th plats on which superphosphate was used and the one of stable manure, tops darkest green. Plats S (stable manure) and N P K (complete fertilizer) a little the most thrifty.*

10—General remarks and questions. *Was well pleased with the experiment. It was both interesting and helpful and was very little extra work or trouble, besides the fertilizer well repaid all the little extra care and grew a fine crop. The experiment showed that the nitrogen used was really detrimental to the potato crop as it caused an extra large growth of vines and LESS TUBERS THAN THE BLANK PLAT.*

We next come to the harvesting of the crop. Bull. 129, p. 146, says:

"In carrying out this part of the work, allowance must be made for the possible growth of the roots of one row into the feeding-ground of the adjoining rows; thus the outside row of one plat may steal food from the next plat, that was not intended for it; hence the directions to exclude the two outside rows of each plat, one on one side and the other on the other side, and not to include the crop of those rows in the harvest measured, are important."

"In measuring the crop, due credit should be given for every part of it that can be utilized in any way; if corn, not only the seed, but the stalks; if wheat, oats, etc., the straw as well as the seed; if potatoes, of course only the tubers."

If each plat contains three rows, then harvest and weigh the middle row. If each plat contains four rows, then harvest and weigh the two inside rows. If each plat contains five rows, then harvest and weigh the three inside rows, and so on.

Bear this important request in mind, namely, that it is necessary to report separately the weight of each crop harvested upon both the limed and unlimed half of each plat.

[Fill out one of the following blank forms as a part of your report of records and observations taken during the summer.]

Size of each plat: length, *16 rods;* width, *½ rod.*

No. of rows grown on each plat. *3*.

No. of rows included in the weighed yield of each plat. *1*.

PLATS OF CORN.		Limed half of Plats	Unlimed half of Plats
1—Plat K.	Weight of corn from rows harvested, in pounds.	....	....
	Weight of stalks and husks harvested, in pounds	....	....
2—Plat N.	Weight of corn from rows harvested, in pounds.	....	....
	Weight of stalks and husks harvested, in pounds	....	....
3—Plat P.	Weight of corn from rows harvested, in pounds.	....	....
	Weight of stalks and husks harvested, in pounds	....	....
4—Plat Blank.	Weight of corn from rows harvested, in pounds. (No fertilizer)	....	....
	Weight of stalks and husks harvested, in pounds	....	....
5—Plat KN.	Weight of corn from rows harvested, in pounds.	....	....
	Weight of stalks and husks harvested, in pounds	....	....
6—Plat KP.	Weight of corn from rows harvested, in pounds.	....	....
	Weight of stalks and husks harvested, in pounds	....	....
7—Plat NP.	Weight of corn from rows harvested, in pounds.	....	....
	Weight of stalks and husks harvested, in pounds	....	....
8—Plat NPK.	Weight of corn from rows harvested, in pounds.	....	....
	Weight of stalks and husks harvested, in pounds	....	....
9—Plat S.	Weight of corn from rows harvested, in pounds. (Stable manure)	....	....
	Weight of stalks and husks harvested, in pounds	....	....

NOTE.—In case the corn is for fodder and not to be husked, then give the weight of stalks and ears combined.

PLATS OF POTATOES.		Unlimed Plats
1—Plat K.	Weight of potatoes from rows harvested, in pounds.	*267*
2—Plat N.	Weight of potatoes from rows harvested, in pounds.	*209*
3—Plat P.	Weight of potatoes from rows harvested, in pounds.	*258*
4—Plat Blank.	(No fertilizer) Weight of potatoes from rows harvested, in pounds.	*211*
5—Plat KN.	Weight of potatoes from rows harvested, in pounds.	*240*
6—Plat KP.	Weight of potatoes from rows harvested, in pounds.	*307*
7—Plat NP.	Weight of potatoes from rows harvested, in pounds.	*208*
8—Plat NPK.	Weight of potatoes from rows harvested, in pounds.	*285*
9—Plat S.	(Stable manure) Weight of potatoes from rows harvested, in pounds.	*315*

NOTE.—If some other crop is grown, one of the above blanks can easily be changed and filled out for that particular crop.

At the close of the season and as soon as the results of each plat have been properly recorded, please return this circular to the Chemist of the Experiment Station at Ithaca, N. Y.

G. C. CALDWELL, *Chemist.*
A. L. KNISELY, *Ass't Chemist.*

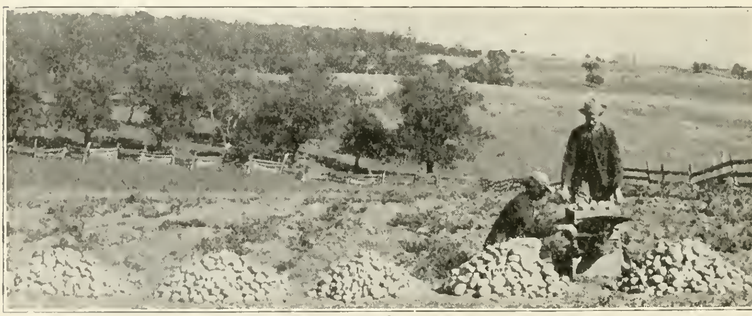
Name of Experimenter. *Homer H. Jones.*

P. O. *Homer.*

County. *Cortland.*

State. *New York.*

Experiments by Mr. H. H. Jones, Homer, N. Y.—Mr. Jones who made the experiments and sent in this completed report states that each plat was ½ rod wide and 16 rods long, making an area of $\frac{1}{20}$ of an acre. Three rows of potatoes were grown on each plat. In harvesting the crop, the outside rows being discarded according to the directions, the yield of the middle row only of each plat was weighed. This row represented $\frac{1}{60}$ of an acre. The weight of potatoes harvested from the central row of plat K (muriate of potash) was 267 lbs. This yield on $\frac{1}{60}$ of an acre multiplied by 60 gives the yield of pounds per acre, which was 16,020 lbs.; this is equivalent to 267 bushels per acre. It so happens that in this experiment the weight per plat multiplied by 60 gives the yield in pounds per acre and that this product divided by 60 gives the number of bushels per acre. Therefore the number of pounds per plat represents the number of bushels per acre.



Plat (**KN**)	*Plat* (**KP**)	*Plat* (**NP**)	*Plat* (**NPK**)	*Plat* (**S**)
Potash Nitrogen.	*Potash Phos. Acid.*	*Nitrogen Phos. Acid.*	*Nitrogen Phos. Acid. Potash.*	*Stable Manure.*

60.—*Mr. Jones harvesting and weighing the experimental plats of potatoes.*

What lessons can be drawn from this set of experiments? We will first consider whether it was a profitable investment to use nitrate of soda. (See page 301.) The blank plat gave 211 lbs. of potatoes; the nitrate of soda plat yielded only 209 lbs.; this would indicate that when used alone the nitrate of soda was injurious rather than beneficial. Muriate of potash used alone gave 267 lbs. per plat, an increase of 56 lbs. over no fertilizers, or 56 bushels to the acre. When nitrate of soda was used with muriate of potash the yield was reduced to 240 lbs. per plat. This means that potash plus nitrogen gave 27 bushels less than potash alone. Here again the nitrogen compound was injurious.

Something more of interest and importance may be learned from this series of experiments. For example, it was observed that while the stable manure gave the largest yield, the crop contained the most small potatoes, and the tubers were more scabby than on the other plats. Also where nitrate was used the potatoes were of a poorer quality and more scabby. On the other hand, plats treated with either potash or superphosphate produced very fine, smooth tubers; the plat with a mixture of potash and superphosphate produced as fine a lot of tubers as the Station representative has ever seen.

It is clearly proved by this set of experiments that it would be a waste of money to buy nitrogenous fertilizers for potatoes on this field; but in all probability it might be a good investment to use a moderate amount of potash and superphosphate. It must however not be forgotten that these results, while applicable to this particular field, may or may not be suited to a neighboring farm or even to another part of this same farm; for, on other farms, even if near by, some at least of the conditions of the soil which may affect the crop may and are likely to be different from those of the soil tested by these experiments. The soil of another farm may be quite different, and it may have received quite different treatment in previous years.

Potato experiments by Mr. H. H. Bonnell, Waterloo, N. Y.— Mr. Bonnell has experimented during the past three years. We give here a condensed form of his experiment for 1899. Each plat was $\frac{1}{20}$ of an acre and contained four rows of potatoes. The two central rows were harvested and weighed giving the yield per $\frac{1}{40}$ of an acre for each plat. The figures in the table represent the yield in bushels per acre, calculated from pounds per $\frac{1}{40}$ of an acre.

	Potatoes per acre in bushels calculated from 1-40 of an acre.	
	Large.	Small.
Plat K*	137.7	6.0
" N	129.5	7 3
" P	118.5	8.2
Blank	122.2	6.3
Plat KN	155.2	5.2
" KP	147.0	5.2
" NP	128.0	5.8
" NPK	170.0	5.7
" S	189.0	5.5

* For the meaning of these abbreviations and the rate at which the fertilizers were applied see page 296.

A study of the above table shows that stable manure (S) gave

Plat (**KP**) *Potash Phos. Acid.* *Plat* (**NPK**) *Nitrogen Phos. Acid. Potash.* *Plat* (**NP**) *Nitrogen Phos. Acid.* *Plat* (**S**) *Stable Manure.*

61.—*Potatoes grown and harvested by Mr. Bonnell.*

the best results and that a complete fertilizer (NPK) gave the next best. Stable manure having increased the yield of large potatoes 66.8 bu. over the the yield on the blank plat and decreased the yield of small potatoes from 6.3 bu. to 5.5 bu. The complete fertilizer (NPK) increased the yield over the blank plat 47.8 bu. of large potatoes and decreased the yield of small potatoes from 6.3 bu. to 5.7 bu.

Of the plant-foods used alone, potash gave better results than either nitrogen or superphosphate. Potash, when used with nitrate of soda, gave better results than when used with superphosphate.

The results of these experiments would seem to indicate that a complete fertilizer would give the best results when used on this field, and that the greater portion of it should be potash with only a moderate amount of nitrogen and but little superphosphate.

In 1897 Mr. Bonnell experimented with potatoes on another part of the farm; the results indicated that potash gave rather the best results. In 1898 oats were grown on this piece of ground and the superphosphate plats gave the best yields. Again in 1899, two years after the fertilizers had been applied, wheat was grown on it. The plats that had received superphosphate in 1897 still gave the largest crops. These results indicated one of two conditions: either that the cereal plants, oats and wheat, could not find enough phosphoric acid in that soil, unless supplied in the fertilizers; or that the *calcium sulphate* (gypsum or land-plaster), of which all superphosphates are largely composed, gradually made available some of the tightly locked potash that existed in the soil, and that it was this *liberated potash* and not the *phosphoric acid* that gave such marked results the second and third year following the application of the fertilizers.

It was formerly a common practice to use calcium sulphate (plaster) upon land for the purpose of making available some of the tightly locked plant-food especially *potash*.

Experiments of Mr. A. O. Stewart, Mariposa, N. Y.—Mr. Stewart has experimented for the past three years, in 1897 and 1898 on potatoes and in 1899 on corn for the silo. On Sept. 21, '99, one square rod of each plat was cut, shocked and photographed. (See cuts, next page.) Then each shock was weighed and the yield per acre estimated. Also after a week of warm weather the remaining crops on each plat were cut and weighed in order to determine whether the estimated yield per acre would vary much whether based on the yield of one square rod, or of eight square rods. In general, the smaller the area taken for estimating the crop per acre, the greater the probable errors in the calculation. These results are tabulated on page 307.

Plat (**S**) *Stable Manure.* *Plat* (**NP**) *Nitrogen Phos. Acid.* *Plat* (**P**) *Phos. Acid.* *Plat* (**N**) *Nitrogen.*

Plat (**K**) *Potash.* *Plat* (**KP**) *Potash Phos. Acid.* *Plat* (**KN**) *Potash Nitrogen.* *Plat* (**NPK**) *Nitrogen Phos. Acid. Potash.* *Plat* (**Blank**) *No Fertilizer.*

62.—*Mr. Stewart harvesting corn fodder for the silo. Each shock represents the yield from one sq. rod of each plat.*

	Corn silage per acre in tons.		Gain in pounds per acre from Sept. 21 to Sept. 28-99.
	Calculated from one square rod. (Sept. 21st.)	Calculated from eight square rods. (Sept. 28th.)	
Plat K*.........	5.28	5.59	620
" N..........	4.56	4.82	520
" P..........	7.68	8.04	720
Blank..........	4.24	4.51	540
Plat KN........	4.64	4.89	500
" KP	6.88	7.27	780
" NP	8.80	9.24	880
" NPK	7.84	8.28	880
" S..........	14.48	15.26	1,560

* For the meaning of these abbreviations and the rate at which the fertilizers were applied see page 296.

On studying this table it is plainly seen that available phosphoric acid in the soil was at a minimum since the yield was best on all the plats which received phosphate, whether alone or mixed with one or both of the other plant-foods. It appears further that neither potash nor nitrogen with phosphate added much to the crop over and above the yield with phosphate alone: therefore it would be poor policy to use a complete fertilizer for corn on this field. The experiments of 1897 and 1898 also showed that phosphoric acid was the one plant-food that was deficient in that soil.

On comparing the estimated yields per acre from each cutting, we see that in every case there was a decided increase in the total crop during the last week of growth and that these increases per ton were quite uniform. This shows that the estimated yields per acre when calculated either from one square rod or from eight square rods are very nearly alike and that correct results can be obtained by measuring the crop of a part only of each plat.

The value of stable manure as a fertilizer is very distinctly shown in the results of this series of experiments, the increase over the yield on the blank plat being more than three times the increase given by any other fertilizer. Although the quantity of the manure applied contained less available nitrogen compounds, potash and phosphate than was contained in the commercial fertilizers used, it was far ahead of the other fertilizers. This result may be due in part to the useful bacteria possibly in the manure, or to the effect of the manure on the physical qualities of the soil, such as its texture, its temperature, etc.

Many other illustrations might be given of the value to the farmer of this kind of experimentation, but lack of space forbids.

Injury caused by Fertilizers.—As already stated in this bulletin, not all the experiments were entirely successful. In some cases the plats were too small, in others not enough care was taken in mixing the fertilizers thoroughly with the soil; the result was either a partial injury to the crop, or killing it completely. Such injurious effects were especially noticeable with the muriate of potash and nitrate of soda. The superphosphate did not seem to cause any damage even when applied very close to the plant or in large quantities, even at the rate of two tons per acre, as in some cases by mistake. Superphosphate may therefore be used very carelessly without doing any harm, while great care must be exercised in the application of nitrate of soda or muriate of potash.

Does it pay to use commercial fertilizers?—This question is frequently asked by farmers, but it is a question that can be answered only by the questioners themselves. They, only, know what the purchased fertilizers cost them ; they only can know or they ought to know what increase of crop is yielded by the fertilizers applied, and how much money they have received for such increase. As a rule, they know only what they have paid for the fertilizers, and how many bushels or tons of their crops they have harvested; but they do not know how many bushels or tons are to be credited to the fertilizers, for they do not know how much the soil will yield without any fertilizer, or with stable manure. Neither do they know what the stable manure has cost them. Furthermore, since as a rule they use complete fertilizers, containing all three of the plant-foods, nitrogen compounds, potash and phosphate, therefore they do not know whether any increase in crop is due to the action of all three of the plant-foods, or to two of them, or to one only. In the case of several of the series of experiments that have been carried out under the supervision of this Station, it has been conclusively shown that phosphate was the only plant-food that was useful, and that all the money paid for the other two was wasted.

Such being the results of a number of the experiments with fertilizers, it would seem that a wise and prudent farmer would attempt to keep a sort of a bank account with every field on his farm that is under cultivation. To accomplish this he would charge to each field the cost of the fertilizer applied to it, if he uses commercial fertilizers ; after the harvest he would credit every field with the market value of its produce. It would cost him but little time and labor to measure three plats, say of a tenth of an acre, in each field to be treated with commercial fertilizers, one plat being left unfertilized ; multiplying the yield of each of these plats by ten would give the yield per acre. He has then all the data that are necessary in order that he may learn by a simple calculation whether the increase of the crop has more than paid for the cost of the fertilizer used.

The farmer may say that he cannot spare the time for carrying out this plan ; or he may say that he does not want to lose the increase of crop that the fertilizer would give on the one unmanured plat. But this loss on a tenth of an acre only, would be very small and it would be of much more importance to him to know whether he gains or loses by the application of fertilizers. Better still would it be if he could carry on a set of experiments with the three important plant-foods in a complete fertilizer, in the manner described in the preceding pages. He might then learn that only one of the three foods, say, for example, the phosphoric acid in a plain superphosphate, or potash, or some combination of two of the three foods is all that the field experimented upon requires, and that money spent for any other food is simply thrown away.

Frequently during the summer the representative of the Station was asked by the farmers if it would pay to use such large quantities of fertilizers as were sent out by the Station and if smaller quantities would not do just as well. The answer was that in these experiments the cost of the fertilizers was not taken into consideration, the main object being to find out whether the use of any one or more of the plant-foods would give profitable yields over and above the yield without any fertilizer. For such a purpose it is better to use large applications rather than small ones in order to make the results of the experiment more marked.

With the cultivated fields of this State in their present condition, with their present amounts of humus and with their present texture, it will not pay, as a general thing, to use large applications of fertilizers, because moderate amounts are usually sufficient to make the available plant-food conditions as good or better than other essential conditions of the soil. Just as soon as plant-food conditions are better than other essential conditions, the plant will not be able to get the benefit of this extra food, and more or less may be wasted.

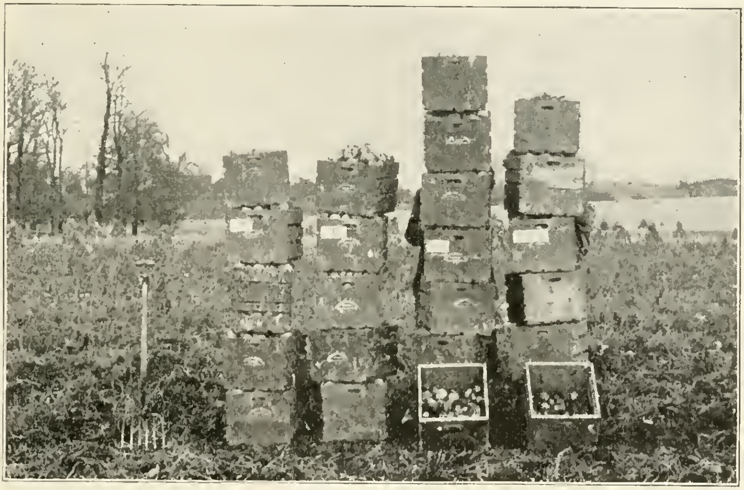
63.—*Mr. Mabee, of Spencer, N. Y., harvesting and weighing experimental plats of potatoes.*

Interest in the experimental work and its value.—In most cases the farmers were very much interested and painstaking with the work. Oftentimes the experimenters said that the work was being watched by neighbors, for they wanted to "see whether there is anything in it or not."

Mr. Wills C. Hatch, of Skaneateles, N. Y., wrote as follows: "Below you will find the results of my third experiment with fertilizers on potatoes under your supervision. Each year's experiments gave practically the same results, proving to me beyond doubt what I had before believed, that the soil on my farm did not need the addition of either potash or nitrogen, or in other words it would not pay me to use them. I am now using plain phosphate alone on all my crops and am getting better results than with the mixed goods. This will save me from fifty to one hundred dollars a year in the cost of purchased fertilizers, and with better results.

The results of my experiments have been given in the Grange and club meetings and also published in the papers. Whether this had anything to do with the case or not I don't know, but I do know that of about forty tons used by our Grange this season only one ton used was other than plain phosphoric acid goods."

Mr. A. O. Stewart, of Mariposa, N. Y., wrote as follows: "In making my report I wish to assure you that we have been greatly benefited by the experimental work in many ways. We have learned that the better preparation of the soil and good cultivation are the prime requisites of a good crop.



Plat (**N**) *Plat* (**K**) *Plat* (**P**) *Plat* (**Blank**)
Nitrogen. Potash. Phos. Acid. No fertilizer.

64.—*Potatoes harvested from four of the experimental plats of Mr. Hatch.*

In making these experiments the past three years we have, with the kindly help and suggestions of the Experiment Station, been able to determine what our soil requires, and now in buying fertilizers we buy only what our soil most needs, thus reducing the cost of the fertilizer bought nearly 50 per cent. Several of our neighbors have been interested in our experimental work and they requested me this last spring to purchase for them a fertilizer containing only phosphoric acid. They claim that it gave them good results on all crops, equally as good as a complete fertilizer costing nearly twice as much, and this in alternate pieces and with the same cultivation."

From a letter of Mr. Chas. Vanderbilt, Alloway, N. Y., we quote, "I am very glad that I undertook the fertilizer experiment work, as it has helped me to know what our land needs, and my neighbors are just beginning to think that one can tell what one needs by carrying on the experimental work. I think that acid phosphate, or superphosphate, will show up better than anything else on our clay land as the work shows so far ; and some of our neighbors are going to try acid phosphate as an experiment on their wheat this fall through me. * * * * As I have got started in the experimental work I shall never stop it. I shall keep on experimenting."

Farmers who have experimented.—The following is a list of the farmers to whom sets of fertilizers have been sent. Some have received them but once, others twice, and still others three times. The column headed "Years of Experimentation" indicates the number of years that each farmer has experimented and how many successive sets of fertilizers have been sent to him.

Name of experimenter.	Post office.	County.	Years of experimentation.
Ackley, Denver	Gowanda	Cattaraugus	I
Adcook, George	Fayetteville	Onondaga	I
Akeley, Ward B	Holley	Orleans	2
Akin, James L	Fluvanna	Chautauqua	I
Albright, John H	Ontario	Wayne	I
Allen, John J	Depauville	Jefferson	I
Allendorph, D	Sliters	Renssalaer	2
Almy, W. C	Dundee	Yates	2
Anderson John	Oriskany Falls	Oneida	3
Anderson, R. E	North Wilna	Jefferson	I
Andrews, F. M	Pompey	Onondaga	I
Averell, Warren	Caledonia	Livingston	I
Backus, J. H	Little Genesee	Allegany	I
Bagg, S. F	Watertown	Jefferson	I
Bailey, A. M	Townsend	Schuyler	2
Baker, N. A	Fishers	Ontario	3
Baldridge, C. J	Kendaia	Seneca	I
Banglar, Frank	East Bloomfield	Ontario	I
Banta, C. J	Conklin	Broome	I
Barney, Frank D	Westfield	Chautauqua	I
Barris, McClellan	Silver Creek	Chautauqua	I
Barrows, George A	Groton	Tompkins	2
Bassett, B. A	Afton	Chenango	I
Bates, C. A	Ellington	Chautauqua	I
Beadle, Geo	Brockport	Monroe	I
Beardsley, F. E	Coventry	Chenango	I
Belknap, J. J	Campville	Tioga	I
Benjamin, Chase	Haskinville	Steuben	2

Name of experimenter.	Post office.	County.	Years of experimentation.
Bennett, Bert	Howard	Steuben	1
Bingham, G. W	Summer Hill	Cayuga	2
Bingham, Henry M	Albion	Orleans	1
Bird, Albert A	Otto	Cattaraugus	2
Birge, E Pratt	Chatham	Columbia	1
Black, J. E	Ithaca	Tompkins	1
Bleaker, Joseph	Mumford	Livingston	1
Bliss, Geo. A	Groton City	Tompkins	3
Blood, Elmer E	West Potsdam	St. Lawrence	1
Bonnell, H. H	Waterloo	Seneca	3
Boynton, L. R	Lakeside	Wayne	1
Briggs, G. D	Lima	Livingston	1
Brigham, R. W	Perry	Wyoming	1
Brill, Thomas	Poughquag	Dutchess	1
Brodie, Geo	Churchville	Monroe	1
Bronson, Geo. H	Vernon Centre	Oneida	1
Brown, Cassius S	*West Bethany	Genesee	2
Brown, P. E	Cicero Centre	Onondaga	1
Buckland, W. F	Lysander	Onondaga	2
Bulkeley, R. P	Coventryville	Chenango	1
Burke, T. Tracy	Afton	Chenango	1
Burnham, Wm. H	Groton	Tompkins	1
Burritt, F. M	Parma Centre	Orleans	1
Burritt, W. B	Hilton	Orleans	1
Campbell, John H	Caledonia	Livingston	1
Cardner, G. R	Tully	Onondaga	1
Carlile, David	Eureka	Sullivan	1
Cary, H. L	Lockwood	Tioga	1
Catchpole, E. W	North Rose	Wayne	1
Cavanaugh, G. W	Watertown	Jefferson	1
Chaffee, L. R	Natural Bridge	Jefferson	1
Chamberlain, Ed	Barnes' Corners	Jefferson	1
Chapman, C. E	Peruville	Tompkins	1
Child, Lewis E	Philadelphia	Jefferson	1
Christy, W. T	Silver Creek	Chautauqua	1
Clark, C. J	LaFayette	Onondaga	1
Clark, C. W	Skaneateles	Onondaga	1
Clark, Ernest A	East Onondaga	Onondaga	1
Clothier, F. B	Silver Creek	Chautauqua	1
Clothier, H. B	Silver Creek	Chautauqua	2
Cockburn, Frank M	Silver Creek	Chautauqua	1
Cockburn, J. E	Silver Creek	Chautauqua	1
Cole, A. P	Howard	Steuben	2
Conklin, Geo. E	Chappaqua	Westchester	1
Cooley, G. W	Verona	Oneida	1
Corbett, M. J	Corbettsville	Broome	1
Cowles, James S	Otisco	Onondaga	1
Curtis, C. H	Waterville	Oneida	2
Curtis, Herbert S	Ridgeland	Monroe	1
Davis, C. E	Heath	Ulster	1
Day, H. N	Canandaigua	Ontario	1

Name of experimenter.	Post office.	County.	Years of experimentation.
Denison, F. E.	Westfield	Chautauqua	1
Drummond, Wm.	Perry City	Schuyler	1
Dudley, Henry C	Bath	Steuben	1
Dunn, Geo. W.	Forest Lawn	Monroe	2
Dunton, H. V.	Camden	Oneida	1
Durham, Wm. C.	Mount Kisco	Westchester	1
Dye, Ernest B.	Villenovia	Cattaraugus	1
Eastman, John M	Woodville	Jefferson	1
Elmendorf, W. E	Strait's Corners	Tioga	1
Emmons, Roy D.	Pulaski	Oswego	1
English, Andrew	Van Etten	Chemung	1
Field, Harry T.	Oneida	Oneida	1
Fitzgerald, Wm.	Alpine	Schuyler	1
Fosmire, Frank L	Freeport	Queens	1
Fredenburg, Lewis E.	Afton	Chenango	2
Fullagar, Howard.	Penn Yan	Yates	1
Fuller, James S.	Poland	Herkimer	1
Fullington, M. C.	Warsaw	Wyoming	1
Garlock, William	Marshville	Montgomery.	1
Garrett, J. D.	North Syracuse	Onondaga	2
Geer, Harvey L.	Forestville	Chautauqua	1
Goodwin, Geo. A	Auburn	Cayuga	1
Greene, Chas. S.	East German	Chenango	1
Griffin, Maurice N	Rutland.	Jefferson	1
Grinnell, W. M	Broadalbin	Fulton	1
Guilford, C. R	Cuba	Allegany	1
Hall, G. A.	Red Creek	Monroe	1
Harrison, L. E.	North Winfield	Herkimer	1
Hartley, S. F	Gouverneur	St. Lawrence.	1
Hatch, Wills C	Skaneateles	Onondaga	3
Hawkins, Noel	Gowanda	Cattaraugus	1
Heap, Henry.	Hamilton.	Madison	1
Heath, Adelbert L	DeRuyter.	Madison	1
Hendrick, James	Slingerlands	Albany	1
Hess, Chas. F	Great Valley	Cattaraugus	1
Heyward, William	Stafford	Genesee	1
Hills, J. Bert	DeRuyter	Madison	1
Hoffman, E. M	Appleton	Niagara	1
Holmes, Frank	Marietta	Onondaga	1
Howard, F. W.	Fredonia	Chautauqua	2
Howe, W. D.	Fayette	Seneca	1
Hoyt, Frank D	Cicero	Onondaga	1
Hulbert, Lorenzo	Dansville	Livingston	3
Hulett, Henry.	French Creek	Chautauqua	3
Hungerford, Nye	Ithaca	Tompkins	1
Ingalls, Chas. W	Watkins	Schuyler	1
Irwin, Wm A	Stone Mills	Jefferson	2
Jackman, Geo. W.	Livonia Station	Livingston	2
Jacks, Corwin	Batavia	Genesee	2
James, V. L	Cooperstown	Otsego	2
Jeffords, Harry A	Upper Lisle	Broome	1

Name of experimenter.	Post office.	County.	Years of experimentation.
Jenkins, E. E	Wolcott	Wayne	1
Jerry, E. J	Risingville	Steuben	1
Johnson, Truman I	North Ridgeway	Orleans	2
Jones, David W	Nelson	Madison	1
Jones, H. H	Homer	Cortland	1
Jones, Thomas W	Watervale	Onondaga	2
Kales, Dr. John W	Franklinville	Cattaraugus	3
Keener, C. L	Potsdam	St. Lawrence	1
Knapp, A. A	Preble	Onondaga	1
Knapp, C. E	Little York	Cortland	1
Knowles, W. A	Germantown	Columbia	1
Koon, Archie M	Auburn	Cayuga	1
Kyes, Caleb	Natural Bridge	Jefferson	1
LaFrenay, Clark C	Hammond	St. Lawrence	1
Lane, Lloyd W	Lyons	Wayne	1
Langdon, E. R	Hermitage	Wyoming	1
Lanphear, Perry	Black River	Jefferson	2
Lewis, R. N	Red Hook	Dutchess	2
Lindsley, B. M	Monticello	Sullivan	2
Lockley, Jesse B	Pultneyville	Wayne	1
Lombard, Louis	Jonesville	Saratoga	1
Long, John D	Williamsville	Erie	1
Loomis, Eugene W	Wilson	Niagara	1
Mabee, C. T	West Candor	Tioga	3
Mabee, E. J	West Candor	Tioga	1
Mapes, Arlington	Rushville	Yates	1
McBirney, S. J	Smithville Flats	Chenango	2
McDonough, John	East Bloomfield	Ontario	1
McMurray, A. H	Walworth	Wayne	1
McNair, A. D	Dansville	Livingston	1
McNair, H. R	Dansville	Livingston	3
Mead, U. W	Forestville	Chautauqua	2
Mead, W. B	Portland	Chautauqua	1
Medbury, C. B	Rockdale	Chenango	2
Metz, John U	Williamsville	Erie	2
Miller, D. M	South Otselic	Chenango	1
Miller, Gage M	Chili Centre	Monroe	1
Moore, D. M	Hooper	Broome	1
Morse, Frank E	Dalton	Livingston	2
Munson, J. O	East Lansing	Tompkins	2
Nash, D. D	Ellisburg	Jefferson	1
Nicholas, T. B	Center	Herkimer	3
North, Geo. R	Copenhagen	Lewis	1
Oaks, Jerome	Ketchumville	Tioga	2
Oaks, W. A	Oaks Corners	Ontario	1
Osborne, Chas. L	Rose	Wayne	2
Ovenshire, T. C	Bath	Steuben	1
Palmer, J. D	Montour Falls	Schuyler	3
Parker, Julius J	Fredonia	Chautauqua	2
Pattat, John	Little France	Oswego	1
Pease, Ira	Oswego	Oswego	1

Name of experimenter.	Post office.	County.	Years of experimentation.
Peo, James A	River View	Jefferson	1
Percy, Martin	Sodus	Wayne	1
Perkins, D. Center	Castile	Wyoming	2
Petrie, J. F	Plessis	Jefferson	2
Pierce, Dr. B	Coopers Plains	Steuben	1
Platt, Clarence J	Hamburg	Erie	1
Poole, J	Center Village	Broome	1
Price, Geo. H	Newark	Wayne	2
Putnam, Wm. R.	Wayville	Saratoga	1
Quereau, C. N	Baldwinsville	Onondaga	1
Randolph, Alva F	Alfred	Allegany	3
Render, Geo. H	Antwerp	Jefferson	1
Rice, Ammon	Wolcott	Wayne	1
Rice Frank D	Homer	Cortland	1
Richardson, B. F	Rome	Oneida	1
Robb, C. F	Webster	Monroe	1
Roe, A. LaVerne	Plymouth	Chenango	1
Rogers, Geo. A	Brookfield	Madison	2
Rumsey, Burr	Ithaca	Tompkins	1
Rutherford, Thomas	Hammond	St Lawrence.	2
Salisbury, J. L	Phelps	Ontario	2
Sanders, Chas P	Schenectady	Schenectady.	2
Schoonmaker & Son	CedarHill	Albany	1
Sears, Geo. L	French Creek	Chautauqua	2
Seeber, D. V	Perch River	Jefferson	2
Seeley, R F	Waterloo	Seneca	1
Selby, A. F	Pultneyville	Wayne	1
Seymour. J. L	Turin	Lewis	1
Shedd, Maurice H	Lowell	Oneida	1
Siddon, Chas	Syracuse	Onondaga	2
Simpson, Frank	Jasper	Steuben	1
Smith, Carlos F	Charlton	Saratoga	1
Smith, Clarence	Forestville	Chautauqua	1
Smith, W C.	Candor	Tioga	1
Snow, C. L	Forestville	Chautauqua	1
Southard, D. W	Gilboa	Schoharie	1
Stanton, Chas. E	East Venice	Cayuga	2
Staplin, Jr., Geo	Mannsville	Jefferson	2
*Starr, Jesse K	Fredonia	Chautauqua	1
Steele, H. J	Elba	Genesee	1
Stephenson, Geo	Ballston Spa	Saratoga	1
Sterling, E. S	Eagle Harbor	Orleans	2
Stewart, A. O	Mariposa	Chenango	3
St. John, J. Henry	Cohocton	Steuben	1
St. John, C. L	Canajoharie	Montgomery.	1
St. John, Lewis S	Canajoharie	Montgomery.	1
Stone. C. A	Pine City	Chemung	1
Storms, E. G	St. Johnsville	Montgomery.	1
Strickland, W. J	Albion	Orleans	1
Suydam, Nelson S	Binghamton	Broome	2

* Mr. Starr furnished his own fertilizers.

Name of experimenter.	Post office.	County.	Years of experimentation.
Taber, H. B	Wells Bridge	Otsego	1
Thomson, F. H	Holland Patent	Oneida	1
Torrence, Clay	Gowanda	Cattaraugus	2
Tubbs, Martin W	Portville	Cattaraugus	1
Turney, John R	Lairdsville	Oneida	1
Tuttle, C. H	Smyrna	Chenango	2
Twitchell, A. B	Pulaski	Oswego	1
Tyrrell, Geo. F	Wolcott	Wayne	1
Tyrrell, J. S	Wolcott	Wayne	1
Ulrick, H. W	Owego	Tioga	1
Vanderbilt, Chas	Alloway	Wayne	2
Van Buskirk, S. B	Purdy Creek	Steuben	2
Van Santford, A. P	Tribes Hill	Montgomery	1
Vary & Son, Nathan C	Ava	Oneida	2
Wager, Ben. M	Catharine	Schuyler	3
Walker, A. J	Portland	Chautauqua	1
Walker, Robt. F	Rome	Oneida	1
Wallace, A. P	Morristown	St. Lawrence	1
Wallis, Edward G	Apulia	Onondaga	1
Warford, C. O	Newburgh	Orange	2
Waterbury, C. B	Whitelaw	Madison	3
Watson, Maurice J	Center Village	Broome	1
Weeks, W. R	Scottsville	Monroe	1
Wells, Geo. S	Knoxboro	Oneida	3
Wheeler, Oscar	Hornellsville	Steuben	1
Wheelock, E. W	Mexico	Oswego	2
Whitcomb, C. H	West Somerset	Niagara	2
*Wilbur, O. B	North Easton	Washington	1
Wilcox, B. F	East Glenville	Schenectady	1
Wilkinson, Ed. C	Penn Yan	Yates	1
Williams, Frank	Catatonk	Tioga	2
Willing, E. L	Sherman	Chautauqua	2
Willson, John R	Shortsville	Ontario	1
Winters, Harry B	Smithboro	Tioga	2
Wood, Geo. W	Northfield	Delaware	1
Woodford, L. L	Berwyn	Onondaga	1
Worden, Palmer	Fayetteville	Onondaga	1
Yates, Martha G	Slaterville Springs	Tompkins	3
York, A. L	North Brookfield	Madison	1
Young, Frank E	East Venice	Cayuga	1

* Mr. Wilbur furnished his own fertilizers.

General results of the field experiments.—A study of all the experiments for three years recorded shows that of the three plant-foods when used alone, nitrogen gave the largest increased yield in 26 experiments, phosphoric acid in 58 experiments and potash in 36 experiments. This would seem to indicate that when one plant-food is used alone, phosphoric acid will in most cases give the best results. When a mixture of two plant-foods was applied, nitrogen and potash gave best results in 24 experiments, phosphoric acid and potash in 48 experiments, and nitrogen and phosphoric acid in 52 experiments. A comparison of a complete fertilizer and stable manure shows in 38 experiments the complete fertilizer gave better results, while in 54 cases stable manure produced the larger crops. These good results accompanying the use of stable manure may not be due so much to the plant-food it contains as to an improvement in the physical conditions of the soil.

In only 40 cases out of a total of 126 recorded, did the complete fertilizer, a mixture of nitrate of soda, phosphate and muriate of potash, give better results than fertilizers containing one or two of the plant-foods.

These results tend to show that more often it is some especially prepared rather than a complete fertilizer that a soil requires, and that when a farmer uses commercial fertilizers he is often not following the wisest policy; he is simply "going it blind" and possibly throwing away money.

A. L. KNISELY.

NOTE.—Farmers wishing to co-operate with the Experiment Station in conducting field experiments with fertilizers should make application soon to G. C. CALDWELL, Chemist. Then if the Station is permitted to continue this experimental work, much valuable time lost in correspondence will have been saved.

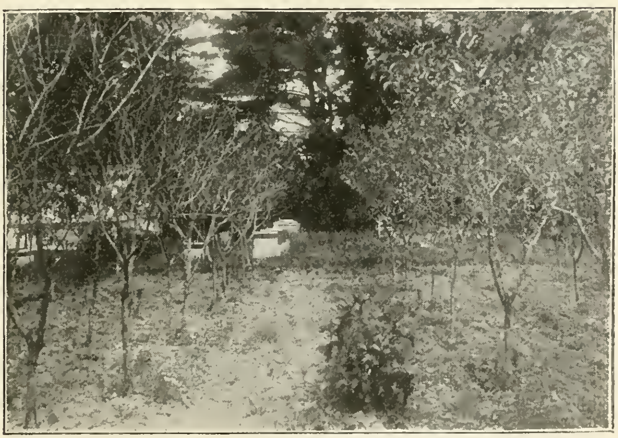
Bulletin 180. **March, 1900.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

BOTANICAL DIVISION.

THE PREVENTION OF PEACH LEAF-CURL.



By W. A. MURRILL.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1900.

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The regular bulletins of the Station are sent free to all who request them.

* Absent on leave.

CORNELL UNIVERSITY, ITHACA, N. Y., Feb. 20, 1900.

THE HONORABLE COMMISSIONER OF AGRICULTURE,

ALBANY, N. Y.

Sir:—This bulletin is submitted for publication under Chapter 430, of the Laws of 1899. It has been prepared by Mr. W. A. Murrill and embodies the results of experiments extending over one year together with a résumé of the investigations on the same subject which are set forth in full in Bulletin 164. The Peach Leaf Curl during the last few years has become a menace to the peach industry in many parts of the State. The two years' experiments lead to the conclusion that the leaf curl of the peach can be easily controlled when proper and timely treatment is given. This bulletin is valuable because it has established the fact that the foliage of peach trees, even of the more tender variety, may be kept healthy and vigorous, and because it gives specific directions as to the time of spraying, the kind of spray material and the method of application.

The investigations in Niagara County have been conducted on a large scale that some facts might be secured to guide the peach grower as to the cost and practicability of treating large orchards. The investigations conducted at Trumansburg were on a smaller scale but large enough to give reliable results.

I. P. ROBERTS,

Director.

THE PREVENTION OF PEACH LEAF-CURL.

In bulletin 164 of this Station, Dr. B. M. Duggar has given an account of the appearance and life history of the fungus causing leaf-curl of the peach, with the results of some very successful experiments undertaken by him for its prevention. It was for the purpose of farther testing these and other treatments on a commercial scale that the experiments here recorded were planned.

The Orchards Selected for Experiment.

The orchards selected for the experiments have, taken together, presented a variety of conditions of soil, moisture, and exposure, as well as wide differences in the trees themselves. The Elberta variety has been given the preference because of its well known susceptibility to curl, but Early Crawford, Hill's Chili, Brigdon, Mountain Rose, Globe, Beer's Late, and seedling trees have also been included in the experiments. Of these varieties, some trees have been young and others old, some fruiting heavily and others entirely without fruit, some isolated and some surrounded by trees of the same or different varieties, some sprayed during the season of '98, but most of them treated in '99 for the first time.

The Season of 1899.

The season of 1899 was a peculiar one and not very satisfactory for experiments with leaf-curl. The weather in April and early May was unusually bright and dry. The leaves were out much in advance of the flowers and were very large when the petals fell. The curl that appeared was doubtless developed for the most part by the short season of cold, rainy weather that occurred about the middle of May. There was little difference in varieties as regards the abundance of curl, but individual trees showed marked differences. The worst cases of curl I noticed were on Yellow St. John in the Bradley orchard near Somerset, Niagara Co. Trees affected with the yellows or otherwise enfeebled showed little or no tendency to curl.

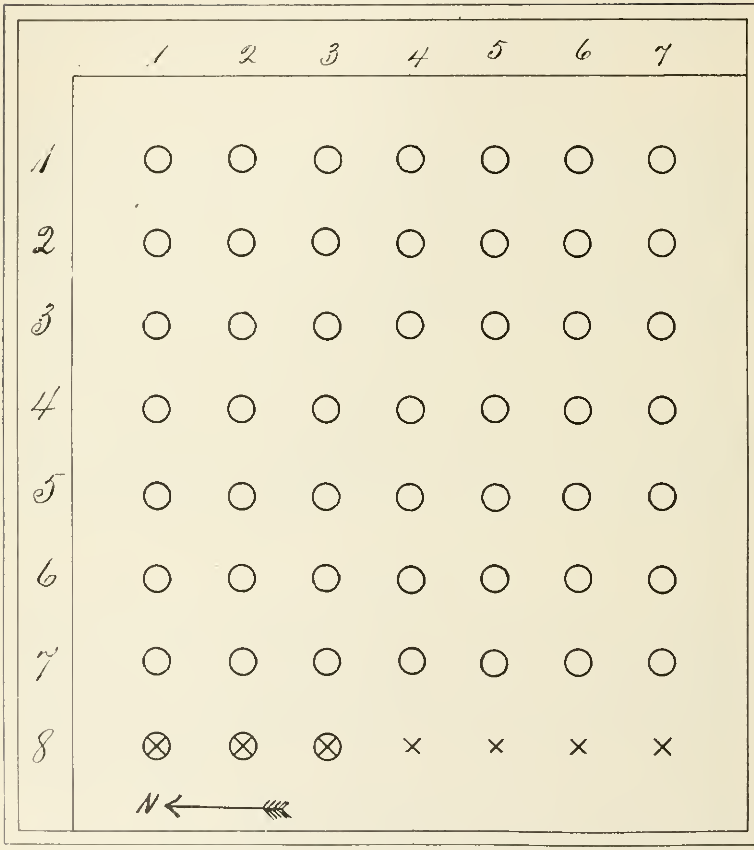
ESTIMATING THE AMOUNT OF CURL.

While the past season has not been favorable to the development of peach-curl, it has been possible to make the estimates in the following experiments with more than usual accuracy. In Mr. Lutts' Elberta block of one hundred and seventy-six trees, the curled leaves were all counted. The same method was used in Mr. Wright's orchard of one hundred and thirty-eight trees. With this experience as a basis and by tedious comparisons of row with row and tree with tree, stopping again and again to correct the estimates by actual counting, I have obtained the results given in the tables to follow. As a farther precaution against error, all records of treatments were left behind when the estimates were made ; and, in nearly every case, the owner of the orchard has kindly accompanied me to check the results.

EXPERIMENT I.

This is a continuation of the experiment described in Bulletin 164, pp. 379–380. The frontispiece, taken from Fig. 68 of that bulletin, shows the effect of early spraying as compared with late. The row on the right received its spraying with Bordeaux on April 8, the one on the left May 10. From the experience of the past year, we can add very little to the results already published for this block. Following is the plan of the experiment with a table showing the treatments used and their comparative effects on the curl. Early in the season, aphis and bud moth appeared in abundance, and a hail storm later on still farther complicated the injuries, so that the effects of the solutions on the foliage were not estimated.

PLAN OF EXPERIMENT I.

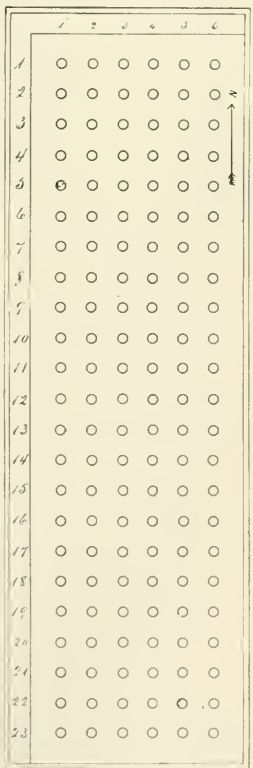


These eight rows, of seven trees each, were selected by Mr. Duggar, for his experiments in 1898. Copper carbonate alone is represented by x, but when preceded by Bordeaux mixture the x is inscribed in a circle.

EXPERIMENT I.—TABLE OF RESULTS.

Row.	Trees.	Treatment Apr. 6.	Treatment May 19.	Treatment May 27.	Relative amounts of curl June 15.
1		Check	Check	Check	200
2		Bordeaux 6–4–50	Bordeaux 6–4–50	Bordeaux 6–4–50	0
3		" "			10
4		" "	Potassium Sulfid	Potassium Sulfid	15
5		" "			12
6			Potassium Sulfid	Potassium Sulfid	127
7		Bordeaux 6–4–50	Ammoniacal Copper Carbonate	Ammoniacal Copper Carbonate	16
8	1–3	" "	Ammoniacal Copper Carbonate	Ammoniacal Copper Carbonate	12
8	4–7		Ammoniacal Copper Carbonate	Ammoniacal Copper Carbonate	44

Bordeaux 6-4-50 represents the normal mixture made with six pounds of copper sulfate, four pounds of good quick-lime, and fifty gallons of water.



EXPERIMENT II.

The orchard of Mr. H. S. Wright, upon which this experiment was made, is situated quite apart from other orchards of its kind, on the slope of West Hill, Ithaca, two or three hundred feet, perhaps, above the level of the principal portion of the city. It consists of young trees and suffered badly from curl in '98, but has not been sprayed until the season just passed. Elberta and Early Crawford varieties are about equally represented, the latter occupying mainly the southern portion of the block. The trees matured a good crop of fruit. Following the table of results by rows, is given one showing the comparative effectiveness of the solutions used.

EXPERIMENT II.—TABLE 1, SHOWING RESULTS BY ROWS.

Row.	Date of Treatment.	Treatment.	Relative amounts of curl June 16.
1		Check	12
2	April 5	Bordeaux 6–4–50	0
3	"	Bordeaux 3–2–50	2
4	"	Copper Sulfate 2–50	0
5	"	" " 2–500	4
6	"	Lime 2–5	6
7		Check	10
8	May 5	Bordeaux 6–4–50	0
9	"	" 3–2–50	0
10	"	Copper Sulfate 1–250	3
11	"	" " 1–500	3
12		Check	22
13	"	Copper Sulfate 1–500	2
14	"	" " 1–250	0
15	"	Bordeaux 3–2–50	0
16	"	" 6–4–50	0
17		Check	40
18	April 5	Lime 2–5	1
19	"	Copper sulfate 1–250	4
20	"	" " 1–25	0
21	"	Bordeaux 3–2–50	0
22	"	" 6–4–50	0
23		Check	30

EXPERIMENT II.—TABLE 2.

Treatments compared by averaging the amounts of curl on rows receiving the same treatment.

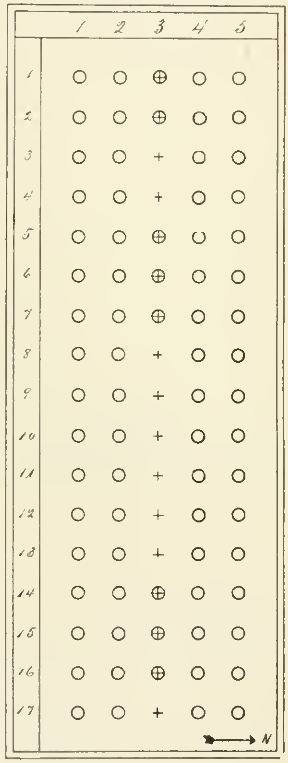
Date of Treatment.	Treatment.	Average amounts of curl.
	Check	23
April 5	Bordeaux 6–4–50	0
"	" 3–2–50	1
"	Copper Sulfate 1–25	0
"	" " 1–250	3.5
"	Lime 2–5	3.5
May 5	Bordeaux 6–4–50	0
"	" 3–2–50	0
"	Copper Sulfate 1–250	1.5
"	" " 1–500	2.5

In the Bordeaux mixtures used in the above tables, the first figure represents pounds of copper sulfate, the last gallons of water, and the middle one, separated from the others by dashes, represents pounds of unslacked lime. When copper sulfate or lime is used alone with water, the last number represents gallons of water and the first the copper sulfate or the lime in pounds.

EXPERIMENT III.

The trees used for this experiment were chosen from the orchard of Messrs. King and Robinson in Seneca Co., on the west shore of Cayuga lake two miles north of Trumansburg. When the curl first appeared in 1898, which was late in the season, the orchard was sprayed with Bordeaux, but without noticeable effect on the curl. The past year, it was again sprayed with Bordeaux, but early in April, and it was at that time that my experiments were made.

The varieties in this orchard most affected with curl in '98 were Elberta and Mountain Rose, Hill's Chili suffering very little; but, in '99, Hill's Chili seems to have been affected more than any other variety. The spraying was done April 8, the rows running across varieties as shown in the plan. Estimates were taken July 5. Table 1 gives results for different treatments; Table 2 for individual trees in a single row, enabling one to compare varieties. All of these trees are very large and were heavily loaded with fruit. There were no injuries to the foliage.



Checks are represented by +.

EXPERIMENT III.—TABLE 1.—A COMPARISON OF TREATMENTS.

Row.	Treatment.	Amount of curl.
1	Bordeaux, 6-6-50	One leaf to the tree
2	" 3-3-50	Seven leaves to the tree
3	Lime, 2-5	Fifteen leaves to the tree
3	Check	Three per cent
4	Copper sulfate, 4-50	Twelve leaves to the tree
5	" " 1-100	Forty leaves to the tree

EXPERIMENT III.—TABLE 2.—A COMPARISON OF VARIETIES.

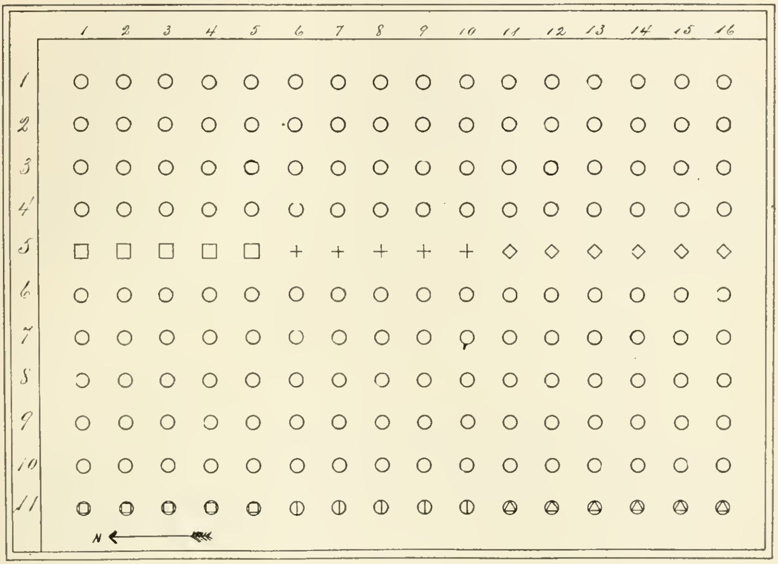
Tree.	Variety.	Treatment.	Amount of curl.
1	Hill's Chili	Lime	None
2	"	"	Less than 1 per cent
3	"	Check	7 per cent
4	"	"	None (set later)
5	Brigdon	Lime	¼ per cent
6	"	"	¼ per cent
7	"	"	¼ per cent
8	"	Check	Less than 1 per cent
9	"	"	" " "
10	"	"	" " "
11	Mountain Rose	"	5 per cent
12	"	"	5 per cent
13	"	"	5 per cent
14	"	Lime	Five leaves to the tree
15	"	"	" " "
16	Globe	"	" " "
17	"	Check	5 per cent.

In the Bordeaux mixtures used in the above tables, the first figure represents pounds of copper sulfate, the last gallons of water, and the middle one, separated from the others by dashes, represents pounds of unslacked lime. When copper sulfate or lime is used alone with water, the last number represents gallons of water and the first the copper sulfate or the lime in pounds.

EXPERIMENT IV.

Experiment IV was made upon a young Elberta orchard belonging to Mr. Henry Lutts situated two miles east of Youngstown in the northwestern corner of Niagara county. The orchard had received no treatment before '99. The trees have been set five years and were badly attacked with curl in '98. There was no crop of fruit the past season. The estimates have all been made by actual counting and the results are given in a table following the plan of this experiment. As may be seen from the plan, there are eleven rows of trees with sixteen trees to the row. Checks are indicated by the plus sign, those treated with Bordeaux 6-8-50 by a square, and those with Bordeaux 3-3-50 by a tilted square. Lime 1-5 is represented by an inscribed line, lime 1-3 by an inscribed triangle, and lime 1-2 by an inscribed square.

PLAN OF EXPERIMENT IV.



EXPERIMENT IV.—TABLE OF RESULTS WITH ELBERTA TREES OBTAINED BY ACTUAL COUNT.

Row.	Tree.	Treatment Apr. 11 13.	Treatment May 11–13.	Relative amounts of curl June 13.
1		Bordeaux 6–4–50	Bordeaux 4–4–50	8
2		" 6–6–50	" 6–6–50	0
3		" 6–6–50	" 3–3–50	23
4		" 3–3–50	" 3–3–50	25
5	1– 5	....	" 6–8–50	247
5	6–10	Check	Check	3520
5	11–16	....	Bordeaux 3–3–50	608
6		Bordeaux 6–4–50	....	209
7		Copper sulfate 4–50	....	854
8		" " 4–50	Copper sulfate 1–250....	450
9		" " 4–50	" " 1–500 ..	512
10		" " 4–50	Bordeaux 4–4–50	70
11	1– 5	Lime 1–2	....	640
11	6–10	" 1–5	....	1552
11	11–16	" 1–3	....	1376

In the Bordeaux mixtures used in the above table, the first figure represents pounds of copper sulfate, the last gallons of water, and the middle one, separated from the others by dashes, represents pounds of unslacked lime. When copper sulfate or lime is used alone with water, the last number represents gallons of water and the first the copper sulfate or the lime in pounds.

EXPERIMENT V.

The trees included in this plot were also selected from one of the orchards belonging to Mr. Lutts. They were all of the Beer's Late variety and were enclosed on three sides by unsprayed trees. They curled badly in '98, though not so much as the Elbertas, and have not been sprayed until the past year. The trees are six years old and have about twenty thousand leaves to the tree. There was no crop in '99. A plan and table of results follow, as in the preceding experiments.

PLAN OF EXPERIMENT V.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
2	O	O	O	O	O	O	O	O	+	O	O	O	O	O	O	O
3	O	O	O	O	O	O	O	O	+	O	O	O	O	O	O	O
4	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
5	□	□	□	□	□	□	+	+	+	+	+	+	+	+	+	+
6	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
7	O	O	O	O	O	O	O	O	+	O	O	O	O	O	O	O
8	O	O	O	O	O	O	O	O	+	O	O	O	O	O	O	O
9	O	O	O	O	O	O	O	O	+	O	O	O	O	O	O	O
10	O	O	O	O	O	O	O	O	+	O	O	O	O	O	O	O
11	O	O	O	O	O	O	O	O	+	O	O	O	O	O	O	O

→ N

From Mr. Lutts' block of the Beer's Late variety. The number and arrangement of of the trees is the same as in experiment IV and the signs used have the same significance as in that experiment.

EXPERIMENT V.—TABLE OF RESULTS WITH BEER'S LATE.

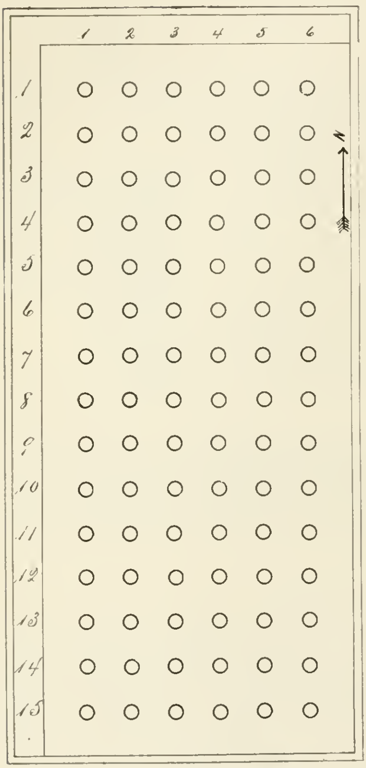
Row.	Trees.	Treatment Apr. 11-13.	Treatment Apr. 11-13.	Amounts of curl June 13.
1		Bordeaux 6-4-50	Bordeaux 4-4-50	None
2		" 6 6-50	" 6-6-50	"
3		" 6-6-50	" 3-3-50	"
4		" 3-3-50	" 3-3-50	"
5	1-6	....	" 6-8-50	Two leaves to the tree
5	7-16	Check	Check	4 per cent on all checks
6		Bordeaux 6-4-50	....	Ten leaves to the tree
7		Copper sulfate 4-50...	....	1 per cent
8		" " 4-50...	Copper sulfate 1-250..	½ per cent
9		" " 4-50...	" " 1-500..	½ per cent
10		" " 4-50...	Bordeaux 4-4-50	None
11		Lime 2-5	....	2 per cent

In the Bordeaux mixtures used in the above table, the first figure represents pounds of copper sulfate, the last gallons of water, and the middle one, separated from the others by dashes, represents pounds of unslacked lime. When copper sulfate or lime is used alone with water, the last number represents gallons of water and the first the copper sulfate or the lime in pounds.

EXPERIMENT VI.

This experiment was made upon a block of Elberta trees chosen from the orchard of Mr. W. T. Mann, one mile west of Somerset, in the northeastern corner of Niagara county. The trees were set in '94 and suffered from the curl in '97 and '98, but were not sprayed before '99. They are very thrifty and bore a large crop of fruit the past season. The orchard from which these trees were selected was sprayed early in the spring with Bordeaux.

Injuries to foliage were observed with some care in this block. The lime used was of the best quality and both it and the copper sulfate were carefully weighed, as was done in the other experiments ; but it soon became evident that the normal Bordeaux mixture contained too much copper sulfate for the foliage of the peach. Injuries began to appear two weeks after the second spraying. The foliage took on an unhealthy look ; shot-holes and yellow tips were abundant and many leaves fell from the trees. By June 14, the injuries to rows 3, 4, 5, 7, 8 and 12 were equally apparent, and doubtless greater than those sustained by the check rows from the attacks of the curl. Row 2, treated with comparatively weak Bordeaux, did not at that time show much injury. All of the rows which received only the first spraying remained in fine condition.



By July 8, on all trees sprayed late with Bordeaux the foliage was thin and the ground beneath the trees was thickly covered with yellow leaves. On August 8, the rows all appeared about alike, since the injured leaves had mostly fallen or become concealed by the new growth. Very few curled leaves had fallen from the checks. The loss of foliage on rows receiving the second spraying with Bordeaux affected to some extent the quality of the fruit on these rows.

Injuries to foliage in experiments IV and V were practically the same as those recorded above.

EXPERIMENT VI. —TABLE OF RESULTS.

Row.	Treatment April 14.	Treatment May 15.	Relative amounts of curl June 14.
1	Bordeaux 6–4–50	.....	18
2	" 6–4–50	Bordeaux 3–3–50	2
3	" 6–4–50	" 4–4–50	0
4	" 6–6–50	" 6–6–50	0.50
5	" 3–3–50	" 3–3–50	2
6	Check	Check	1500
7		Bordeaux 6–6–50	31
8	Copper sulfate 4–50	" 4–4–50	0.33
9	" 4–50	Copper sulfate 1–250	0.50
10	" 4–50	.....	19
11	" 2–50	.....	34
12	Lime 1–2½	Bordeaux 4–4–50	0.66
13	" 1–2½	.....	375
14	" 1–5	.....	750
15	Check	Check	1500

CONCLUSIONS.

There is no good reason for giving up the Elberta or any other variety of peach sensitive to leaf-curl, as this disease can be controlled by spraying at trifling expense.

Of the three substances employed as fungicides in these experiments, the Bordeaux mixture is the most useful; and, though several different strengths of this mixture have been found nearly equal in efficiency the past season, for the early spraying a strong solution is recommended. When Bordeaux of good strength is used early and a season of warm, dry weather follows, continuing as late as the middle of May, a second spraying is not profitable. But if the weather is cold and wet, it is well to spray again with Bordeaux after the petals fall, using only two pounds of copper sulfate (with excess of lime) to fifty gallons of water, for, notwithstanding some statements to the contrary, the foliage of the peach seems sensitive to stronger solutions.

The treatment, then, for the prevention of peach leaf-curl based upon my own and other experiments is briefly as follows:

1. Spray with Bordeaux consisting of 6 lbs. of copper sulfate, 4 lbs. of good quick-lime, and 50 gals. of water about the first of April when the buds are beginning to swell.

2. Spray again when the petals have fallen with Bordeaux consisting of 2 lbs. of copper sulfate, 2 lbs. of good quick-lime, and 50 gals. of water. If the weather of April and early May is warm and dry, this second spraying may be omitted.

Lime or copper sulfate alone with water have been almost as effective as Bordeaux the past season when used for the first spraying and followed later by Bordeaux, but their effects are not so lasting, particularly in rainy weather, and, whether the season is favorable or unfavorable, the second spraying with Bordeaux should not be omitted when lime or copper sulfate are used alone for the first.

HOW TO MAKE THE BORDEAUX.

Prepare a stock solution by suspending 25 lbs. of copper sulfate in a coarse sack in 25 gals. of water for a day or more until completely dissolved. To make 50 gals. of strong Bordeaux for the early spraying, take 6 gals. of the stock solution and dilute it with 19 gals. of water. Weigh out 4 lbs. of the best quick-lime, slack it slowly, dilute to 25 gals., and strain through a metallic sieve into the copper sulfate solution while the latter is being stirred.

To prepare 50 gals. of the weak Bordeaux for the late spraying, proceed in the same manner, using 2 gals. of the stock solution of copper sulfate, 2 lbs. of quick-lime, and 48 gals. of water.

Those conducting spraying operations on a larger scale will find it convenient to prepare fifty gallons or more of the stock solution of copper sulfate, keeping it covered to prevent evaporation, and to slack a considerable quantity of lime at once and keep it in the form of a paste in a barrel partially sunk in the ground or in a trough made specially for the purpose. If the surface of the paste is kept covered with a little water, the lime may be preserved for an indefinite length of time in this form and the amount required for a given quantity of Bordeaux determined by testing the mixture with a solution of potassium ferrocyanid in about ten parts of water. A drop of this solution on being added to a solution of copper sulfate produces immediately a dark reddish brown color. When sufficient lime has been added in the preparation of the Bordeaux mixture, this change in color does not occur on the addition of potassium ferrocyanid. It is well to add a little more lime, even after the test indicates a sufficient quantity, since a large excess of lime is rather a benefit than otherwise, while a slight excess of copper sulfate may prove injurious to the foliage. A first-class spraying outfit and a convenient water supply are very important where much spraying is attempted.

W. A. MURRILL.

The writer's thanks are due Messrs. King and Robinson, of Trumansburg, Mr. H. S. Wright, of Ithaca, Mr. Henry Lutts, of Youngstown, and Mr. W. T. Mann, of Barker, who have offered their orchards for the above experiments and most heartily coöperated with him to make them successful.

Bulletin 181. March, 1900.

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

HORTICULTURAL DIVISION.

POLLINATION IN ORCHARDS.

By S. W. FLETCHER.

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ORGANIZATION.

The regular bulletins of the Station are sent free to all who request them

* Absent on leave.

CORNELL UNIVERSITY, ITHACA, N. Y., March 1, 1900.
HONORABLE COMMISSIONER OF AGRICULTURE,
ALBANY, N. Y.

Sir:—One of the most trying experiences of the orchardist and also one of the most frequent, is to see his trees bloom but not set fruit. Various investigations of such difficulties have been made and published, but much more needs to be done. In order to understand the subject, particularly in its relations to practical orcharding, an investigation was set on foot by Professor Bailey. This investigation has been continued three years under his direction and supervision, and the summary results are published in this bulletin, which is submitted for publication under Chapter 430 of the Laws of 1899.

The study of pollination in orchards is made necessary by the rise of commercial fruit-growing. When fruit is grown only for home use, or in small areas for a local market, there is not likely to be serious loss from imperfect pollination ; but in large commercial orchards, any general unfruitfulness from this source is quickly noticed. The commercial orchard seems destined to be the most important single factor in American horticulture, and with its growth comes a corresponding increase in the liability of loss from imperfect pollination. This bulletin will find its greatest usefulness, therefore, in the hands of the commercial fruit-grower. Aside from extended investigations in this State, experiences have been secured from all parts of the country.

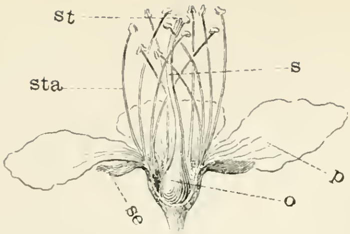
This bulletin is divided into two parts :

I. Incidental or occasional causes for loss of fruit.

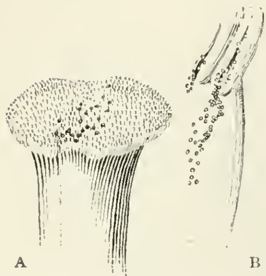
II. Self-sterility, which is the main part of the work.

Respectfully submitted,

I. P. ROBERTS, Director.



65.—*The structure of a plum blossom. se. sepals ; p. petals ; sta. stamens ; o. ovary ; s. style ; st. stigma. The pistil is comprised of the ovary, style and stigma. It contains the female part. The stamens are tipped with anthers in which the pollen, or male part, is borne. The ovary, o, ripens into the fruit.*



66.—*B, pollen escaping from anther. A, pollen germinating on the stigma. Enlarged. The transfer of pollen to the stigma is called pollination.*

67.—*Pollen grain germinating. Greatly magnified.*

65–67.—*Details of a fruit blossom.*

68.—*At 7 a. m.*

69.—*At 10 a. m*

70.—*At 3 p. m.*

71.—*At 8 a. m. the next morning.*

68–71.—*The opening of a flower of Kieffer pear. The flowers of pears and apples have five styles and stigmas. All natural size.*
(Courtesy of *American Gardening*.)

POLLINATION IN ORCHARDS.

I. VARIOUS REASONS WHY FLOWERS DO NOT SET.

All observing fruit-growers have seen trees which blossom full but do not set a fair amount of fruit; many have found their orchards unprofitable for this reason. It is a practical point to know the causes of this loss and the best way to prevent it.

Not all the flowers can set fruit.

In the first place, but a small percentage of the blossoms set fruit anyway, even in the most favorable seasons and with the most productive varieties. In blossoming time a Japanese plum tree is a mass of white, carrying scores of flowers on a single branch; yet scarcely a dozen fruits may set on that twig, and some of those must be removed or the tree will overbear. In the pollination work at Ithaca in 1899, 4,725 untouched blossoms, including apples, pears, plums and apricots, set but 617 fruits. The blossoms counted were those on the tree at large and were used for comparison with the hand crosses. This is about one fruit for every eight blossoms; yet most of the trees set what would be called a good crop. All of these blossoms were apparently uninjured by the winter, and the weather during the blossoming season was very favorable for the setting of fruit.

This normal failure in the setting of fruit blossoms may be due to a number of causes; as poorly nourished fruit-buds, lack of pollination, or winter injury to the pistils which cannot be seen with the eye alone. It is usually a distinct advantage to the fruit-grower, as it saves thinning. If all plum blossoms set fruit, the expense of thinning would be multiplied many times. Only when the failure of fruit blossoms to set becomes general, does the fruit-grower feel the loss and call for an explanation.

This wholesale failure in the setting of fruit is often called self-sterility. Properly speaking, a self-sterile tree is one which is self-unfruitful: it must have other varietes near it in order to bear well. But it appears that self-sterility in orchard fruits is often confused with the unfruitfulness resulting from other causes.

It would therefore be well to clear away this confusion at the outset, in order that the discussion of self-sterility may be better understood. The influences which sometimes make trees unfruitful, which are often confused with the unfruitfulness resulting from self-sterility, are (1) heavy wood growth, (2) the attack of fungi on the blossoms, (3) frosts, (4) unfavorable weather during the blooming season. It should also be said that a tree is not self-sterile when it does not blossom. This bulletin does not attempt to tell why trees do not bloom, except that it is generally due to poor management. The only thing which concerns us now is, why trees which blossom full do not set a reasonable amount of fruit.

Blossoms may drop because of heavy wood growth.

Young trees generally set little or no fruit the first few years, when they are growing fast, although they may blossom full. With most varieties this early dropping of the blossoms occurs only two or three seasons, but Northern Spy and a few other varieties of apples are often unfruitful ten to thirteen years from this cause. Older trees may show the same results if stimulated too highly with nitrogenous fertilizers. The logical remedy is to check this excessive growth of wood by witholding nitrogen or by putting the orchard into sod for a few years.

The direct cause of this unfruitfulness is not known. The stamens and pistils are usually well developed and pollen may be produced in abundance. Since young trees drop their blossoms as badly in a mixed orchard where other pollen is available, as when alone, the trouble probably lies more with the pistils than with the pollen.

Up to this limit of excessive growth, there is a fairly constant relation between the vigor of a tree and its productiveness. Lack of vigor causes much more unfruitfulness than excessive vigor. If a tree is unhealthy or dying because of poor nourishment, few of its blossoms are strong enough to set fruit. The same results may follow if the tree is exhausted by over-bearing.

Blossoms may be killed by fungi.

If the weather is warm and wet in early spring, conditions are favorable for the growth of fungi and it sometimes happens that fruit blossoms are "blasted" by the early growth of these parasites. The common brown-rot fungus often kills peach blossoms and may seriously decrease the setting of fruit. It is probable that this fungus sometimes attacks plum and cherry blossoms also. Apple and pear scab may kill the blossoms, but more often it kills the young fruits soon after they are set. Wherever spraying is practiced faithfully, the killing of fruit blossoms by fungi need not occur, especially if one thorough application is made to the trees before the buds open. The killing of pear blossoms by blight, however, cannot be prevented by spraying. The blossoms on Kieffer and LeConte trees are especially liable to be destroyed by the growth of blight microbes, which are carried from flower to flower. The only way to prevent this loss is to have no blighted trees in or near the orchard.

72.—*Winter-injured fruit buds of Royal apricot.*

Winter and spring frost may injure the blossoms.

The unfruitfulness arising from winter or spring frost injury is sometimes confused with self-sterility. Various forms of winter injury to fruit buds are shown in Figs. 72–77. At A in Fig. 72 is a fruit bud which has been completely winter-killed and has made no growth whatever. B and C are buds which will never be able to open; while D is a very weak blossom which cannot set fruit. The single open flower on this branch is the only one which can possibly set fruit. A winter-injured cluster of Bietigheimer blossoms is seen in Fig. 73, with a section of one bud in Fig. 74 to show the shriveled stamens and pistils. The leaves in this cluster came through all right, but the flowers were injured. The single flower which has expanded is too small and weak to develop into fruit. These winter-injured clusters were

73.—*Winter-injured fruit buds of Bietigheimer apple.*

common on all varieties of pears, particularly Angouleme and Manning Elizabeth, and on some varieties of apples, in the spring of 1899.

Two forms of winter or spring frost injury to the pistils are seen in Fig. 75 and 76, with a normal blossom for comparison in Fig. 77. A common form of injury is that in Fig. 75, in which the pistil is blackened and stunted, having made no perceptible growth during the opening of the flower. These pistils always drop from the tree soon after the petals have fallen. Another and not less common form of injury is that in Fig. 76, in which the pistil has made a partial growth but has no well developed ovary. Unless a careful examination is made, blossoms like this would not be considered as winter-injured. Of fifty which were tagged, none gave fruit, although several fruits grew to the size of peas. The killing of the pistils is the most common form of winter injury to fruit buds. Some of the native and Japanese plums had as high as 80 per cent of defective pistils last spring, but with their enormous amount of bloom this did not materially decrease the crop of fruit which the trees were able to carry. The Japanese plums bloom so early that their blossoms are liable to be injured by frost in the middle states and south.

74.—*Section of one bud in Fig. 73.*

It is thus seen that the injury to fruit blossoms from cold is of all degrees. During the opening of a normal flower, the pistil grows. It is often taken for granted that if this growth occurs the pistil is uninjured; but it may be that even though a pistil reaches its full size, it may yet be so injured that it cannot develop into fruit. In 1899 about ten per cent of the blossom buds of a Royal apricot opened fully, like the one in Fig. 72. All of these blossoms appeared to be perfect, with long pistils, plump ovaries and well developed stamens. Yet hardly a dozen fruits set on the whole tree, although the weather during the blooming season was ideal, bees were numerous, and some of the

75.—*Catherine apricot; injured pistil.*

flowers were even crossed by hand with the pollen of other varieties. Since the variety had already shown itself so susceptible to winter injury, it is probable that this wholesale failure was due to the weakened vitality of the pistils, which could not be seen with the eye alone.

76.—*Catherine; injured pistil.*

Some of the imperfect development of flowers which we attribute to winter injury may be caused by unfavorable conditions during the previous season, when the buds were being formed; yet it seems likely that winter injury to pistils is more common and more serious than appears at first sight. These remarks on winter injury are introduced simply to emphasize the fact that all blossoms which do not set fruit are not self-sterile; and also to promote a more careful discrimination between the various causes which decrease the setting of fruit.

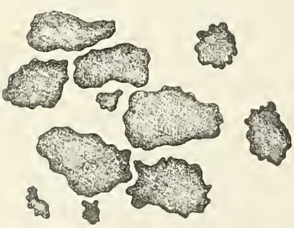
Rain may injure fruit blossoms.

The unfruitfulness which often follows a rain during the blooming season is sometimes confused with self-sterility. A careful fruit-grower watches the weather anxiously when his trees are in blossom, for he knows this is the most critical period in the growth of the crop. Injury to fruit blossoms from rain is common wherever fruit is grown, but is particularly serious along the Pacific coast and near the shores of the Great Lakes. It has been estimated that more fruit is lost in California from cold rains during blooming time than from all other causes combined. Like winter injury to fruit buds, there is no way of preventing this loss except to secure a more favorable location, since it is not in man's power to prevent rain, however much he may be able to induce it by bombarding the sky. Nevertheless, it is interesting to know in what way rain decreases the setting of fruit.

77.—*Catherine; normal flower.*

If a rain comes while the trees are in full bloom the pollen is washed from those anthers which have already opened, and is thus prevented from reaching the stigma. Should the rain be a short one, no serious harm need result from this loss of pollen, for the unopened anthers will burst and pollination will begin again soon after the sun comes out. The washing away of pollen has very little influence in decreasing the setting of fruit, particularly when the rain is short. There will generally be enough pollen to supply the pistils before or after the rain.

The poor setting of fruit which often follows a long rain and sometimes a shower is due more to a loss of vitality in the pollen or to some mechanical injury to the pistils; also, in large measure, to the fact that bees and other insects which promote the beneficial cross-pollination between varieties are absent. If the rain lasts for several days, the pollen may lose its vitality. After a week of rainy weather at Ithaca in the spring of 1898, nearly all the pollen of the apricots then in bloom was disorganized and stuck together, so that it could not possibly grow and fertilize the pistils. Some of this pollen is shown in Fig. 78. It is also natural to suppose that a hard rain may wash off, dilute, or otherwise injure the juices of the stigma so that the pollen cannot germinate after it falls upon the stigma. Perhaps a long "spell" of wet weather may even kill the pistils after they have been fertilized.



78.—*Pollen injured by rain. Much magnified. Compare Fig. 80.*

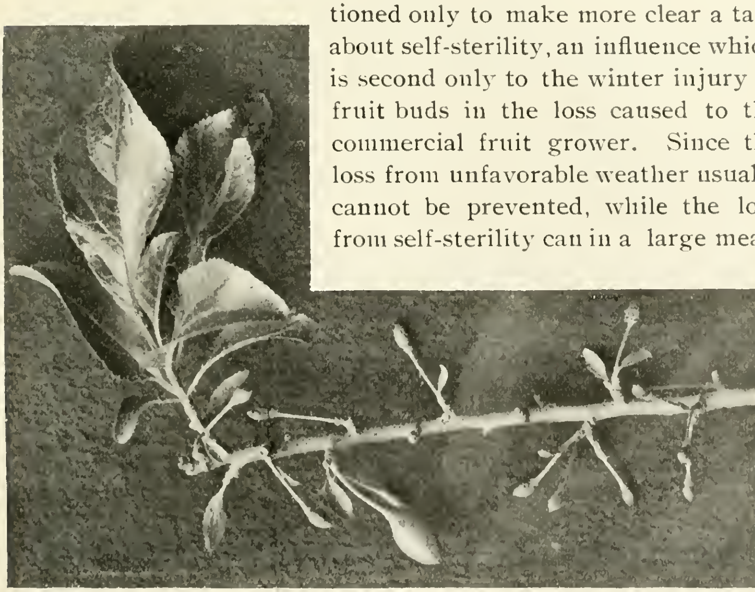
Thus a rain during the blooming season may decrease the setting of fruit in four ways: (1) By preventing the pollen from reaching the stigma, both because it is too wet to fly and because pollen-carrying insects are absent. This is important only when the rain lasts several days and most of the pistils pass their receptive state before the rain ceases. (2) By destroying the vitality of the pollen. (3) By injuring the stigma. (4) By preventing fertilization or the germination of the pollen because of low temperature.

The blossoms may be injured by strong or drying winds.

Near the sea and large lakes, fruit blossoms may be whipped off by very severe winds. In such cases a mixed windbreak of deciduous and evergreen trees may be used to advantage. Drying winds during the blossoming season are not common in the east but are often serious in some parts of the west. Luther Burbank, one of our best observers and experimenters in orchard pollination, says a dry wind sometimes causes a short fruit crop in some parts of California by drying up the juices of the stigma so that the pollen cannot germinate.

II. SELF-STERILITY.

There have been described in the preceding pages some of the influences which decrease the setting of fruit. These were mentioned only to make more clear a talk about self-sterility, an influence which is second only to the winter injury of fruit buds in the loss caused to the commercial fruit grower. Since the loss from unfavorable weather usually cannot be prevented, while the loss from self-sterility can in a large measure, the latter subject deserves more than the brief notice which has been given to the former at this time.



79.—Coe Golden Drop. But one fruit has set; the others will soon drop.

There are some trees which blossom full year after year but set little or no fruit, even in the most favorable seasons. These trees are usually in solid blocks, or at a distance from any other variety. Planting near them other trees of the same variety does not make them fruitful; but if trees of other varieties are planted near they are often made fruitful. *A self-sterile variety is one which is unable to set fruit when alone: in order to be productive, it must be planted near some other variety.* Two varieties very commonly self-sterile are Miner and Wild Goose plums. Large blocks of the Kieffer pear and some of the great prune orchards on our Pacific coast have been unprofitable from this cause. Besides these striking examples, there is reason for believing that much of the unsatisfactory fruiting of orchards all over the country is due to the isolation or indiscriminate mixing of varieties.

The main cause of self-sterility.

In general, *the cause of self-sterility is that the pollen of a variety is unable to fertilize the pistils of that same variety.* That is, if pollen from a Wild Goose blossom falls on a Wild Goose pistil, whether on the same tree or any other Wild Goose tree, no fruit will result as a rule. The pollen of a self-sterile variety may be and generally is produced in abundance and is well formed. Wild Goose generally bears pollen freely, although it is one of the most self-sterile varieties in cultivation. The Bartlett pear is often self-sterile, yet its pollen is perfect. (Fig. 80.) The pollen of a self-sterile variety also has vitality, for it will fertilize the pistils of other varieties. For example, plant together trees of the two self-sterile varieties, Miner and Wild Goose, and both will often be made fruitful, because the pollen of each, though infertile on itself, is fertile on the other. It is not known in what way this infertility is usually shown, but with Wild Goose at least, the pollen grain actually germinates and the pollen tube passes down to the ovule. Why the two sexes are unable to unite after having got thus far, the embryologist has not yet told us.

80. *Pollen of Bartlett. Much magnified.*

Minor causes of self-sterility.

Aside from the impotency of pollen, the main cause of self-sterility, there may be several other incidental causes. Goff and

Waugh have shown that self-sterile varieties of native plums often have a large per cent of pistils which are too weak to develop into fruit. This could not be a general cause of self-sterility, however, for self-sterile varieties can usually be made fruitful by planting other varieties near them. This shows that there are enough sound pistils on the tree for a good crop of fruit, provided they receive the right kind of pollen.

Again, the blossoms of some varieties may produce but a small amount of pollen. When these varieties are planted alone they may not have enough pollen to set a good crop, even though the pollen is fertile on its associated pistils. The amount of pollen which flowers produce is greatly modified by weather conditions and the vigor of the tree.

Many plums are worked on Marianna and Miner stocks, two of the most self-sterile varieties in common cultivation. It has been thought that possibly there might be an influence of the stock on the scion in the direction of self-sterility, but this assumption seems to be without foundation.

Finally, the stamens and pistils of a tree may not mature simultaneously, which would make a tree unfruitful unless pollen is supplied from other sources. With many varieties of orchard fruits the pistil of each flower matures a little before the stamens; and not infrequently the stamens mature before the pistil is ready to receive the pollen. But there is usually enough variation in the opening of flowers on the same tree to promote pollination with each other and so prevent serious loss from this alternate ripening of the sexes. Defective pistils, scanty pollen supply, and the premature ripening of either pistils or stamens may often be important in determining the fruitfulness of a tree; but the main cause of unfruitfulness in most self-sterile varieties is the failure of the pollen to fertilize its associated pistils. This cause cannot be removed, but its injurious results may often be prevented by a judicious selection of varieties.

A practical application.

The practical bearing of the self-sterility problem is this: There are certain varieties of fruit which we wish to grow largely for the general market, but we find that they are not productive when planted alone. They need the pollen of other varieties to make them fruitful. Then we must do what some of our most intelligent fruit-growers have been doing for years—plant other varieties near them as pollinizers. Orchardists along the Atlantic coast have been obliged to do this with Kieffer. The Californians often find it necessary with their prunes ; and many an unproductive orchard of Wild Goose has been made fruitful by being partially top-worked with another variety. Cross-pollination of varieties is no longer a theory ; it is an established orchard practice.

The history of the self-sterility discussion.

There are at least sixty species of plants which are known to be often sterile with their own pollen. The study of this problem had its origin mainly in the investigations of Darwin. While Darwin was not the first to observe the value of cross-pollination, he so far exceeded his predecessors in this, as in most other work, that the beginning of a systematic study of self-sterility is usually dated from the publication of his "Origin of Species" in 1859. Self-sterility in orchard fruits was first studied by Waite, under the direction of the United States Department of Agriculture. Since the publication of his work, in 1894, (Bul. 5, Div. Veg. Pathology) many experimenters have continued the lines of study indicated by him.

The unfruitfulness arising from self-sterility had been noticed many years before by fruit growers. The benefit which some varieties gained by being planted near other varieties also had been noticed, and mixed planting was often practiced with success, particularly with Wild Goose and Miner. There are now one hundred and twenty-six entries in my bibliography of references to "barren" trees in American literature before the appearance of Waite's bulletin in 1894. The real cause of this barrenness, however, was not known definitely before the experiments of Waite ; although it had long been supposed by many to be the pollen. Of late years, many experimenters have done careful work along this line. Among these are Goff, Waugh, Craig, Kerr, Crandall and Heideman, on orchard fruits ; Beach, Earle, T. V. Munson, Whitten and Green on grapes. The California and Oregon State Boards of Horticulture are also making a special inquiry on the self-sterility of prunes.

Varieties which are often self-sterile.

Self-sterility is not a constant character with any variety. It is influenced by the conditions under which the tree is grown, as are the size, shape and color of the fruit. The adaptation of a variety to soil and climate has much to do with its self-fertility, and if a tree is poorly nourished it is more likely to be infertile with its own pollen. No one can separate varieties of fruit into two definite classes, the self-sterile and the self-fertile. Thus Bartlett and Kieffer are often self-sterile, but there are orchards of both which are self-fertile. The same may be said of many other varieties. The best that can be done, therefore, is to give a list of those varieties which *tend* to be more or less self-sterile and which it would be unsafe to plant alone.

Following is a conservative list of these risky varieties, drawn both from experimental work and from the reports of over five hundred fruit growers who have favored me with their experience. *Pears:* Angouleme (Duchess), Bartlett, Clapp, Idaho, Kieffer, Nelis. *Apples:* Bellflower, Primate, Spitzenburg, Willow Twig, Winesap. *Plums:* Coe Golden Drop, French Prune, Italian Prune, Kelsey, Marianna, Miner, Ogon, Peach, Satsuma, Wild Goose, and according to Waugh and Kerr, all other varieties of native plums except Robinson. *Peach:* Susquehanna. *Apricot:* White Nicholas. *Cherries:* Napoleon, Belle de Choisy, Reine Hortense. Most of these varieties are self-fertile in some places, but the weight of evidence shows them to be uncertain.

It must not be inferred that all other varieties are always able to set fruit when planted alone. There are some, however, which have exceptionally good records for fruitfulness when planted in solid blocks, other conditions being favorable. Among these are: *Apples:* Baldwin, Ben Davis, Fallawater, Janet, Oldenburg, Rhode Island Greening, Red Astrachan, Smith Cider. *Plums:* Burbank, Bradshaw, DeSoto, Green Gage, Lombard, Robinson and some of the common blue Damsons.

All this goes to show that the problem of self-sterility is as much a study of conditions as of varieties. We can set no limits; we can only indicate tendencies.

The great and growing Kieffer pear industry in the eastern United States warrants a fuller discussion of this variety. Many large blocks of Kieffer are being planted with no other varieties intermingled, and it is an important point to know whether this practice will give the best results. Eight blocks of Kieffer in New Jersey and Delaware have been reported as completely or partially unfruitful because of self-sterility, and there are also many solid blocks of Kieffers in the same states which bear well. Kieffer is unreliable, especially on the Delaware peninsula. A large block of Kieffer may be productive, but it does not pay to take the risk, particularly since the pollen of other varieties is likely to give better fruit, as will be seen later on.

Selecting the pollinizer.

Let us suppose that we intend to plant a large block of an uncertain variety, as Kieffer, because it has distinct merit as a market sort. We wish to plant with it some other variety to make it fruitful. There are two points to be considered when selecting a pollinizer for Kieffer or for any other self-sterile variety; the choice should not be indiscriminate. These are simultaneous blooming, and mutual affinity.

The first and most important point is that the two shall blossom together, since the only way in which a pollinizer can make a self-sterile variety fruitful is by supplying it with pollen. This means that the pistils of the self-sterile variety must be receptive when the stamens of the pollinizer are ripe, which is possible only with simultaneous blooming.

The comparative blooming of varieties is more or less a local problem. Differences of latitude, altitude, soil, nearness to large bodies of water, and weather conditions during the blooming season not only hasten or retard the time of blooming but also disturb the order in which the different varieties open. Varieties blossoming together at one place may not at another. The best that can be done in the way of generalizing on the question of simultaneous blooming for cross-pollination is to make a chart for each well marked geographical district. To this end several hundred fruit growers have kindly taken notes the past two seasons, and when sufficient data is collected these charts may be published. They will indicate in a general way which of our standard commercial varieties may be expected to bloom together; yet each fruit grower should be prepared to make minor corrections for his own farm. Until more definite knowledge is available, each orchardist should learn how varieties bloom in his own neighborhood before planting them for cross-pollination. It is better, but not always necessary, that the two should bloom exactly together; if they overlap two or three days that is often enough.

It is sometimes desirable to plant varieties of different botanical species together for cross-pollination, but this will often be impracticable because of the difference in their blooming seasons. Thus the Oriental pears, as Kieffer, and the European pears, as Bartlett, usually do not blossom together. Kieffer generally blooms several days before Bartlett, hence it is necessary to pollinate it with a variety of its own class, as Le Conte or Garber. In some places, however, the two groups blossom approximately together, and then varieties like Bartlett and Seckel should be used in preference to Le Conte or Garber, since their fruit has a greater market value and the trees are less likely to blight. Whenever the European pears are used as pollinizers for Kieffer it would be well, if otherwise practicable, to work them on quince roots. Standard Kieffers will often bloom two or three years before standard Bartletts planted at the same time, and unless early blooming dwarfs are intermingled they may be unproductive these first few years.

The three classes of commercial plums,—Japanese, domestica and native,—will usually bloom at different periods in the order named; but when a "spell" of warm weather succeeds a cold and backward spring, varieties of all these groups will come on nearly together and cross-pollination will result. In some places the blooming seasons of these groups overlap so that some varieties of each might be used regularly for cross-pollination.

The mutual affinity of varieties.

Another point to be looked after when selecting a pollinizer for Kieffer, or for any other self-sterile variety, is the mutual affinity of the two. That is, will the pollen of the pollinizer fertilize the pistils of the self-sterile variety readily and also develop them into high grade fruit? At present but little is known about this matter. Taking first the possibility of cross-pollination between varieties of different species, there seems to be no doubt but that many varieties of native, Japanese and domestic plums will fertilize each other. Orchard experience in many places indicates this; as when Satsuma is used to pollinate Coe Golden Drop in Californian prune orchards. Several successful crosses between the three were also made at Ithaca the past season. Among these are Abundance × Grand Duke (Fig. 84), Georgeson × Wayland, Berckmans × Coe Golden Drop, Coe Golden Drop × Satsuma. That is, if we wish to use Satsuma as a pollinizer for Coe Golden Drop, or Lombard for Wild Goose, the probability is that the combination would work, if the two varieties bloom together; but since the three groups usually bloom at somewhat different periods there can be no general cross-pollination outside the limits of the species.

Numerous crosses and common orchard practice have also shown that the European pears, as Bartlett, and the Sand Pear hybrids, as Kieffer, will fertilize each other regularly when they bloom together. Several Kieffer fruits from Bartlett pollen and Bartlett fruits from Kieffer pollen were secured in the crossing work of 1899. In fact, my experience has been that if Kieffer pollen is put on the pistils of our common pears, of the European class, it will usually produce larger fruit than pollen from most varieties of that type. Kieffer is a good pollinizer for Bartlett, Angouleme, Clapp, Nelis and like varieties, when they bloom together. In Fig. 81, compare the size of the Seckels which received Kieffer pollen with those which had Lawrence pollen. The specimens shown are typical of thirty fruits secured from these two crosses in 1899.

It is necessary to study not only the mutual affinity of varieties belonging to different species, but also of varieties of the same species. Some varieties will not fertilize each other, though blossoming at the same time. Kerr has found that Whitaker plum will not fertilize Wild Goose nor will Early Red help Caddo Chief. Again, the pollen of some varieties will give better fruit than that of others when used on the pistils of self-sterile or even on self-fertile varieties. There is very little definite knowledge as to what varieties are best adapted for pollinating self-

81.—*Seckel. From Kieffer pollen above, from Lawrence pollen below.*

sterile sorts. Waugh and Kerr have studied this point with native plums for several years and their judgment is united in a table of recommended pollinizers for plums (12th Report Vt. Ag. Ex. Sta.). A few results from crosses made at Ithaca in 1899 will illustrate this point. Fig. 81 shows the comparative size of Seckel when pollinated with Kieffer and with Lawrence pollen. Clapp pollinated with Kieffer was also larger than Clapp pollinated with Lawrence or Louise Bonne. Howell blossoms which received the pollen of Clapp gave fruits of nearly twice the size of those which received Bartlett pollen. Bartletts crossed with Angouleme were larger than Bartletts crossed with Sheldon. In some cases no difference could be noticed, yet most of our standard commercial varieties will be likely to yield enough better fruit when planted with some varieties than with others, to make a study of this point worth the while.

Some of the combinations which have been very successful in the commercial orchards of the country are: Bartlett with Nelis, Flemish Beauty, Easter, White Doyenne ; Idaho with Bartlett ; Kieffer with LeConte, Garber ; Coe Golden Drop with French Prune, Green Gage, Italian Prune (Fellenburg); Statsuma with Abundance, Burbank, Red June ; Miner with De Soto, Forest Rose, Wild Goose ; Wild Goose with De Soto, Newman, Miner.

Does crossing change the appearance of the fruit?

In connection with the mutual affinity of varieties which are selected for cross-pollination, there comes the question of the "immediate influence" of pollen. For instance, if Seckel pollen is put on Kieffer pistils, will it impart the Seckel flavor, color and characteristic shape to the resulting fruit? Of course the characters of both may be united in the seeds, and the trees which come from these seeds may be expected to be intermediates ; but is the flesh of the fruit ever changed by foreign pollen?

The increase in size which often follows crossing cannot be called a true immediate influence, for the foreign pollen generally stimulates the fruit to a better growth because it is more acceptable to the pistils, not because it carries over the size-character of the variety from which it came. In 1899, Hyslop Crab pistils which were fertilized with pollen from the great Tompkins County King, grew into fruits of the usual crab size. An immediate influence in size may be possible, for the size of the fruit is nearly as constant a varietal character as is the shape ; but most of the increased size in crosses of orchard fruits probably arises from the fact that the pollen is more acceptable.

Setting aside the usual gain in size resulting from crossing, we wish to know whether there will be any change in the shape, color, quality and season of ripening of the fruit. A few undoubted instances of this influence have been noticed with some plants in which the seed is the principal part of the fruit, as the mixing of sweet corn and field corn; also perhaps in various peas and beans. When the seed is surrounded by a fleshy pulp, however, as in our common orchard fruits, it is still in dispute whether this pulp is influenced, however much the seeds themselves may be. Most men have formed their convictions about the immediate influence of pollen

82.—*Stark. From Wagener pollen above, from Stark pollen below. Marked benefit from cross-pollination.*

from observation, rather than from experimental proof. It does not necessarily follow that "sweet and sour" apples are due to cross-pollination, nor that the russet on Greening apples borne on the side of the tree next a Roxbury was produced by the influence of the Roxbury pollen.

Most of the changes in fruit which are attributed to the influence of cross-pollination are due to variation. Every bud on a tree is different in some way from every other bud on that tree and may develop unusual characters, independent of all the other buds, according to the conditions under which it grows.

The best way to determine whether there is an immediate influence of pollen is by hand crossing. Among the forty-five different crosses which were made in 1899 with this particular point in view, not one showed any change which could be positively attributed to the influence of pollen. Even the concentrated sweetness of Seckel made no impression on the poor quality of Kieffer; nor were there any constant differences in color, shape, or season of ripening in any of the other crosses. Nearly every-

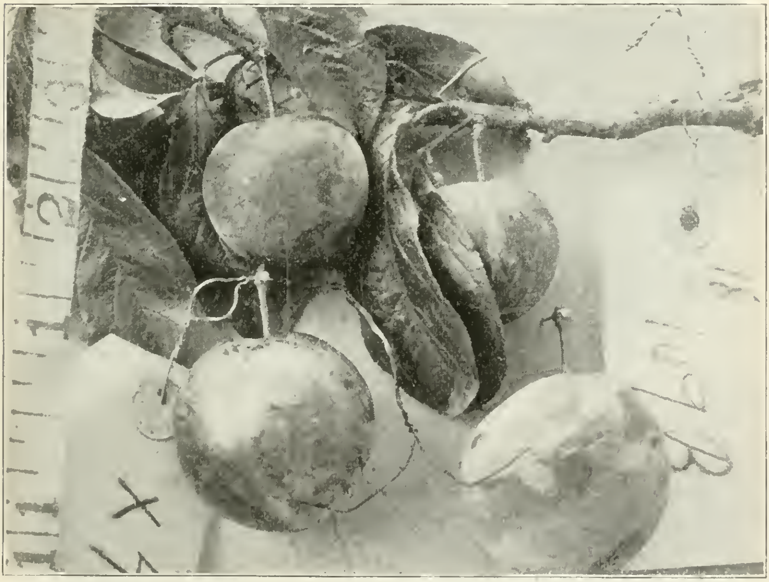
83.—*Longfield. From Greening pollen below, from Longfield pollen above. Marked benefit from cross-pollination.*

body who has crossed varieties of orchard fruits has had a similar experience.

Most of the evidence supporting the theory that there is an immediate influence of pollen in the crosses of fruits comes from observation; most of the evidence against it comes from experiment. The observer, however careful, is likely to jump at conclusions; the experimenter tries to give due weight to every influence which might bear on the problem. Since many observers and a few experimenters have found what seems to be an immediate influence of pollen on the fruit, we cannot doubt but that this influence is sometimes exerted. But it is certainly much less frequent than is commonly supposed.

The distribution of the pollinizers.

Having selected a pollinizer with reference to simultaneous blooming and mutual affinity, the fruit-grower now wishes



84.—*Abundance. From Abundance pollen above, from Grand Duke pollen below. Some benefit from cross-pollination.*

to know how many trees will be necessary to pollinate the self-sterile variety. There are three things to be considered here: the ability of the pollinizer to produce pollen, its market value, and the class of fruit to which the self-sterile variety belongs.

Varieties differ in the amount of pollen which they produce, and the pollen production of the same variety is also greatly modified by differences in locality and season. Other things being equal, the variety which produces pollen freely could be used more sparingly in a block of self-sterile trees than one of scanty pollen production. Little comparative observation has been made on this point as yet; but as a matter of fact, most of our common varieties produce an abundance of pollen.

The number of trees of the pollinizer would also depend largely

85.—*Talman Sweet. From Talman Sweet pollen above, from Wagener pollen below. No benefit from cross-pollination.*

on whether it has value in itself. If we are planting LeConte to pollinate Kieffer, we would naturally try to get along with the least possible number which will do the work; but if Bartletts are to be used for the same purpose, we can afford to increase the proportion. Some growers plant every tenth row to the pollinizer, but the proportion should usually be greater. This might be enough if the weather during the blossoming season is very favorable for cross-pollination by wind and insects; but if it is showery, the pollinizers should be more abundant, in order that

86.—*Bradshaw Plum. From German Prune pollen above, from Bradshaw pollen below. No benefit from cross-pollination.*

cross-pollination may be more general during the bright weather between showers. If using Garber or LeConte to pollinate Kieffer, every third row may be the pollinizer; if using Bartlett, every other row. For apples, cherries and domestic or Japanese plums, the same proportion may be used. In a commercial orchard, the pollinizer should be planted in a solid row. Theoretically, it is much better to have the pollinizer more evenly distributed among the self-sterile trees; practically, it will not pay to so mix them except in small orchards.

The advantages of general mixed planting.

It would appear that the only thing to do now is to find out what varieties are inclined to be self-sterile and the varieties which are best adapted for fertilizing them. But as a matter of fact, cross-pollination gives better results with nearly all varieties, be they self-sterile or self-fertile. A variety may be able to bear good fruit when it is planted alone, but it will often bear better fruit if suitable varieties are near it. Mixed orchards are more productive than solid blocks, taking the country over. It is a common observation in Western New York that Baldwins in mixed orchards are more uniformly productive than Baldwins in large blocks. Furthermore, although a variety may be able to set an abundance of fruit with its own pollen, this fruit will often be smaller than if other pollen were supplied. From a number of experiments made in 1899, a few representative results are here given to illustrate this point.

Compare the size of self-pollinated and cross-pollinated fruits in Figs. 82–86. In some varieties the difference was very marked, as with Stark and Longfield apples (Fig. 82–83); in others the difference was not so marked, as Abundance (Fig. 84); while a few showed no appreciable increase in size from cross-pollination, as Talman Sweet and Bradshaw (Fig. 85–86). The difference between the cross- and self-pollinated Starks and Longfields is so striking that one would almost be tempted to think the self-pollinated fruits were wormy, but they were not. The self-pollinated Talmans and Bradshaws were apparently as fine in every way as the cross-pollinated fruits. Manning Elizabeth pear also was not benefited by pollen from other varieties.

The three self-pollinated Longfields here shown (Fig. 83) had but five sound seeds; while the two crossed specimens had seventeen sound seeds. In general, cross-pollinated fruits have more good seeds than self-pollinated fruits, but there is no constant relation between the size of a fruit and the number of seeds it contains. Some of the biggest apples or pears may have only two or three good seeds. In case the ovules in one cell of an apple or pear core are not fertilized, that part of the fruit adjoining is often stunted and the fruit becomes lop-sided in consequence ; but this, likewise, does not always follow.

All of the above varieties are self-fertile, at least in Ithaca. They will produce fruit with their own pollen. But we have seen that some of them will produce better fruit if other pollen is supplied. Is it not worth while, then, to plant pollinizers even with self-fertile varieties—that is, to practice mixed planting with all varieties? There are three good reasons for doing this : First, some believe that self-sterility is likely to increase in the future, under the stimulus of high cultivation. Second, we can never be perfectly sure that any variety will be self-fertile on our soil and under our culture ; even those varieties which are self-fertile elsewhere may be partially self-sterile with us. Third, most self-fertile as well as self-sterile varieties are benefited by cross-pollination. It is taking risks to plant a very large block of one variety. The trees may bear just as much and just as fine fruit as though other varieties were with them, but the chances are against it.

The pollen-carriers.

The pollen of one variety is carried to the pistils of another in two ways : by the wind and by insects. There are many kinds of insects which aid more or less in the cross-pollination of orchards fruits, principally bees, wasps and flies. Of these, the wild bees of several species are probably the most important. In a wild thicket of plums or other fruits, they are usually numerous enough to insure a good setting of fruit. But few if any wild bees can live in a large orchard, especially if it is well tilled. As the extent and thoroughness of cultivation increases, the number of these natural insect aids to cross-pollination decreases ; hence it may become necessary to keep domestic honey bees for this purpose.

SUMMARY.

1. Scarcely one fruit blossom in ten sets fruit, even in the most favorable seasons and with the most productive varieties.

2. Trees making a very vigorous growth may drop their blossoms.

3. Brown rot, apple or pear scab, and pear blight may kill the blossoms.

4. Frost injury to blossoms is of all degrees. Even flowers which appear to be uninjured may be so weakened that they cannot set fruit.

5. Rain during the blooming season prevents the setting of fruit chiefly by destroying the vitality of the pollen, injuring the stigma, or by preventing fertilization because of the low temperature. The washing of pollen from the anthers seldom causes serious loss.

6. Much of the unsatisfactory fruiting of orchards all over the country is due to self-sterility. A tree is self-sterile if it cannot set fruit unless planted near other varieties.

7. The main cause of self-sterility is the inability of the pollen of a variety to fertilize the pistils of that variety.

8. Poor stamens and pistils or the premature ripening of either are but minor causes of self-sterility.

9. An indication of self-sterility is the continued dropping of young fruit from isolated trees or solid blocks of one variety.

10. Self-sterility is not a constant character with any variety. The same variety may be self-sterile in one place and nearly self-fertile in another.

11. Poorly nourished trees are more likely to be sterile with their own pollen than well fed trees are.

12. The loss of fruit from self-sterility usually may be prevented by planting other varieties among the self-sterile trees.

13. The European and Oriental pears can fertilize each other, and many varieties of the domestica, Japanese and native plums are likewise inter-fertile, provided they bloom together.

14. The pollen of some varieties will give larger fruit than that of others when it falls on or is applied to the pistils of either self-sterile or self-fertile varieties.

15. Among our common orchard fruits cross-pollination seldom has an immediate influence on of the fruit itself.

16. Cross-pollination probably gives better results than self-pollination with nearly all varieties.

17. It is advisable and practicable to plant all varieties of orchard fruits, be they self-sterile or self-fertile, with reference to cross-pollination.

18. Insects are probably more important than wind for carrying pollen from tree to tree.

19. *Final suggestions.*—a. When setting out new orchards do not plant a solid block of each variety, but mix them intelligently.

b. If established orchards are unfruitful because of self-sterility it may be profitable to put a few grafts of another variety in each tree.

c. Keep fruit trees well nourished but do not stimulate them to an over-vigorous growth.

S. W. FLETCHER.

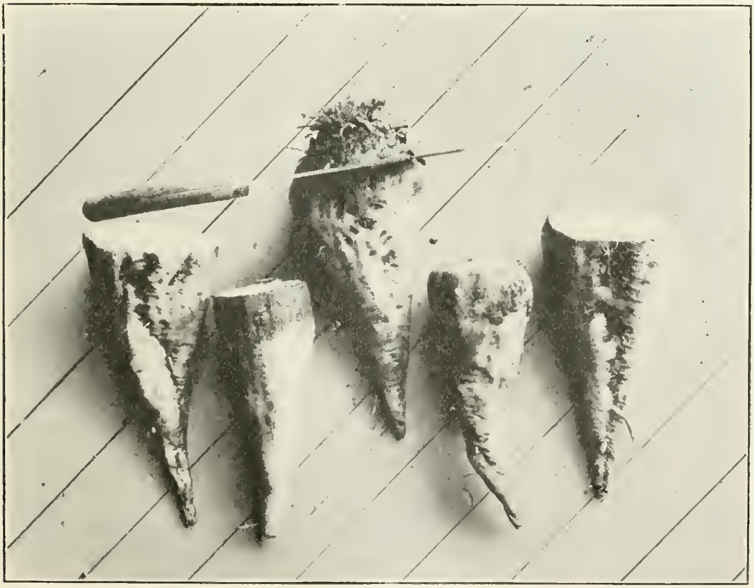
Bulletin 182. **April, 1900.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

AGRICULTURAL DIVISION.

Sugar Beet Investigations for 1899



By J. L. STONE and L. A. CLINTON.

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CORNELL UNIVERSITY, ITHACA, N. Y., March 15, 1900.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir:—The following report contains the results obtained from the coöperative experiments with sugar beets throughout the state, and also the results obtained upon the experimental grounds at Cornell University. The coöperative experiments were in charge of Mr. J. L. Stone, and consisted of making tests of varieties and also of fertilizers. Owing to peculiarities of the season the fertilizer work is not here reported, but a full account is given of the test of varieties. This coöperative work with the farmers throughout the state is valuable not only for the results obtained from the experiments, but also for the interest which it creates among the farmers in the work which is being done by the state through the College of Agriculture, and by the Experiment Station to advance the cause of agriculture.

The work upon the home grounds was in charge of Mr. L. A. Clinton. Experiments have been conducted with fertilizers upon sugar beets, and a summary of the work for three years is given. This report is of value owing to the care taken to make the plats uniform and to the length of time during which the experiment has been conducted. An account is also given of the field plat experiments with sugar beets during 1899.

The data obtained add to our knowledge of the subject of sugar beet growing, and the report is submitted for publication under Chapter 430 of the Laws of 1899.

I. P. ROBERTS,
Director.

PART I. CO-OPERATIVE EXPERIMENTS.

BY J. L. STONE.

The investigations relating to sugar beets conducted by this station during the season of 1899 have been chiefly along the lines of comparison of varieties, and testing the effect of different fertilizers on the yield and quality of beets. No effort was made to locate experiments outside the territory that is producing beets for the two factories now in operation in the state. However, requests were received from some thirty persons living in other sections asking for seeds and instruction for growing beets, both of which were forwarded, and the beets received from such persons have been tested for sugar and purity.

Arrangements were made with thirty-eight farmers who were engaged in sugar beet culture, and therefore vitally interested in the work, to make a practical comparative test of five varieties of sugar beets, the seed of which was furnished to the station by the U. S. Department of Agriculture, Washington, D. C. By having the five varieties grown side by side, and thus under as nearly uniform conditions as to fertility and culture as possible in each of the experiments, it was believed that the average results obtained would be much more significant than a larger number of tests where the varieties were separated and perhaps subjected to different conditions.

In previous work it has been the custom of the station to receive two beets as a sample for determining the percentage of sugar and purity of the juice. It is frequently observed when these beets are examined separately that they show considerable difference in content of sugar and purity of juice, thus leading to the conclusion that the individuality of the beet may lead to an erroneous estimate of the crop where so few as two beets are used as a sample. It was therefore decided that each sample should consist of six beets, which were forwarded by express, instead of through the mails as formerly, thus materially reducing the liability to error from the cause mentioned.

The season for preparing the land and sowing was unusually favorable so that the seed was gotten in the soil in fine condition and at an early date. In fact the early date at which the seeding was completed had the effect of reducing the number of our experiments, as we had expected at least two weeks more time in which to go among the farmers to arrange the work. The weather conditions were favorable for germination, a good stand was obtained and early and economical tillage was generally facilitated so that up to the middle of August the crop was unusually promising. From this time on the effect of drought, which in some localities was the most destructive on record, was very manifest. In some instances the damage was so great that the experiment was abandoned as not likely to give trustworthy data. In fact it is believed that abnormal conditions of any kind, and especially drought, lessen the value of experimental data, as they emphasize the unavoidable inequalities of soil as regards texture, natural water supply, etc.

The variety tests—The following table No. 1, gives a statement, somewhat in detail, of the results obtained by each experimenter. The table gives the name and address of the grower, the character of the soil, the varieties of beets grown, the yield per acre in tons, the percentage of sugar in the beets and the purity of the juice.

All analyses recorded in this bulletin were made by Mr. G. W. Cavanaugh and Mr. A. L. Knisely, Assistant Chemists of the Experiment Station.

TABLE I.

Name and Address of Grower.	Character of Soil.	Variety of Beets.	Tons per Acre.	Sugar per cent. in Beets.	Purity of Juice.
Robert Wright, Little York, Cortland Co., N. Y.	Gravelly	Kleinwanzlebener	11.90	15.96	82.4
		Vilmorin	11.55	14.35	77.4
		Zehringen	10.75	15.01	81.9
		Mangold	13.30	12.92	75.6
		*Biendorf Elite Klein.	10.75	13.30	76.9
F. E. VanCamp, Preble, Cortland Co., N. Y.	Gravelly	Kleinwanzlebener	10.89	18.15	84.9
		Vilmorin	9.15	17.48	85.2
		Zehringen	10.02	18.72	87.5
		Mangold	9.80	17.53	85.4
		Biendorf Elite Klein.	9.80	17.29	84.0
Frank Daley, Preble, Cortland Co., N. Y.	Gravelly loam	Kleinwanzlebener	9.24	19.00	85.8
		Vilmorin	13.20	17.48	82.5
		Zehringen	10.06	18.81	83.3
		Mangold	12.20	17.77	83.1
		Biendorf Elite Klein.	9.24	18.38	86.4
Clark Esty & Son, Tully Valley, Onondaga Co., N. Y.	Gravelly loam	Kleinwanzlebener	17.10	17.72	86.7
		Vilmorin	14.25	14.54	79.7
		Zehringen	17.25	15.96	82.7
		Mangold	17.00	15.15	82.6
		Biendorf Elite Klein.	14.25	14.49	77.4
C. A. Knapp, Little York, Cortland Co., N. Y.	Gravelly loam	Kleinwanzlebener	7.46	12.26	72.9
		Vilmorin	7.86	11.50	69.9
		Zehringen	6.97	13.87	76.8
		Mangold	8.13	12.16	71.5
		Biendorf Elite Klein.	7.39	10.64	66.7
W. E. Bowen, Little York, Cortland Co., N. Y.	Gravelly loam	Kleinwanzlebener	13.45	17.86	87.0
		Vilmorin	16.80	16.77	84.9
		Zehringen	13.90	16.48	83.0
		Mangold	14.90	16.34	82.7
A. A. Knapp, Preble, Cortland Co., N. Y.	Sandy loam	Kleinwanzlebener	13.80	15.20	76.5
		Vilmorin	15.80	16.10	76.7
		Zehringen	12.90	18.15	80.2
		Mangold	14.80	16.44	79.7
		Biendorf Elite Klein.	14.80	14.49	76.7
G. H. Thomas, Chenango Bridge, Broome Co., N. Y.	Sandy loam	Kleinwanzlebener	8.80	15.77	82.6
		Vilmorin	8.16	14.87	83.2
		Zehringen	7.96	13.82	80.4
		Mangold	10.66	15.34	80.8
		Biendorf Elite Klein.	9.43	13.63	77.6

* Biendorf Elite Kleinwanzlebener.

TABLE I—*Continued.*

Name and Address of Grower.	Character of Soil.	Variety of Beets.	Tons per Acre.	Sugar per cent. in Beets.	Purity of Juice.
Wm. Weale, Owego, Tioga Co., N. Y.	Sandy loam	Kleinwanzlebener	10.10	14.25	78.6
		Vilmorin	10.40	9.83	72.9
		Zehringen	8.85	14.63	79.4
		Mangold	10.00	15.20	82.8
		Biendorf Elite Klein.	11.85	12.92	73.1
O. B. Wilmot, Chenango Bridge, Broome Co., N. Y.	Sandy loam	Kleinwanzlebener	13.50	14.25	82.0
		Vilmorin	11.20	12.92	79.5
		Zehringen	12.90	15.58	84.1
		Mangold	15.05	14.39	81.5
		Biendorf Elite Klein.	12.60	13.82	85.2
John J. Smith, Candor, Tioga Co., N. Y.	Loam	Kleinwanzlebener	11.00	14.39	80.6
		Vilmorin	10.75	12.87	77.0
		Zehringen	11.85	15.20	80.4
		Mangold	10.70	14.44	80.9
		Biendorf Elite Klein.	11.25	13.30	78.2
Edwin Lawrence, Binghamton, Broome Co., N. Y.	Loam	Kleinwanzlebener	15.00	14.96	82.9
		Vilmorin	12.50	14.06	80.0
		Zehringen	12.50	15.01	82.7
		Mangold	15.00	14.54	82.3
		Biendorf Elite Klein.	16.25	13.73	78.9
C. J. Banta, Conklin, Broome Co., N. Y.	Upland loam	Kleinwanzlebener	7.00	17.01	84.4
		Vilmorin	8.00	18.05	86.8
		Zehringen	6.66	18.86	87.4
		Mangold	7.50	16.63	88.4
		Biendorf Elite Klein.	6.00	17.48	87.2
Jessel Hall, Chenango Bridge, Broome Co., N. Y.	Loam	Kleinwanzlebener	12.50	14.77	82.3
		Vilmorin	9.50	13.02	77.4
		Zehringen	10.50	13.63	79.7
		Mangold	10.50	13.30	77.8
		Biendorf Elite Klein.	9.00	13.59	77.3
H. E. Parsons, Chenango Bridge, Broome Co., N. Y.	Alluvial loam	Kleinwanzlebener	16.39	13.16	78.2
		Vilmorin	12.03	14.49	81.6
		Zehringen	13.88	15.68	82.9
		Mangold	14.34	13.30	77.3
		Biendorf Elite Klein.	14.34		
P. Judson Peck, Sherburn, Chenango Co., N. Y.	Loam	Kleinwanzlebener	12.05	16.82	83.5
		Vilmorin	13.34	15.20	78.4
		Zehringen	13.06	16.29	82.9
		Mangold	14.10	15.91	83.3
		Biendorf Elite Klein.	14.10	16.10	80.7

TABLE I—*Concluded.*

Name and Address of Grower.	Character of Soil.	Variety of Beets.	Tons per Acre.	Sugar per cent. in Beets.	Purity of Juice.
L. J. English, Binghamton, Broome Co., N. Y.	Black loam	Kleinwanzlebener	17.04	13.40	82.4
		Vilmorin	13.92	14.11	83.4
		Zehringen	16.00	15.06	82.6
		Mangold	17.25	13.87	82.0
		Biendorf Elite Klein.	17.92	14.44	82.2
W. C. Smith, Candor, Tioga Co., N. Y.	Gravelly loam	Kleinwanzlebener	7.50	13.82	80.8
		Vilmorin	8.32	12.21	77.4
		Zehringen	7.50	13.02	78.7
		Mangold	8.75	13.82	81.3
		Biendorf Elite Klein.	8.12	12.25	82.0
A. C. Bethka, East Syracuse, N. Y.	Loam	Kleinwanzlebener		16.34	85.6
		Vilmorin		15.72	84.9
		Zehringen		16.25	85.9
		Mangold		15.72	84.0
		Biendorf Elite Klein.		13.40	79.2
Geo. Lamb, East Hamilton, N. Y.	Mucky loam	Kleinwanzlebener		14.58	79.5
		Vilmorin		16.86	82.7
		Zehringen		15.63	82.7
		Mangold		16.72	84.2
		Biendorf Elite Klein.		15.96	81.5
T. S. Mulaney, Poolville, N. Y.	Loam	Kleinwanzlebener	7.19	12.83	75.8
		Vilmorin	4.91	14.06	75.9
		Zehringen	7.58	15.39	79.0
		Mangold	8.92	16.20	82.8
		Biendorf Elite Klein.	5.80	12.35	76.0
T. J. Collier, Preble, Cortland Co., N. Y.		Kleinwanzlebener		14.73	76.4
		Vilmorin		15.34	80.0
		Zehringen		16.06	79.0
		Mangold		14.25	77.0
		Biendorf Elite Klein.		11.40	69.5
S. W. Paddleford, Sherburn, Chenango Co., N. Y.	Loam	Kleinwanzlebener		14.48	82.4
		Vilmorin		14.35	81.2
		Zehringen		13.63	81.1
		Mangold		14.35	84.4
		Biendorf Elite Klein.		14.96	83.8
J. C. Fish, Corbettsville, Broome Co., N. Y.	Loam	Seed from Binghamton Beet Sugar Co		12.97	78.4
		Kleinwanzlebener		12.49	76.9
		Vilmorin		14.39	79.3
		Zehringen		14.92	80.1
		Mangold		14.01	80.6
		Biendorf Elite Klein.		14.44	82 6
		Lanes' Imp. Sugar		10.31	74.8

From an inspection of table No. 1 it may be seen that in the individual experiments important differences as to yield, content of sugar and purity of juice occur. These differences are sometimes sufficient to materially affect the profitableness of the crop, but the different varieties do not fall into any regular order as to yield or quality of crop. Each variety takes first place in some experiments and last in others.

Kleinwanzlebener	produces	largest	yield in	three	cases and	smallest in	four.
Vilmorin	"	"	"	four	"	"	eight.
Zehringen	"	"	"	two	"	"	seven.
Mangold	"	"	"	six	"	"	one.
Biendorf Elite Klein.	"	"	"	four	"	"	five.

A study of the kinds of soils upon which these experiments were conducted does not seem to indicate that any one of these varieties is preëminently adapted to a particular soil.

As regards quality of the beets it is also true that each variety takes first place in some experiments and last in others, but here there is a marked tendency for Kleinwanzlebener and Zehringen to appear at the head of the list, Vilmorin and Biendorf Elite Kleinwanzlebener to appear at the foot.

Kleinwanzlebener	shows	largest	% of	sugar in	ten	cases.	smallest in	four.
Vilmorin	"	"	"	"	one	"	"	seven.
Zehringen	"	"	"	"	ten	"	"	one.
Mangold	"	"	"	"	three	"	"	three.
Biendorf Elite Klein.	"	"	"	"	one	"	"	nine.

In some instances the highest content of sugar is associated with the largest yield but the tendency is to reverse this and associate high quality with low yield and vice-versa.

In table No. 2 are given the averages of the several varieties as set forth in table No. 1. The yields per acre are the averages for nineteen plats each growing the five varieties mentioned, except that Biendorf Elite Kleinwanzlebener was omitted from one plat. The columns showing the percentage of sugar and the purity of the juice are the averages for twenty-four plats each growing the five varieties except that the variety mentioned above was omitted from two of them.

TABLE NO. 2.—COMPARISON OF AVERAGE RESULTS.

Varieties.	Average Weight of Beets, Ozs.	Yields tons per acre.	Sugar in juice per cent.	Sugar in beets, per cent.	Purity of juice.	Sugar produced per acre, Lbs.
Kleinwanzlebener ...	16.1	11.67	15.75	15.16	81.2	3538
Vilmorin	15.7	11.14	14.80	14.07	79.9	3235
Zehringen	15.4	11.10	16.47	15.65	81.8	3474
Mangold	15.7	12.20	15.80	15.01	81.3	3662
Biendorf Elite Klein.	15.0	11.30	14.33	14.19	79.2	3207

While the average yield and quality of the different varieties of beets as shown in the above table are quite uniform, still between the highest and lowest there is a difference of more than one ton per acre in yield and above one and one-half per cent. in content of sugar.

A gain or loss of one ton per acre as resulting from the variety of beets planted is of very material importance to the farmer and a difference of one or one and a half per cent. of sugar in the beets is of even greater significance to the manufacturer.

It is estimated that a factory slicing during the season 25,000 tons of beets containing 15.5 per cent. sugar will turn out 3,250 tons of pure granulated marketable sugar, while if it were to slice the same amount of beets 1.3 per cent poorer in sugar, it would turn out 2,925 tons of marketable product—a difference of 325 tons of sugar which at $50.00 per ton would amount to $16,250. It will be seen that while in each case the expense incurred for beets, labor, fuel, etc., is the same, there is a difference in gross receipts for manufactured sugar amounting to a sum that will go a long ways towards a fair dividend on the investment.

Unfortunately, the variety showing the highest content of sugar (Zehringen) seems to be the lightest yielder. In our trials of 1898 (see Bulletin 166 pp. 135 and 136) this variety took the same rank when compared with Kleinwanzlebener and Vilmorin as to yield and quality that it does this season.

The variety of sugar beets known as Mangold was tested by this station for the first time this season and with very favorable results. As to productivity it heads the list and the quality is good. So far as the experience of this season on nineteen different farms may be an indication, it would seem that this variety might well be placed along with the well tried and ever reliable Kleinwanzlebener.

The fertilizer tests.—As stated at the beginning of this bulletin the plan of experimentation included a study of the effect of different fertilizing materia upon the yield and quality of sugar beets. Arrangements were made with a number of farmers to receive sets of experimental fertilizers from the station and apply them according to instructions. The scheme embraced eight plats of one-twentieth acre each as follows: Plat No. 1, 15 lbs. muriate of potash; plat No. 2, 15 lbs. nitrate of soda; plat No. 3, 30 lbs. superphosphate; plat No. 4, no fertilizer; plat No. 5, 15 lbs. muriate of potash and 15 lbs. nitrate soda; plat No. 6, 15 lbs. muriate of potash and 30 lbs. superphosphate; plat No. 7, 15 lbs. nitrate soda and 30 lbs. superphosphate; plat No. 8, 15 lbs. nitrate soda, 15 lbs. muriate of potash and 30 lbs. superphosphate; and, at the option of the farmer, plat No. 9, stable manure.

The conditions surrounding these experiments during the early part of the season were favorable and the prospect of securing valuable data seemed good up to the time that the drought became severe. As the season advanced it became evident that the real struggle of the plant was for moisture rather than for plant-food. Since it is impossible to secure nearly an acre of land that is perfectly uniform in texture and natural water supply it often occurs that the crop will vary more on account of these inequalities than from different fertilizers applied to the various parts. That commercial fertilizers may produce their full effect it is necessary that there be a liberal supply of moisture in the soil to take the plant-food thus furnished into solution. Hence it will be seen that the drought largely neutralized the effect of the fertilizer while it emphasized the inequalities of the soil. The data received from these experimenters are in some cases incomplete and owing to the effect of the drought it is considered unreliable and not valuable for publication.

PART II. SUGAR BEET EXPERIMENTS AT CORNELL UNIVERSITY EXPERIMENT GROUNDS, 1899.

BY L. A. CLINTON.

The land upon which the experiments were conducted was a part of the series of permanent plats. These plats have been subjected to intensive culture without the application of any fertilizer since the fall of 1893 when about ten tons of barn manure were applied per acre. Each fall after the removal of the crop from the land some cover crop as wheat or rye has been sown. But the lateness of the sowing prevented the cover crop from making much growth and as a consequence but little organic matter has been returned to the soil. The result is that the humus has been depleted and the soil, instead of remaining loose and friable, becomes very hard and compact under the action of rains. The fact is emphasized that where intensive culture is practiced, for best results it must be accompanied by a liberal application of barn manures or green manuring must be adopted, at least the organic matter of the soil must be maintained if the soil be kept in good physical condition.

The land for beets was plowed May 2—all except plat 27, which was plowed immediately before the beets were planted. After plowing the land was harrowed and rolled. Between time of plowing and time of planting the land was harrowed frequently.

Planting the beets.—On May 15 and 16 plats 21, 22, 23, 24, 26 and 27 were planted to variety Kleinwanzlebener, seed for which was furnished by the U. S. Dept. of Agriculture, Washington, D. C. Plat 27 was plowed deeply immediately before planting and harrowed and rolled. The object in leaving plat 27 without plowing until time of planting was to determine the effect of deep plowing immediately before planting. Plat 25 was planted to varieties—Mangold, Biendorf Elite Kleinwanzlebener, Vilmorins Improved and Zehringen. These plats were all planted with the rows 20 inches apart and the seed was covered to a depth of about one half inch.

Effects of a hailstorm.—Within a few days after planting and before the beets had appeared above ground a severe hailstorm occurred. The whole surface of the ground was covered with a layer of hail from one to two inches deep. The hail rapidly melted and the surface of the ground was made very wet. The effect upon the beets was most disastrous. The soil which had become depleted of its humus was compacted and the crust was so hard that the small beet plants were unable to force their way through. An attempt was made to break the crust by means of garden rakes, but the beet seed was covered so shallow that the plants were rooted near the surface and the soil directly over the young plants could not be disturbed without uprooting the plants and thus destroying them. It finally became apparent that a satisfactory stand of beets could not be secured upon all the plats and it was decided to plow and replant them so there would be secured a somewhat uniform stand of beets.

The second planting.—All beet plats were plowed June 5, and harrowed once with the spring tooth harrow and once with the spike tooth harrow and the beet seed was planted in rows 20 inches apart. Plats 21, 22, 23 and 24 were planted to Biendorf's Elite Kleinwanzlebener sugar beet seed. On plats 25, 26 and 27 there were planted fourteen rows of Zehringen Elite beet seed from Germany, grown by Dippe Brothers; twelve rows were planted to Zehringen Elite sugar beet seed from Germany, grown by Strandes; eight rows were planted to Zehringen beet seed and seven rows were planted to variety Mangold.

Object of experiment.—Upon plats 21, 22, 23 and 24 the object was to determine the effect upon the growth and yield of the beets of thinning at various times. With many farmers who grow beets for the factory it is often impossible to thin all the beets at the time of growth which has been recommended as most favorable. Owing to the large area to be thinned or to the pressure of other work the beets are often neglected for some time. Upon plats 25, 26 and 27 the experiment was simply a variety test.

Methods of tillage and thinning on plats 21, 22, 23 and 24.—The first tillage given the beets was on June 30 when a hand weeder was used on all plats. This weeder had the knife blade attachments which loosened the soil close to the plants and destroyed small weeds near the beets.

July 5th thinned to a stand the beets on the east one-half of plat 21 and on the east one-half of plat 22, and on plats 23, 24, 25, 26 and 27. The west one-half of plat 21 was permitted to remain without any thinning while the west one-half of plat 22 was bunched. On the west one-half of plat 21 the beets were allowed to remain thickly in the row until July 19 when they were thinned to a stand, there being left a space of about nine inches between beets in the row. On the west one-half of plat 22, the beets which had been bunched were permitted to remain in bunches until July 19 when they were thinned to a stand of one beet in a place. Tillage was given all plats on July 7, July 19 and July 25.

The thorough working of the land before the beets were planted tended to hasten their growth. The weed seeds which were present in the soil germinated before the second planting of the beets and were thus destroyed by the late plowing. The soil was thoroughly warm and owing to an abundant rainfall during July, 3.46 inches, the seeds germinated quickly and the plants grew rapidly.

The beets were not seriously injured by insects or disease. The growth of top was relatively small compared with the growth of root. To a casual observer the field never presented the appearance of having more than half a crop of beets.

Harvesting and yield.—The sugar beet harvest began November 3. A Syracuse chilled sub-soil plow was used to loosen the beets in the ground, after which they were trimmed by hand. The yield of trimmed beets from the various plats, also the per cent. of sugar and the per cent. purity are shown in the following table.

Plat No.	Variety.	Date of Planting.	Date of Thinning.	Yield Per Acre.	Per cent. Sugar in Beet.	Per cent. Sugar in Juice.	Purity.	Average weight of beets Analyzed.
21 East half	Biendorf's Elite Kleinwanzlebener	June 5	July 5	7.5 tons	15.49	16.30	82.8	12 oz.
21 West half	Biendorf's Elite Kleinwanzlebener	June 5	July 19	7.5 tons	14.82	15.60	80.8	13
22 East half	Biendorf's Elite Kleinwanzlebener	June 5	July 5	8.7 tons	14.06	14.80	79.6	11
22 West half	Biendorf's Elite Kleinwanzlebener	June 5	Bunched July 5 Thinned July 19	8.6 tons	15.01	15.80	83.2	13
23	Biendorf's Elite Kleinwanzlebener	June 5	July 5	10.1 tons	14.25	15.00	83.3	14
24	Biendorf's Elite Kleinwanzlebener	June 5	July 5	12.8 tons	15.34	16.15	82.1	12½
25	Zehringen Elite by Dippe Bros.	June 5	July 5	13.1 tons	15.44	16.25	82.9	14
26	Zehringen Elite by Strandes	June 5	July 5	12.6 tons	16.77	17.65	86.1	14⅓
27 East half	Zehringen	June 5	July 5	10.7 tons	16.01	16.85	85.5	15
27 West half	Mangold	June 5	July 5	9.6 tons	15.77	16.60	84.7	14

Results from early and late thinning.—In Bulletin 166 of this station the following statement was made with reference to the time of thinning beets. "Where conditions are favorable, considerable range may be taken as to time of thinning. With the weather coo and the soil moist, thinning may be safely done when the beets have attained a height of three to four inches. However, thinning is such a slow process that it would better be commenced on time, viz., when the second pair of leaves appear the plants should at least be bunched. The bunches may then safely be allowed to remain for a week or ten days before the beets are thinned to a stand of one beet in a place. If one could always be certain that the weather would be cool and soil moist, then there would not be the imperative necessity for beginning thinning early. If thinning be delayed until there exists drought accompanied by hot weather the growth of the plants may be seriously impaired, if the plants are not entirely destroyed."

The results of the experiment during 1899 lead us to change in no way the opinion expressed above, but rather enforce the conclusions heretofore drawn.

The month of July 1899 was especially favorable for late thinning of beets. It rained eleven days during the month an average of .314 inch each day, and on four other days during the month there was a trace of rain, the total rainfall for the month being 3.46 inches. The probability is that had the month of July been one of drought instead of one of abundance of rainfall the results might have been far different. Under the conditions which prevailed the late thinning seemed to be in no way injurious to the growth of the beets.

The yield of beets was not large enough to make the crop a paying one. This was not to be expected upon land which has been continually cropped for six years without the use of manures or fertilizers. The late planting occasioned by the failure to secure a stand from the first planting no doubt materially lessened the yield. The quality of the beets was all that could be desired. The per cent. of sugar and the per cent. of purity seemed to be affected in no way by the time of thinning.

Variety tests.—The variety giving the largest tonnage of beets

13.1 tons per acre was the Zehringen Elite from seed grown by Dippe Bros., Germany. The highest per cent. of sugar in the beets, 16.77, was found in the Zehringen Elite from seed grown by Strandes, Germany, and the highest per cent. purity 86.1, was also found in the Zehringen Elite from seed grown by Strandes.

In selecting the sample beets to be tested those were selected which seemed to represent fairly the beets grown on the plat. The size of the beets analyzed seems not to have affected the results. The smallest beets, those grown on the east one-half of plat 22 were the lowest in purity. The variety tests in no way prove anything. The conditions of the soil may have had more effect upon the yield than did the variety grown. The Zehringen Elite strains seemed to be better adapted to the soil and conditions present during 1899 than were the other varieties. Another season and on other soil the results might vary widely.

Fertilizer experiments with sugar beets —During the years 1897, 1898 and 1899 fertilizer experiments with sugar beets have been conducted upon some specially prepared plats. Before commencing this experiment it was determined to make the soil conditions uniform as to quality and treatment. In the spring of 1897 a space was measured off for 14 plats each 4x5 feet in size. The soil of this whole area was then removed to a depth of 24 inches, each layer of eight inches being thrown out upon boards by itself. A solid brick cement wall was constructed around each plat and to a depth of two feet below the surface of the ground. This wall was constructed so that there would be no possible chance for the beets in one plat to receive the benefit of the fertilizer applied to any other plat. After the construction of the wall the soil which had been removed was replaced in the inverse order of its removal, the eight inches removed last was returned first so that it would occupy its original place at the bottom. Before being returned each eight inches of soil was thoroughly mixed and then an equal number of pounds was put into each plat and packed. In this way all the plats were prepared, each layer of soil after being thoroughly mixed was returned to its original position.

During the years 1897, 1898 and 1899 the same experiment has been repeated, the various plats receiving each year the same kind of fertilizer received the previous year.

The small area upon which the experiments were conducted precludes the possibility of making any calculations of value as to the effect of the fertilizers upon the yield of beets. The only determinations of value hoped for are those which relate to the effect of the fertilizer upon the sugar content of the beets. We present the following tables which give the results of the three years work separately and also a table which gives the average of results for the three years.

TABLE SHOWING EFFECT OF FERTILIZER UPON THE QUALITY OF BEETS, 1897.

Plat.	Fertilizer used.	Rate per acre. Lbs.	Per cent. of sugar in beet.	Per cent. of sugar in juice	Per cent. solids in juice.	Purity of Juice
3	Sulfate of potash.....	544	17.06	17.96	20.08	87.56
4	Superphosphate......	544	17.29	18.18	20.12	90.36
5	Sulfate of potash...	277				
	Nitrate of soda.....	277	16.20	17.06	19.06	89.50
6	Nitrate of soda.......	544	16.71	17.59	19.49	88.40
7	No fertilizer.........		16.48	17.35	19.42	89.20
8	No fertilizer.........		16.23	17.09	19.22	88.60
9	Sulfate of potash....	277				
	Superphosphate....	277	16.61	17.49	19.14	91.38
10	Nitrate of soda.....	277				
	Superphosphate....	277	16.94	17.84	19.84	89.86
	Sulfate of potash...	184⅔				
11	Nitrate of soda.....	184⅔	17.43	18.35	20.08	91.22
	Superphosphate...	184⅔				
12	Muriate of potash....	544	17.73	18.67	20.72	89.94
13	Lime	1089	16.49	17.36	19.30	89.44
14	Ground ph'phate rock	1089	16.18	17.04	19.08	89.14

TABLE SHOWING EFFECT OF FERTILIZER UPON QUALITY OF BEETS, 1898.

Plat.	Fertilizer used.	Rate per acre. Lbs.	Per cent. of sugar in beet.	Per cent. of sugar in juice.	Per cent. of solids in juice.	Purity of juice.
3	Sulfate of potash	1089	16.77	17.65	20.6	85.7
4	Superphosphate......	1089	16.39	17.25	20.1	85.8
5	Sulfate of potash ..	1089	16.72	17.60	20.4	86.3
	Nitrate of soda	1089				
6	Nitrate of soda	1089	13.78	14.50	18.4	78.3
7	No fertilizer		16.15	17.00	20.5	82.9
8	No fertilizer		17.05	17.95	20.4	88.0
9	Sulfate of potash ..	1089				
	Superphosphate....	1089	17.96	18.90	21.6	87.5
10	Nitrate of soda	1089	17.53	18.45	21.1	87.4
	Superphosphate....	1089				
11	Sulfate of potash..	1089				
	Nitrate of soda.....	1089	16.48	17.35	20.3	85.4
	Superphosphate....	1089				
12	Muriate of potash....	1089	17.48	18.40	21.2	86.8
13	Lime..	1089	16.72	17.60	20.1	87.5
14	Ground ph'phate rock	1089	16.01	16.85	19.5	86 4

TABLE SHOWING EFFECT OF FERTILIZER UPON QUALITY OF BEETS, 1899.

Plat.	Fertilizer used.	Rate per acre. Lbs.	Per cent. of sugar in beet.	Per cent. of sugar in juice.	Per cent. of solids in juice.	Purity. of juice.
3	Sulfate of potash ...	1089	16.15	17.00	20.5	82.9
4	Superphosphate......	1089	13.78	14.50	18.1	80.1
5	Sulfate of potash ..	1089	14.25	15.00	18.6	80.6
	Nitrate of soda.....	1089				
6	Nitrate of soda.......	1089	13.11	13.80	17.6	78.1
7	No fertilizer		13.96	16.80	20.1	83.5
8	No fertilizer		15.15	15.95	19.3	82.6
9	Sulfate of potash ..	1089				
	Superphosphate....	1089	16.15	17.00	19.6	86.3
10	Nitrate of soda.....	1089				
	Superphosphate....	1089	13.02	13.70	16.5	83.0
11	Sulfate of potash ..	1089				
	Nitrate of soda.....	1089	14.44	15.20	19.0	80.0
	Superphosphate ...	1089				
12	Muriate of potash....	1089	15.87	16.70	20.5	81.1
13	Lime........	1089	14.73	16.50	19.9	82.9
14	Ground ph'phate rock	1089	15.39	16.20	19.6	82.6

TABLE SHOWING EFFECT OF FERTILIZER UPON QUALITY OF BEETS.

Average of Results for 1897, 1898 and 1899.

Plat.	Fertilizer used.	Per cent. of sugar in beet.	Per cent. of sugar in juice.	Per cent. of solids in juice.	Purity of juice.
3	Sulfate of potash	16.66	17.53	20.39	85.38
4	Superphosphate........	15.82	16.64	19.44	88.75
5	Sulfate of potash .... Nitrate of soda.......	15.72	16.55	19.35	85.46
6	Nitrate of soda	13.53	15.29	18.49	81.60
7	No fertilizer	15.53	17.05	20.00	85.53
8	No fertilizer	16.14	17.03	19.64	86.40
9	Sulfate of potash.... Superphosphate......	16.90	17.79	20.11	88.39
10	Nitrate of soda ...... Superphosphate......	15.83	16.66	19.14	86.75
11	Sulfate of potash..... Nitrate of soda ...... Superphosphate	16.11	16.96	19.79	85.54
12	Muriate of potash	17.02	17.92	20.80	85.94
13	Lime	15.98	17.15	19.76	86.61
14	Ground phosphate rock.	15.86	16.69	19.39	86.04

By a study of the above tables the two facts which seem to be most pronounced are : First, where nitrate of soda was used alone as a fertilizer the per cent. of sugar in the beets was very materially reduced as was also the purity of the juice. The average per cent. of sugar in the beets where nitrate of soda alone was used was 13.53, with the purity of the juice 81.60.

The average of all plats where no nitrate of soda was used was 16.24 per cent. of sugar in the beets with a purity of juice of 86.63.

Second—Contrary, to the popular belief, the beets upon the plat receiving muriate of potash alone as a fertilizer contained the highest per cent. of sugar of any of the beets grown, and the purity of the juice compared well with that of all others. The per cent. of sugar in the beets fertilized with muriate of potash alone was 17.02 with a purity of the juice of 85.94. The average per cent. of sugar in the beets grown on all plats not receiving any muriate of potash was 15.82 with purity of the juice of 86.04. It is usually considered that the sulfate of potash is superior to the muriate of potash as a fertilizer for sugar beets but our experiments do not indicate that the sulfate is superior in any way to the muriate. This fact is important because the muriate of potash can usually be secured at a price materially less than the price asked for the sulfate of potash. Where nitrate of soda is used as a fertilizer for sugar beets it should be used in conjunction with the mineral fertilizers superphosphate and potash. Muriate of potash may safely be used as a fertilizer for sugar beets. The other chemicals used seem not to have any marked effect upon the quality of the beets.

L. A. CLINTON.

The Following Bulletins are Available for Distribution to Those Who may Desire Them.

40 Removing Tassels from Corn, 9 pp.
55 Greenhouse Notes, 31 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
74 Impressions of the Peach Industry in N. Y., 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western N.Y. 116 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western N. Y., 27 pp.
87 Dwarf Lima Beans, 24 pp.
93 Cigar-Case-Bearer, 20 pp.
95 Winter Muskmelons, 20 pp.
96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to the Care of Fruit Trees, 21 pp.
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp
114 Spraying Calendar.
116 Dwarf Apples, 31 pp.
117 Fruit Brevities, 50 pp.
119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp.
121 Suggestions for Planting Shrubbery,
122 Second Report upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol-Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and the Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp.
128 A Talk about Dahlias, 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp.
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.
138. Studies and Illustrations of Mushrooms: I. 32 pp.
139. Third Report upon Japanese Plums 16 pp.
140 Second Report on Potato Culture, 24 pp.
141 Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142 The Codling-Moth.
143 Sugar Beet Investigations, 88 pp.
144 Suggestions on Spraying and on the San José Scale.
145 Some Important Pear Diseases.
146 Fourth Report of Progress on Extension Work, 26 pp.
147 Fourth Report upon Chrysanthemums, 36 pp.
148 Quince Curculio, 26 pp.
149 Some Spraying Mixtures.
150 Tuberculosis in Cattle and its Control.
151 Gravity or Dilution Separators.
152 Studies in Milk Secretion.
153 Impressions of Fruit-Growing Industries.
154 Table for Computing Rations for Farm Animals.
155 Second Report on the San José Scale.
156 Third Report on Potato Culture.
157 Grape-vine Flea-beetle.
158 Source of Gas and Taint Producing Bacteria in Cheese Curd.
159 An Effort to Help the Farmer.
160 Hints on Rural School Grounds.
161 Annual Flowers.
162 The Period of Gestation in Cows.
163 Three Important Fungous Diseases of the Sugar Beet.
164 Peach Leaf-Curl.
165 Ropiness in Milk and Cream.
166 Sugar Beet Investigations for 1898.
167 The Construction of the Stave Silo.
168 Studies and Illustrations of Mushrooms; II.
169 Studies in Milk Secretion.
170 Tent Caterpillars.
171 Concerning Patents on Gravity or Dilution Separators.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1899.

171. Gravity or Dilution Separators.
172. The Cherry Fruit-fly: A New Cherry Pest.
173. The Relation of Food to Milk-Fat.
174. The Problem of Impoverished Lands.
175. Fourth Report on Japanese Plums.
176. The Peach-Tree Borer.
177. Spraying Notes.
178. The Invasion of the Udder by Bacteria.
179. Field Experiments with Fertilizers.
180. The Prevention of Peach Leaf-Curl.
181. Pollination in Orchards.

APPENDIX II.

Detailed Statement of Receipts and Expenditures of the Cornell University Agricultural Experiment Station, for the fiscal year ending June 30, 1900.

EXPENDITURES.

FOR SALARIES.

1899			
July	31.	I. P. Roberts, Director	$ 125 00
"	31.	L. H. Bailey, Horticulturist	125 00
"	31.	H. H. Wing, Dairyman	125 00
"	31.	G. F. Atkinson, Botanist	83 33
"	31.	L. A. Clinton, Assistant Agriculturist	100 00
Aug.	31.	I. P. Roberts, Director	125 00
"	31.	L. H. Bailey, Horticulturist	125 00
"	31.	H. H. Wing, Dairyman	125 00
"	31.	G. F. Atkinson, Botanist	83 33
"	31.	L. A. Clinton, Assistant Agriculturist	100 00
Sept.	30.	I. P. Roberts, Director	125 00
"	30.	L. H. Bailey, Horticulturist	125 00
"	30.	H. H. Wing, Dairyman	125 00
"	30.	G. F. Atkinson, Botanist	83 33
"	30.	G. W. Cavanaugh, Assistant Chemist	100 00
"	30.	L. A. Clinton, Assistant Agriculturist	100 00
"	30.	L. V. Maloney, Stenographer	47 67
Oct	31.	I. P. Roberts, Director	125 00
"	31.	L. H. Bailey, Horticulturist	125 00
"	31.	H. H. Wing, Dairyman	125 00
"	31.	G. F. Atkinson, Botanist	83 33
"	31.	G. W. Cavanaugh, Assistant Chemist	100 00
"	31.	L. A. Clinton, Assistant Agriculturist	100 00
Nov.	30.	I. P. Roberts, Director	125 00
"	30.	L. H. Bailey, Horticulturist	125 00
"	30.	H. H. Wing, Dairyman	125 00
"	30.	G. F. Atkinson, Botanist	83 33
"	30.	G. W. Cavanaugh, Assistant Chemist	100 00
"	30.	L. A. Clinton, Assistant Agriculturist	100 00
"	30.	E. A. Butler, Clerk	60 00
"	30.	L. V. Maloney, Stenographer	47 67
Dec.	30.	I. P. Roberts, Director	125 00
"	30.	L. H. Bailey, Horticulturist	125 00
"	30.	H. H. Wing, Dairyman	125 00
"	30.	M. V. Slingerland, Assistant Entomologist	135 00
"	30.	G. F. Atkinson, Botanist	83 33
"	30.	L. A. Clinton, Assistant Agriculturist	100 00
"	30.	G. W. Cavanaugh, Assistant Chemist	100 00
"	30.	E. A. Butler, Clerk	60 00
"	30.	L. V. Maloney, Stenographer	47 67
		Amount carried forward,	$3,947 99

1900		Amount brought forward	$3,947 99
Jan.	31.	I. P. Roberts, Director	125 00
"	31.	L. H. Bailey, Horticulturist	125 00
"	31.	H. H. Wing, Dairyman	125 00
"	31.	M. V. Slingerland, Assistant Entomologist	135 00
"	31.	G. F. Atkinson, Botanist	83 33
"	31.	G. W. Cavanaugh, Assistant Chemist	100 00
"	31.	L. A. Clinton, Assistant Agriculturist	100 00
"	31.	E. A. Butler, Clerk	60 00
"	31.	L. V. Maloney, Stenographer	49 50
Feb.	28.	I. P. Roberts, Director	125 00
"	28.	L. H. Bailey, Horticulturist	125 00
"	28.	H. H. Wing, Dairyman	125 00
"	28.	M. V. Slingerland, Assistant Entomologist	135 00
"	28.	G. F. Atkinson, Botanist	83 33
"	28.	G. W. Cavanaugh, Assistant Chemist	100 00
"	28.	L. A. Clinton, Assistant Agriculturist	100 00
"	28.	E. A. Butler, Clerk	60 00
"	28.	L. V. Maloney, Stenographer	44 00
Mar.	31.	I. P. Roberts, Director	125 00
"	31.	L. H. Bailey, Horticulturist	125 00
"	31.	H. H. Wing, Dairyman	125 00
"	31.	M. V. Slingerland, Assistant Entomologist	135 00
"	31.	G. F. Atkinson, Botanist	83 33
"	31.	G. W. Cavanaugh, Assistant Chemist	100 00
"	31.	L. A. Clinton, Assistant Agriculturist	100 00
"	31.	E. A. Butler, Clerk	60 00
"	31.	L. V. Maloney, Stenographer	49 50
Apr.	30.	I. P. Roberts, Director	125 00
"	30.	L. H. Bailey, Horticulturist	125 00
"	30.	H. H. Wing, Dairyman	125 00
"	30.	M. V. Slingerland, Assistant Entomologist	135 00
"	30.	G. F. Atkinson, Botanist	83 33
"	30.	L. A. Clinton, Assistant Agriculturist	100 00
"	30.	G. W. Cavanaugh, Assistant Chemist	100 00
"	30.	E. A. Butler, Clerk	60 00
May.	31.	I. P. Roberts, Director	125 00
"	31.	L. H. Bailey, Horticulturist	125 00
"	31.	H. H. Wing, Dairyman	125 00
"	31.	M. V. Slingerland, Assistant Entomologist	135 00
"	31.	G. F. Atkinson, Botanist	83 33
"	31.	G. W. Cavanaugh, Assistant Chemist	100 00
"	31.	L. A. Clinton, Assistant Agriculturist	100 00
"	31.	E. A. Butler, Clerk	60 00
"	31.	L. V. Maloney, Stenographer	49 50
June	30.	I. P. Roberts, Director	125 00
"	30.	L. H. Bailey, Horticulturist	125 00
"	30.	H. H. Wing, Dairyman	125 00
"	30.	M. V. Slingerland, Asst. Entomologist	135 00
"	30.	G. F. Atkinson, Botanist	83 33
"	30.	G. W. Cavanaugh, Assistant Chemist	100 00
"	30.	L. A. Clinton, Assistant Agriculturist	100 00
"	30.	E. A. Butler, Clerk	60 00
		Total for salaries	$9,460 47

FOR OFFICE AND PRINTING.

1899			
July	5.	Postage	$ 63 00
"	7.	Engravings	15 46
"	17.	Gas	80
"	17.	Circular Letters	1 25
"	18.	Freight and cartage	2 91
"	24.	Printing Bulletin No. 171.	200 00
Aug.	2.	Labor	6 40
"	2.	Labor	5 31
"	5.	H. H. Wing, traveling expenses	79 75
"	8.	Postage	25 00
"	8.	Book binding	2 48
"	9.	Gas	45
Sept.	11.	Gas	1 05
"	15.	Postage	30 00
"	25.	E. A. Butler, traveling expenses	7 37
Oct.	7.	Repairing typewriter	4 62
"	7.	Printing Bulletin No. 172	242 00
"	11.	Paper	2 00
"	17.	Gas.	90
"	17.	City Directory	2 50
"	18.	Wrapping paper	21 50
"	20.	Express	25
"	21.	Freight and cartage	4 53
"	23.	Engravings	11 70
"	31.	L. V. Maloney, salary	47 67
"	31.	Labor	7 80
"	31.	Express..	40
Nov.	4.	Coöperative Society, Office supplies	7 91
"	16.	Gas	2 10
"	17.	Stationery	40
"	27	Postage	25 00
"	28.	Engravings	2 00
Dec.	1.	Freight and cartage	6 85
"	1.	MacMillan Co., 12 vols. *Rural Science* series	8 78
"	1.	Printing Bulletin No. 173	353 10
"	1.	E. A. Butler, traveling expenses.	7 60
"	1.	Labor	9 05
"	4.	Blank books	4 50
"	4.	Books	1 16
"	5.	Freight and cartage	5 86
"	9.	Oil for office floor	2 50
"	12.	Office supplies	60
"	12.	Gas	3 13
"	12.	American Book Co., Book	1 30
"	15.	Book	68
"	18.	W. J. Beal, S. P. A. S. Rept	59
"	18.	I. P. Roberts, traveling expenses	2 70
"	22.	Photos	30 60
"	30.	Labor	14 97
"	30.	Labor and material for mailing list	350 00
"	30.	Labor on Bulletin No. 172	27 20
1900			
Jan.	3.	Stationery	2 00
		Amount carried forward,	$2,657 58

		Amount brought forward	$2,657 58
Jan.	3.	Advertisement for old reports	1 50
"	8.	Postage	25 00
"	8.	Express	30
"	17.	Repairing office clock	2 25
"	17.	Gas	3 13
"	23.	I. P. Roberts, traveling expenses	18 19
"	26.	Printing Bulletin No. 176	406 20
"	26.	Freight and cartage	3 71
"	27.	G. W. Cavanaugh, traveling expenses	4 91
Feb.	5.	Membership dues to A. A. A. C. & E. S	10 00
"	5.	Stationery	6 75
"	5.	Postage	25 00
"	9.	Gas	2 50
"	12.	Office supplies	3 03
"	12.	Gas	1 38
"	12.	Invoice book	2 25
"	17.	Express	25
"	23.	Cutting cards	20
"	23.	Express	40
Mar.	1.	Labor	7 15
"	5.	Freight and cartage	5 32
"	6.	Stationery	2 00
"	9.	Office supplies	3 56
"	9.	Gas	2 00
"	14.	G. C. Caldwell, traveling expenses	21 00
"	16.	Postage	25 00
"	19.	Engravings	7 37
"	27.	Express	25
"	31.	Labor	16 00
Apr.	3.	Stationery	2 00
"	4.	Office supplies	4 30
"	6.	Gas	1 38
"	7.	Engravings	9 20
"	10.	Photos	2 00
"	26.	Postal Guide	2 50
May	5.	Office supplies	10 05
"	15.	Shipping tags	1 60
"	15.	Postals and printing	6 25
"	16.	Gas	1 12
"	16.	Book	1 50
"	25.	Express	6 35
June	1.	Labor	8 00
"	1.	Express	1 30
"	11.	Mimeograph work	70
"	15.	Repairs on Camera	40
"	15.	Gas	88
"	15.	Book	1 00
"	25.	Gas	3 76
"	30.	Mimeograph work and supplies	2 50
		Total for Office and Printing	$2,331 07

FOR AGRICULTURAL DIVISION.

1899			
July	17.	Printed slips	$ 1 50
		Amount carried forward,	$ 1 50

		Amount brought forward	$ 1 50
Aug.	8.	Grass seeds	1 55
"	8.	Photos	2 00
"	21.	Express	55
"	31.	Labor	20 79
Sept.	11.	L. A. Clinton, traveling expenses.	5 82
"	21.	Tape	25
"	21.	Letter heads	6 88
Oct.	2.	Labor	17 85
"	16.	Freight and cartage	15 00
"	17.	Photos	1 50
"	20.	Eleven pigs, $2 each	22 00
"	21.	Express	85
"	21.	Spring balances (2)	5 50
"	23.	Sundry drugs	9 99
"	31.	Letter heads	4 25
"	31.	Gas pipe	76
"	31.	Photographic material	1 86
"	31.	Ton of Oil meal	27 50
Nov.	17.	Freight and cartage	15 00
"	23.	L. A. Clinton, traveling expenses	3 50
Dec.	1.	Labor	75 37
"	2.	Labor	1 89
"	8.	Telephone Co.	1 00
"	14.	Freight and cartage	15 00
"	15.	Beet pulp	21 50
"	30.	Labor	13 35
1900			
Jan.	3.	Copy book	2 25
"	27.	Express	1 25
"	31.	Labor	28 44
Feb.	5.	Bone meal	1 90
"	20.	Freight and cartage	55
"	24	Freight and cartage	50
Mar.	5.	Photo	50
"	9.	Telegram	40
"	17.	Express	2 20
"	22	Express	35
"	31.	Labor	12 17
"	31.	Tar soap	25
Apr.	6.	Photographic supplies	90
"	9.	Iron work for silo	5 43
"	11.	Freight and cartage	50
"	11.	Milk bottles (4 doz)	2 08
"	11.	Spring balances (3)	8 25
"	12.	Oil meal	1 30
"	17.	Seeds	50
"	25.	Repairing pipes	1 26
"	27.	Labor	5 00
"	28.	Express	30
May	1.	Labor	1 50
"	5.	Cheese samples and expense	3 33
"	12.	Alkaline tablets	2 00
"	31.	Seeds	1 02
June	1.	L. A. Clinton, traveling expenses	3 25
		Amount carried forward,	$380 39

		Amount brought forward	$380 39
June	7.	L. Anderson, traveling expenses	1 75
"	7.	Labor	5 00
"	7.	Cans (1 doz)	60
"	9.	A. R. Ward, traveling expenses	1 75
"	15.	Seeds	1 95
		Total for Agricultural Division	$ 391 44

FOR HORTICULTURAL DIVISION.

1900			
July	3.	Labor	$ 32 56
"	8.	Express	1 20
"	17.	Burlap	3 79
"	24.	Express	1 75
"	24.	Letter heads and postals	26 38
"	24.	Drugs	2 00
Aug.	1.	Labor	28 00
"	8.	Express	1 00
"	9.	Labor	37 50
"	21.	Express	2 35
"	21.	Index cards	2 00
"	21.	Plants	1 00
Sept.	1.	Labor	28 00
"	2.	Labor	37 50
"	3.	Horseshoeing	3 60
"	12.	Oats	22 53
"	19.	Straw and hay	12 87
"	19.	Brush, comb, etc	1 50
"	19.	Stoneboat	5 00
"	19.	Seeds and bulbs	1 45
"	21.	Horseshoeing	5 10
"	21.	Photographic supplies	9 57
"	21.	Crates and baskets	1 15
Oct.	3.	Labor	37 50
"	3.	Hay	17 55
"	14.	Fertilizers	3 00
"	19.	Fertilizers	3 00
"	21.	Freight and cartage	1 05
"	31.	Express	45
Nov.	1.	Labor	37 50
"	1.	Labor	20 00
"	3.	Straw	11 40
"	4.	Ground feed	2 04
"	14.	G. N. Lauman, traveling expenses	2 80
"	14.	Lamp, shade and reflector	1 45
"	16.	Photographic supplies	64
"	17.	Oats	35 90
"	22.	Express and custom duty on plants	8 48
Dec.	1.	Horseshoeing	2 00
"	1.	Baskets	11 50
"	2.	Labor	37 50
"	2.	Labor	20 00
"	4.	Clover seed	12 50
"	6.	Freight and cartage	70
		Amount carried forward,	$534 76

		Amount brought forward	$534 76
Dec.	7.	Sundry hardware supplies	23 75
"	9.	Seeds	19
1900			
Jan.	3.	Repairs on wagon	2 50
"	17.	Straw	13 02
"	27.	Express	30
Feb.	1.	Labor	37 50
"	1.	Seeds	40
"	5.	Horseshoeing	3 70
"	23.	Fertilizers	5 40
"	26.	Publications	20 23
Mar.	2.	Labor	20 00
"	3.	Labor	37 50
"	6.	Office supplies	85
"	27.	Oats	36 95
"	31.	Labor	37 50
Apr	3.	Drugs	5 50
"	3.	Feed and bran	4 40
"	25.	Fertilizers	1 00
"	28.	Express	70
May	4.	Labor	32 50
"	16.	Index cards	2 05
"	23.	Publications	14 49
June	2.	Labor	37 50
		Total for Horticultural Division	$872 69

FOR CHEMICAL DIVISION.

1899			
July	17.	Gas, chemicals and apparatus	$ 66 05
"	17.	Office stool	2 75
1900			
Feb.	23.	Repairs	9 97
Mar.	15.	Chair	1 75
		Total for Chemical Division	$ 80 52

FOR BOTANICAL DIVISION.

1899			
July	8.	Express	$ 70
"	17.	Dry plates, etc	16 54
Aug.	8.	Botanical publications	3 93
"	15.	Postage	18 76
Oct.	11.	Photographic supplies	75
"	11.	Dry plates	2 81
"	18.	Dry plates	4 59
Nov.	14.	Photographic supplies	19 23
Dec.	1.	Botanical supplies	1 60
"	6.	Freight and cartage	93
1900			
Jan.	17.	Freight and cartage	1 10
Feb.	9.	Typewriter and table	97 78
"	16.	Botanical publications	24 29
"	16.	Binding publications	1 50
		Amount carried forward,	$194 51

		Amount brought forward	$194 51
Mar.	8.	Freight and cartage	54
"	17.	Express	80
Apr.	3.	Index to American Botany	5 00
"	3.	Photographic supplies	6 79
May	23.	Botanical publications	13 61
		Total for Botanical Division	$221 25

FOR ENTOMOLOGICAL DIVISION.

1899			
July	24.	Entomological publications	$ 7 25
"	24.	Hammers	1 00
Aug.	8.	Binding publications	4 50
Nov.	4.	Standard dictionary	22 00
"	17.	Binding 16 vols	10 80
"	28.	Office supplies	1 87
1900			
Feb.	5.	Stamped envelopes	22 20
Mar.	26.	Criterion lanterns (2)	66 75
May	15.	Barrel kerosene oil	6 19
		Total for Entomological Division	$142 56

SUMMARY.

The Agricultural Experiment Station of Cornell University.
In account with
The United States Appropriation.

1900	Dr.		
	To Receipts from Treasurer of the United States as per appropriation for the year ending June 30, 1900, under Act of Congress approved March 2, 1887		$13,500 00
	Cr.		
June 30.	By Salaries	$9,460 47	
	Office and Printing	2,331 07	
	Agriculture	391 44	
	Horticulture	872 69	
	Chemistry	80 52	
	Botany	221 25	
	Entomology	142 56	
			$13,500 00

RECEIPTS.

Balance from 1898–99	$ 627 32	
Receipts from owners of herds tested	517 02	
Receipts from sale of produce	240 36	
		$ 1,384 70

DISBURSEMENTS.

Repairs on Horticultural Forcing Houses	$ 356 79	
Supervisors of Milk Tests	517 02	
Sundry Supplies	223 86	
Balance on hand June 30, 1900	287 03	
		$ 1,384 70

GENERAL INDEX.

INDEX OF CUTS.

Appendix III.

Nature-Study Quarterlies.

No 2. A Handful of Soil.
No. 3. Cuttings and Cuttings.
No. 4. The Burst of Spring.
No. 5. A Brook.

READING-COURSE FOR FARMERS.

No. 6. Computing Rations for Farm Animals. (See Bulletin No. 154.)
No. 7. Balanced Rations for Stock.
No. 8. A Farmer's View of Balanced Rations.
No. 9. Sample Rations for Milch Cows.
No. 10. Peter's Idea of Improving "Worn Out" Lands.

JUNIOR-NATURALIST MONTHLIES.

No. 1. Seed Travelers.
No. 2. The Story an Apple Tree Can Tell.
No. 3. How we Shall Please St. Nicholas.
No. 4. Oxygen and Carbon in Partnership.
No. 5. Waiting for the Birds.
No. 6. The Coming of Spring.
No 7. The Four Chapters in an Insect's Life.
No. 8. A Children's Garden.

October, 1899.

CORNELL
NATURE-STUDY QUARTERLY
NO. 2.

Issued by the College of Agriculture and Experiment Station of Cornell University, under Chapter 430 of the Laws of 1899, of the State of New York. I. P. Roberts, Director.

PUBLISHED BY THE UNIVERSITY.
ITHACA, N. Y.
1899.

ORGANIZATION.

BOARD OF CONTROL:

THE TRUSTEES OF THE UNIVERSITY.

THE AGRICULTURAL COLLEGE AND STATION COUNCIL.

JACOB GOULD SCHURMAN, President of the University.
FRANKLIN C. CORNELL, Trustee of the University.
ISAAC P. ROBERTS, Director of the College and Experiment Station.
EMMONS L. WILLIAMS, Treasurer of the University.
LIBERTY H. BAILEY, Professor of Horticulture.
JOHN H. COMSTOCK, Professor of Entomology.

STATION AND UNIVERSITY EXTENSION STAFF.

I. P. ROBERTS, Agriculture.
G. C. CALDWELL, Chemistry.
JAMES LAW, Veterinary Science.
J. H. COMSTOCK, Entomology.
L. H. BAILEY, Horticulture.
H. H. WING, Dairy Husbandry.
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J. W. SPENCER, Extension Work.
J. L. STONE, Sugar Beet Investigation
MISS M. F. ROGERS, Nature-Study.
A. L. KNISELY, Chemistry.
C. E. HUNN, Gardening.
W. W. HALL, Dairy Husbandry.
A. R. WARD, Dairy Bacteriology.
L. ANDERSON, Dairy Husbandry.
W. E. GRIFFITH, Dairy Husbandry.

OFFICERS OF THE STATION

I. P. ROBERTS, Director.
E. L. WILLIAMS, Treasurer.
EDWARD A. BUTLER, Clerk.
Office of Director, Room 20, Morrill Hall.

NATURE-STUDY LEAFLET NO. 15.

A HANDFUL OF SOIL.

PART I: WHAT IT IS.

BY R. S. TARR.

WIND drifts a seed from the parent plant until it settles to the ground, perhaps in a field or by the roadside, or even in the school-yard. There it remains through the long winter; but with the return of spring, encouraged by the warm sunlight, the seed awakens from its dormant condition, breaks open the seed-cover and sends leaves into the air and roots into the ground. No one planted the weed; but it has made its way in the world and it thrives until it has given to other seeds the same opportunity to start in life.

Had the seed fallen upon a board or a stone, it might have sent out leaves and roots; but all in vain, for something was lacking and that seed was a failure in life. What is there in the soil that is so necessary to the success of plant life? And how has it come to be there? Indeed, what is this soil that plants need so much? These are some of the questions which we will try to answer.

One readily sees that the soil furnishes a place for the plants to fix themselves; an anchorage, as it were. It is also easy to see that from the soil the plants obtain a supply of water; and, moreover, that this water is very necessary, for the vegetation in a moist country suffers greatly in time of drought, and few plants are able to grow in a desert region because there is so little water. You can make a desert in the school room and contrast it with moist soil by planting seeds in two dishes of soil, watering one dish, but furnishing none to the other.

That water is necessary to plants is also proved by the plant itself. The sap and the moisture which may be pressed out of a grass stem or an apple are principally water taken from the soil by the roots. But there is more than water, for the juice of an apple is sweet or sour, while the sap and juice of other plants may be sweet or bitter. There are some substances dissolved in the water.

It is these dissolved substances that the plants need for their growth, and they find them ready for use in the soil. There is a plant-food which the roots seek and find, so that every plant which sends roots into the soil takes something from it to build in the plant tissue. The sharp edges of some sedges, which will cut the hand like a dull knife, and the wood ashes left when a wood

14.—*A boulder-strewn soil of glacial origin with one of the large erratics on the left similar to those which early attracted attention to the drift. See page 42.*

fire is burned, represent in part this plant-food obtained from the soil.

Let us take a handful of soil from the field, the school yard, or the street and examine it. We find it to be dirt that "soils" the hands; and when we try to brush off the dirt we notice a gritty feeling that is quite disagreeable. This is due to the bits of mineral in the soil; and that these are hard, even harder than a pin, may often be proved by rubbing soil against a piece of glass, which the hard bits will scratch, while a pin will not.

Study this soil with the eye and you may not see the tiny bits, though in sandy soils one may easily notice that they are bits of mineral. Even fine, loamy and clay soils when examined with a pocket lens or a microscope will be found to be composed of tiny fragments of mineral. It is evident that in some way mineral has been powdered up to form the soil ; and since the minerals come from rocks, it is the rocks that have been ground up. That powdered rock will make just such a substance as soil may be proved by pounding a pebble to bits, or by collecting

15.—*A glacial soil, containing numerous transported pebbles and boulders, resting on the bed rock.*

some of the rock dust that is made when a hole is drilled in a rock. Much the same substance is ground from a grindstone when a knife is sharpened on it, making the water muddy like that in a mud hole.

It will be an interesting experiment to reduce a pebble to powder and plant seeds in it to see if they will grow as well as in soil; but in preparing it try to avoid using a sandstone pebble, because sandy soils are never very fertile.

Not only is soil made up of bits of powdered rock, but it everywhere rests upon rock (Fig. 15). Some consider soil to be only the surface layers in which plants grow; but really this is, in most places, essentially the same as the layers below, down even to the very rock, so that we might call it all soil, though, since a special name, *regolith* (meaning stone blanket), has been proposed for all the soft, soil-like rock-cover, we may speak of it as regolith and reserve the word soil for the surface layers only.

In some places there is no soil on the bare rocks; elsewhere the soil-cover is a foot or two in depth; but there are places where the regolith is several hundred feet deep. In such places, even the wells do not reach the rocks; nor do the streams cut down to it; but even there, if one should dig deep enough, he would reach the solid rock beneath.

How has this hard rock been changed to loose soil? One of the ways, of which there are several, may be easily studied whenever a rock has been exposed to the air. Let us go to a stone wall or among the pebbles in a field, for instance, and, chipping off the surface, notice how different the inside is from the outside. The outer crust is rusted and possibly quite soft, while the interior is hard and fresher. Many excellent examples of this may be seen in any stony field or stone wall.

As hard iron rusts and crumbles to powder when exposed to the weather, so will the minerals and the rocks decay and fall to bits; but rocks require a very much greater time for this than does iron. It happens that the soil of New York has not been produced by the decay of rock; and, therefore, although most soils of the world have been formed in this way, we will not delay longer in studying it now, nor in considering the exact way in which rocks are enabled to crumble.

Another way in which rocks may be powdered may also be seen in most parts of New York. The rains wash soil from the hillsides and the streams become muddy. In them there are also many pebbles, representing the larger fragments that have fallen into the stream after having been broken from the ledges. The current carries these all along down the stream, and, as they go, one piece striking against another, or being dragged over the rocks in the stream bed, the pebbles are ground down and smoothed (Fig. 16), which means, of course, that more mud is supplied to the stream, as mud is furnished from a grindstone when a knife or scythe is being sharpened on it. On the pebbly beaches of the sea or lakeshore much the same thing may be seen; and here also the constant grinding of the rocks together, wears off the edges until the pebbles become smooth and round.

Supplied with bits of rock from the soil, or ground from the pebbles and rocks along its course, the stream carries its load

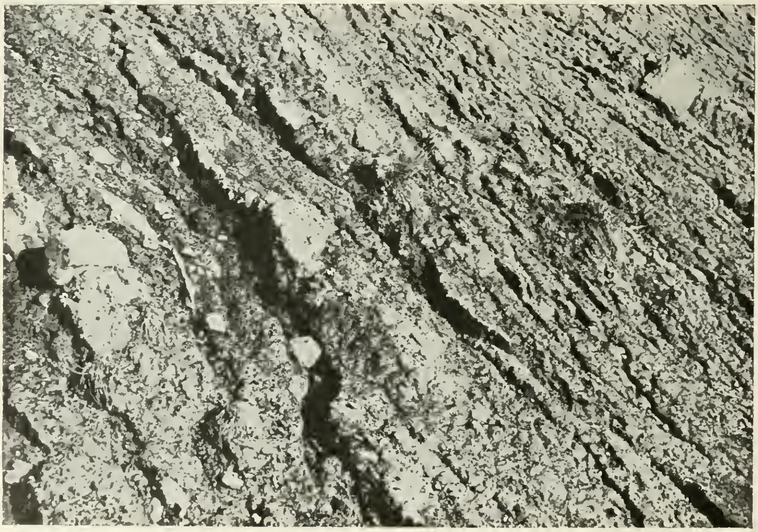
16.—*The bed of a stream at low water, revealing the rounded pebbles that have been worn and smoothed by being rolled about, thus grinding off tiny bits which later are built into the flood-plains.*

onward, perhaps to a lake, which it commences to fill, forming a broad delta of level and fertile land, near where the stream enters the lake. Or, possibly, the stream enters the sea and builds a delta there, as the Mississippi river has done.

But much of the mud does not reach the sea. The greatest supply comes when the streams are so flooded by heavy rains or melting snows, that the river channel is no longer able to hold the

the water, which then rises above the banks, overflowing the surrounding country. Then, since its current is checked where it is so shallow, the water drops some of its load of rock bits on the flood-plain, much as the muddy water in a gutter drops sand or mud on the sidewalk when, in time of heavy rains, it overflows the sidewalk.

Many of the most fertile lands of the world are flood-plains of this kind, where sediment, gathered by the streams farther up their courses, is dropped upon the flood-plains, enriching them by



17.—*Near view of a cut in glacial soil, gullied by the rains, and with numerous transported pebbles embedded in the rock flour.*

new layers of fertile soil. One does not need to go to the Nile, the Yellow or the Mississippi for illustrations of this; they abound on every hand and many thousands of illustrations, great and small, may be found in the State of New York. Doubtless you can find one.

There are other ways in which soils may be formed (Fig. 17); but only one more will be considered, and that is the way in which most of the soils of New York have been made. To study this let us go to a cut in the earth, such as a well or a stream bank (Figs. 15 and 17). Scattered through the soil numerous pebbles and boulders will doubtless be found; and if they are compared with the solid or bed rock of the country, which underlies the soil (Fig. 15), some of them will be found to be quite different from it. For instance, where the bed rock is shale or limestone, some of the pebbles will no doubt be granite, sandstone, etc. If you could explore, you would find just such rocks to the north of you, perhaps one or two hundred miles away in Canada; or, if your home is south of the Adirondacks, you might trace them in those mountains.

18.—*A scratched limestone pebble taken from a glacial soil.*

On some of these pebbles, especially the softer ones, such as limestone, you will find scratches, as if they had been ground forcibly together (Fig. 18). Looking now at the bed rock in some place from which the soil has been recently removed, you will find it also scratched and grooved (Fig. 19); and if you take the direction of these scratches with the compass, you will find that they extend in a general north and south direction, pointing in fact in the same direction from which the pebbles have come.

19.—*The grooved bed rock scratched by the movement of the ice sheet over it.*

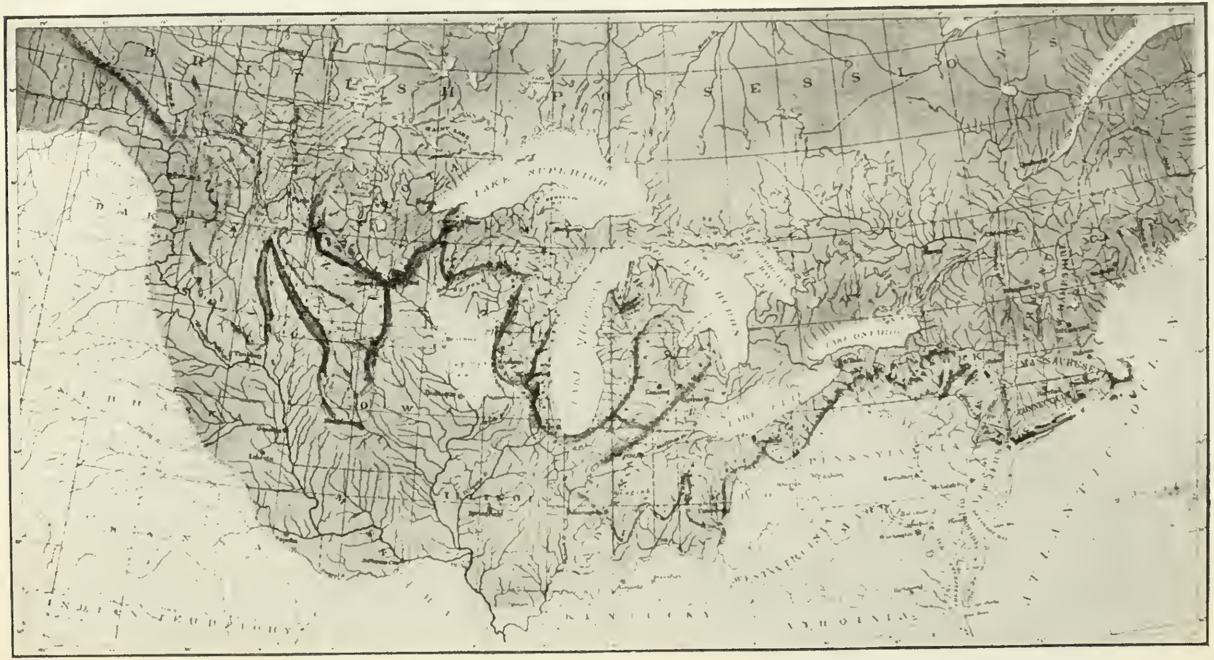
All over northeastern North America and northwestern Europe the soil is of the same nature as that just described. In our own country this kind of soil reaches down as far as the edge of the shaded area in the map (Fig. 20) and it will be noticed that all of New York is within that area excepting the extreme southwestern part near the southern end of Chautauqua lake.

Not only is the soil peculiar within this district but there are many small hills of clay or sand, or sometimes of both together (Figs. 26 and 27) They rise in hummocky form and often have deep pits or kettle-shaped basins between, sometimes, when the soil is clayey enough to hold water, containing tiny pools. These hills extend in somewhat irregular ranges stretching across country from the east toward the west. The position of some of these ranges is indicated on the map (Fig. 20).

For a long time people wondered how this soil with its foreign pebbles and boulders, all together called "drift," came to be placed where they are ; they were especially puzzled to tell how the large boulders, called erratics (Fig. 14), should have been carried from one place to another. It was suggested that they came from the bursting of planets, from comets, from the explosion of mountains, from floods, and in other ways equally unlikely ; but Louis Agassiz, studying the glaciers of the Alps and the country round about, was impressed by the resemblance between the "drift" and the materials carried by living glaciers.

Agassiz, therefore, proposed the hypothesis that glaciers had carried the drift and left it where we now find it ; but for many years his glacial hypothesis met with a great deal of opposition because it seemed impossible that the climate could have changed so greatly as to cover what is now a temperate land with a great sheet of ice. Indeed, even now, although all who have especially studied the subject are convinced, many people, even those who are educated in some directions, have not accepted Agassiz's explanation, just as years ago, long after it was proved that the earth rotated each day, many people still believed that it was the sun, not the earth, that was moving.

The glacial explanation is as certain as that the earth rotates. For some reason, which we do not know, the climate changed and allowed ice to cover temperate lands, as before that, the



20.—*Map showing the extent of the ice sheet in the United States. Position of some of the moraines indicated by the heavily shaded lines. (After Chamberlain.)*

climate had changed so as to allow plants like those now growing as far south as Virginia, to live in Greenland, now ice covered. When the ice of the glacier melted away it left only signs of its presence ; but when the temperate latitude plants grew in Greenland they left seeds, leaves and tree trunks which have been imbedded in the rocks as fossils. One may now pick the leaves of temperate climate trees from the rocks beneath a great icecap.

21.—*A view over the great ice plateau of Greenland with a mountain peak projecting above it.*

Nevertheless, to one who studies them, the signs left by the glacier are as clear proof as the leaves and seeds. From these signs we know that the climate has changed slowly, but we have not yet learned why it changed.

There are now two places on the earth where vast glaciers, or ice sheets, cover immense areas of land, one in the Antarctic, a region very little known, the other in Greenland, where there is an ice sheet covering land having an area more than ten times that of the State of New York. Let us go to this region to see what is being done there, in order to compare it with what has been done in New York.

In the interior is a vast plateau of ice, in places over 10,000 feet high, a great icy desert (Fig. 21), where absolutely no life of any kind, either animal or plant, can exist and where it never rains, but where even in the middle of summer the storms bring snow. Such must have been the condition in northeastern America during the glacial period.

This vast ice sheet is slowly moving outward in all directions from the elevated center, much as a pile of wax may be made to flow outward by placing a heavy weight upon the middle. Moving toward the north, east, south and west this glacier must of course come to an end somewhere. In places, usually at the heads of bays, the end is in the sea, as the end of our glacier must have been off the shores of New England. From these sea-ends, icebergs constantly break off; and, floating away toward the south, often reach, before they melt, as far as the path followed by the steamers from the United States to Europe. Between the bays, where the glacier ends in the sea, the ice front rests on the land (Fig. 22), as it did over the greater part of New York and the states further west. There it melts in the summer, supplying streams with water and filling many small ponds and lakes. The front stands there year after year, sometimes moving a little ahead, again melting further back so as to reveal the rocks on which it formerly rested.

22.—*The edge of a part of the great Greenland ice sheet (on the left) resting on the land, over which are strewn many boulders brought by the ice and left there when it melted.*

23.—*A scratched pebble taken from the ice of the Greenland glacier.*

Examining this rock it is found to be polished, scratched and grooved just like the bed-rock in New York; and the scratches extend in the direction from which the ice moves. Resting on the rock are boulders and pebbles (Fig. 22), sometimes on the bare rock, sometimes imbedded in a clay as they are with us. As we found when studying the soil in our own region, so here the pebbles are often scratched, and many of them are quite different from the rock on which they rest.

24.—*A part of the edge of the Greenland glacier, clean white ice above, and dark discolored bands below where laden with rock fragments. In the foreground is a boulder-strewn moraine.*

Going nearer to the ice we find the lower part loaded with pebbles, boulders and bits of clay quite like those on the rocks near by. Fig. 23 shows one of these, scratched and grooved, which I once dug from the ice of this very glacier. The bottom of the ice is like a huge sandpaper, being dragged over the bed rock with tremendous force. It carries a load of rock fragments, and as it moves obtains more by grinding or prying them from the rocks beneath. These all travel on toward the edge of the ice,

25.—*Hummocky surface of the boulder-strewn moraine of Greenland.*

being constantly ground finer and finer as wheat is ground when it goes through the mill. Indeed the resemblance is so close that the clay coming from this grinding action is often called *rock flour.*

Dragged to the front of the ice, the rock bits, great and small, roll out as the ice melts, some, especially the finest, being carried away in the water, which is always muddy with the rock flour it carries ; but much remains near the edge of the ice forming a *moraine* (Figs. 24 and 25). This moraine, dumped at the

26.—*A view over the hummocky surface of a part of the moraine of the great American ice sheet in Central New York.*

edge of the glacier, very closely resembles the hummocky hills of New York (Figs. 26 and 27), mentioned above, which are really moraines formed at the ice edge during the glacial period. While their form is quite alike, the New York moraines are generally less pebbly than the Greenland moraines, because the Greenland glacier carries less rock flour than did the glacier which covered New York.

In the Greenland glacier, as you can see in Fig. 24, there is much dirt and rock ; in the glacier of the glacial period there was even more. When it melted away the ice disappeared as water, but the rock fragments of course fell down upon the rock beneath and formed soil. If over a certain region, as for instance over your home, the ice carried a great load of drift, when this gradually settled down, as the ice melted, it formed a deep layer of soil ; but if the glacier had only a small load a shallow soil was left. Again, if the ice front remained for a long time near a certain place, as near your home, it kept bringing and dumping rock fragments to form moràines, which, of course, would continue to grow higher so long as the ice dumped it, much as a sand pile will continue to grow higher so long as fresh loads are brought and dumped.

There are other causes for difference in the glacial soils, but most of them cannot be considered here. One of them is so important, however, that it must be mentioned. With the melting of so much ice, vast floods of water were caused, and these came from the ice, perhaps in places where there are now no streams, or at best small ones. These rapid currents carried off much of the rock flour and left the coarser and heavier sand, gravel, or pebbles, the latter often well rounded, with the scratches removed by the long continued rolling about in the glacial stream bed.

One often finds such beds of sand or gravel in different parts of the state, telling not only of ice where it is now absent, but of water currents where is now dry land. The rock flour was in some cases carried to the sea, elsewhere to lakes, or in still other places deposited in the floodplains of the glacier-fed rivers. Now some of this rock flour is dug out to make into bricks.

Enough has been said to show that the soils of New York were brought by a glacier and to point out that there are many differences in the thickness of the soil as well as in kind and condition. The agriculture of the State is greatly influenced by these differences. In some cases one part of a farm has a deep, rich soil, another part a barren, sandy, pebbly or boulder covered soil (Fig. 14), while in still another part the bed rock may be so near the surface that it does not pay to clear it. Moreover, some farms are in hummocky moraines, while others, near by, are on level plains (Fig. 27), where a broad glacial stream built up a flood-plain in a place where now the stream is so small that it never rises high enough to overflow the plain.

There are even other differences than these and one who is familiar with a region is often puzzled to explain them ; but they are all due to the glacier or to the water furnished by it s melting, and a careful study by a student of the subject of Glacial Geology will serve to explain them. Each place has had peculiar conditions and it would be necessary to study each place carefully in order to explain all the differences much further than has been done here.

27.—*Hummocky moraine hills in the background and a level gravel plain, —an ancient glacial-stream flood-plain—in foreground.*

Not only is agriculture influenced greatly by the differences in the soil from place to place, but also by the very fact that they are glacial soils. In a soil that has been formed by the decay of rock some of the materials needed by plants, the plant foods, have been leached out and carried off by the water while the rock was decaying ; but the glacial soils have most of these foods still stored up for use. Here the minerals are simply ground up and not much decayed, while in the other case they are badly decayed, the difference being something like that between iron filings which are able to decay and rust, and iron rust which is already decayed.

Slowly the glacial soils are decaying, and, as they do so, are furnishing plant food to the water which the roots greedily draw in. So the glacial soil is not a mere store house of plant food, but a manufactory of it as well, and glacial soils are therefore "strong" and last for a long time. That decay is going on, especially near the surface, may often be seen in a cut in this kind of soil, where the natural blue color of the soil itself is seen below, while near the surface it is rusted yellow by the decay of certain minerals which contain iron.

Few materials on the earth are more important than the soil; it acts as the intermediary between man and the earth. The rocks have some substance locked up in them which animals need; by decay, or by grinding up, the rocks crumble so that plants may send roots into them and extract the substances needed by animals. Gifted with this wonderful power the plants grow and furnish foods to animals, some of them the very plant foods from the rocks; and so the animals of the land, and man himself, obtain a large part of their food from the rocks. It is then worth the while to stop for a moment and think and study about this, one of the most marvelous of the many wonderful adjustments of Nature, but so common that most people live and die without even giving it more than a passing thought.

PART II: WHAT IT DOES.

BY L. A. CLINTON.

The more one studies the soil the more certainly it will be found that the earth has locked up in her bosom many secrets, and that these secrets will not be given up for the mere asking. As mysterious as the soil may appear at different times, it always is governed by certain laws. These principles once understood, the soil becomes an open book from which one may read quickly and accurately.

Uses of the Soil.

The soil has certain offices to perform for which it is admirably fitted. The most important of these offices are:

1. To hold plants in place.
2. To serve as a source of plant-food.

3. To act as a reservoir for moisture.

4. As a storehouse for applied plant-food or fertilizer.

Some soils are capable of performing all these offices, while others are fitted for only a part of them. Thus a soil which may be pure sand and almost entirely deficient in the essential elements of plant-food, may serve, if located near a large city, merely to hold the plants in position while the skillful gardener feeds the plants with specially prepared fertilizers, and by irrigation supplies the moisture.

Early in the study of soils an excursion, if possible, should be made into the woods. Great trees will be found and under the trees will be found various shrubs and possibly weeds and grass. It will be noticed that the soil is well occupied with growing plants. The surface will be found covered with a layer several inches thick of leaves and twigs. Beneath this covering the soil is dark, moist, full of organic matter, loose, easily spaded except as roots or stones may interfere, and the soil has every appearance of being fertile.

Soil Conditions as Found in Many Fields.

After examining the conditions in the forest, a study should be made of the soil in some cultivated field. It will be found that in the fields the soil has lost many of the marked characteristics noticed in the woodland. In walking over the fields, the soil will be found to be hard and compact. The surface may be covered with growing plants, and if the seeds which have been put into the soil by the farmer have not germinated and the plants made growth, nature has quickly come to the rescue and filled the soil with other plants which we commonly call weeds. It is nature's plan to keep the soil covered with growing plants, and from nature we should learn a lesson. The field soil, instead of being moist, is dry ; instead of being loose and friable, is hard and compact, and it appears entirely different in texture from the woodland soil. The cause of the difference is not hard to discover. In the woods, nature for years has been building up the soil. The leaves from the trees fall to the ground and form a covering which prevents washing, and these leaves decay and add to the humus or vegetable mold of the soil. Roots are constantly decaying and these furnish channels through the soil and permit of air and water drainage.

In the field, nature's lesson has been disregarded and too often the whole aim seems to be to remove everything from the soil and to make no returns. Consequently the organic matter or humus has been used up; the tramping of the horses' feet has closed the natural drainage canals; after the crop is removed, the soil is left naked during the winter and the heavy rains wash and erode the surface and remove some of the best plant-food. After a few years of such treatment, the farmer wonders why the soil will not produce as liberally as it formerly did.

Experiment No. 1.—The fact that there is humus or vegetable mold in certain soils can be shown by burning. Weigh a potful of hard soil and a potful of lowlands soil or muck, after each has been thoroughly dried. Then put the pots on the coals in a coal stove. After the soil is thoroughly burned, weigh again. Some of the difference in weight may be due to loss of moisture, but if the samples were well dried in the beginning, most of the loss will be due to the burning of the humus.

Conditions which Affect Fertility.

There are certain conditions which affect soil fertility and of these the most important are:

Texture.
Moisture-content.
Plant-food.
Temperature.

Texture and its Relation to Fertility.

By texture is meant the physical condition of the soil. Upon good texture, more than upon any other one thing, depends the productivity of the soil. When the texture is right the soil is fine, loose and friable; the roots are able to push through the soil and the feeding area is enlarged. Each individual particle is free to give up a portion of its plant-food or its film of moisture. The conditions which are found in the woods' soil are almost ideal.

Experiment No. 2—The importance of good texture can be well shown in the class-room. Pots should be filled with a soil which is lumpy and cloddy and other pots with the same kind of material after it has been made fine and mellow. Seeds should then be planted in the different pots and a careful study made of the length of time required for germination and of the health and vigor of the plants.

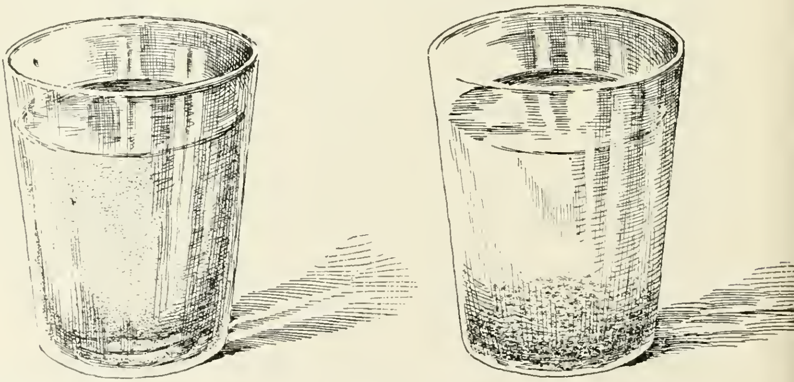
Experiment No. 3.—The greater part of our farming lands do not present the ideal conditions as regards texture. Clay soils are especially liable to be in bad condition. If samples of the various soils can be collected, as sand, loam, clay, etc., it may be clearly shown how different soils respond to the same kind of treatment. With a common garden trowel, the soils should be stirred and worked while wet and then put away to dry. After drying, the conditions presented by the soils should be noted, also the length of time required for the soils to become dry. Whereas the sand and the loam will remain in fairly good condition when dry, the clay will have become "puddled," *i. e.*, the particles will have run together and made a hard, compact mass. Thus it is found in practice that clay soils must be handled with far more care and intelligence than is required for the sand and loams, if the texture is to be kept perfect.

Experiment No. 4.—If, in the experiment above suggested, the clay soil is mixed with leaf-mold or humous soil from the woods, it will be found to act very differently. The vegetable matter thus mixed with the mineral matter prevents the running together of the particles of clay.

Two principles, both important as relating to soil texture, now have been illustrated. Soils must not be worked when they are so wet that their particles will cohere, and organic matter or humus must be kept mixed with the mineral matter of the soil. In practical farm operations, if the soil can be made into a mud ball it is said to be too wet to work. The required amount of humus is retained in the soil by occasionally plowing under some green crop, as clover, or by applying barn manures.

Clay soils are also frequently treated with lime to cause them to remain in good condition and be more easily tilled. Lime causes the fine particles to flocculate or to become granular, *i. e.*, several particles unite to form a larger particle and these combinations are more stable and do not so readily puddle or run together. A mud-puddle in clay soil will remain murky until the water has evaporated entirely. Let a little water-slaked lime be mixed with the muddy water and the particles of clay will be flocculated and will settle to the bottom and the water becomes clear.

Experiment No. 5.—Into two glasses of water put some fine clay soil and thoroughly stir the mixture (Fig. 28). Into one glass thus prepared put a spoonful of water-slaked lime and stir thoroughly, then allow both glasses to remain quiet



28.—*The glass of water at the right has received lime and the clay has been flocculated.*

that the soil may settle. Notice in which glass the water becomes clear first and note the appearance of the sediment in each.

The Moisture in the Soil.

In a former leaflet (No. 14) has been given the history of a thunder shower. We are not told much about the history of the water after it reaches the earth. If we go out immediately after a heavy shower we find little streams running alongside the road. These little streams unite to make larger streams, until finally the creeks and rivers are swollen, and, if the rain was heavy enough, the streams may overflow their banks. In all these streams, from the smallest to the largest, the water is muddy. Where did this mud come from? It was largely washed from the cultivated fields, and the finest and best soil is certain to start first on its voyage to the valleys or to the sea. If the farmer only had learned better the lesson from nature and kept his fields covered with plants, a large part of the loss might have been prevented. A rain gauge should be kept in every school yard, so that every shower can be measured. It can then be determined easily by the pupils how many tons of rain fall upon the school grounds, how much falls upon an acre of land, and it will be a matter of surprise that the amount is so great.

Not all the water which falls during a summer shower is carried off by surface drainage, but a considerable part sinks into the soil. As it passes down, each soil grain takes up a portion and surrounds itself with a little film of water much as does a marble when dipped into the water. If the rain continues long enough the soil will become saturated and the water which cannot be retained, will, under influence of gravity, sink down to the lower layers of soil until it finally reaches the level of the free water. From this free water, at varying depths in the soil, wells and springs are supplied. If the soil were to remain long saturated seeds would not germinate, and most cultivated plants would not grow because all the air passages of the soil are filled

29—*a*. *Soil too dry.* *b*. *Soil in ideal condition.* *b*. *Soil too wet.*

with water (Fig. 29). The water which sinks down deep into the soil and helps supply our wells is called free water. That portion which is held as a film by the soil particles (as on a marble) is called capillary water. After the rain is over and the sun shines, a part of the moisture which is held by the particles near the surface is lost by evaporation. The moisture which is below tends to rise to restore the equilibrium, and thus there is created a current toward the surface, and finally into the air; and the moisture which thus escapes aids in forming the next thunder storm.

Experiment No. 6.—Humus enables the soil to take up and hold large quantities of water. To illustrate this: Two samples of soil should be obtained, one a humus or alluvial soil, rich in organic matter, and the other a sandy soil. Put the two samples where they will become thoroughly air dry. Procure, say five pounds each of the dry soils, and put into glass tubes over one end of which there is tied a piece of muslin or fine wire gauze. From a graduated glass pour water slowly upon each sample until the water begins to drain from the bottom of the tube. In this way it can be shown which soil has the greater power of holding moisture. Both samples should then be set away to dry. By weighing the samples each day it can be determined which soil has the greater power of retaining moisture. This experiment can be conducted not only with sand and humus, but with clay, loam, gravel and all other kinds of soil.

Experiment No. 7.—A finely pulverized soil will hold more film-moisture than a cloddy soil. To illustrate the importance of texture as related to moisture, soil should be secured which is cloddy or lumpy. One tube should be filled as heretofore described (Exp. No. 6) with the lumpy soil, and the other tube with the fine soil which results from pulverizing the lumps, equal weights of soil being used in each case. From a graduated glass pour water upon each sample until the drainage begins from the bottom. Notice which soil possesses greater power of absorbing moisture. Put the samples away to dry, and by carefully weighing each day it can be determined which soil dries out most readily.

The prudent farmer will take measures to prevent the escape of this moisture into the air. All the film-moisture (on the soil particles) needs to be carefully conserved or saved, for the plants will need very large amounts of moisture before they mature, and they can draw their supply only from this film moisture. We can again apply the lesson learned in the woods. The soil is there always moist; the leaves form a cover or blanket which prevents the evaporation of moisture. Underneath an old plank or board, the soil will be found moist. If we can break the connection between the soil and the air we can check the escape of moisture. A layer of straw over the soil will serve to prevent the loss of moisture. But a whole field cannot be thus covered. It has been found that by keeping the surface soil loose, say about three inches of the top soil, it can be made to act as a blanket or covering for the soil underneath. While this top layer may become as dry as dust, yet it prevents the escape by evaporation of moisture from below. It is a matter of common observation that if tracks are made across a freshly cultivated field the soil will become darker where the

30—"*Foot-prints on the sands of time.*"

tracks are (Fig. 30). This darker appearance of the soil in the foot-marks is due to the moisture which is there rising to the surface. The implement of tillage makes the soil loose and breaks the capillary connection between the lower layers of soil and the surface and the upward passage of the water is checked. Where the foot-print is, the soil has been pressed down again at the surface, the particles have been crowded closer together and capillarity is restored to the surface and the moisture is free to escape (Fig. 31). In caring for flower-beds, or even in growing plants in a pot in the school-room, it is important that

31.—*A cross section through one of the foot-prints.*

the surface of the soil be kept loose and mellow. Far better is a garden rake in a flower garden than a watering pot.

Experiment No. 8.—To show the importance of the surface mulch, fill several pots with a sandy loam soil, putting the same weight of the same kind of soil into each pot. In one pot pack the soil firmly; in another pot pack the soil firmly and then make the surface loose. These pots of soil may then be put away to dry, and by weighing each daily it can be readily determined what effects the various methods of treatment will have upon the moisture-holding power.

Experiment No. 9.—This experiment may be varied by covering the soil in some of the pots with leaves or straw or paper, care being taken that the added weight of the foreign matter be properly accounted for.

Soil Temperature.

If a kernel of corn be placed in the ground in early spring before the soil has become warm, the seed will not germinate.

32.—*The moss-grown lawn or grass plot.*

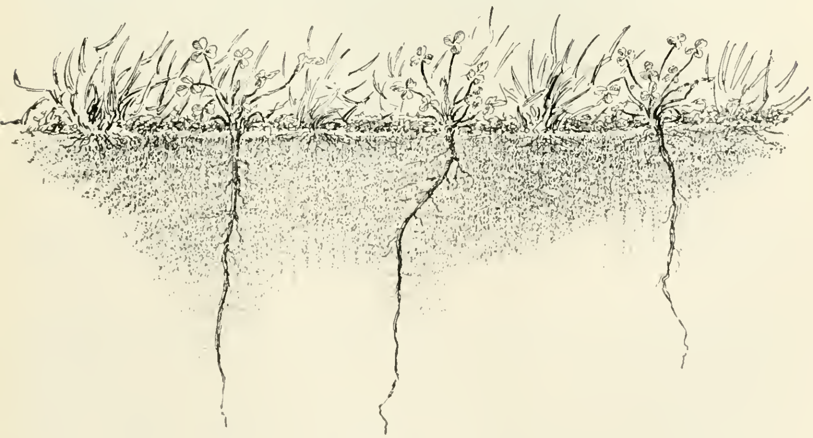
Abundance of moisture and oxygen may be present, but the third requisite for germination, proper temperature, is lacking. The soil is very slow to become warm in the spring, and this is due to the large amount of water which must be evaporated. During the winter and spring the rain and melting snow have saturated the soil. The under-drainage is deficient and there is no way for the escape of the surplus water except by evaporation, and evaporation is a cooling process. A well drained soil is thus warmer.

The atmosphere is much quicker to respond to changes in temperature than is the soil. In the spring the air is warm while the soil continues cold and the rains which fall during this time are warmed by passing through the warm air, and in sinking through the soil the water parts with some of its heat and the soil is made warmer. During mid-summer the soil becomes very warm, and it is not affected by cool nights, as is the atmosphere. Consequently a summer rain may be several degrees cooler than the soil, and in passing through the soil the water takes up some of the heat, and the soil conditions are made more favorable for plant growth. Therefore, soil temperature is regulated somewhat by the rainfall.

Experiment No. 10.—The color of a soil also effects it temperature, a dark soil being warmer than a light colored soil. By having thermometers as a part of the school room equipment, interesting experiments can be conducted in determining the effect of color and moisture upon the temperature of soils.

Air in the Soil.

While that part of the plant which we can see is entirely surrounded by air, yet it is necessary that the soil be in such a con-



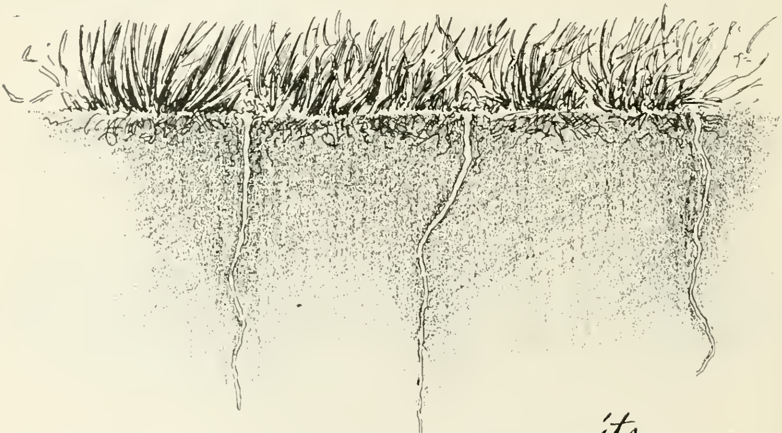
33. – *The clover roots penetrate the soil deeply.*

dition that it can be penetrated by the air. Indeed, growth cannot begin in a soil from which the air is excluded.

Experiment No. 11.—To prove this, put clay soil in a pot, plant seeds and then wet the surface of the soil and puddle or pack the clay while wet and watch for the seeds to germinate and grow. At the same time put seeds in another pot filled with loose, mellow, moist soil.

Frequently after the farmer has sown his grain there comes a heavy, beating rain, and the surface of the soil is so packed that the air is excluded and the seeds cannot germinate. If plants are grown in pots and the water is supplied at the top of the soil it may become so hard and compact as to exclude the air and the plants will make a sickly growth. The surface soil must be kept loose that the air can penetrate.

On many lawns it is noticed that the grass is not thriving. It has a sickly appearance and even the application of fertilizer



34.—*After the clover dies the soil is in better condition for ~~their~~ its having lived.*

does not seem to remedy the conditions. Perhaps the ground has become so hard the air cannot penetrate and the grass is being smothered. If the surface of the soil can be loosened with a garden rake and clover seed sown, much good may be accomplished. The clover is a tap-rooted plant, and sends its main root deep into the soil.

After the death of the plant the root decays, the nitrogen which is stored up can be used as food by the other plants, and most useful of all, in such cases, the decay of the tap-root of the clover makes a passage deep into the soil and thus allows the air to enter. Consult Figs. 32–34.

STEALING A RIDE.

Part I. Sir Bur, Tramp and Traveler.

BY MARGARET BOYNTON.

"Chick-a-dee-dee-dee-dee-dee" sounded from the hedge. I caught the motion of the little feathered food-gatherers but could not see a single black-capped head.

"Chick-a-dee-dee-dee-dee-dee. Come and play with me-me-me-me-me." With such an invitation how could I help going out into that brilliant, blue and golden mid-winter day? Against the clearest of skies each tiny bud-tipped maple twig glowed ruddily. The mountain ash berries still hung in bright clusters, crowned with light pyramids of fluffy snow. The deserted nests in the orchard recalled the busy householders of the warmer, leafier seasons and a few withered apples offered scanty nourishment to solitary wayfarers. Under my feet the snow spread a creaking carpet, and all about me it afforded a background of diamonds for the devious patterns of the shriveled weeds showing clear and fantastic against it. What a joyous day for the chick-a-dees and me!

Presently, attracted by the regiment of teasels there encamped, I turned aside into a small common, a vacant lot well within the borders of our small city, and I tramped it over rejoicing in the short skirt and leggins that permitted unhampered wading in the snow. There were many things to be seen in that little area. Bitter-sweet berries draped the fence. Ragged miniature umbrella skeletons recalled the filmy, white parasols of the wild carrot in its summer guise. "Devil's pitchforks" and bristling burdocks plucked at my skirt in passing, and a few hoary aster heads still lingered amid the star-tipped stems whence most of the feathery parachutes had flown. A kindly farmer caught me shaking the teasel heads and called cheerily "I guess you've got a kind of a putterin' job there, ain't ye?" and charitably took me into his bob-sleigh for the short half mile back to my corner; but he was not a nature-student and did not know what fun I had been having. Nor could he know that the handful of brown and withered stuff that formed the trophy of my half hour's trip would offer me a juicy cud to chew.

Prominent in my winter bouquet were several sprigs of burdock with rigid stems and bristling burs (Fig. 35). If you, too, want to hear the story Sir Bur will tell under questioning you can probably find the material in plenty on the nearest waste land or in a fence corner, or by the roadside.

35.—*Burs of the Burdock. One-third natural size.*

You, as well as I, in all likelihood, made bur baskets and furniture, and even people richly garbed in green and purple, all your childhood days; yet did you ever stop to think how the burs stick so pertinaciously? Why they should? And what they do for the plant? No, even the tormenting little boy from across the road who made use of their valuable properties in ornamenting your long hair with bunches of burs probably could not have told you why they were so effective.

Notice first, then, the numerous tiny hooks bristling in every direction (Fig. 36). How abrupt is the curve of each hook, how smooth and polished the outer surface! It will push readily between the finest and closest fibers. How sharp is the incurved point! See, it has penetrated your skin, as you press the bur lightly between your fingers! The slender shanks of the hooks yield readily to pressure only to gain more tenacious hold. In disentangling one you are caught by five. The stems all stand stiff and rigid, holding the burs unyieldingly in your way and adding to the advantage of the flexible hooks. Your clothing brushes a bur ever so lightly, the fibres at the base break readily and away your bur travels; and not singly usually, for note how the branches have so grown,

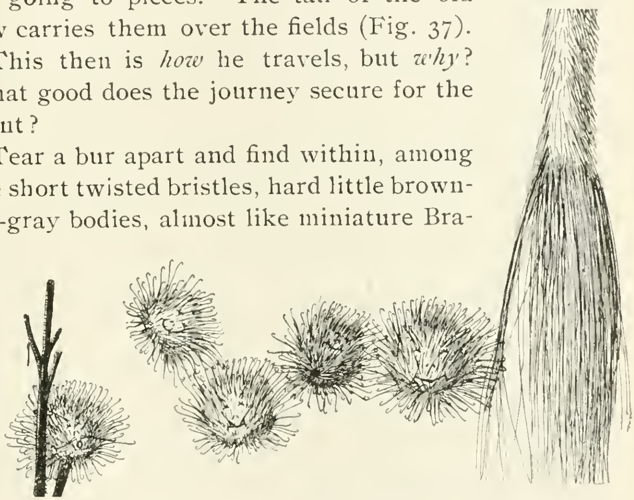
36.—*Burdock hook.*

the lower ones lengthening, that the burs are practically clustered by twos and threes and fours, with hooks interlacing, and they go together. So, clinging with a score or two of little hands to the hair of some passing animal or the clothing of a human tramp, Sir Bur steals many a long ride, often relaxing his hold only by going to pieces. The tail of the old cow carries them over the fields (Fig. 37).

38.—*The burdock akene.*

This then is *how* he travels, but *why*? What good does the journey secure for the plant?

Tear a bur apart and find within, among the short twisted bristles, hard little brownish-gray bodies, almost like miniature Brazil nuts (Fig. 38), that are —what? If you have not thought you will say seeds, for they look like seeds. But are all seed-like bodies properly so called? Where do these little fellows come from?



37.—*Burs stealing a ride.*

If you have studied the flower in general, you will remember that its important parts in view of its office of reproduction are the *stamens* which produce the pollen and the *pistil* with its *ovary* or seed-case. Within the ovary grow the small bodies which develop into the seeds. Further, the ripened ovary with whatever parts may consolidate with it in development, and with the matured seeds contained, is called the fruit. That is to say, we name things in natural history not alone from appearance and function or office, but according to their origin and development.

What then have we in the bur, seeds or fruits?

You would not think of calling a pea pod a seed would you? You know if you stop to consider that each pea is a seed, and the pod with its peas is the fruit, because developed from the minature pod in the blossom which was the ovary, and contained the ovules or young seeds. Similarly you easily distinguish morning-glory seeds from its fruits, the nasturtium seeds from the fruits. In all these cases and in hundreds of others the fruit is a pod and opens at maturity to let the seeds escape, but there are also hundreds of kinds of plants in which the ovary ripens with a single seed inside of it and does not open at maturity. In this case the fruit is usually but little larger than the contained seed and often looks like a seed itself. However that be, a single-seeded dry fruit that does not open at maturity is called an *akene.* Akenes are what we find in the bur.

How do I know? How can *you* tell in other cases? Unfamiliar akenes found away from the parent plant might not be so easily detected, for the single seed within is not always readily found free from the ovary walls, but it can usually be identified by its relation to the plant. You remember that the *seed* is borne *within the ovary.* The pea pod and the morning glory and nasturtium pods you know were closed up tight to the time of maturity. But this bur never was nor could have been closed, evidently. In all probability then it is not an ovary. What then? The purple color of our young bur were borne, we remember, at the top of each bur. These blossom-tops, we can think out now, were masses of pinky-purple flowers, each bur containing many small flowers. The whole is called a compound flower. Each of the little brown wrinkled fruits within the bur is an *akene*, the fruit of a single flower. Perhaps we shall find crowning some of the akenes the withered remains of the flowers. The tiny blossom was one of several that grow inside the big bur; and each little blossom makes, or tries to make, an akene.

Of course the seed within the akene germinates and produces a new plant just as any other seed does. Because of Sir Bur's adroitness at stealing rides, the new little burdock plant usually finds its chance at greater or less distances from its parent plant, and reaps much the same advantage as any pioneer. In favorable circumstances it finds freedom from the competition of its kind, that is, it does not have to struggle with its fellows for the same food-stuffs, the same conditions of growth and health. It has room.

Indeed, it is because of his travelling powers that Sir Bur is here at all, for his race originated in Europe. He was not in New England to greet the pilgrims, as they left Plymouth Rock, nor in the south to welcome the Virginian settlers. His earliest immigrant ancestors possibly came in the Mayflower, but more probably took stowaway passage some time later in the tail of some dog or sheep brought from across the sea. However he came, he is here, numerous and widespread as you know him, and he is still travelling, the veriest tramp of the roadside, stealing rides and pressing ever onward toward the west, following the trail of man and his domesticated animals.

Part II. The Red Cow and the Maple Tree.

BY JOHN W. SPENCER.

The day was so warm as to suggest an oven. The rays of the sun came the most direct way—as a boy would make a bee-line cross-lots. A blue haze hung about the heavens, dimming the sun at midday and at sunrise and at sunset, making it look like an immense orange, and the heated air shimmered across the level pasture. It was one of those days that warps the slivers in the plank walk and makes prickly the path of the barefooted boy—a day when most boys want to go to the swimming hole at the bend of the creek under the leaning beech.

On a gravelly knoll a slick red cow stood in the dark thick shade of a maple tree. A colony of persistent flies was clinging to her shoulder and scattering ones flew about her ears, and others would have found a resting place on her hips and back but for the incessant switching of her tail. With all the persistent switching, the cow, with half closed eyes, chewed her cud with the regularity of the swinging of a pendulum.

Said the Red Cow to the Maple Tree, "You have no troubles such as I have. See how I am pestered with flies every hour of the day. Flies do not trouble you."

Said the Maple Tree to the Red Cow, "It is fortunate they do not for I have no tail with which to switch them."

Said the Red Cow to the Maple Tree, "I am very thirsty and I shall not find a refreshing drink until, while on my way to the barn to be milked this evening, I shall wade through the brook."

Said the Maple Tree to the Red Cow, "You complain because you have to walk for a drink of water. Is that not better than to long for it and be obliged to wait until it comes to you from the clouds? All of us plant-fellows in this neighborhood need water badly, and some whose roots do not extend deep into the soil have suffered unto death. It is for this reason that the grass has famished and you no longer find a nearby lunch as you found it earlier in the season. I would, indeed, consider it a privilege to travel all day, if I could then have a refreshing drink. But alas! when I made this spot my home, it was to be the only place I should ever live during all my life. Food is as difficult for me to obtain as water. In the earlier part of the season when rains were more plentiful, you found a daily lunch within a stone's throw of this spot; but now when there is nothing here to your liking, you are able to wander to any part of the pasture in search of the best food. I must content myself with what I can find in this one spot. When a drought comes, like the present one, and there is not enough moisture to satisfy my thirst, nor to float sufficient plant-food to my roots, I must endure a double suffering —thirst and hunger. In the cold weather you can seek the warm and sunny side of a straw stack, while I must stand out here on this bleak and unprotected knoll with the winds of winter whistling through my bending limbs."

39.—*The red cow.*

"I should not complain," continued the Maple Tree, "for Nature is kind to us all, and we can see her kindness if we look for it in the right way. She has provided blessings for us all, but not of the same kind or in the same way. She has planned that plants never move their homes; that where they make a start in life, there they must remain. She affords all plants great opportunities, however, for sending their children abroad in large numbers and gives them means for traveling long distances. In this way many are sure to find congenial places for a life of prosperity. I have no fear that maples will ever become extinct. Some years I send out so many children that if one in every thousand becomes a tree, my family will be a large one.

40.—*The maple tree.*

"Do you see the big thistle in yonder fence corner? The children are now mature and ready to travel miles and miles in a balloon, and will settle down into some quiet nook and become plants. The farmer, who calls them weeds, has been fighting them for a life time; but, although he is able to keep them from making serious encroachments upon his crops, the thistle will always be with him. It is abundantly able to take care of itself. Were it not for the sharp needles on the leaf, a red cow might have swallowed them long ago.

"See those dark clouds forming in the west—wool sacks they are called. Hark! Did I hear thunder? If a red cow fears being struck by lightning, she had better hasten to the bars at the end of the pasture and call to be put into the barn. I hope we shall have a shower. If even some crumbs from it should fall this way, it would be a comfort to me."

NOTES FOR JUNIOR NATURALISTS.

A BULB GARDEN.

"It's rather dark in the earth to-day."
Said one little bulb to his brother;
"But I thought that I felt a sunbeam ray—
We must strive and grow till we find the way!"
And they nestled close to each other.
Then they struggled and toiled by day and
by night,
Till two little snowdrops in green and white,
Rose out of the darkness and into the light,
And softly kissed one another.

—*Boston Journal.*

PART I. A TALK BY UNCLE JOHN.

BY JOHN W. SPENCER.

To succeed with the cultivation of flowers, the first thing to have in mind is to make the plant comfortable. This condition should be not only the first thought, but also the last thought. If you can do this successfully, the plant will do the rest of the work and your results will be abundant.

What plant comfort is, is a question more easily suggested than answered, for it is a very large subject—about as large as the surface of the earth. As a guess we will say that there are as many different kinds of plants as there are people. It is at least safe to say that plants have as many different notions as to their conditions of life as have the people of the different nations and tribes of the world.

If you were to have a birthday party and should invite as your guests the children from the four corners of the earth, and by magic could bring them to you in a jiffy, the boys and girls from Greenland would come enfolded in seal skin, and those from Hawaii would bring only their bathing suits. You would have a busy time keeping them comfortable, for when you opened the door to cool off the little Greenlanders, the little Kanakas would complain of too much draft; and at table the former would ask if you happened to have some tallow candles for desert, and the latter would ask for bread-fruit and bananas.

41.—*The Snow-drop.*

Many of our flowering plants have been brought together from such remote quarters as that. We have bulbs from Holland, and pansies from England, and phlox from the dry atmosphere of Texas.

There is as much difference in the conditions necessary for comfort in these different plants as there is in the requirements of the little Eskimos and little Polynesians. To some extent, plants can change their manner of living, but in the main they are happiest when they can have their own way, just as you and I are.

We cannot bring about the foggy, damp weather of Holland and England when we want it, neither can we bring the dry atmosphere of Texas—air so dry that meat will cure hard in the hottest weather without tainting. It so happens, however, that from one Fourth of July to the next we have many kinds of weather, and if one could not find conditions suited to almost any kind of plant it would be strange. If we cannot make the weather accomodate itself to the best comfort of the plants, we must set the plants so as to accomodate itself to the weather.

Pansies from foggy England and bulbs from the low lands of Holland should be planted to bloom in the cool days of spring, and the phlox from Texas will be quite happy in the heat and drought of July and August.

With this idea well fixed in your mind, you will easily see that when you know the country from which a plant has come, a knowledge of the physical geography of that country will be helpful in knowing how to make the plant happy and prosperous.

We must also make the plant comfortable in the soil. There is great difference in what plants require to make them comfortable. Some, like thistles or mullein or ragweed, will thrive on almost any soil and are no more exacting as to food than a goat or a mule ; but other plants are as notional as children reared in the lap of luxury.

As a rule, flowering plants belong to the lap-of-luxury class. Elsewhere in this number you are told how nature has developed soil. I hope you will read the article carefully, for there you will understand that all earth is not soil. Soil covers the land as thin skin covers an apple or as you would spread a thin coat of butter over bread, and it holds more or less plant-food.

When men erect school buildings and afterwards grade the ground they usually turn a part of the soil upside down. There is also considerable rubbish of the builders left scattered about, such as brick-bats, chips of stone, and the like, that go to make the place an uncomfortable one for notional plants. For this reason I wish particularly to call your attention to the manner in which you should prepare the ground on which you intend to plant. The first thing to do is to spade the soil very thoroughly to the depth of at least ten inches. All stones as large as a big boy's fist should be thrown out, and all lumps given a bat with the back of the spade to make all the particles fine. This is to be a flower bed and should be soft like your own bed. It would be better to make it up more than once. After the first spading it would be well to cover the bed with a coat of stable fertilizer to a depth of six to eight inches, which will give additional plant-food ; and in spading the second time, this fertilizer will become thoroughly mixed with the soil. The surface should next be raked smooth, and your flower bed will then be ready for planting.

We all admire the bright bulb flowers that are among the first to blossom in the spring. These mostly come from Holland, or at least attain their perfection there. We have just spoken of the importance of planting flowers at such a time that they may live their career when our climate is most like that from which they come. In the case of bulbs, spring and early summer is the most favorable time for them in this country, and fall is the proper time for planting.

The exact time in the fall to plant, how to plant, what bulbs to plant, when to put a winter overcoat on the bed, and other details, we will leave for Mr. Hunn to tell. He has had many years experience in the management of flowers, and we advise you to read carefully what he says.

Part II. A Talk by the Gardener.

BY C. E. HUNN.

Your Uncle John has told you something about preparing a bed for your plants. His advice is very good ; but the bulbs we are to talk about are like those notional children whom he mentions and they do not want tallow candles for any part of their meal.

What I mean is that bulbs do not want to come in direct contact with the stable fertilizer, but they want it down below them where the feeding roots that grow out of the bulb may nibble at it when the bulb is hard at work developing the leaves and flower. You know that all the leaves and the flowers were made the year before, and the bulb simply holds them until the new roots have formed. No kind of treatment will make a bulb produce more flowers than were formed in the year it grew (last year); but the better the treatment, the larger and finer the flowers will be.

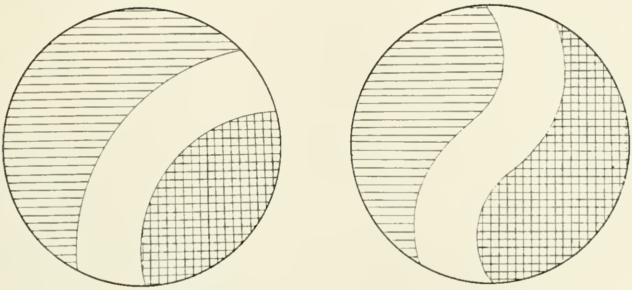
If I wanted to make a bulb bed, I should choose, if possible, a sandy soil and throw out the top soil to the depth of six inches. Then I should put into the bottom of the bed about two inches of well rotted manure and spade it into the soil. Then I should throw back half of the top soil, level it off nicely, set the bulbs firmly on this bed and then cover them with the balance of the soil; in this way you will have the bulbs from three to four inches below the surface. It is dark down there and in the fall months the top of the ground is cooler than at the depth of five or six inches and the top of the bulb will not want to grow, while the bottom which is always in a hurry will send out roots, to push out the leaves and flowers the next spring.

When the weather is cold enough to freeze a hard crust on the soil, the bed should have its winter overcoat. This may be straw, hay, cornstalks or leaves spread over the bed to the depth of six inches if the material is coarse; but if you use leaves, three inches will be enough, because the leaves lay close together and may smother out the frost that is in the ground and let the bulbs start. What we want is to keep them asleep until spring, because if they start too early the hard freezes of March and early April will spoil their beauty if the leaves or flowers are near or above the surface. Early in April the covering may be removed gradually and should all be off the beds before the leaves show above the ground.

Perhaps many of you cannot find a sandy place for your beds; if not, make your beds as has been told you, leaving the stones in the bottom of the bed for drainage. Then, when you are ready to set the bulb place a large handful of sand where your bulb is to go and set your bulb on it; this will keep the water from standing around the bulb. Very fine results may be had on heavy soil by this method.

What kind of bulbs shall we put into these beds? Select hyacinths, tulips or narcissus or daffodils, with snowdrops or crocuses of various colors around the edge.

If you use hyacinths you can have the national colors, red, white and blue, or many shades of either color, as shown in the diagrams (Figs. 42). Of tulips you can have stars or ribbons of yellow, white or crimson, or in fact almost any color except true blue. In narcissus, yellow, sulfur and white are the colors. The little crocuses come in yellow, blue, white and striped colors, and are in bloom and gone before the large flowers take your attention. Many other bulbs are fine for spring flowering but as most of them are more difficult to grow and



42.—*Simple designs for bulb beds.*

many of them rather expensive, I do not think we will discuss them now.

Suppose we want a bed of red, white and blue hyacinths (Figs. 42), and make it six feet in diameter. How many bulbs would you want? Now, hyacinths should be planted six inches apart each way, and the outside row should be at least three inches from the edge of the bed. You see you will want a little over one hundred bulbs, which if one person had to buy would cost him or her quite a little; but if fifty or more boys and girls would club together it would be easy for everyone, especially if, after making out a list of all the bulbs you want, you were to write to one of the dealers in bulbs telling him what you want, and how you expect to enjoy the flowers, asking him to let you have them as cheaply as possible. You will find that he will be glad you are interested in bulb growing, and be surprised how cheaply he will let you have them.

If you want a bed of tulips, they should be planted four or five inches apart instead of six inches, so you will need more bulbs; but they are cheaper than hyacinths. The narcissus bulbs being still smaller than tulips, may be planted three inches apart ; and the little crocuses, the first flower of spring, should touch one another, as should also the snowdrops.

Perhaps many of you do not wish to wait until spring for your bulbs to flower, in which case we must try to persuade them to bloom through the winter, say at Christmas. Nearly all bulbs are good natured and may be coaxed to do things that nature never asks them to do ; so if we go at it right we will find it very easy to make them think their time to bloom has come, even if the ground is covered with snow and the ice is thick on the ponds. Hyacinths, narcissus and crocus all can be made to flower in the winter by starting this way. Get the bulbs so as to be able to pot them by the middle or last of October, or if earlier all the better. The soil should be rich, sandy loam if possible ; if not, the best you can get, to which add about one-fourth the bulk of sand and mix thoroughly. If ordinary flower pots are to be used, put in the bottom a few pieces of broken pots, charcoal or small stones for drainage, then fill the pot with dirt so that when the bulbs are set on the dirt the top of the bulb is even with the rim of the pot. Fill around it with soil, leaving just the tip of the bulb showing above the dirt. If the soil is heavy a good plan is to sprinkle a small handful of sand under the bulb to carry off the water the same as is done in the beds outdoors. If you do not have pots you may use boxes. Starch boxes are a good size to use as they are not heavy to handle, and I have seen excellent flowers on bulbs planted in old tomato cans. If boxes or cans are used, care must be taken to have holes in the bottoms to let the water run out. A large size hyacinth bulb will do well in a five-inch pot. The same size pot will do for three or four narcissuses or eight to twelve crocuses.

After the bulbs are planted in the pots or other receptacles, they should be placed in a cool place, either in a cold pit or cellar or on the shady side of a building or, better yet, plunged or buried up to the rim of the pot in a shady border. This is done to force the roots to grow while the top stands still ; as only the bulbs with good roots will give good flowers. When the weather gets cold enough so a crust is frozen on the soil, the pots should be covered with a little straw, and as the weather gets colder more straw must be used. In from six to eight weeks after planting the bulbs, they should have made roots enough to grow the plant, and they may be taken up and placed in a cool room for a week or so, after which, if they have started into growth, they may be taken into a warmer room where they can have plenty of light. They will grow very rapidly now and will want lots of water, and after the flowers begin to show, the pots may stand in a saucer of water all the time. When just coming into bloom the plants may have full sunlight part of the time to help bring out the color of the flowers. Fig. 43 shows a pot of tulips.

43.—*Pot of tulips.*

I want to tell you of two bulbs that do not need so much fussing to get them to bloom for Christmas. One of them is called freesia (Fig. 44) and if I could have but one kind of bulb to flower in the winter, I would choose this. The little bulbs are not half as large as crocus bulbs and you will be astonished at the large leaves and flowers such a bulb can produce. The bulbs are about the cheapest of all winter bulbs and they grow without putting them away to make roots, as the tops do not seem as impatient to start as most other bulbs, but wait until there are plenty of roots to help it along. The flowers are borne on a slender stem and look very graceful, either on the plant or in bouquets. They are also very fragrant and a pot with five or six bulbs will perfume a large room. All they need is good light soil, sunlight, water and warmth to make glad the heart of anyone who plants them.

The other bulb I would select is the Oriental narcissus or Chinese Sacred lily. This grows in water without any soil whatever. Just take a bowl or glass dish about three times the size of the bulb; put some pretty stones in the bottom; set in the bulb and build up around it with stones so as to hold it stiff when the leaves have grown; tuck two or three small pieces of charcoal among the stones to keep the water sweet, then fill up the dish with water and add a little every few days, as it evaporates. Set the dish in a warm, light place. In about six weeks the fragrant, fine white flowers will fill the room with perfume and you will have had the pleasure of watching the roots start and grow, the top throw up long green leaves and the flower spikes develop and open their flowers. Hyacinths may also be grown in water, but not as easily as this narcissus, or in such inexpensive dishes.

44—*Pot of the freesia.*

The picture (Fig. 45) of a bulb box was taken last winter from a box of mixed bulbs grown at Cornell. The calla in the center and the Kenilworth ivy trailing over the front of the box were planted in the box in September, and pots of geraniums and other plants set on the dirt to fill the space. When the bulbs that were in pots were ready to be started they were taken out of the pots and set in the dirt in the box where they grew and flowered; the

45.—*Winter box of bulbs.*

tall stems are Paper White narcissus, the last variety for winter. On each side there is a hyacinth just starting and in front a little freesia in bloom. When these bulbs were done flowering, small pots of blooming plants were set on the box and a charming window box was had with many different things in it through the winter.

CLUB NOTES.

We must have a yell for the Junior Naturalist Clubs. What shall it be? We shall be very glad if each of you send us something for that purpose, and we will make a selection. Let it be something the girls can yell as well as the boys.

***

The new school year brings a change of teachers to our Junior Naturalist Clubs of last spring. Our plan is to have clubs that organized last spring retain their charters and reorganize under the new teacher. Some of the former members may drop out, but we hope new members will take their places.

***

Our club buttons are now ready for distribution and will be sent to each of our old members as soon as their clubs reorganize under their new teachers, and to members of our new clubs as soon as they show an interest by paying the fortnightly dues.

***

Whenever your Uncle meets in public a boy or girl wearing a Junior Naturalist Club button, he will speak to the wearer without any formality; and he thinks it a good plan if members will do the same thing. Let us feel that we belong to the same fraternity and all have the same interest in nature, and we will be friends to each other. He wishes to encourage a feeling of friendship among members of different clubs. When convenient, it will bring good results for one club to visit another, and the host club can show the guest club what it is doing in the study of nature.

***

Your Uncle is always glad to receive your photographs either in groups or singly. He has a number on hand now and will welcome more. Next to meeting you boys and girls is the sight of your shadows, for that is what a photograph means.

***

Your Uncle wishes to speak to you about the letters he receives from his friends, the Junior Naturalists. At one time last spring the number was about two hundred each day. Every one of these was read. The ones written as payment of club dues were sorted out and given to a department where the letters, after a a close reading, were passed to the credit of the writer. Those of a personal nature or asking information concerning some nature-study topic were handed to your Uncle for his perusal, and for his answer, so far as he could. Do not think that any of your letters are thrown away without being read.

***

Your Uncle is anxious that each of you boys and girls shall receive his pnrsonal attention. With such a large number of letters you must be thoughtful and helpful, and he asks you to send your letters and drawings, that go as dues, in one envelope under the direction of the secretary of your club, and be addressed BUREAU OF NATURE-STUDY, CORNELL UNIVERSITY, ITHACA, N. Y. He hopes that you will feel like writing him freely, and in your natural way, all about your difficulties in your investigations as naturalists, and he wishes you to tell him of some of the bright things that come into your lives, and some of the shadows, too, if there are any such. All such should be addressed to JNO. W. SPENCER, DEPUTY CHIEF, BUREAU OF NATURE-STUDY, CORNELL UNIVERSITY, ITHACA, N. Y.

HOME NATURE-STUDY COURSE.

AY MARY ROGERS MILLER.

This work is to be continued through the year and new students are welcome at any time. It is designed for teachers and others who have had little opportunity to study nature, yet wish to prepare themselves to teach children to know nature.

For the present the material for the Home Nature-study course will consist of various publications of the Nature-study Bureau and Farmers' Reading-Course, together with the quiz. If the work is taken up with enthusiasm and the quizzes are returned regularly, it is probable that special Home Nature-study publications will be issued. When the interest warrants a separate series of publications for use in this department, they will be forthcoming.

Just a word with you about the Home Nature-study. It is not primarily a reading course. The pamphlets sent you are full of suggestions for you to follow, experiments for you to perform, work for you to do. Unless you actually do these things, you fail to make the experiences your own, you take statements on authority, and miss the point of the whole course. Reading what others have observed about nature, lacks the freshness and freedom of original investigation. Without the element of discovery and personal contact, nature-study deteriorates into lesson-getting. Seeing nature with other people's eyes, reading their thoughts about her ways, is most delightful, after one has seen and thought for one's self.

For example, scientists tell us that a certain brown and black butterfly with a long name migrates southward to spend the winter. We read the words, and straightway forget the fact. "What if it does," we say. But let us some day in fall, see the air and the trees full of red butterflies fluttering so bravely yet so silently, thousands and thousands winging their way toward the sunny southland, and we *care*. When we see, straggling back again in spring the survivors of these hordes, their wings all rags and tatters, their beauty gone with their youths, again we are impressed. We marvel at their instinct and their fortitude. There is a wide difference between knowing a thing and hearing about it !

It is expected that students in this course will see nature from a new point of view, and study with a new spirit.

Every question in the quiz will be for the purpose of bringing out some facts in the students' own experience. Reports should be sent in within eight weeks after the receipt of the lesson.

Lesson No. 3 will be on "The Soil," and will be sent to all applicants. Suggestions and questions are always welcome.

L. H. BAILEY, Chief,

JOHN W. SPENCER, Deputy Chief,

Of Bureau of Nature-Study and Farmers' Reading-Course.

January, 1900.

CORNELL

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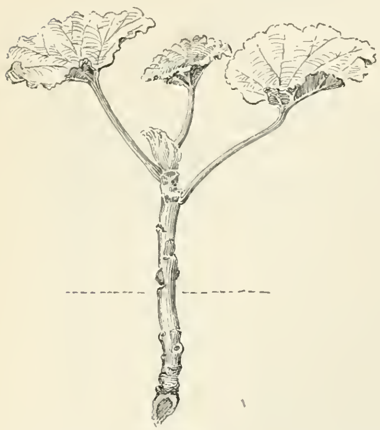
CUTTINGS AND CUTTINGS.

BY L. H. BAILEY.

PERHAPS no subject connected with the growing of plants awakens so much popular wonder and inquiry as their propagation by means of cuttings and grafts. We assume that propagation by means of seeds is the natural way, and therefore do not wonder, notwithstanding that it is wonderful. We assume that propagation by cuttings is wholly unnatural, and therefore never cease to wonder, notwithstanding that is less wonderful than the other. To common minds, common things are not wonderful. Mere commonplace familiarity takes away the charm, for such minds have no desire of inquiry. The well trained mind goes beneath the surface, and wonders at everything; and this wonder, grown old and wise, is the spirit of science.

A plant does not have a definite number of parts, as an animal does. It may have ten branches or fifty. Each of these branches may do what every other branch does,—produce leaves, flowers, fruits, seeds. It is not so with the higher animals, for in them each part may do something which some other part cannot do: if the part is a leg, it runs; if an ear, it hears. Each part serves the whole animal; and it cannot reproduce the animal. But in the plant, each branch lives for itself; it grows on the parent stock: or, if it is removed, it may grow in the soil. And if it grow in the soil, it is relieved of competition with other branches and grows bigger: it makes what we call a plant.

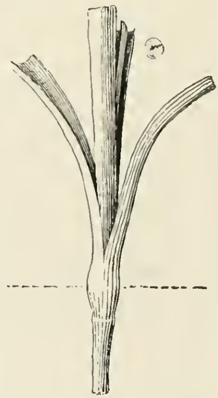
Having thus bewildered my reader, I may say that a bit of a plant stuck into the ground stands a chance of growing; and this bit is a cutting. Plants have preferences, however, as to the kind of a bit which shall be used, but there is no way of telling what this preference is except by trying. In some instances this preference has not been discovered, and we say that the plant cannot be propagated by cuttings. Most plants prefer that the cutting be made of the soft or growing wood, of which the "slips" of geraniums and coleus are examples. Others grow equally well from cuttings of the hard or mature wood, as currants and grapes; and in some instances this mature wood may be of roots, as in the blackberry. Somewhat different principles underlie the handling of these two kinds of cuttings; and these principles we may now consider. We shall find it excellent practice to set the pupils to making cuttings now and then. If we can do nothing more, we can make cuttings of potatoes, as the farmer does; and we can plant them in a box in the window.



46.—*Geranium cutting. One-half natural size.*

The Softwood Cutting.

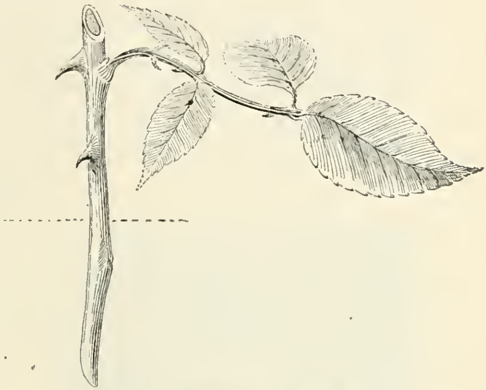
The softwood cutting is made from tissue which is still growing, or at least from that which is not dormant. It must not be allowed to wilt. Therefore, it must be protected from direct sunlight and dry air until it is well established; and if it has many leaves, some of them should be removed or at least cut in two in order to reduce the evaporating surface. Keep the soil uniformly moist; and avoid soils which contain much decaying organic matter, for these soils are breeding places of fungi which attack the soft cutting and cause it to "damp off."



47.—*Carnation cutting. Natural size.*

For most plants, the proper age or maturity of wood for the making of cuttings may be determined by giving the twig a quick bend: if it snaps and hangs by the bark, it is in proper condition ; if it bends without breaking it is too young and soft or too old ; if it splinters, it is too old and woody.

The tips of strong upright shoots usually make the best cuttings. Preferably each cutting should have a joint or node near its base ; and if the internodes are short, it may comprise two or three joints. Allow one to three leaves to remain at the top. If these leaves are large, cut them in two.



48.—*Rose cutting. More than one-half natural size.*

Insert the cutting half or more its length in clean sand or gravel. Press the earth firmly about it. Throw a newspaper over the bed to exclude the light—if the sun strikes it—and to prevent too rapid evaporation. See that the soil is moist clear through, not on top only.

49. —*Cutting-bed, showing carnations and roses.*

Mason's sand is good earth in which to start cuttings. Or fine gravel—sifted of most of its earthy matter—may be used. If the cuttings are to be grown in a window, put three or four inches of the earth in a shallow box or a pan. A soap box cut in two lengthwise, so that it makes a box four or five inches deep—like a gardener's flat—is excellent.

If the box does not receive direct sunlight, it may be covered with a pane of glass to prevent evaporation ; and then the children may see the plants more readily. But take care that the air is not kept too close, else the damping-off fungi may attack the cuttings and they will rot at the surface of the ground. See that the pane is raised a little at one end to afford ventilaton ; and if water collects in drops on the under side of the glass, remove the pane for a time. Cuttings of common plants, as geranium, coleus, fuchsia, carnations, should be kept in a living-room temperature.

50.—*Verbena cutting ready for transplanting. Two-thirds natural size.*

The pictures are better than words. The line across them shows where the soil comes. There are softwood cuttings of geranium (Fig. 46), carnation (Fig. 47), and rose (Fig. 48) ; and there is a gardener's cutting-bed (Fig. 49) with cuttings of carnations and roses.

Be patient. As long as the cuttings look bright and green, they are safe. It may be a month before roots form. When roots have formed, the plants will begin to make new leaves at the tip. Then they may be transplanted into other boxes or into pots. The verbena in Fig. 50 is just ready for transplanting. Each child will want a plant.

It is not always easy to find growing shoots from which to make the cuttings. The best practice is to cut back some old plant severely, then keep it warm and well watered, and thereby force it to throw out new shoots. The old geranium plant from the window garden, or the one taken up from the lawn bed, may be served this way. See Fig. 51. This may seem hard treatment, but that is all the old plant is good for ; it has passed its usefulness for bloom. The best plants of geranium and coleus and many window plants are those which are not more than one year old. The cuttings which are made in January, February, or March, will give compact blooming plants for the next winter; and thereafter new ones take their place.

Some plants may be propagated by means of cuttings of leaves. The Rex begonias or "beefsteak geraniums" are the commonest examples. The large, nearly mature leaf is divided into triangular pieces, each piece containing at its point a bit of the leaf-base (top of the leaf-stalk). This kind of cutting is shown in Fig. 52. This base is sometimes split (as at o) by gardeners to hasten the formation of roots. Only the tip of the cutting is stuck into the sand; otherwise it is treated like other softwood cuttings.

51.—*Old geranium plant cut back to make it throw out shoots from which cuttings can be made.*

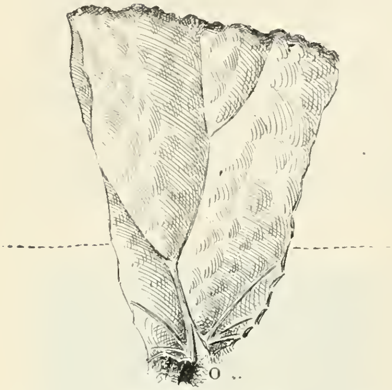
The Hardwood Cutting.

Many plants grow readily from cuttings of ripe or dormant wood. The willows cast their branchlets in snow and wind, and these, falling in pleasant places, propagate their kind; and thus the river sides and the lake shores become willow-crowned.

Grapes, currants, gooseberries, poplars, readily take root from the hard wood. Fig. 53 shows a currant cutting. It has only one bud above the ground.

Best results are attained when the cuttings are made in the fall, and then buried until spring in sand in the cellar. They are not idle while they rest. The lower end calluses or heals, and the roots form more readily when the cutting is planted in the spring. But if the children are interested, take cuttings at any time in winter, plant them in a deep box in the window, and watch. They will need no shading or special care.

When plants of any variety are scarce, the cuttings may be shorter. Sometimes they are reduced to a single "eye" or bud, with an inch or two of wood attached; and these single-eye cuttings are planted much as one plants seeds.



52.—*Begonia leaf cutting. Natural size.*

The Graft.

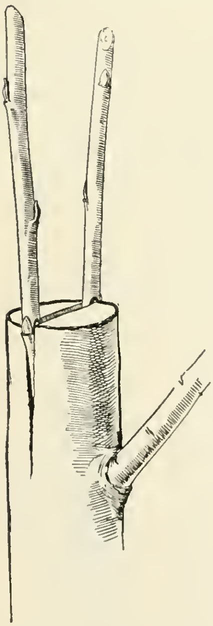
If the cutting were planted in a plant rather than in the soil, we should have a graft; and the graft might grow. In this case, the cutting would not make roots, but it would grow fast to the other plant, and the twain would become one. When the cutting is inserted in a plant, it is no longer called a cutting, but a cion; and the plant in which it is inserted is called the stock. The completed thing—cion growing in the stock—is a graft.

53.—*Currant cutting. One-third natural size.*

Plants are particular as to their companions, when it comes to such close relationships as these. They choose the stocks upon which they will grow; but we can find out what their choice is only by making the experiment. There are queer things about it. The pear grows well on the quince, but the quince does not grow so well on the pear. The pear grows on some of the hawthorns, but it is an unwilling subject on the apple. Tomato plants will grow on potato plants and potato plants on tomato plants. When the potato is the root, both tomatoes and potatoes may be produced; when the tomato is the root, neither potatoes nor tomatoes will be produced. Chestnuts will grow on some kinds of oaks.

Why do we graft? Think a bit. If I sow seeds of a Baldwin apple, I will probably have as many kinds of apples as I have trees. Some of these apples may be like the Baldwin, and they may not. That is, apple seeds do not reproduce the particular variety. They will not be held to any stricter account than merely to produce apples; these apples may range all the way from toothsome kinds to Ben Davis. The nurseryman knows this, and he does not wait for the trees to bear in the hope that they will produce something to his liking. So he grafts them when they still are young,—takes a cion from the kind which he wishes to perpetuate. So it happens that all the Baldwins and Kings and Russets, and all other named varieties, are growing on alien roots; and what kinds of fruits these stocks would have produced, no one will ever know, because their heads were cut off in their youth and heads were put on to order. In this way apples and pears and plums and peaches and cherries and apricots are propagated, for they will not grow readily from cuttings. But raspberries and blackberries and gooseberries and currants and grapes grow willingly from cuttings, and they are not grafted by the nurseryman.

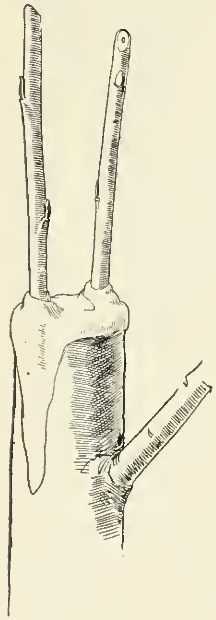
54.—*Cion for cleft-grafting. One-half natural size.*



55.—*Cleft-graft. One-half natural size.*

The forming, growing tissue of the trunk is the cambium, lying on the outside of the woody cylinder, beneath the bark. In order that union may take place, the cambium of the cion and the stock must come together. Therefore, the cion is set in the side of the stock. I once knew a man who believed that everything was designed for some useful purpose. The hole in the pith bothered him, until he discovered that a cion just filled it. He grafted his trees accordingly; but the experiment was productive of nothing except pithy remarks.

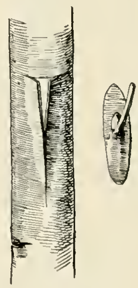
There are many ways of shaping the cion and of preparing the stock to receive it. These ways are dictated largely by the relative sizes of cion and stock, although many of them are matters of mere personal preference. The underlying principles are two: see that there is close contact between the cambiums of cion and stock; cover the wounded surfaces to prevent evaporation and to protect the parts from disease.



56.—*The graft waxed.*

On large stocks the common form of grafting is the cleft-graft. The stock is cut off and split; and in one or both sides a wedge-shaped cion is firmly inserted. Fig. 54 shows the cion; Fig. 55 the cions set in the stock; Fig. 56 the stock waxed. It will be seen that the lower bud—that lying in the wedge—is covered by the wax; but being nearest the food supply and least exposed to weather, it is the most likely to grow: it pushes through the wax.

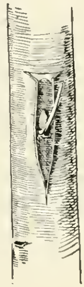
The wax is made of beeswax, resin and tallow. The hands are greased, and the wax is then worked until it is soft enough to spread. For the little grafting which any school would do, it is better to buy the wax of a seedsman. However, grafting is hardly to be recommended as a general school diversion, as the making of cuttings is; and this account of it is inserted chiefly to satisfy the general curiosity on the subject. But we hope that now and then a youngster will make the effort for himself, for nothing is more exciting than to make a graft grow all by one's self.



57.—*Shield-budding. One-half natural size.*

Cleft-grafting is done in spring, as growth begins. The cions are cut previously, when perfectly dormant, and from the tree which it is desired to propagate. The cions are kept in sand or moss in the cellar. Limbs of various sizes may be cleft-grafted,—from one-half inch up to four inches in diameter; but a diameter of one inch is the most convenient size. All the leading or main branches of a tree top may be grafted. If the remaining parts of the top are gradually cut away and the cions grow well, the entire top will be changed over to the new variety in three or four years. Each cion may be a different variety; but there is no difference in the operation or the treatment of the tree.

On young or small stocks, like nursery trees, the cleft-graft is not practicable, and a different form of grafting is employed; but the teacher will not care to be confused with further details.



58.—*The bud set in the matrix. One-half natural size.*

We have seen that a cutting may be reduced to a single bud; so may a cion. If the bud-cion has very little or no wood attached, and is inserted underneath the bark, the operation is known as budding. The commonest form of budding is shown in Figs. 57, 58, 59. This is the method known as shield-budding, because the bud, with its attached bark, is shield-shape (Fig. 57). A T-shape incision is made in the stock, and under the bark the bud is inserted (Fig. 58); then the wound is tightly bound with soft cord or bast.

59.—*The bud tied.*

Budding may be performed whenever the bark will "slip" and when well grown buds can be secured,—that is, either in spring or late summer. It is usually performed at the latter season; and then the bud does not throw out a shoot the same season, but merely grows fast to the stock. The next spring it throws out a shoot and makes a trunk; and in the meantime the stock has been cut off just above the bud. That is, the bud-shoot takes the place of the top of the stock.

Shield-budding is performed only on small and young stocks. It is usually exclusively employed in the propagtion of stone fruits, as cherries, peaches, plums, apricots, for experience has proved that it is preferable to other forms of grafting. It may also be employed for other fruit trees.

How is a peach tree made? In 1898, a pit or seed is saved. In the spring of 1899, it is planted. The young tree comes up quickly. In August 1899, the little stock has one bud—of the desired variety—inserted near the ground. In the spring of 1900, the stock is severed just above the bud : the bud throws out a shoot which grows to a height of four or six feet ; and in the fall of 1900 the tree is sold. It is known as a year-old tree ; but the root is two years old.

How is an apple tree made? The seed is saved in 1898, planted in 1899. The seedlings do not grow so rapidly as those of the peach. At the end of 1899, they are taken up and sorted ; and in the spring of 1900 they are planted. In July or August, 1900, they are budded. In the spring of 1901 the stock is cut off above the bud ; and the bud-shoot grows three or four feet. In 1902, the shoot branches, or the top begins to form ; and in the fall of 1902, the tree may be sold as a two-year-old, although most persons prefer to buy it in 1903 as a three-year-old. In some parts of the country, particularly in the west, the little seedling is grafted in the winter of 1899–1900, in a grafting-room; and the young grafts are set in the nursery row in the spring of 1900, to complete their growth.

I have now given my reader an elementary lesson in horticulture ; but I shall consider it of little avail if it is not transformed into practice for the children. February is the gardener's time for the starting of his cutting-beds, in which to grow plants for the summer bloom. Ask the children to bring the old geraniums and fuchsias and coleus, and other favorites. Keep them in a warm window ; cut them back ; see that they are well watered ; then take the cuttings when the time comes. The children will be interested to watch the fortunes of the different cuttings. They will be interested in Vergil's couplet, as set to rhyme in old English :

> Some need no root, nor doth the Gardner doubt,
> That Sprigs, though headlong set, will timely sprout.

NOTES.

THE project of organizing the children of the state into nature-study bands or clubs is meeting with unexpected success. The Junior Naturalist Club is organized, in the language of its charter, that "every member thereof shall love the country better and be content to live therein." The Cornell Nature-Study movement has for its purpose the awakening of a love for natural and native things. It stands for naturalness and freedom. It would deepen every life which it touches, by giving it fuller sympathy with everything that is and by enriching its experience. It does not attempt to teach elementary science, nor primarily to popularize knowledge ; and herein it differs from other nature-study movements. It is not seeking to make investigators of the coming generation, to the end that the boundaries of science may be widened. It wants to teach the child how to live. It is the spirit, rather than the letter, that quickeneth.

* * *

Each Junior Naturalist Club receives a charter, and each member may receive a button. Each member pays dues twice each school month by sending a letter on something which has been seen or studied. Often these letters are the school-room compositions concerning nature subjects. Each month we issue to the clubs a Junior Naturalist Lesson, suggesting what topic may be studied to advantage. This fall we have made much of the topic "seed travelers ;" and our office has been full of seeds from the four corners of the State. How much the little minds have opened as they have pictured the journeys of the thistle-down and the stick-tight, no one can ever know.

* * *

A School of Nature-Study for teachers is offered at Cornell in the summer of 1900, as in 1899. Term opens just after the Fourth, and continues six weeks. Because of lack of room and equipment, the number of students is limited to one hundred. First come, first served. Applications are already coming in. To teachers in New York State, there is no tuition. Instruction is given in three general subjects by Professors Roberts, Comstock and Bailey. This instruction comprises a full course in itself. It is a one-session course. Persons who desire advanced instruction, register in the other courses of the summer session.

UNCLE JOHN'S TALK WITH THE CHILDREN.

IF YOU have not yet organized a Junior Naturalist Club in your school, we most cordially invite you to do so. If you desire it, we will gladly mail you instructions. By the instructions you will learn all about the election of club officers, the charter, monthly lessons, and the conditions under which we send badge buttons. The observations of the month can be made the topic for compositions and drawings, and these are sent to us once or twice each month and are considered by us as payment of dues. For each member there is an index card in our office on which his record is kept.

* * *

In our plans for simplifying the work never for a moment have we entertained the idea that the thousands of letters received as dues should be neglected. Never do we pick up a letter without the feeling that its production meant much to the author and that it is entitled to respectful consideration. Those of our staff to whom this work falls, have become expert in "catching the key" of each letter when reading the first few lines. The original, unpruned letter, expressing the natural boy or girl, pleases us most. We want their ideas more than their scholarship.

* * *

Ideally one might suppose that our most enthusiastic clubs would come from outside of the city, where Nature is to be observed. While we have had very gratifying reports from such quarters, we have been much delighted by the zeal shown by clubs in such citiesas Albany, Auburn, Binghamton, Brooklyn, Buffalo, Cohoes, Corning, Dunkirk, Elmira, Gloversville, Johnstown, Jamestown, Lockport, New York, Niagara Falls, New Rochelle, Olean, Poughkeepsie, Rochester, Schenectady, Syracuse, Utica and Yonkers.

* * *

If you know of any boys or girls or adults who by reason of illness belong to the band of "shut-ins," you may perhaps be doing them a favor by placing us in touch with them. You understand that all our services are free.

* * *

When preparing dues for mailing, put them in envelopes or in rolls with plain wrapper. Do not fail to give name and address in upper left hand corner of the envelope or roll. It is well to do this even when identification cards are placed inside. When sending letters or drawings, pasteboard sides are unnecessary and when used add much to the postage.

* * *

We must again speak of the conditions on which we send the badges or buttons. They are not sent as a bonus or premium for joining a Junior Naturalist Club, but as a testimony that the recipient has done faithful work in Nature-Study. So far as possible, we rely upon the judgment of the teacher when such conditions have been complied with, and to her we consign the buttons for distribution. We wish them to be badges of honor and not be cheapened by being worn by the undeserving.

* * *

We shall continue to send monthly lessons to all Junior Naturalists. We find that most interest is found in the study of living and growing things,and material for such is not so easy to obtain during January and February. We shall, however, select topics suceptible of some illustration. Perhaps it will be just as well to exact but one set of dues for these months.

* * *

As soon as possible after receiving the roster of a club, we send a charter. During October and a part of November we were unable to be as prompt in doing this as we desired. No doubt some of our Junior Naturalists felt impatient by such enforced neglect, but we are sure we suffered more than they. It is not an easy thing to register twenty-one thousand boys and girls. We have done this and now know where to find each one and also the address of the teacher by whom the work of the club is conducted.

* * *

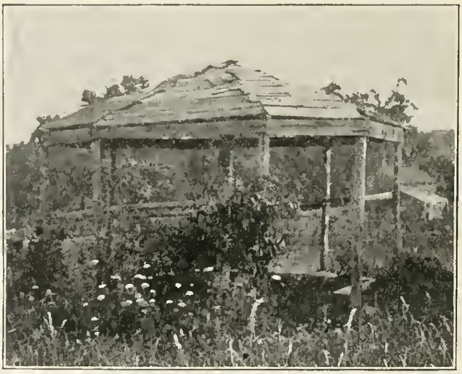
We are often asked—" Will it not answer your purpose of dues just as well if we send you a few samples?" No, it will not by any means. A record of the work done by each boy and girl is kept in our department on a card, and we want the communications of every member so that proper credit can be given.

* * *

The inquiry is not infrequent—" What do you do with the thousands of letters in the form of dues sent each month?" We are glad to assure all Junior Naturalists that each letter received in payment of dues is handled with great respect and proper credit given on each card.

* * *

The Junior Naturalist family now numbers more than 21,000 boys and girls. They live in many states; and there is one club in Egypt and another in Tasmania.



A Junior Naturalist Club House.

March, 1900.

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THE BURST OF SPRING.

I. The Opening of the Buds. (*L. H. Bailey.*)

SPRING is coming! The buds will burst and the birds will sing!

How do the buds burst? Watch them as the spring opens; or if you are impatient, cut long twigs and place them in bottles of water in a living-room, and the buds will swell. First notice what the winter buds are like, — that they are spherical, or oblong, or conical bodies lying close to the limb and tightly covered with scales. Notice that there is a mark or scar beneath the bud, showing where a leaf was borne.

It is excellent practice to collect winter twigs of different kinds of trees and bushes, and to compare the form and color of the shoots, and the size, shape, color and make-up of the buds. Lay the twigs side by side on the table and notice how one differs from the other. What part of the twig grew last year? Notice the "ring" at the base of the last year's growth. After all the differences are noted, put the twigs in water, as you would a bouquet. Sometimes flowers and leaves will appear. If the twigs are two or three feet long, the buds are more likely to grow, for then there is sufficient supply of food (or starch). Change the water frequently, and cut off the lower ends of the twigs so that a fresh surface will be exposed to the water. It will be two to five weeks before the buds open, depending mostly on the kind of plant.

Mark one bud on a maple, or apple, or lilac, or other plant, by tying a string about the twig. Look at it carefully from day to day: observe how it opens, and what comes out of it.

The pupil should know that a winter twig has interest.

* * *

The bud may be peach or apricot. Soon the bud begins to swell at its top. The scales open. A white lining appears. This lining soon protrudes (Fig. 60). Soon the lining opens. We see that it is a flower. Or, perhaps the peach bud sends out a green shoot rather than a flower. There must be two kinds of peach and apricot buds,—a flower-bud and a leaf-bud. Can you tell them apart? The flower-bud is thicker and rounder. Usually one stands on either side of a leaf-bud. But the leaf-bud may stand alone. Find one: any peach tree or apricot tree will have leaf-buds, but all may not have flower-buds. As the bud expands and the flower or leaf appears, notice that the bud-scales fall away. Do not these scales leave scars? And do not these scars, standing together, make the "ring" which marks the beginning of the new growth?

60. — *Opening of an apricot bud.*

* * *

Observe a pear bud. Notice that the scales elongate as the bud swells. You can see the white bases of the scales, marking the new growth (Fig. 61.) If it is a leaf-bud, the scales may become three-fourths of an inch long before they fall. But sooner or later, they are cast, and their places are marked by scars. If it is a flower-bud, notice that several flowers come out of it. In the apricot and peach, there is only one flower in each bud. Each of these little pear flowers is closed up like a bud, and elevates itself on a stalk before it opens: and this stalk becomes the stem of the pear fruit. But this pear flower-bud contains leaves as well as flowers. Fig. 62 shows what comes out of a pear bud. This, then, is a mixed flower-bud,—it contains both leaves and flowers. The apricot and peach bear true or simple flower-buds.

61. — *Opening of a pear bud.*

62.— *What came out of a pear bud.*

* * *

Watch apple buds. The scales do not elongate as in the pear, but the flower-buds are mixed.

Fig. 63 shows the expanding cluster from an apple flower-bud. Four flowers will open; and there are six leaves. If the buds are made to open in the house on severed twigs, the leaves do not grow so large before the flowers expand, for the twig does not contain sufficient food. Fig. 64 is a photograph of an apple twig which I had in my window one winter's day.

63.—*Opening of an apple bud.*

* * *

Examine a hickory twig. The illustration (Fig. 65) shows the "ring" marking the beginning of the annual growth. See the large leaf-scars. Notice that the terminal bud is much the largest. It is the one which will grow. The other buds will remain dormant unless they are forced into growth by the death of the terminal bud or by other unusual circumstance. Notice that buds differ in size on shoots of all plants: consider that not all the buds are to grow: there is struggle for existence. When the hickory bud expands, some of the scales fall away; but some of the inner parts enlarge into leaf-like bodies, as shown in Fig. 66. In some hickories these bodies become two or three inches long before they fall. Hickories

64.—*Apple flowers in midwinter.*

open very late in the season. The Norway Maple, commonly planted on lawns, behaves in a similar way. Observe the Sugar Maple.

* * *

65.—*Shoot of a hickory.*

A twig of the common elm is shown in Fig. 67. Notice the "ring". See the two kinds of buds. We suspect that the three large ones are flower-buds. With the very first warm days —before the robin has built her nest —these three buds will burst; soon the red-brown tassels will hang on the leafless twigs. Each tassel is a flower. Several flowers come from each bud. We see them in Fig. 68: and the leaf-buds have elongated somewhat. Watch for the fruits or seeds that blow about the walks so early in spring: and note how the leaves come out.

66.—*The opening of a hickory bud.*

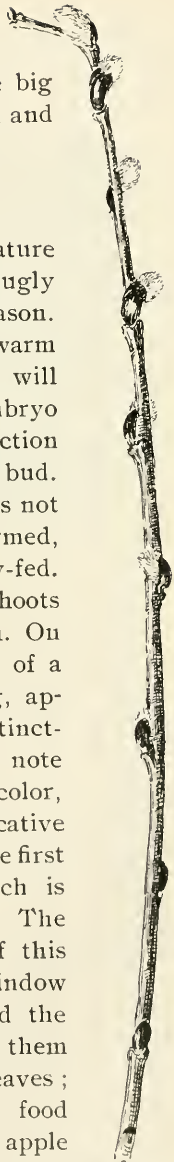
* * *

With the first breath of spring, the "pussy willows" come.

67.—*Twig of elm.*

68.—*Blossoms of the elm.*

And what are the "pussies"? They are clusters of flowers. So snugly are the little flowers wrapped in wool, that the "pussies" are silken-soft as they begin to expand. Fig. 69 is a willow shoot. Find one when the buds first begin to burst. Notice the big brown-black scale that covers the bud as a shield and falls when the "pussy" first begins to appear.



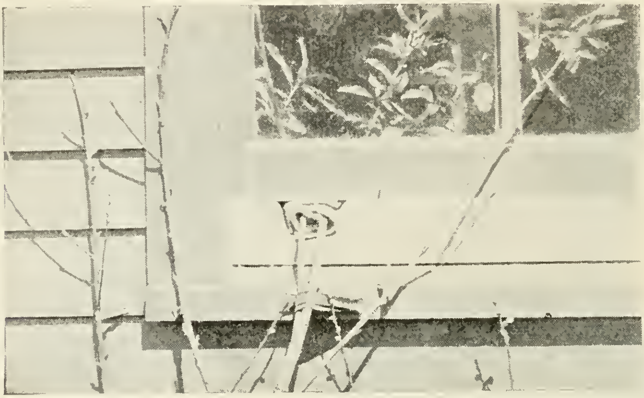
69.—*The opening of a pussy willow.*

* * *

And now what is a winter bud? It is a miniature shoot or flower, resting for the time, and snugly wrapped for the long winter. It was made last season. It is ready to leap into growth the moment the warm rain of spring wakens it. A good hand lens will show the embryo branch, if a section is made of the bud.

70.—*Bloom of azalea.*

This bud is not only ready-formed, but it is ready-fed. The winter shoots contain starch. On a cut surface of a dormant twig, apply a drop of tincture of iodine; note the bluish color, which is indicative of starch. This starch is insoluble; but with the first awakening of life, it changes into sugar, which is soluble and is transferred to the growing point. The burst of spring is made possible by means of this stored food. Notice the azalea in the florist's window (Fig. 70). The large flower-buds were formed the year before, and it is a short operation to force them into bloom. The flowers come in advance of the leaves; therefore these leaves could not have made the food required for the bloom. The blooming of the apple twig (Fig. 64) in the winter shows that the food is in the twig and buds. Once I drew a branch of a tree into a room and fastened it there. It made leaves and began to grow while the tree to which it was attached was perfectly dormant (Fig. 71).



71.—*Branch of a tree bearing leaves inside a window, when the tree itself is dormant.*

* * *

Not only are the buds ready-formed and ready-fed, but they are covered. Snugly is the tender, growing point protected. Pull away the scales of a winter bud one by one. Observe how closely they are placed. Often the chinks are filled with a packing of wool, or are sealed with varnish. Dip the bud in water : then see if the water permeates the covering. The chief value of the bud-covering is not to protect from freezing, as commonly supposed, but to prevent the soft growing parts from drying out.

* * *

The plants are waiting for spring. They are ready.

II. The Early Birds. (*Louis Agassiz Fuertes.*)

AFTER a long winter, many of us are too impatient for spring to wait for the swelling of the buds, the opening of the early flowers, and the springing of the grass. Several weeks lie between the end of winter and the truly genial spring days, and during this interval we look for something to herald the settled spring season. And the thing which gives us that for which we are unconsciously looking, more than all other signs, is the arrival of the birds. Who has not warmed to the quavering call of the first blue-bird, or been suddenly thrilled some early spring day with the sunny notes of the song-sparrow!

In the southern part of this state, notably in the lower Hudson Valley, several birds spend the winter which elsewhere we are accustomed to see only after the winter has passed. Among these are the blue-bird, robin, song-sparrow, white-throated-sparrow, meadow-lark, and possibly purple-finch. But in most of the state we must wait until the first or second week in March before we can be sure of seeing any of them. It is a question which of the earlier birds will first make its appearance, as these early migrants are much less regular in their movements than those that come late in April and in May, after the weather has become settled. Many a robin and blue-bird arrives during some early warm "spell," to find himself suddenly surrounded by flying snow and blown about by cold winds. But these and a few other hardy ones seem able to stand such rebuffs with great equanimity, and the momentary shining of a fickle March sun will often evoke some pent up song-sparrows' notes from the shelter of a hedge or thicket. Robins, blue-birds, song-sparrows, cowbirds, meadow-larks, phoebes, bronzed grackles, kingfishers and doves may be looked upon as the vanguards of the hosts of migrating birds that come to us each year, and the first four or five may be expected almost any time after the first week in March. If the winter has been late, these may not appear until the middle or even the latter part of the month, in which case one is busy keeping track of the arrivals, as the other birds have caught up then, and all come nearly at the same time.

It is unnecessary to give detailed descriptions of robins, bluebirds and song-sparrows, as nearly everyone is familiar with them ; but some of the other early comers may be more easily recognized if some field impressions of them be given.

* * *

Almost any warm day in early March we may hear a thin, clear "tsssss" in a high piping key, and on looking up see from one to five black birds, about the size of orioles, flying in a strange undulating manner—some up and some down, with the wings held close to their sides during the "drop" in their flight. They are cowbirds. The flock may swirl into the top of a tree and sit close together. (Fig. 72.) If this happens within eyeshot, stop and watch them for a moment. One or two of the males are almost certain to utter the ridiculous song of the species, which, like that of their relatives, the grackles, is accompanied by the the most grotesque of actions. The bird spreads its wings to their utmost, spreads and elevates the tail, stretches its neck upwards and forwards, and then, quivering and tottering, nearly falls forward off the perch. The only sound which accompanies this absurd action is a faint chuckling "clk-sfs'k" which is scarcely to be heard a hundred feet away.

72.—*Cowbirds.*

* * *

With the cowbirds we may expect the arrival of the bronzed grackles, which resemble them much in flight, but are larger and come in far larger flocks,— sometimes ten, sometimes a hundred or more. Their arrival is known by the vigorous calls they utter while flying, a loud bass "jook." When seen squabling in the spruce trees or in the bare branches of the willows fringing the streams, the males are likely to be giving their "song." It is scarcely more of a note than the cowbird's, a rusty squeak, and it is accompanied by a contortion in the same manner. It is not such a pronounced effort, however, and is often only a slight shudder and shrug of the shoulders. They feed, like cowbirds, mostly on the ground, and walk about most sedately in the grass like small crows. In tall grass, however, they waddle too much to be graceful. When taking flight they spread their long pointed tails in a very peculiar and characteristic manner—not out in a horizontal plane, like most birds, but up at the sides in the shape of a gardeners' trowel, which gives them an extraordinary appearance.

* * *

The redwings begin to come into the marshes soon after the grackles, and are at that time in full feather and song. Their rich, deliberate "clonk-ka lrrrrrr," interlarded with the clear piping whistles of some of the flock, make a concert of bird-notes very dear to all who are familiar with it. In their scarlet and black velvet dresses these birds are impossible to mistake, whether seen chasing over the marshes, singing from an elm-top, or balancing with spread tail upon some tall reed stalk.

* * *

There is a bird-note so often and so justly mistaken for that of the phœbe that the error certainly merits correction. The spring song of the chick-a-dee (which may be heard on almost any warm day all winter, and is very easy to call forth by even a poorly whistled imitation) is a clear, pure "eee — eee" or "—— — —" which really says "Phœbe" much more plainly than the true phœbe note, this latter being much lower in tone, and only to be heard after March is well on, and almost always in the vicinity of running streams and brooklets; while the gay little chick-a-dee whistles at any time or place that suits his versatile fancy.

* * *

73.—*Meadow larks.*

The mellow flute notes of the meadow lark (Fig. 73) float to us from the middle of some large, open field, and are among the most beautiful bits of bird music we ever hear. They are not to be represented by notes, and can only be most inadequately described. There is great variation in the sequence of notes, but all are beautifully clear and ringing, and have a decided tinge of what would be sadness if it were not so sweet. The bird flies in a very characteristic manner, never raising the wings above the plane of the back, and when seen below the horizon line always shows the white feathers in the tail. His saffron breast and black breastmark seldom show on the living birds, and the mottled brown back is a wonderful safeguard against his many overhead enemies.

* * *

Two or more doves may be seen winging their headlong flight through the air. These are among the swiftest of birds, and are generally out of eyeshot almost before you have seen them. (That is one way of knowing what they were.) In flight, they look like small pigeons with very long graduated tails, and when, in some old orchard or open wood you see one rise from the ground into a tree, the white lateral feathers in the tail make an easily recognizable mark. (Fig. 74.) Their cooing notes are well known—a high pitched "overtone" followed by several long bell-toned "ooooo,— ooooo," notes.

74.—*Mourning doves.*

* * *

About April 1 to 10, you may hear a scratching in the dead leaves among the underbrush in any thickly grown tangle, and upon cautiously coming up, you may discover the authors—not big grouse as you may have supposed, but a flock of fine vigorous fox-sparrows, on their way to their northern breeding grounds. They are bright bay fellows, with boldly blotched brown and white breasts, diligently scattering the leaves for their food of seeds, spiders, ants and other insects. If you have been fortunate enough not to have been seen you may hear their song, which is one of the finest of our sparrow songs, readily recognizable as such, though not resembling any of its fellows—a clear vigorous carol, often ending abruptly with a rather unmusical "clip." If however, they have seen you, you will be treated to a sharp "tseep!" and a rear view of a flock of rapidly retreating birds, for they are not sociable (with us, at least) and generally take a hint to move on before you know of their presence. They do not stay long with us on their migration, and seeing them one day is no indication that you can find them the next.

* * *

Although the white-throated sparrows spend the winter in our southern counties, they do not start their northward journey as early as we might expect, and it is not until the first part of April that we may be sure of finding them. I have one list, indeed, that shows their first appearance on May first!

They are to be found in similar places to those which the fox-sparrows choose, and are very similar to them in habits, but the boldly striped head and gray breast are very distinctive marks. Almost all of our native sparrows have a call note, the "tseep" note, which is hard to distinguish in the different species without much patient listening—and I doubt if any person is infallible in this distinction. The white-throat has this note, as well as the song-sparrow, tree-sparrow, (a winter bird) fox-sparrow, white-crown, chippy, field-sparrow grass-finch, in fact all our brown-backed sparrows. But the song of the white-throat is his own, and may be heard frequently during his very leisurely journey through our state. His Canadian name, "Peabody bird" is descriptive of his notes, "—— — - -, — - -, — - -." When a number get together and whistle, as if they were singing a round, it makes a very sweet concert.

75.—*White-throated sparrow.*

* * *

One of the foremost birds in the spring movement is the grass-finch (vesper-sparrow or bay-winged bunting). It is to be found in open fields and along roadside fences, in company with meadow larks, and its sweet song may be heard almost any warm evening after the middle of April. Unlike most of our birds, this sparrow sings at its best late in the afternoon and during twilight, which perhaps makes its song seem the sweeter. It is rather a gentle song, though to be heard at some distance, carrying quite as far as that of the song-sparrow. Although the quality of voice is somewhat similar in these two birds, the grass-finch lacks the merry abandon that characterizes the song-sparrow's song, but has instead a deeper chord, which is called by some people sadness. The bird may be easily recognized in the fields by the white tail-feathers, which always show in flight. It is about the size and general color of the song-sparrow.

*   *   *

By the time the foregoing birds are comparatively common, and the maple buds are burst and the lilacs swelling, the gay purple finch appears. He is not purple at all, but has a crimson head, which fades on the lower breast through rosy pink into pure white. He is fond of spruces and larches, feeding greedily on the tender buds as well as on the ants and scale insects that infest them. His song is a fine one, and in addition to the charm of being poured forth in full flight, is so long and intricate that one finds himself holding his breath as the burst of melody continues, as if to help the little fellow catch up with his music.

*   *   *

Along the banks of some lake or stream, sitting idly on a telegraph pole or wire, rising and settling, elevating and depressing his long parted top-knot, a patriarchal old kingfisher may be seen silently awaiting the gleam of a shiner in the water below (Fig. 76). Or perhaps you may first see him flying like a big woodpecker, screaming his chattering cry high in the air, or scaling periously close to the water under the fringing hemlock branches that overhang the stream. His large size, slate-blue back, loud notes and characteristic flight make him a hard bird to mistake in any case.

76.—*Kingfisher.*

*   *   *

There are many other birds which pass us on their way north, but they rather herald the summer than the breaking of spring. The following list of spring migrations is taken from Mr. Chapman's "Handbook of the Birds of Eastern North

America," and was compiled for use about New York City. The dates nearly coincide with those I have found about the central part of the state, and are, in the main, only a few days in advance of those for the northern countries. The latter dates in the column are about what may be taken for the middle tier of counties.

It is the earnest hope of the writer that these few very brief sketches may be of use to those interested in entering the delightful field of the study of birds; your experience may and probably will be different from that which I have cited, which only goes to show that everyone must really see for himself, and not only that, but by so doing may make new observations and get new ideas on practically all of even our best known birds. Birds are not, as a rule, hard to watch, and the patience it requires to sit still and "be a stump" long enough for birds to cease noticing you is soon and amply repaid by the new insight into an unknown realm which is sure to follow.

LIST OF BIRDS COMPRISING THE SPRING MIGRATION.

(Until April 20—Approximate.)

(*Taken from Chapman's Handbook of Birds of Eastern North America.*)

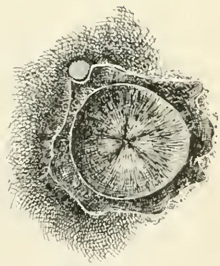
Date of arrival.		Date of arrival.	
Feb. 15–Mar. 10.	Purple Grackle	April 1–10.	Vesper-sparrow
	Rusty Grackle		Savanna-sparrow
	Red-winged Blackbird		Chipping-sparrow
	Robin		Tree Swallow
	Bluebird		Myrtle Warbler
Mar. 10–20.	Woodcock		American Pipit
	Phœbe		Hermit Thrush
	Meadow Lark	April 10–20.	Yellow-bellied Woodpecker
	Cowbird		Barn Swallow
	Fox-sparrow		Yellow Palm Warbler
Mar. 20–31.	Wilson's Snipe		Pine Warbler
	Kingfisher		Louisiana Water Thrush
	Mourning Dove		Ruby-crowned Kinglet.
	Swamp-sparrow		
	Field-sparrow		
April 1–10.	Great Blue Heron		
	Purple Finch		

III. The Opening of a Cocoon. (*Mary Rogers Miller.*)

AMONG the commonest treasures brought into the school by children in the fall or winter are the cocoons of our giant silk worms. If one has a place to put them where the air is not too warm or dry, no special care will be necessary to keep them through the winter. Out-door conditions must be imitated as nearly as possible. If early in the fall one is fortunate enough to meet one of these giants out for a walk, it is the simplest thing in the world to capture him and watch him spin his marvellous winter blanket. Two members of this family of giant insects are quite commonin this state: the largest, the Cecropia, called sometimes the Emperor, and the Promethea.

77.—*Cocoon of the Cecropia moth. It sometimes hangs from a twig of some fruit tree.*

The Cecropia moth often measures five or six inches across—a veritable giant. Its main color is dusty brown, with spots and bands of cinnamon brown and white. On each wing is a white crescent bordered with red and outlined with a black line. The body is heavy and covered with thick, reddish-brown hairs crossed near the end with black and white lines. On its small head are two large feathery feelers or antennæ. The Cecropia moth emerges from the cocoon, full grown, in early summer when out of doors. Those kept in the house often come out as early as March. The eggs are deposited by the adults upon apple, pear, cherry, maple and other shade and fruit trees. Professor Comstock says that the spiny caterpillars which hatch from the eggs in about two weeks, are known to feed upon the leaves of some fifty species of plants. One could therefore hardly make a mistake in offering refreshment to these creatures, since they are anything but epicures. The full-grown caterpillar, having spent the summer eating and growing, with now and then a change of clothes, is often three inches long and an inch in diameter. It is a dull bluish-green in color. On its back are two rows of wart-like protuberanceser (tubcles), some yellow, some red, some blue. As there is nothing else in nature which is just like it, one need have no difficulty in recognizing the Cecropia in its different phases.



78. — *End of cocoon of Cecropia, inside view, showing where the moth gets out.*

The cocoon which this giant silk worm weaves is shown in Fig. 77. It may be found on a twig in some tree in the dooryard, but sometimes on a fence-post or equally unexpected place. Inside the cocoon the brown pupa, alive but helpless, waits for spring.

After the moth comes out, it is interesting to examine the structure of the cocoon, and to discover how the moth managed to free itself without destroying the silken blanket (see Fig. 78).

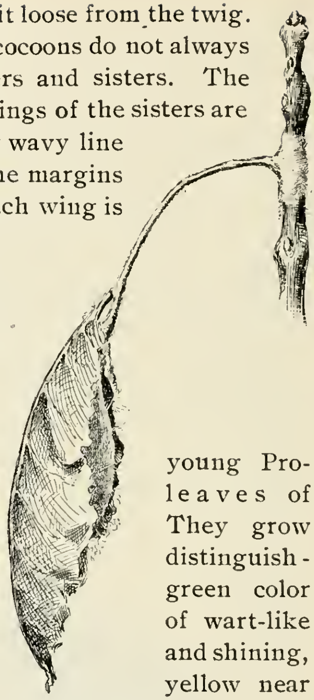
* * *

Swinging loosely from last summer's twigs in lilac bushes, and on such trees as wild cherry and ash, one often finds the slender cocoons of the Promethea moth (Fig. 78). We cannot help admiring the skill and care displayed by the spinner of this tidy winter overcoat. The giant silk worm which spun it chose a leaf as a foundation. He took care to secure himself against the danger of falling, by fastening the leaf to the twig which bore it by means of shining strands of silk. It is easy to test the strength of this fastening by attempting to pull it loose from the twig.

The moths which come from these cocoons do not always look alike, but they are all brothers and sisters. The brothers are almost black, while the wings of the sisters are light reddish brown, with a light grey wavy line crossing the middle of both wings. The margins of the wings are clay-colored. On each wing is a dark velvety spot. The adults emerge in spring and are most often seen in the late afternoon. Their flight is more spirited than that of the Cecropia, which moves very sedately as becomes a giant.

* * *

The caterpillars of this species, the young Promethea, feed during the summer on leaves of wild cherry, ash and other trees. They grow to be about two inches long, and are distinguished from others by their pale bluish green color and yellow legs. They also have rows of wart-like elevations on their backs, some black and shining, four of a bright red and one large and yellow near the hindmost end.



79.—*Cocoon of Promethea-moth fastened to a twig with silk.*

* * *

80.—*Cocoon of Promethea, cut open lengthwise to show the valve-like device at upper end, through which the adult moth pushes its way out.*

The life of these giant insects is divided into four distinct stages: the egg, deposited by the adult moth usually on or near the food plant; the larva, or caterpillar stage, when most of the eating and all the growing is done; the pupa, passed inside the cocoon woven by the larva; and the adult, a winged moth.

The life cycle or generation is one year, the winter being passed in the pupa stage. The insect lives but a short time in the adult stage and the egg stage is but two or three weeks. Most of the summer is devoted to the caterpillar phase of its life.

These creatures are entirely harmless. They seldom appear in numbers sufficient to make them of economic importance.

NOTES.

Have you done anything towards establishing a school garden? If you know of any interesting efforts in that direction, we should be glad if you would let us know about them. Do you know of any school premises which have been planted and ornamented? If you are interested in garden-making by children, our Leaflet No. 4 ("A Children's Garden"), is at your disposal. Our Bulletin 160 will give you suggestions for the planting of the school ground.

* * *

We wish to inaugurate a movement for flower-shows and other nature-study exhibitions in schools and churches. If you have had experience, please give us suggestions.

* * *

Good subjects for spring work are: The Soil (Leaflet No. 15); toads (No. 9); tent-makers (No. 5); apple twigs (No. 3), particularly in connection with the present Leaflet; showers (No. 14); birds (No. 10).

* * *

Persons frequently ask if we believe in teaching sentiment in nature-study. We disapprove of sentiment and poetic interpretations when they give the wrong point of view, and when they substitute mere emotion for patient inquiry. Sentiment should be incidental in any interpretation of nature. Yet we have a right to the poetic interpretation. Scientists are likely to go so far as to forbid the use of figures of speech and of parables: this is unfortunate. A metaphor or parable may be of distinct value when it teaches a true lesson or drives home a point, even though it is not literally true. One is justified in saying, to some audiences, that a potato puts up a lunch for future use. Everybody knows that the statement is a metaphor. He knows that a potato has no brains. The statement does not mislead. If one cannot say that much about a potato, it is not allowable to say that it has eyes. One can scarcely speak a sentence without saying things which are not literally true under all conditions. Even astronomers say that the sun sets. Persons who insist that every statement about nature must be literally true, take the life and spirit out of writing and conversation. They might say that Bryant's lyric, "Robert of Lincoln," is untrue: the bird is not "drest" since he has no clothes; he has no "Quaker wife" since he is mated, not wed. Yet there is more real bob-o-link in Bryant's poem than in the formal descriptions of the bird.

Yet, we wish to protest against that teaching of nature which is mere sentimentalism, which makes the "goody-goody" part of the work so prominent that it becomes the child's point of view. Interest in things themselves should be the primary motive: sentiment comes chiefly as a result. But if there is danger of making sentiment too prominent, there may be equal danger in insisting on a perfunctory scientific point of view.

* * *

The publications of the Cornell Bureau of Nature-Study and Farmer's Reading-Course are four: Nature-Study Quarterly, for teachers; Home Nature-Study Lesson, for teachers; Junior Naturalist Monthly, for children; Farmer's Reading-Lessons (with quizzes), for farmers. Aside from these, the College of Agriculture publishes the regular Experiment Station Bulletins. With so many publications, it is desirable to keep the mailing lists as small as possible and yet serve those persons who earnestly desire them. The lists are revised, in order to eliminate "dead" names. The lists as they now stand are "live" lists. They are approximately as follows (March 9, 1900):

Teacher's leaflets	26,000	names
Teacher's home lessons	2,000	"
Junior naturalists	30,000	"
Farmer's Reading-Course	17,000	"
Bulletins	20,000	"
	95,000	names

The incidental personal requests for the publications considerably increase this constituency.

L. H. Bailey, Chief,
John W. Spencer, Deputy Chief,
Of Bureau of Nature-Study and Farmers' Reading-Course.

June, 1900.

CORNELL NATURE-STUDY QUARTERLY

No. 5.

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* Absent on leave.

A BROOK.

A BROOK is the best of subjects for nature-study. It is near and dear to every child. It is a world in itself. It is an epitome of the nature in which we live. In miniature, it illustrates the forces which have shaped much of the earth's surface. Day by day and century by century it carries its burden of earth-waste and lays it down in the quiet places. Always beginning and never ceasing, it does its work as slowly and as quietly as the drifting of the years. It is a scene of life and activity. It reflects the sky. It is kissed by the sun. It is caressed by the wind. The minnows play in the pools. The soft weeds grow in the shallows. The grass and the dandelions lie on its sunny banks. The moss and fern are sheltered in the nooks. It comes one knows not whence: it flows one knows not whither. It awakens the desire of exploration. It is a realm of mysteries. It typifies the flood of life. It goes "on forever."

In many ways can the brook be made an adjunct of the school-room. One teacher or one grade may study its physiography; another its birds; another may plat it. Or one teacher and one grade may devote a month or a term to one phase of it. Thus the brook may be made the center of a life-theme.

L. H. B.

I. A Brook and Its Work. (*J. O. Martin.*)

ON a rainy day most of us are driven indoors and thus we miss some of nature's most instructive lessons, for in sunshine or rain the great mother toils on, doing some of her hardest labor when her face is overcast with clouds. Let us find our waterproofs, raise our umbrellas, bid defiance to the pattering rain and go forth to learn some of the lessons of a rainy day.

81.—*The brook may be made the center of a life-theme.*

Along the roadside the steady down-pouring rain collects into pools and rills, or sinks out of sight in the ground. The tiny streams search out the easiest grade and run down the road, digging little gullies as they go. Soon these rills meet and, joining their muddy currents, flow on with greater speed down the hillside until they reach the bottom of the valley and go to swell the brook which flows on in sunshine or rain. The water which sinks into the ground passes out of our sight for a time, but its journey is also downward toward the brook, though the soil, acting as a great sponge, holds it back and makes it take a slower pace than the rushing surface water. This slower-moving underground water percolates through the soil until it comes to a layer of rock, clay, or other impervious substance along the slope of which it flows until it is turned again to the surface in the form of a spring. Perhaps this spring is one of those clear cold pools with the water bubbling up through its sandy bottom from which we love to drink on a hot summer's day ; or again it is a swampy spot on the hillside where the cat-tails grow. In whatever form it issues from the ground, a tiny rill carries away its overflow and this sooner or later joins the brook.

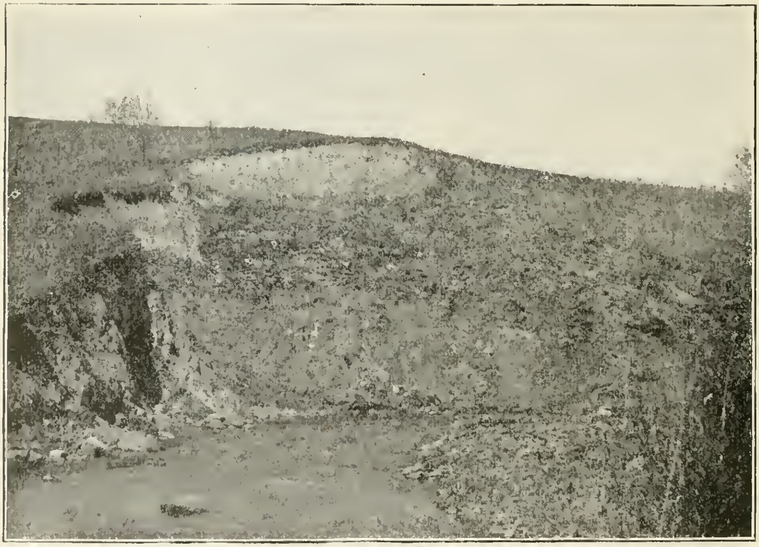
The brook we see is simply the collected rainfall from the hillsides flowing away to join the river. It grows larger as other brooks join it and becomes a creek and finally a river. But where is the dividing line between brook, creek and river? So gradually does the brook increase in volume that it would be difficult to draw any dividing line between it and the larger streams. And so with the rills that formed the brook : each is a part of the river, and the names rill, brook, creek and river are merely relative terms. If we go to other states, we should find that in different parts of the country brooks vary much in size.

Brooks are but small-scale rivers ; and if we study the work that a brook is doing we shall find it engaged in cutting down or building up just as the river does, although, owing to the smaller size of the brook, we can see most of these operations in a short distance. Let us take our way through the wet grass and dripping trees to the brookside and see what work it is doing.

The countless rain-born rills are pouring their muddy water into the brook and to-day its volume is much greater than when it is fed by the slower-moving underground water of the springs, as it is in fair weather. It roars along with its waters no longer clear but full of clay and sand ("mud" as we call it).

If we should dip up a glassful of this muddy water we should find that when it had settled, there remained on the bottom of the glass a thin deposit of sediment. The amount of this sediment is small, no doubt, for a single glassful, but when we think of the great quantity of water constantly flowing by we can see that considerable sediment is going along with it. But this sediment in suspension is not all the load that the brook is moving. If you will roll up your sleeve, plunge your hand to the bottom of the brook and hold it there quietly, you will feel the coarser gravel and small stones rolling along the bottom.

All this load of sand and gravel comes, as we have seen, from the valley sides, the banks of the brooks and from its bed. It is moving downward away from its original resting place ; and what has been the result? For thousands upon thousands of years our brook may have been carrying off its yearly load of sediment,



82.—*A brook cutting under its bank and causing a land-slide.*

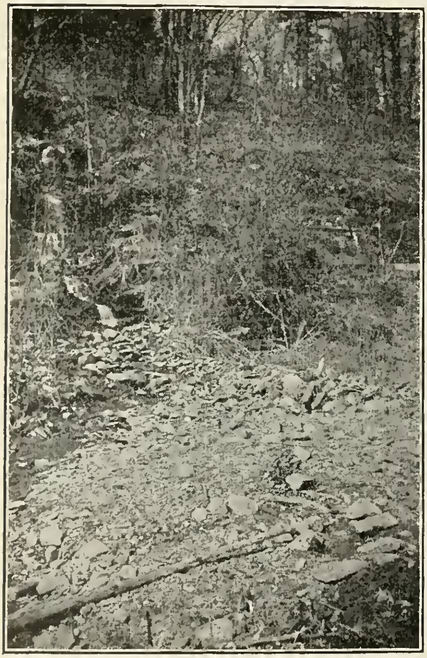
and though each day's labor is small, yet the added toil of centuries must have been great. The result of this labor we can see in the great trough or valley through which the brook flows. Tennyson speaks of the ceaseless toil of the brook in the following words :

"I chatter, chatter, as I flow
To join the brimming river,
For men may come and men may go,
But I go on forever."

We have seen how the rills and torrents bring into the brook their loads of sand, clay and gravel ; let us walk along the bank and see what the brook is doing to increase this load. Just here there is a sudden turn in the channel and so sharp is the curve that the rushing stream is not able to keep in mid-channel but throws itself furiously against the outer bank of the curve, eating into the clay of which it is composed, until it is undermined, allowing a great mass of clay to slide down into the stream bed where it is eaten up and carried away by the rushing water (Fig. 82). Farther on, the brook dashes down a steep, rocky incline and if we listen and watch we may hear the thud of boulders hurled along or even see a pebble bound out of the muddy foaming water. These moving pebbles strike against each other and grind along the bottom, wearing themselves out as well as the large unmovable boulders or the rocky bed of the brook. Thus the larger stones are ground down, rounded at first but in time reduced to sand, adding in this way to the moving burden of the brook. By this slow process of cutting and grinding the deep rock gorges of New York state, like those at Watkins, Ithaca, Au Sable Chasm and even the mighty gorge of Niagara, have been made. The Grand Canyon of the Colorado, over a mile in depth, is one of the greatest examples of stream cutting to be found in the world.

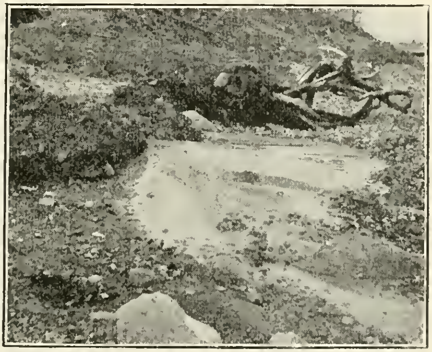
Now the brook leads us into a dripping woodland and just ahead we can hear the roar of a little waterfall, for at this point the cutting stream has uncovered and flows upon the bed rock with its alternating bands of hard and soft rock through which the busy brook is cutting a minature gorge. Here is a hard layer which the stream has undermined until it stands out as a shelf and over which the water leaps and falls in one mass with a drop of nearly ten feet. Watch how the water below boils and eddies; think with what force it is hammering its stony cutting tools upon the rocky floor. Surely here is a place where the brook is cutting fast. Notice that swirling eddy where the water is whirling about with the speed of a spinning top; let us remember this eddy and when the water is lower we will try to see what is happening at its bottom.

On the other side of the woods our brook emerges into a broad meadow; let us follow it and see what becomes of its load, whether it is carried always on or whether the tired brook lays it down occasionally to rest. Out of the woods the brook dashes down a steep incline until the foaming tide comes to rest in a deep pool. What becomes of the large pebbles which have been swept down? Do they go on or do they stop? If you go to the outlet of the pool you will see that the water is coming out with nothing in its grasp but the fine clay and sand, the gravel and pebbles having been dropped by the less rapid current of the pool. This is one of the most important of the brook's lessons, for anything that tends to check the current makes it drop some of the sediment that it carries (Fig. 83). Yonder is an old tree stump with its crooked roots caught fast on the bottom; the mid-stream current rushes against it only to be thrown back in a boiling eddy and the waters split in twain and flow by on either side with their current somewhat checked. In the rear of the stump is a region of quiet water where the brook is building up a pile of gravel. Farther on, the banks of the brook are low and here the waters no longer remain in the channel, but overflow the low land spreading out on either side in a broad sheet. The increased friction of this larger area reduces the current and again we see the brook laying down some of its load. The sand and gravel deposited here is spread out in a flat plain called a *flood plain* because it is built up when the stream is in flood. It is on the large flood plains of rivers that many of our richest farm lands occur. These receive a fresh coating of soil mixed



83.—*A pile of brook debris deposited by the checking of the current* with fragments of vegetable matter each spring when the stream is in flood, and thus grow deeper and richer year by year. The flood plains of the Mississippi and the Nile are notable examples of this important form of stream deposit.

And now let us make one more rainy day observation before going back to our warm, dry homes. Just ahead on the other side of that clump of alders and willows lies the pond into which the brook flows and where its current is so checked that it gives up almost all of its burden of sediment. Close to the shore it has dropped its heaviest fragments while the sand and clay have been carried farther out, each to be dropped in its turn, carefully assorted as to size and weight. Here you can see that the stream has partly filled this end of the pond and is now sending its divided current out over the deposit which it has made in a series of branching rivulets. This deposit is called a *delta* (Fig. 84) and deltas are another important form of stream deposits. In the lakes and ponds deltas may grow outward until the lake is filled when the stream will meander across the level plain without much current and hence without much cutting power (Fig. 85). In the sea great deltas are being formed in some places, like those at the mouths of the Mississippi, the Nile and the Ganges. Large areas of dry land have thus been built. Deltas, like flood plains, afford rich farming lands when they are built high enough to remain above the water.

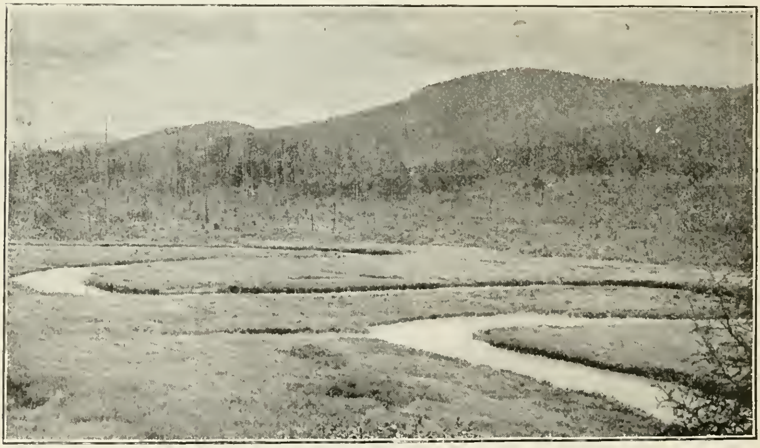


84.—*A delta built by a tiny rill flowing from a steep clay bank.*

Here let us end our study of the brook for to-day, and wait until the rain ceases and the water runs clear again ; then we can see the bottom and can also learn by contrast how much more work the brook has been doing to day than it does when the volume of water is less.

On the road home, however, we can notice how the temporary streams have been cutting and depositing, as well as the ever-flowing brook. See where this tiny rill has run down that steep clay bank until its current was checked at the foot. Notice how it has spread out its sediment in a fan-shaped deposit. This form of deposit is sometimes made by larger streams, especially in a mountainous country with plains at the foot of the slopes. They are called *alluvial fans* or *cone deltas* (Fig. 86), but they are not as important as flood plains and deltas.

The next dry, sunny morning that comes let us visit the brook again : it no longer roars, but its clear waters now sing a pleasant melody as they ripple along the stony bed. We can see at a glance that comparatively little work is going on to-day, and



85.—*A brook flowing across a pond which has been filled.*

yet, if we look closely, we shall see glittering particles of sand moving along the bottom. The clear water, however, allows us to study the bottom which before was hidden by the load of mud.

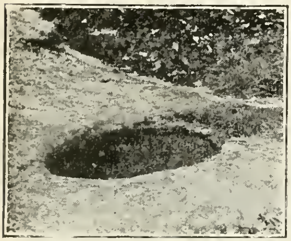
First we see the rounded boulders and pebbles of all sizes which must have been rolled about for a long time to make them so smooth. Some of them are so very hard that we cannot even scratch them with our knives; others are soft and easily broken. What would be the effect of rolling together stones of such varying hardness? We must think of these stones as the brook's tools with which it cuts and grinds, for water without sediment can do little more than slightly to dissolve the rock.

Let us go at once to the little waterfall, for we shall be curious to see what lies at the bottom of the whirling eddy that drew our attention yesterday. As we look down into the sunlit pool we see that the eddy is gone for the volume of water is not great enough to cause it to revolve, but there in the rock on the bottom is a deep basin-like hole. In the bottom of this hole we shall see a number of well rounded stones with perhaps some sand

86.—*A brook building a delta into a lake. Formerly the brook flowed straight ahead, but its own delta has caused it to change its direction.*

and gravel. These stones are the tools which, whirled about by the eddying water, have cut the basin-like holes. Holes of this sort are common in rocky stream beds, especially in the neighborhood of falls or in places where falls have once been; they are called *pot-holes* and represent another form of stream cutting. (Fig. 87.)

Next let us visit the flood plains which we saw forming when the water was high. Now we shall find the brook flowing in its channel with the flood plain deposits left high and dry. If we dig down into the flood plain we shall see that it is made up of successive layers varying in thickness and in the size of the fragments. Each of these layers represents a period of high water and the size of the fragments in the layer tells us something of the strength of the current, and therefore of the intensity of the flood. Some layers are thicker than others, showing a longer period of flood or perhaps several floods in which there was little variation. This *stratification*, as it is called, is one of the peculiarities of water deposits and it is due to the assorting power of currents which vary in force. If we were to cut into the delta we should find the same thing to be true—a regular succession of layers though sometimes confused by changes in direction of flow.



87.—*A pot-hole cut in the rock of a stream's bed.*

To-day we shall notice something which escaped our attention when it was held by the rushing torrent—the valley bottom is much wider than the bed of the stream; if we keep our eyes open we shall see the explanation of this in the abandoned channels, where, owing to some temporary obstructions, the stream has been turned from side to side of the valley, now cutting on one bank and now on the other. In this turning from side to side the cutting area of the stream is increased and it goes on widening its valley as well as cutting it downward.

And now we have learned some of the most important ways in which the busy brook is toiling; but there are other points which we might have seen, and in some brooks there are special features to be noted. However, we have learned that the brook is no idler, that its main purpose is to conduct to the ocean the rain that falls upon the earth's surface, and that in doing this it is wearing down the hills, carrying them away only to build up in other deposits. The cheerful song of the brook takes on a new meaning as we lie in the shade and watch it hurry by. It is not the song of idleness nor pleasure, but the song with which a cheerful and tireless worker seeks to make its task lighter.

II. Insect Life of a Brook. (*Mary Rogers Miller.*)

WHAT wader, be he boy or water-fowl, has not watched the water insects? How they dart hither and thither, some skimming the surface, others sturdily rowing about in the clear shallows! The sunlight fastens for an instant their grotesque reflections on the smooth bottom, then away—the shadow is lost, save for the picture it left in the memory of the onlooker.

The splashing, dashing wader, with his shout and his all-disturbing stick, stands but a poor chance of making intimate acquaintances among water-folk. Your true brook-lover is a silent individual except when occasion demands action. The lad in the title-page picture has the right spirit. From the vantage ground of a fallen log or overhanging bank he looks down on the housekeeping affairs of his tiny neighbors, nor do they seem offended. Indeed, I doubt if they are aware of his presence or curiosity.

Time was when the enjoyment of brook life was limited to boys. White aprons, dainty slippers and fear of being called "Tom-boy" restrained the natural impulses of the "little women." Happily that day is past, and it no longer looks queer for girls to live in the open air and sunshine, free to chase butterflies and hunt water-bugs with their brothers.

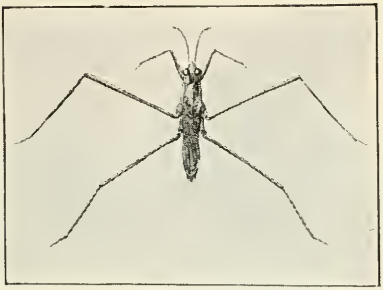
My brooks abound in swift eddies, perfect whirlpools in miniature, and water-falls of assorted sizes. They have also their quiet reaches, where whirligig beetles perform their marvelous gyrations, and bright eyed polliwogs twirl their tails in early May. On the banks are ferns and mosses, and sometimes willows and alders form a fringing border.

The heart-leaved willows along many brooksides are found to bear knob-like bodies at the tips of many of their branches, which look like pine cones. (See Fig. 88.) Now everybody knows that willows bear their seeds in catkins. Why then should so many brookside willows thrust these cones in our faces? On cutting one of the cones open one will learn the secret. A tiny, colorless grub rolls helplessly out of a cell in the very centre of the cone. It is the young of a small gnat, scarcely larger than a mosquito, and known as a "gall gnat." The cone-shaped body on the willow branch is called a "pine-cone willow-gall." The little gray gnat comes out in the spring. Any one can collect the galls from the willows and keep them in some kind of cage in the house until the gnats come forth.

88.—*Knob-like bodies, resembling pine cones.*

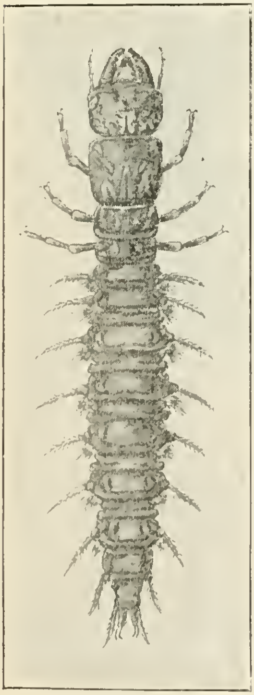
The pine-cone gall is an enlarged and deformed bud. The twig might have developed into a branch but for the presence of the little larva. The scales of the cone are the parts which would have made leaves under more favorable conditions. The brook-lover can not afford to miss the pine-cone willow-galls.

Wandering along the brookside in spring or early summer, one is surprised to find so many insect visitors darting about in the air. There are dragon-flies of all shapes, sizes and colors; dainty damsel-flies perch airily on reeds, their gleaming wings a flutter in the sunshine; sometimes a nervous mud-wasp alights for a moment and then up and away. The dragon flies seem intent on coming as near to the water as possible without wetting their wings. They pay no heed to other visitors, yet how easily they escape the net of the would-be collector! Let them alone. Their business is important if we would have a new generation of dragon-flies to delight the eye next year. The eggs of these creatures are left in the water and the young ones are aquatic. If you would know more of them, dip down into the stream in some sluggish bay. Dip deep and trail the net among the water plants. Besides dragon-fly nymphs there will be caddice-worm cases like tiny cob-houses, water-boatmen, back-swimmers, and giant water-bugs.* These are insects characteristic of still or sluggish water, and are found in spring and summer.



89.—*Water-striders have long, thin legs.*

The insects which skip lightly over the surface of the water where the current is not too strong, are water-striders. (See Fig. 89.) Some are short and stout, others slender-bodied; but all have long, thin legs. Their color is nearly black. As they scurry about in the sunshine the delighted watcher will sometimes catch a glimpse of their reflections on the bottom. Six oval bits of shadow, outlined by rims of light; there is nothing else like it! Be sure you see it.

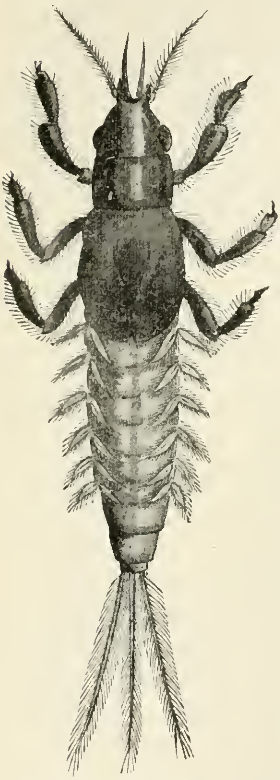


90.—*The Dobson makes no pretensions to beauty (natural size).*

Let us leave the quiet, restful pools and the sluggish bays and follow the hurrying water to the rapids. Every stone changes the course of the current and the babble makes glad the heart of the wayfarer. Let us "leave no stone unturned" until we have routed from his favorite haunt that genius of the rapids, the Dobson. (See Fig. 90.) These creatures bear other common names and are prized by fishermen in the black bass season. Dirty brown in color and frankly ugly in appearance and disposition, these larvæ, for such they are, have little to fear from the casual visitor at the water's edge. When a stone is lifted the Dobsons beneath it allow themselves to be hurried

* These and other forms found in still or slow flowing water are described and pictured in Leaflet No. 11, Life in an Aquarium.

along for some distance by the current. The danger over, they "catch hold" and await their prey farther down stream. In spite of their vicious looking jaws these insects are not venomous. At the very worst they could do no more than pinch the finger of the unwary explorer.



91.—*May-fly nymph, three times natural size.*

When the Dobson is full grown, it is called a Hellgrammite fly or horned Corydalis. It has lost none of its ugliness, though it has gained two pairs of thin brownish gray wings, and flies about in the evening. It has been known to create some consternation by flying in at an open window. It is harmless and short-lived in the adult stage.

Upturned stones are likely to bring to view other strangers. Lying close against their wet surfaces one usually finds young May-flies. (See Fig. 91.)* These, like the young dragon-flies, are called *nymphs*.

When they are ready to leave the water they make their way to the shore and clinging to some convenient tree trunk or building they shed their nymph skins. I have seen trees and buildings on the banks of the St. Lawrence River literally covered with these cast skins. In the early morning in June and July one can watch the molting process, the unfolding of the gauzy wings and the unsheathing of the long filaments. (See Fig. 92.)

Do not believe that May-flies are harmful. They are sometimes too numerous for comfort at summer resorts where myriads of them swarm about the lights. But stories of their

* Figures 91, 92 and 93 are adapted from Dr. R. Leuckart's Zoological charts.

stinging and biting are entirely without foundation. They are short-lived in the adult stage. The name of the family to which they belong, *Ephemeridæ*, suggests their ephemeral existence. It is of these that poets have sung.

92.—*The May-fly sheds its nymph skin.* (*Twice natural size.*)

Stone-fly nymphs also cling closely to the flat stones. The cast skins of these are frequently found on the banks of streams. They resemble the May-fly nymphs but can be identified by comparing with these illustrations. (See Fig. 93.)

Sometimes on the very brink of a cataract one will see what appears like patches of loose black moss. Strangely enough, these are the larvæ of black flies, related to the terrible "Punkies" of the north woods. The black fly larvæ can live only in the swiftest water. There they pass through their transformations and succeed in emerging into their aërial stage, in spite of the rushing current.

93.—*Stone fly, showing one pair of wings. The lower figure is a nymph. (Twice natural size.)*

All these things and many more they see who frequent the water brooks. They cannot tell all they see, for some things are too deep for words. They can and do say to one and all "Come let us visit the brook together. The water and all that dwell in it and roundabout invite us and make us welcome."

NOTES FROM THE CLUBS.

OUR observations of a large number of Junior Naturalist clubs have clearly shown us that best results come when the teacher gives inspiration and guidance without dictating, and leaves the members of the club to feel that the organization is all theirs. The pride of proprietorship and the feeling of the members that they are doing the same work in the same manner as is done by their elders, is a strong factor in keeping up an interest.

* * *

A principal of one of the schools has asked us to publish a leaflet on parliamentary practice, a suggestion which we have under serious consideration. He has made much of the meetings of the clubs and has conducted them on a basis of civics and adroitly let the club proceedings drift into parliamentary and legislative usages, whenever nature-study subjects are under consideration. He speaks with much spirit of the interest awakened in a certain class of boys in his school in the election of club officers. These pupils are not distinguished for love of study, being emphatically boys of the street. They are lads in whom was born a spirit of leadership of a certain kind, and the club meeting is an occasion when it comes out in full force. To the boys' credit, be it said, their purpose was the election of the best members, as judged by their standard. Many situations come up in which proper parliamentary ruling is beyond the knowledge of the teacher and therefore he suggested that we issue a leaflet giving aid in that direction.

* * *

Many teachers in whom the taste for good literature is strong, open the club meetings with a roll call in response to which each member gives a quotation appropriate to the lesson of the month.

* * *

The correlation of nature-study with language and also with drawing, seems to be popular. In language it gives a definite and concrete topic and one of interest to the child. From our point of view, it is more important that we have the child's thoughts than his scholarship. We desire more the expression of what was seen and what such observation meant than to have mere correct English. Each teacher has his own standards and is best able to judge of the requirements, and we therefore never insist that our view-point be made that of the teacher. Drawing is a valuable correlation. We have received much in this line, with which we are greatly pleased. A considerable amount of our best examples have been sent to foreign countries where the fame of our Junior Naturalists has gone, and we have shown our pride in them by sending samples of their work.

* * *

The suggestion for the payment of monthly club dues in the form of compositions and drawings made during the respective periods in the regular school work, has been fulfilled to a degree gratifying to us.

* * *

The large increase of membership has made the correspondence very great indeed, making an increased clerical force necessary, but we have so far succeeded in examining each paper sent and giving the author proper credit. We keep a personal account with every Junior Naturalist. We believe that the movement cannot succeed permanently if our work ends with the organization of clubs.

* * *

This issue of the Quarterly closes its publication for the present school year. The brook is a good vacation subject. Start the children in the study of it before the school closes; then ask them to continue to explore it during the summer and report their discoveries in the fall.

* * *

During our summer vacation we shall revise the mailing list for our Nature-Study Quarterly. If, since receiving the April number, you have not requested that your name be retained on our mailing list, you would better attend to it at once. We shall be pleased to have you remain with us, but if we hear nothing from you we shall conclude you no longer care for our publications. A postal card will be sufficient notice, and please attend to it at once. If you receive no September number, you will know the probable reason.

L. H. Bailey, Chief,
John W. Spencer, Deputy Chief,
Bureau of Nature-Study and Farmer's Reading Course,
Cornell University, Ithaca, N. Y.

CORNELL READING-COURSE FOR FARMERS.

READING-LESSON No. 7, DECEMBER, 1899.

By A. L. KNISELY.

Balanced Rations for Stock.

David and John lived on the outskirts of a village, but on opposite sides thereof. One Saturday morning there was an auction sale in town, and among the things sold were several fine milch cows, of no particular breed. David and John each bought two cows. These cows were "fresh;" that is, they had been giving milk for about one month. Each cow gave an average of twenty-five to thirty pounds of milk a day. Each man intended to buy feed for his cows and to sell his milk to the village people. These cows were to be used as machines with which to convert raw material, as grain and coarse fodder, into the manufactured product, milk. About three months later we heard that David had sold his two cows to John. He complained that they had steadily fallen off in milk since he had bought them, until each cow gave scarcely fourteen pounds a day. John's cows were still giving thirty pounds a day. Here was a difference of sixteen pounds, or over half, in three months. What was the reason?

It at once occurred to us that John must have given his cows better care than David. We went to each man and asked him how he had fed his cows. David said he had given each cow a small armfull of timothy hay and three or four quarts of corn meal, every morning and night. This would be about twenty pounds of hay and ten of meal each day. He did not think it was necessary to feed his cows any particular kinds of food in order to get the most milk from them. Anything the cows would eat was good enough, if only it filled up their stomachs and satisfied their hunger.

John said that he gave each of his cows a daily ration of about twenty pounds of clover hay, three pounds of wheat bran and six pounds of ground oats. He believed that a cow needs variety in what she eats, as well as a man ; and he tried always to give his cows an occasional relish of carrots, turnips, small potatoes, or even apple parings from the kitchen. "Of course," said John, "a cow can live and will give milk if kept on the same feed day after day; but I have always found that she is grateful for a little personal attention, and will pay for it with a larger yield of milk." David had been paying $6.00 a month for the food of each of his cows, actually more than the milk was selling for : John's ration cost him but $5.00 a month per cow, yet he was getting double the amount of milk which David did, and was making money. David was disappointed ; John was well pleased. But the chief reason for John's success was not because he gave his cows a greater variety of food than David, but because he fed them those foods which are well suited for the production of milk. David gave his cows a liberal allowance of hay and corn meal. These are both good foods for making fat but are not rich in those materials which a cow needs in order to increase her flow of milk. They are better for fattening steers than for feeding to milch cows. In other words, John had been feeding a balanced ration, and David an unbalanced ration. This leads us to inquire about some of the principles or reasons which underlie the feeding of animals.

1. *An animal is a living machine.*—There is always wear and tear on its various parts. As we shovel in coal at the furnace door to make the energy which will turn the great wheels of the shop, so is food taken into the body to supply energy and to repair the waste which comes from using the body. In the first place there must be enough of this food, or fuel, to do all the work ; and in the second place, it must contain that which is needed to build up those parts of the body which are breaking down.

2. *There are two purposes for which foods are required: to maintain or support the animal, or the maintenance ration ; and to lay up extra or reserve materials, or the productive ration.*—The maintenance ration is that which keeps up the bodily heat, and repairs the normal wastes. The productive ration stores up fat, supplies flow of milk, and the like. The profit in feeding comes in supplying more than a mere maintenance ration.

3. *An idle animal needs less food than one which is hard at work.*—A locomotive does not require nearly as much fuel to keep up steam when it is running "light," as when drawing a freight train on an up grade. The little driving mare which stands in your barn most of the time must have some food to renew the energy used up in breathing, pumping blood throughout its body and other wastes ; but the big team horse which has to pull the plow all day or sled logs out of the swamp must have much better fare.

4. *It is as much tax on a cow to give a big yield of milk as it is on a horse to do a big day's work.*—There are other ways of using up energy than by physical exertion. Probably each of John's cows spent as much energy in producing thirty pounds of milk a day as a big Percheron horse does in a heavy day's work before the plow. The food David gave his cows cost enough, and there was enough of it ; but is was not the right kind to repair the waste made in producing milk. Probably he did not know much about the philosophy of milk production. That is the reason why he failed.

The cows which John bought of David soon began to pick up under the new fare, and to give more milk. When David found his cows were not paying him, he ought not to have been above seeking advice from a more successful man, like John. Or if he had several cows and many kinds of feed-stuffs, he might have changed rations till he had hit upon some combination of foods which gave better results. But neither David nor any other farmer has time for much of such work. It must be done by the Experiment Station. The way we can best help the Davids of this State is to tell them what they should aim to supply in their animal rations, and the reasons for this selection. Then each man can pick out for himself the various materials which answer his needs, and which may be obtained to best advantage in his section.

5. *Many kinds of food are required.*—We can be sure of this by studying the composition of the animal body ; also by reflecting on the many kinds of work which an animal does. The body of an animal is made mostly of water, mineral matter, nitrogenous matter, and fat.

There is always much *water* in all parts of the body. Often one-half of an animal is water. Water itself becomes a part of all bone and flesh, but its chief use is to carry building material. When an animal eats, the food goes into the stomach and is there acted upon by different juices. The proper parts are then taken by the blood, which is mostly water, to every part of the body which needs repair. Water also helps to carry off the wastes, or worn out parts of the body.

The *mineral matter* in the body of an animal is found mostly in its bones. Flesh and muscle are so soft that they cannot stand hard use alone, and so they are placed on a bony framework. From two to five per cent of the animal body is mineral matter.

Nitrogenous matter is a term the chemist uses for all parts of the body which contain *nitrogen*. This is the same element you are feeding to your farm crops; for plants as well as animals must have nitrogen. Flesh, skin, muscle, hair, wool, horn, hoof, feathers, blood, lean meat, the white of an egg and the curd of milk all contain nitrogen. When you put horn and hoof waste or dried blood on your land they give up their nitrogen to the plants, and thus have a fertilizer value.

The *fat* of an animal varies with its age, the amount of work it has to do, and the food it gets. The leanest animal has seldom less than five per cent of fat, and the fattest not much above thirty per cent. Fat is a sort of store or reserve supply of food. Late in the fall a fat bear goes to sleep in a hollow tree. When he comes out in the spring, his ribs show through his hide. He has lived all winter on the reserve fat stored in his body when autumn nuts and berries were abundant.

6. *Fat keeps the body warm.*—All the higher animals are warm blooded and this body heat must come from the food. That is why most animals eat more food in cold weather than in warm weather; and why you yourself relish fat more often in winter than in summer. The Esquimaux and other people of very cold climates, live almost wholly on fatty meats. They need a lot of the little heat-giving atoms to keep them warm.

Fat-producing materials are given to the animal, sometimes in the form of fats; but mostly as starches and sugars, or carbohydrates, as the chemist calls them. After being taken into the body, these carbohydrates are changed into fat. Generally it is better not to feed an animal fat directly,but to feed carbohydrates.

The larger part of all dried plants, including all kinds of hay and fodder,is carbohydrate. We often hear a farmer speak of corn as "heatening." In the winter he will feed more cracked corn to his horse and corn meal to his hens than in summer. This is a fairly good practice ; but very often the farmer does not know the reason. It is because the corn kernel is full of starch grains; and after the animal has eaten it, the wonderful chemistry of the stomach turns it into heat-saving and heat-producing fat.

7. *The nitrogenous matters, sometimes called protein, build up the working machinery of the body.*—They make lean flesh, blood, muscle, skin, hair, wool, feathers, etc., and are especially needed in making milk. If you are keeping cows for their milk, sheep for their wool, horses for their muscle, or even geese for their feathers, it would be wise to feed them enough protein to best develop the desired points in each. This means that you ought to know the food value of everything you feed to your animals. You ought to know whether it will tend to fatten the cow or to increase her flow of milk ; whether it will tend to fatten the hen, and make her lazy, or give her the material for more eggs. The Experiment Station will be glad to answer any questions on this point.

Some of the common feed-stuffs which are especially rich in protein are all-animal substances ; also oil-cake, cotton-seed meal, gluten feeds and many other concentrated foods.

8. *The different kinds of hay, grain, etc., which we feed to our farm animals contain all these four foods: water, mineral matter, nitrogenous matter and fat.*—But the point is this, to increase or diminish the supply of each food according to the end in view, That is, to feed a *balanced ration.* We need not bother much about the water and mineral matter. Enough of both are supplied in ordinary food and drink ; although we should always satisfy the craving of cows and horses for salt, and other appetizers.

David was feeding timothy hay and corn meal, both of which are poor in protein. What he wanted was milk ; and milk is rich in protein. He gave his cows only enough protein to make fourteen pounds of milk, and so the yield dwindled down to that amount. Then David wondered why he did not get thirty pounds, like John. Probably he upbraided the man from whom he had bought the cows, or kicked against his "luck." He should know that there is a reason for everything.

On the other hand, the hay and meal which David was feeding are very rich fat-forming foods. He was not only stinting his cows on milk-producing food, but was also giving them more fattening food than the cows really needed. John was feeding a *balanced ration;* David was feeding an *unbalanced ration.* It will pay every farmer who reads this to find out if he is not abusing his beast and robbing his pocketbook as David did.

9. *A balanced ration is one which contains the nutritive materials (protein, carbohydrates and fat) in those proportions which experience has shown to produce the best results. The composition of a ration should vary with the different animals and with the end in view.*—What is a balanced ration for a horse may not be for a sheep. Again, a particular ration may be balanced for a cow when she is in milk, but not when we wish to fatten her for the butcher. A ration suitable for a hard worked ox is not a good one for this ox during a period of rest. Let us find out why this is so.

When an animal is hard worked, there is a great strain on the muscles, tendons, etc. (working machinery) of the body and this is best kept in order by feeding a ration which contains a large proportion of the repairing and muscle forming nutrient *protein.* If the animal is at rest in the stall there is no severe strain on the working machinery of the body and in such cases rations containing much smaller proportions of *protein* as compared to the *carbohydrates and fat* should be fed.

10. *Only a part of the protein, carbohydrates and fat is digestible.*—Foods are valuable as sources of nourishment only in so far as they can be digested and assimilated. The chemist analyzes a food and tells exactly how much protein, carbohydrates and fat it contains, but he is unable to say how much of each is *digestible.*

Only a portion of the food ingredients which are eaten, is digested and rendered soluble by the changes they undergo in the mouth, stomach and intestines. This soluble portion is assimilated, and from this alone is the animal nourished. The undigested part passes on and is excreted as manure. This undigested part is of no use to the animal.

11. *The value of feeding-stuffs varies with the amount of digestible food nutrients which they contain.*—Chemical analysis shows the total amount of nutritive ingredients in food-stuffs, but the digestible portion can be found only by carefully conducted feeding experiments with farm animals. Since the amount of digestible nutrients varies with different foods, it must be found for each one by careful experimentation upon animals. Many such experiments have been conducted with each of the common food-stuffs, so that at the present time there are many tables of figures giving for each feeding-stuff the digestible part of its protein, carbohydrate and fat, the total amount of which has been shown by chemical analysis.

In practical feeding experiments it has been found that one pound of digestible fat will go as far as 2¼ pounds of digestible carbohydrates; or, in other words, that one pound of digestible fat will go 2¼ times as far as one pound of digestible carbohydrates. Therefore, it is necessary to multiply the fat by 2¼ in order to get its equivalent in carbohydrates.

12. *The proportion between the digestible protein and digestible carbohydrates + (fat × 2¼) in a given food is called a nutritive ratio.*—When we know the digestible nutrients in a food we can easily find its nutritive ratio. Thus a given food contains 2 parts digestible protein, 10 parts digestible carbohydrates and 1 part fat: the 1 part fat is equivalent to 2¼ parts digestible carbohydrates; 10 parts carbohydrates + 2¼ is equivalent to 12¼ parts of digestible carbohydrates. That is: this particular food contains digestible nutrients equivalent to 2 *parts protein* and 12¼ *parts carbohydrates*, or for each part of digestible protein there are 6⅛ parts of digestible carbohydrates and fat. Therefore, this food has a nutritive ratio of 1:6⅛.

13. *To find the nutritive ratio of any food, add the (fat × 2¼) to the digestible carbohydrates and divide this sum by the digestible protein.*—A nutritive ratio shows how many equivalents of digestible carbohydrates there are for one of digestible protein. The greater the number of these carbohydrate equivalents for one of

protein the wider the nutritive ratio, and the fewer the number the narrower the nutritive ratio. Hence we use the terms "wide" and "narrow" nutritive ratios.

If a farmer has tables showing the composition of the different food-stuffs and their content of digestible nutrients, he can figure out the nutritive ratio for himself.

The Cornell Bulletin No. 154 contains such information, and it will be sent to applicants.

Lesson No. 8, soon to follow, will continue this subject.

Reading-Lessons :

1. *The soil : What it is.*
2. *Tillage and under drainage : Reasons why.*
3. *Fertility of the soil : What it is.*
4. *How the plant gets its food from the soil.*
5. *How the plant gets its food from the air.*
6. *The problem of depleted lands (Bull. 174)*
7. *Balanced rations for stock.*

L. H. Bailey, Chief of Farmers' Reading-Course.
John W. Spencer, Deputy Chief
Cornell University, Ithaca, N. Y.

CORNELL READING-COURSE
FOR FARMERS.

QUIZ ON
READING-LESSON
No. 7,
JANUARY, 1900.

By S. W. FLETCHER.

These questions constitute a supplement to Reading Lesson No. 7 ("Balanced Rations for Stock"). Its purpose is to induce the reader to think carefully about what he reads. Answer the questions as best you can and return this sheet to us (2 cents postage). We want these answers in order that we may know what interest you are taking in the Reading-Course and how much good you are getting from it; and we want to help you when you do not understand the problems involved. We are after results, and do not care about the handwriting nor the grammar. These answers are for our own examination and will not be made public. Do not be afraid to say "I do not know." We shall be glad of any comments on these lessons. Those who answer the questions will receive future lessons.

1. What is a food?

2. Why do all animals need food?

3. Is there such a thing as an all round food? Why?

4. Why will it pay to give a cow more food than is needed to keep her alive?

5. Are some foods better adapted for making milk than others; some for making fat?

6. Does a man usually require as much food when idle as when hard at work? Why?

7. Do you suppose it makes a student or business man as tired to think hard all day as it does a farmer to work hard all day? Why?

8. If both must have food, do they need different kinds?

9. Have you ever tried feeding different kinds of foods to your stock in order to find out which gives the best results?

10. Did you ever ask the Experiment Station to help you in this?

11. Have you found any difference in results in feeding clover and timothy hay?

12. If so, for what special purpose do you think each best adapted?

13. Is water a food?

14. Why does a hog suffer less from the cold than a horse? He has not as thick a coat of hair as the horse.

15. If you wish to fatten a farrow cow for the butcher what would you feed her?

16. What would you feed a new milch cow?

17. What is the difference between a balanced ration and an unbalanced ration?

18. Do you feed your farm horses the same kind and amount of food in winter as in summer? Why?

19. What is animal manure?

20. Will it pay a farmer to work out the nutritive ratio of his feed stuffs? Why?

21. Give an example of how you would do it?

22. What is a maintenance ration?

23. What is a productive ration?

24. Do all animals pay for their keep?

Name..

Post Office..

CORNELL READING-LESSON FOR FARMERS.

Issued by the College of Agriculture, Cornell University, Ithaca, N. Y., in the months of November, December, January, February and March.

No. 8. January, 1900. A Farmer's View of Balanced Rations.

BY S. W. FLETCHER.

I have read your Lesson No. 7 on "Balanced Rations for Stock," and think I see why John succeeded and David failed. I believe that there is a good deal in what you say about feeding different kinds of food for different purposes. Cake and pie are all right for me when I go visiting, but I must have pork and beans when I am pulling a cross-cut saw. I notice, however, that you say corn meal is not good for feeding to milch cows. Now I have found that I can get most anything I want out of my stock if I have a well filled crib of corn. Can you tell me why your theories do not work in this case? I do not feel quite sure that I understand what you mean by "carbohydrates" and "protein." If you can, please be more plain.

Very truly yours,

MY DEAR SIR:

I am very glad you have asked about that corn crib. There are many other farmers who will not discard corn as the best grain for feeding all kinds of stock; and if I can make a convert of you I shall expect you to argue this point with all the corn farmers in your neighborhood.

You have learned in Lesson No. 7 that *there are only two kinds of food which the farmer needs to feed his animals in large amounts.* These are the *muscle-makers* (proteids, protein, albuminoids or nitrogenous substances) and the *fat-makers* (fats and carbohydrates). The chief office of the muscle-makers is to build up all parts of the body which have work to do, including, with the other vital organs, the milk machinery of a cow's udder. They also enter largely into the composition of nearly all animal products, as hair, wool, eggs, lean meat and milk. The chief function of the fat-makers, on the other hand, is to supply the fuel from which the animal heat is maintained. They also supply, at least in part, the energy which enables the muscles to work and they enter largely into the composition of various products, particularly eggs and milk. Any surplus of these substances which the food contains may be and usually is stored up in the tissues of the body as fat. These statements show what usually takes place, but since the muscle-makers may perform any of the functions of the fat-makers, it is more exact not to speak of these substances according to their functions but according to their composition and to refer to them as protein, and fats or carbohydrates, instead of muscle-makers and fat-makers.

We might illustrate roughly the main point to this problem of stock feeding by saying that a cow is something like a grist mill, and that her stomach is the hopper. A mill will grind out only the grist of what is put into the hopper ; just so a cow in a large measure will turn out fat or milk according to the food which we put into her stomach. Are you keeping a cow for milk ? Then feed largely milk-makers. Are you raising a steer for beef? Then feed more fat-makers. Does not this seem reasonable ?

Now let us see which among the different kinds of hays, grains and fodders that we commonly feed to our farm animals contain carbohydrates or protein in large amounts. The chemist takes all of them into his laboratory and treats them with chemicals for many hours. Finally he tells us that every one of them contains both protein and carbohydrates, but most of them are richer in one or the other. So we must not think to find our muscle-makers and fat-makers put up in separate packages, ready to be mixed as needed. *They are combined in different proportions in all kinds of feeding stuffs.* The chemist finds out what these proportions are, so we can tell at a glance for which purpose each kind of grain or hay is more valuable, whether for fat or milk.

In Bulletin No. 154 of the Cornell Experiment Station, on pages 142 to 152 you will find a table which shows the amount of protein and carbohydrates which different hays and grains contain.

In order that you may understand more clearly what the different columns of figures mean, I will copy a few and explain them here :

Kinds and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat×2.25.)	Total.	
Corn, 1 lb...	.89	.079	.764	.843	1: 9.7
Wheat bran, 1 lb...........	.88	.122	.453	.575	1: 3.7
Timothy hay, 1 lb..........	.87	.028	.465	.493	1:16.6
Red clover, 1 lb............	.85	.068	.396	.464	1: 5.8

Suppose you take a pound of your corn meal to the chemist and ask him what is its value for feeding to stock. He will first heat it to dry out all the water, for you already know that a large part of all plants and animals is water. Nearly a seventh of this corn meal is water; so that after being dried for several hours only 89 parts are left of the original 100. Thus in the first column, called "Total dry matter," you will find .89.

The chemist then takes this perfectly dry corn meal now left from the original pound, and treats it with his chemicals. In the 89 parts he finds that 7 parts are muscle-makers and 76 parts are fat-makers. Of the remaining 6, a part is mineral and helps to make the bones of the animals; others are indigestible and are discarded. In the second column, headed "Protein" he puts the muscle-makers, .079; and in the third column, headed "Carbohydrates," etc. are the fat-makers. The fourth column headed "Total," is simply the sum of both muscle-making and fat-making foods; its shows that out of every 100 parts of corn meal the animal can use 84. These are called *digestible nutrients.**

You hear much about the "nutritive ratio" in stock

As a matter of fact, the column headed "carbohydrates" is made up of both carbohydrates and fats in food, the fat having been multiplied by 2¼. This is done solely as a matter of convenience in computation. The function of carbohydrates and fats is identical, but fats will evolve 2¼ times as much heat as carbhydrates: therefore the percentage of fats has been multiplied by 2¼ and added to the carbohydrates.

feeding, and perhaps have been puzzled to find out just what it means. I have told you that most feeding stuffs contain both muscle-making and fat-making food, but in different proportions. *The "nutritive ratio" of the chemist is simply the proportion or ratio between the protein and the carbohydrates.* Take your corn meal, for instance. It has 7 parts of muscle-making food and 76 parts of fat-making food. This would be the same as 1 part of muscle-making food to about 9 of fat-making food. In the last column of the table, therefore, you will find 1: 9.7, which is simply the comparative amounts of the two kinds of foods. The two dots between the 1 and the 9 show that one food is being compared with the other. It is very important that you should know what the nutritive ratio is, for you will need to use it when selecting materials for making a balanced ration.

One reason why John's cows gave more milk than David's was because he fed them wheat bran instead of corn meal. Let us see how much protein and how much carbohydrates the chemist finds in one pound of wheat bran. I have put his figures under those for corn meal so you can compare the two easily. Do you not see that the bran has 12 parts of muscle-making food, or nearly twice as much as the meal? Also that it has over a third less of fat-making food? The proportion, or nutritive ratio, for wheat bran is therefore 1:3.7, since it contains 1 part of muscle-making food for every $3\frac{7}{10}$ parts of fat-making food.

Here, then, is my argument: the wheat bran which John fed his cows was nearly two times richer in muscle-making food than the corn meal which David fed. Most muscle-making food is also milk-making food. Do you wonder, then, that David's cows soon began to grow fat and dry off? They were starving for muscle-makers, though glutted with fat-makers. That well filled corn crib of yours will make you lose many a dollar in the same way if you trust to it entirely for feeding your milch cows. David fed timothy hay. John fed clover hay. The table tells us that clover hay has nearly three times as much muscle-making food as timothy hay and almost as much fat-making food; yet you will pay $12.00 a ton for timothy and feed it to your dairy cows, when clover can be bought for $9.00. Is there profit in this?

I have nothing against your corn crib, *if you will only use it* *wisely*. I have tried to show that corn is a fat-maker ; yet you feed it alike to shotes and hogs, team horses and roadsters, broilers and laying pullets, milch cows and fattening steers. You say that you can get most anything you want out of your stock with corn. Have you had anything to compare it with ? How do you know that you could not get better results with another ration ? Suppose you make your farm a little experiment station by feeding John's ration to part of your cows, and David's to the remainder. Or take four fresh cows giving about the same amount of milk a day, and feed John's ration to two and David's to the other two. I know it is rather hard to see how the figures in these tables are going to make differences in the milk pail ; but if you can see what goes into the manger and what comes into the pail you will doubt no longer, for most every man believes his own eyes. Try it ! I shall be pleased to hear the results of your own experiment.

To this the correspondent replied essentially as follows :

I think I begin to see into this feeding problem more clearly. What you want me to do is to prevent a waste of food, do you not ? If I am keeping cows for their milk you want me to feed a ration which will make milk, and not be wasted in making fat. To feed with the milk-making food a lot of fat-making food which is not needed would be poor economy.

There are a few things in those tables which I do not understand yet. What has that first column, called "total dry matter," to do with this feeding question. I cannot see where it comes in at all. Again, you said in Lesson No. 7 that animal manure is that part of the food which the stomach cannot use. I do not see where the chemist has made any allowance in his tables for the undigested part of the grain and hay which we feed. Just one more question. You have shown that there are two sides to this feeding problem : one is, what the animal needs ; the other is, what the food supplies. Now how am I to know what and how much my animals need ? How did John know ?

My Dear Sir :

You are a shrewd farmer. It is a pleasure to answer the questions of a man who takes such an intelligent interest in the subject. I wonder if it would be more plain to you if I should say "bulk" instead of "total dry matter." It is possible to put all the nourishment in the food which you eat during a day into a few very small tablets. Do you not think this would be a great saving of time and labor? You could eat the tablets while at work and would not need to stop for dinner. But how long would you live on such a diet? In the same way you could feed all the muscle-making and fat-making food which your cows need in a comparatively small amount of gluten feed and corn meal: but you know the cows would not be likely to thrive long on such high living. The reason in both cases is that *the food of most animals must be bulky enough to distend the stomach and give the digestive organs plenty of room to work.* It is natural for a cow to eat a large amount of coarse fodder, much of which is indigestible and is cast off as manure. In selecting a ration for animals, therefore, one of the very first things to look out for is to make it bulky enough; and the column of "dry matter" will help us in this. We usually depend upon hay and fodder for most of the bulk of the ration and add grains to make it concentrated enough for our purpose. There is also a danger of making the ration too bulky. Clover hay alone is nearly a balanced ration for milch cows; yet the cows would have to eat so much of it in order to get all the food they need that their stomachs would be unduly distended. Have you ever noticed how "pot-bellied" a horse gets if fed on hay alone?

I am glad you have brought up the point that the figures of the chemist only tell how much muscle-making and fat-making food the material contains. He cannot find out in the laboratory whether or not the animal can use it all after it is taken into the stomach. We must make feeding experiments with the animals themselves. This point has been carefully studied for many years and we now know approximately how much of the two foods in our common feeding stuffs the animal can use. You will notice that over the columns of fat-making and muscle-making foods in the table is "Pounds of digestible nutrients." This means that the figures given are not the whole amount of food in the feeding stuff, but only that part which the animal probably can use. In making up your rations, therefore, these figures may be taken as they stand without deducting anything for waste.

On page 140 of the bulletin, you will find a table of "Feeding

Standards;" or the average amount of food which many experimenters have found to be best suited for making milk, beef or for other purposes. I will copy three items in it to show you how the table works:

	Dry matter.	Digestible.			Nutritive ratio.
		Protein.	Carbo-hydrates and fat.	Total.	
	Lbs.	Lbs.	Lbs.	Lbs.	
Oxen at rest in stall.......	17.5	0.7	8.3	9.0	1:11.9
Oxen heavily worked......	26.0	2.4	14.3	16.7	1:63
Milk cows, Wolff's standard	24.0	2.5	13.4	15.9	1:5.4

Here is a good illustration of the fact that *animals which are hard at work need a liberal supply of muscle-makers.* The table shows that oxen in the stall need only 17 pounds of feed a day (that is, after the water has been dried out of it), while those in the yoke need 26 lbs. But the difference is not only in bulk: it is also in composition. Oxen at rest can get along with only seven-tenths of a pound of muscle making food a day, while oxen at work need three and one-half times that amount. On the other hand, oxen on the cart need but three quarters more fat-making food than oxen in the barn; so that while a working animal requires one pound of muscle-making food to every six pounds of fat-making food, his idle brother can get along very well with a ration having a nutritive ratio of one to twelve. Since there is this difference in the needs of working and idle animals, do you not think it would pay to make a difference in what you feed the two, beside in mere amount?

Now compare the needs of a milch cow with those of a working ox. You see they are nearly the same all the way through, and yet the cow may be standing in the barn all day. Why should she need as much muscle-making food as the great, brawny ox, straining in the yoke? I have told you the reason before: it is because milk-making is accompanied by great activity of the vital organs of the cow and also because milk itself is very rich in muscle-making food. In order to give a good pailfull, the cow must have enough material on hand to do the work.

In Table I of Bulletin No. 154, you will learn what the animal needs; in Table II you will find what the different hays and grains supply. I think you will have no difficulty in making up your animal rations from these two tables.

Again he replies:

Those "Feeding Standards" figure out well on paper, but I am wondering how they will work in the stable. I have two horses: Cherub, who is always plump and good natured, and Spider, who is always lean and vicious. I call Cherub an easy keeper and Spider a hard keeper; for although both do the same amount of work and get the same amount of feed, Cherub is fat and jolly while Spider shows both ribs and temper. Some of my cows are the same way. With such differences in animals, I do not see how you can show your tables to be of much value.

My Dear Sir:

What you say about the differences in the producing power of animals is very true. It would not do to lay down a general rule that all ten-year old boys need four pieces of bread and meat for supper. Their needs are different because the boys are different; not only in appetite but also in the ability to digest food. I cannot tell you just how much food your milch cow needs because I do not know the cow. What I can do, however, is to tell you the amount of food which has given the best results for many other milch cows, and which will probably be somewhere near what your cows need. *These feeding standards are not rules, but hints. The skill of the feeder may be measured by his ability to find out how far the needs of each animal will warrant a variation from the standard when feeding that animal.* You would not give a snap for a hired man who does everything by rule of thumb. I want you to come to this table for suggestions, not for directions. Do not follow it pound for pound, but vary the amount with each animal according to its appetite and ability to use food.

The above teaching shows *what is likely to take place. Every animal is a law unto itself.* The farmer must experiment with his animals. The above remarks will *set you to thinking* on the subject, and that is the most that we can hope to do.

CORNELL READING-COURSE FOR FARMERS.

Supplement to Lesson No. 8, January, 1900, on Balanced Rations.

1. How many farmers in your neighborhood feed corn-meal for all purposes?

2. What and how much would you feed a fresh milch cow?

3. What is protein? Of what special use is it to the animal?

4. How is the body of an animal kept warm?

5. What kind or kinds of food must an animal have in order to do work?

6. What is a "nutrient"?

7. May any one hay or grain contain both the foods which the animal needs most? In the right proportions?

8. Explain why corn-meal is said to have a nutritive ratio of 1:9.7.

9. If you are keeping cows for milk will it pay you to grow more clover and less timothy? Why?

10. Will you try the experiment suggested?

11. In what way is an unbalanced ration wasteful?

12. Why not feed animals grass alone?

13. Why not feed hay alone?

14. How much corn-meal can the animal use?

15. Why does a working animal need more food and often different kinds of food than an idle animal?

16. Do you think it would be practicable to make a difference in what you feed the two?

17. Have you any "hard keepers"? Among what animals?

18. What makes them hard keepers?

19. Could you make up a balanced and economical ration from the tables, which would be so unpalatable that the animals would not eat it?

20. Can you make more than one balanced ration for milch cows from clover hay, timothy hay, corn-meal and wheat-bran? Give examples.

21. Which would be cheaper?

22. Which would the cows relish most?

Name ....

Post Office ....

Answer, and return to

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No. 9. February, 1900. Sample Rations for Milch Cows.

BY LEROY ANDERSON.

In Lesson No. 8 we learned that a daily ration for a milch cow (weighing 1,000 lbs.) should contain about 24 lbs. of dry matter of which the 2.5 lbs. should be digestible protein or the muscle-making food which the cow can use, and 13.4 lbs. digestible carbohydrates and fat. The object of Lesson No. 9 is to show how this "balanced ration" can be made from the many kinds of feed-stuffs which the farmer can raise or buy.

Ration No. 1. An Ideal Ration.

Let us first make a sample ration which may be taken as a type of what a milk ration should be. Suppose we have on hand corn silage, clover hay, buckwheat middlings, wheat bran, corn meal and cottonseed meal. The first thing to do is to guess, or estimate, how many pounds of each food the cow will relish in a day. The longer our experience in stock-feeding, the closer will be our guess as to the actual needs of the cow. Next we should find, in Bull. No. 154 (to be had for the asking), the amount of dry matter, protein, and carbohydrates and fat in the quantity of each food which we think the cow will eat. From these figures we can work out the nutritive ratio of our ration.

It has been the experience of many stock-feeders that a cow will usually eat and relish about 40 lbs. of corn silage per day. On page 143 of Bull. 154, this amount of silage is said to contain 8.4 lbs. of dry matter, .36 of a lb. of protein, and 5.16 lbs. of carbohydrates and fat. An experienced feeder also knows that a cow will eat about 10 lbs. of clover hay per day, in addition to the 40 lbs. of silage. On page 144 of the bulletin, this amount of clover is found to contain 8.5 lbs. of dry matter, .68 of a lb. of protein, and 3.96 lbs. of carbohydrates and fat. Adding together the dry matter in both silage and hay we have 16.9 lbs., which is 7.1 lbs. short of the 24 lbs. needed to make the ration bulky enough. This 7.1 lbs. of dry matter will be supplied in the grain.

Nearly all grains are about nine-tenths dry matter, so that we shall need 8 lbs. of grain to make a ration of the proper bulk. It is generally a good plan to have two-thirds of the dry matter in a ration come from coarse fodder and the remainder from the grain.

We have four kinds of grain in the bins, and the eight lbs. needed for the ration should be so divided among these four grains as to make a ration which will give the most milk. Suppose we use 3 lbs. of buckwheat middlings, which the chemist finds to contain 2.61 lbs. of dry matter, .66 of a lb. of protein and 1.368 lbs. of carbohydrates and fat (page 148); 2 lbs. of wheat bran, containing 1.76 lbs. of dry matter, .224 of a lb. of protein, and .906 of a lb. of carbohydrates and fat (page 147); and 2 lbs. of corn meal, containing 1.78 lbs. of dry matter, .158 of a lb. of protein, and 1.528 lbs. of carbohydrates and fat (page 145). This leaves only one lb. of cotton seed meal to make the eight lbs. of grain. This contains .92 of a lb. of dry matter, .372 of a lb. of protein and .444 of a lb. of carbohydrates and fat. Adding all of these figures together we have this table :

	Dry matter.	Protein.	Carbohydrates and fat.
	Lbs.	*Lbs.*	*Lbs.*
40 lbs. corn silage	8.40	.360	5.160
10 lbs. clover hay	8.50	.680	3.960
3 lbs. buckwheat middlings.	2.61	.660	1.368
2 lbs. wheat bran	1.76	.244	.906
2 lbs. corn meal	1.78	.188	1.528
1 lbs. cottonseed meal	.92	.372	.444
Total,	23.97	2.474	13.366

This is a balanced ration for milch cows, because it contains very nearly the amounts of dry matter, protein, and carbohydrates and fat which experienced feeders have found to give the best results. If the total amount of carbohydrates and fat (13.366) is divided by the total amount of protein (2.474), the result is 5.4. Thus for every lb. of protein there is 5.4 lbs. of carbohydrates and fat. In other words, this ration has a nutritive ratio of 1:5.4; which is the ratio suggested on page 140 of the bulletin.

The nutritive ratio of a ration for milch cows need not always be 1.:5.4. It may vary from 1.:5 to 1.:6, or even wider and still give good results in some cases. But since rations with a nutritive ratio of 1.5 to 1.6 have been most successful in the past, it would be good policy for every farmer to so combine his feedstuffs that the nutritive ratio will come between these limits.

This ration will be eaten with a relish by most cows and will make them give a good flow of milk. Others may not do so well and a change may help them. This is because the stomachs of cows vary just as much in their power to digest food as do the stomachs of men, which was brought out in the last paragraph of Lesson No. 8. Here is where the Experiment Station man cannot help the farmer much. All he can do is to *suggest* a ration which has given good results with many cows, but which may not give good results with some cows. *If a man is to feed his stock intelligently and economically, he must learn the needs of each cow, and how far he should depart from the regular balanced ration in feeding her.*

Ration No. 2.

One man writes, "The ration you give is all right for the man who has those feeds, but I do not have them and cannot afford to buy them. I have ground oats, corn meal, mixed hay and corn stover (stalks). Can a balanced ration for milk be made from these without buying other feeds?"

Estimate how much of each feed a cow can eat daily, and then look in Bull. 154 for the amount of dry matter, protein, and carbohydrates and fat in each. This gives the following table:

	Dry matter.	Protein.	Carbohydrates and fat.
	Lbs.	*Lbs.*	*Lbs.*
12 lbs. corn stover	7.20	.204	4.080
10 lbs. mixed hay	8.70	.620	4.600
4 lbs. corn meal	3.56	.316	3.056
5 lbs. ground oats	4.45	.460	2.840
Total	23.91	1.60	14.576

The ration is bulky enough, for it contains nearly 24 lbs. of dry matter ; but it needs another pound of protein, and has a pound too much of carbohydrates and fat. Its nutritive ratio is 1:9.1, which is far too "wide." Had we known beforehand the nutritive ratio of each of the feeds, we could have told at once that they cannot possibly be combined in any way to make a balanced ration for milch cows. The nutritive ratio of each feed is given in Bull. 154. That of corn stover is 1:19.9 ; of mixed hay, 1.7.4 ; of corn meal, 1:9.7 ; of oats, 1:6.2. Since even the most concentrated of the four feeds has a nutritive ratio of only 1:6.2, no balanced ration for milk can be made from these materials alone. We must put in some other feed with a very "narrow" nutritive ratio to make the ration balanced.

On page 150 of Bull. 154, is given the composition of three feed-stuffs which are often fed to stock, all of which are very rich in protein. These are old and new process linseed oil meal and cottonseed meal. We need about 3 lbs. of one of these to make our wide ration as narrow as it should be. It is not wise to feed a cow 3 lbs. of oil meal per day, because this grain has a laxative effect on the animal. On the other hand, too much cottonseed meal has a constipating effect on the animal and tends to make hard and tallowy butter ; but 3 lbs. per day ought not to produce any bad effect. Let us see what this quantity will do towards balancing the ration :

	Dry matter.	Protein.	Carbo-hydrates and fat.
	Lbs.	*Lbs.*	*Lbs.*
12 lbs. corn stover	7.20	.204	4.08
10 lbs. mixed hay	8.70	.620	4.60
3 lbs. corn meal	2.67	.237	2.292
3 lbs. ground oats	2.67	.276	1.704
3 lbs. cottonseed meal	2.76	1.116	1.332
Total	24.00	2.453	14.008

Here the bulk remains the same, the protein is increased nearly 2.5 lbs., and the carbohydrates and fat are decreased over one half pound. The nutritive ratio of this ration is 1:5.7, which is within the limits suggested at the beginning of this Lesson. If it is found that the 3 lbs. of cottonseed meal constipate the cows, one pound might be replaced by a pound of linseed oil meal.

Protein can usually be bought cheaper in cottonseed meal than in linseed meal, but both are expensive. Perhaps this man can buy some cheaper feed which will do as well. Suppose he tries buckwheat middlings, which have a nutritive ratio of 1:2.1. He must use 5 lbs. of middlings to supply as much protein as the 3 lbs. of cottonseed meal. Then he can feed but 4 lbs. of corn meal and ground oats, because the bulk of the ration must be kept down to 24 lbs. Since it is for his interest to feed these two grains of his own raising as much as possible, it may be cheaper in the end to buy the feed which will give the most protein, that is, cottonseed meal.

Ration No. 3.—A Corn-Stalks Ration.

Another man says, "I have plenty of corn fodder and ear corn of my own raising. I can buy clover hay for $13.00 per ton, wheat bran for $19.00, wheat middlings or red dog flour for $21.00, cotton-seed meal for $30.00, linseed meal for $30.00 and mixed feed for $18.00. What is the cheapest balanced ration for milch cows which can be made from these materials?"

Some of these feeds should not be used at all in this case: linseed meal, because it is too costly, mixed feed because one never knows what it contains, wheat middlings and red dog flour because the protein in them costs more than the protein in wheat bran. Mixed feed is made up largely of wheat products, as bran middlings, and refuse from other grains, as oat hulls. It may also contain sweepings from the mill, whole grains, dirt, etc., and can never be relied upon to be uniforn in quality. Clover hay is very valuable for milch cows, but since it costs this man so much it must be used sparingly. As he wishes to use his own corn fodder, the following ration is suggested:

	Dry matter.	Protein.	Carbo-hydrates and fat.
	Lbs.	*Lbs.*	*Lbs.*
20 lbs. corn fodder	11.60	.500	7.460
5 lbs. clover hay	4.25	.340	1.980
3 lbs. wheat bran	2 64	.366	1.359
2 lbs. corn meal	1.78	.158	1.528
3 lbs. cottonseed meal	2.76	1.116	1.332
Total	23.03	2.480	13.659

This ration has enough protein and carbohydrates and fat, but the dry matter is one pound short. It is not necessary to make any change, however, since the ration is otherwise very good, having a nutritive ratio of 1:5.5. If the appetites of the cows warrant it, one lb. of corn meal may be added to the ration with good results. It will be noticed that the table of feeding standards on page 140 of Bull. 154 is for an animal weighing 1000 lbs. It is not always necessary to subtract from or add to this standard ration, according as a cow weighs less or more than 1000 lbs. Experienced feeders have found that the appetite of a cow is a more important cause for varying the ration than the weight, although it is always well to have the size of a cow in mind when doling out her meals.

Ration No. 4.—A Roots Ration.

A different problem is presented by another man who has no home grown feed-stuffs but mixed clover and timothy hay, and a quantity of mangels. He can buy oats for $20.00, corn meal for $18.00, wheat bran for $19.00 and wheat middlings for $20.00.

It is generally best to feed dairy cows at least three grains. Variety makes the ration more appetizing and also gives a better chance of securing a well balanced ration. Bran and middlings contain about the same amount of animal food, but since bran is cheaper it is more desirable for this man. The mangels will make this a better ration in some respects than any of the preceding, because they add succulence to the ration.

The tables in Bulletin 154 tell us that bran is the only feed-stuff mentioned by this farmer which has a nutritive ratio of less than 1.6, the usual limit of a successful ration for milch cows. It would be difficult to make a balanced ration from these materials without using a large amount of bran in order to supply enough protein to make up for what is lacking in the hay and mangels. Unlike cottonseed meal and linseed meal, large amounts of bran are not likely to injure the health of the animal. But it is too bulky to be fed at the rate of 9 or 10 lbs. a day, and the ration would also lack variety. It will be far better and cheaper for this man to buy another feed which is rich in protein, as gluten meal. (Bull. 154, p. 149.) Gluten meal should never be fed in amounts over 4 lbs. a day, and even that is more than some cows ought to have. It can usually be bought at about the same price as middlings, and its feeding value is much greater. The ration we suggest is this:

	Dry matter.	Protein.	Carbo-hydrates and fat.
	Lbs.	*Lbs.*	*Lbs.*
18 lbs. mixed hay	15.66	1.116	8.280
30 lbs. mangels	2.70	.330	1.680
1 lbs. corn meal	.89	.079	.764
2 lbs. oats	1.78	.184	1.136
2 lbs. wheat bran	1.76	.244	.906
2 lbs. gluten meal	1.84	.516	1.312
Total	24.63	2.469	14.078

This is a well balanced ration, with a nutritive ratio of 1:5.7. We have used a larger proportion of coarse fodder and less of grain than in the other rations, because this man must buy.

Ration No. 5.—A Silage Ration.

Another enterprising farmer says, "I believe I can provide a succulent food cheaper in the form of corn silage than in roots. How much of it shall I feed? I have clover hay, corn and cob meal and peas. I can buy wheat bran, gluten feed, and buckwheat middlings. How shall I put them together?

Corn silage certainly is a cheaper form of succulent food than roots. It also has much more food value per ton than roots. A cow will eat and relish 30–40 lbs. of good silage a day. It is not usually advisable to feed silage more than once a day, unless there is a large supply of silage on hand and but little hay. In such cases about 30 lbs. of silage may be fed both morning and night, and as much hay as the cow will eat at noon. Our cows do well when fed only twice a day: hay in the morning and silage at night. Mix the grain of the ration with the silage.

There is no advantage in grinding the corn cob when plenty of coarse fodder like hay and silage is on hand. Cob should be fed only when it is necessary to supply a lack of coarse food.

Cob has very little value itself as a food ; it merely gives bulk to the ration. But since this man already has the cob ground, we will put it in his ration. The feed stuffs which he has on hand are rich in fats and carbohydrates, but are poor in protein, so we will buy buckwheat middlings instead of gluten feed, because they contain more protein. This ration is suggested :

	Dry matter.	Protein.	Carbo-hydrates and fat.
	Lbs.	*Lbs.*	*Lbs.*
40 lbs. corn silage..................	8.40	.360	5.160
8 lbs. clover hay..................	6.80	.544	3.168
3 lbs. corn and cob meal...........	2.55	.132	1.995
3 lbs. ground peas..........	2.70	.504	1.602
2 lbs. wheat bran..................	1.76	.244	.906
2 lbs. buckwheat middlings.... ...	1.74	.440	.912
Total.....................	23.95	2.224	13.743

We have tried to use as much of his home-grown grain as possible, and in doing this have made a ration which is a little short in protein. It has a nutritive ratio of 1:6.2, which is wider than the limits suggested, but which might give good results in some cases. However, the ration can easily be made narrower without buying any more feed. Notice that the corn and cob meal is very poor in protein, while the peas contain even more protein than wheat bran. By feeding one pound more of peas and one pound less of meal the nutritive ratio would be 1:5.8:

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Cornell Reading-Course Bureau.

CORNELL READING-LESSON FOR FARMERS.

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No. 10. March, 1900. Peter's Idea of Improving "Worn Out" Lands.

BY JOHN W. SPENCER.

It was near to the shortest days of the year that I fulfilled a promise to attend a Grange meeting to be held in a small town in Western New York. I arrived in Rochester the night before, in order to be able to catch the early morning train. As I passed the Douglas monument in the early gray of the morning, with hat drawn low on my head and ulster turned up to protect my ears, the sharp frost sifted through the air like ashes and the snow creaked beneath the wheels of the early wagons. I wondered what I should say at the meeting.

The village was a typical country hamlet. It contained neither wealth nor squalid poverty. No one of its inhabitants could meet with a misfortune without receiving the sincere sympathy of all. The public buildings were a school house, a church with a horse shed, a blacksmith shop, and a store carrying a stock of goods of such completeness as to remind me of the *multum in parvo* jack-knife which an uncle once gave me. I wondered the more what I should say. Would I find good farmers here?

The meeting was a forenoon and afternoon affair in the Grange hall over the store. The hall had a dining room and kitchen annex, much to my welfare. In the early part of the afternoon session, I noticed among the faces that seemed interested in the discussion, a middle aged man with full beard, blue flannel shirt and felt boots. He sat on the front bench, and I soon decided that he was not one of those who had come into the hall just to get warm. I tried to draw him out and soon had him asking questions. At the close of the meeting, I accepted his invitation to spend the night with him. I took note that others addressed him as Peter, and I called him Peter also. When he drove up to the store for me in a two-seated democrat, a woman sat on the back seat. No introduction being given, I inquired if she was Mrs. Peter and she informed me that she was, What could these people know about scientific farming?

But this was the beginning of a cordial and what has been to me, a very profitable acquaintance. To this day I address them as Mr. and Mrs. Peter and the two children as Repeaters.

During that afternoon I had done most of the talking; but after supper, Peter began to talk, having confidence from being beneath his own roof. Then it was that he told me his experience in restoring the fertility of "worn out" soils. I found that Peter was wise in the ways of the farm, and I gladly became the listener. Following is substantially what Peter said:

Before I began thinking much about plant-food I had a vague idea that it lay in the soil like salt or sugar, to be dissolved by water and sucked up by the roots of plants; I thought that when it was all dissolved the soil was exhausted; and that if I wished to raise another crop I should be obliged to cart on to the soil whatever plant-food my crop might require. When I was asked why mullein and rag weed will grow where our common farm crops cannot, I explained it by the theory that weeds use different kinds of plant-food than farm crops.

It was a great revelation to me when a reading lesson showed that even "worn out" soils may have enough plant-food to grow many crops if it can only be put in such form that plants can use it; also that all plants require about the same kinds of food although varying a little in the proportions. The idea that plants differ in their ability to digest or use food set me to thinking. The illustration which it gave, that a goat will thrive where a Jersey cow will fare hard, explained a great deal to me and led me to see that weeds are the goats of plant life, since they will thrive where many other plants cannot.

Another idea that I pondered over a great deal was the statement that tillage makes a soil more fertile. Experience had taught me that the better I prepared my corn ground and the more I cultivated, the better the orop; but I had supposed that this was merely because the soil was made more mellow and the roots had a chance to spread out further in the soil. Little by little I have come to understand that *good tillage helps to make* *digestible, or available, some of the tough plant-food which lies in the soil.*

When you published your first three lessons on the soil and its fertility, I wish you had directed the printer to put in large letters the idea that *the soil is a laboratory which must be kept in good repair*, so that "chemical activities," as you say, can go on rapidly and unlock the locked-up fertility. You ought to have made more clear that it is my business to keep the laboratory in repair so that the "chemical activities" can go on without hindrance. If you were to ask my idea of a worn-out soil, I should say that it is a case in which the farmer has let the soil laboratory go to ruin. If this is true, then the problem of restoring fertility is, How can I best put the laboratory in repair?

They tell me that soil is made of vegetable matter and rock ground into very fine particles, what I should call stone flour. Please let me say vegetable matter instead of organic matter, for that is the way I am in the habit of thinking. Yes, thank you for suggesting humus ; I suppose it means much the same thing. They also tell me that by much cropping, this vegetable matter will gradually pass out. It came to me, that this may become exhausted, leaving only the stone flour behind. Stone flour is next thing to clear sand and clear sand is next thing to a granite boulder. I cannot conceive much "chemical activity" going on in a boulder.

If I am right in this, then *the first step for me to take towards promoting chemical activities is to imitate nature and add more humus to the soil by plowing under green crops.* I have been experimenting along this line for several seasons and in the main I think this is the first principle in trying to improve worn out soils. I say "in the main," for usually one cannot carry a point by one idea. It seems to me that this often causes the failure of many well meaning men who would be progressive : they go on just one idea. It is comparatively easy to drive one horse, but when it comes to four or six there are a good many lines to keep at just the proper slack or tightness and there is a constant letting up and taking out. As I said before, my experience of several seasons has made me firm in the belief that adding humus is the first and leading idea in the restoration to fertility of worn out soils.

But I do not forget that there are a number of other things in this soil laboratory which should not be overlooked. In carrying on my experiments I find that I have more than one set of reins to manage. One reading lesson showed us that the leading agents in this laboratory are moisture (not standing water), heat and air, and that these must be in the right proportions to have good results. Many soils are so made that these agents occur in about the right relations, and no artificial aids, as drainage, are needed ; yet the productiveness of the soils to-day is much less than years ago. I would advise those who intend to make experiments in restoring fertility to select, for first trial, land which has given paying crops at some time in the past, for it is probable that moisture, heat and air will be present in such soils in the right conditions. Right here I wish to warn everybody against trying to restore fertility on land that never was fertile. Restoring fertility is hard enough, say nothing about creating it.

The piece of land on which I have been making my experiments is part of a farm which I bought a few years ago. It has been rented and abused by tenants for many years. Brush grew in what were fence corners before the fences rotted, and there was a circle of weeds about each stump. It had been a long time since grass seed would catch on that land. Of late years the plowed land had been sown to buckwheat, and no crop was certain without a liberal application of "phosphate." What was not under the plow grew up to "poverty grass." My father-in-law tells me that before the war and mowing machines, he mowed grass in those fields shoulder high, and that timothy did not require re-seeding for five seasons or more.

I think my chances are good for getting those fields back to their early productiveness, without having them cost me more than the price of good land elsewhere. But I have made some mistakes, mostly because I did not take into account all of the workers in my soil laborabory. My first mistake was in not seeing a difference in maintaining fertility and restoring fertility. On my small home farm I kept stock and for a number of years had used clover successfully in a short rotation. I found that the rules which worked all right in maintaining fertility there, failed to restore fertility on the new place. In some respects it was like two horses beginning the Spring work : one well wintered and in good condition, will require a maintenance ration only ; the other so poor and weak that it cannot digest enough food to furnish strength for its work and gain flesh at the same time. For two years I found that clover was a failure on the new farm because the land was too poor or too dry. I have my opinion of some of the agricultural advisers who would make clover a cure-all for all infertility. Many of these men have never tried it themselves but simply repeat what they have heard other people say. You may put me down as saying that clover is of little use for beginning the restoration, although it is all right for maintaining it, and for adding fertility when the soil has reached a fair degree of tilth or productiveness.

I cannot say that there is any one best way of adding humus to the soil: Conditions vary so much that no hard and fast rule can be followed. I have attended enough Farmers' Institutes to know that many men go there expecting to be given a recipe on how to succeed in farming. This cannot be given any more than a recipe can be given for making money by selling goods or making wagons. But I will tell you my experience:

On one of my worn out fields, I plowed and harrowed the best I could, aiming at the "onion bed" quality of tillage. On this land I planted fodder corn in drills, and let only one half or one-third as many stalks grow as I would on the strong soil of my home farm. Before planting I applied commercial fertilizer with a liberal hand to give the corn a start. I gave frequent cultivations until the corn was waist high, and at the last cultivation sowed rye between the rows. In the following spring the rye was plowed under just about the time it began to stalk up and before it had made any head.

My experience in using rye for adding humus to the soil has been considerable and for two seasons I have made the mistake of letting it head out before plowing it under. In this condition it is stubborn stuff to rot, and lays in the soil like very fine brush. Instead of being a benefit to the soil it is a nuisance. The quality that makes rye straw wear well as bedding is a detriment when the straw is plowed under. It is an easy mistake to let rye get too far grown before plowing it under. May is a farmer's busy month and he finds many things which ought to be done first. When rye has reached a certain stage it heads out very quickly, particularly if the weather suddenly becomes dry. You look the field over one Sunday and think it will be safe to leave for a few days and by the next Sunday it will be too far advanced to bring satisfactory results if plowed under.

The first crop of corn fodder on my worn out soil generally pays all the expense of fertilizers and cultivation, and the second crop is an improvement on the first. I am confident that *this improvement is not all due to the humus added by the rye, but is also the result of good tillage.* How much of it is due to tillage I have no means of knowing; but I wish that all restoration crops could be hoed crops. When once the fertility of a field has reached a point at which I can get a fair crop of clover, I feel that the restoration period has ended and maintenance period begun. Some farmers object to clover because of the frequent re-seeding which is necessary, and expense of the seed. One point in favor of the more extensive use of clover is the short rotation which it necessitates, thus giving an opportunity for frequent seasons of tillage. I believe in a short rotation for either the restoration or maintenance of fertility ; for there is fertility in tillage.

Another way of adding humus is to sow Canada peas and oats as early in the spring as the land can be worked. This involves more expense and brings no return in money for the first year, but it will generally improve the land sooner than fodder corn and rye. Before sowing, an "onion bed" preparation should be given. Commercial fertilizers may be used as a starter. This crop may be turned under in late June and another humus crop can immediately follow. The cow pea, which is no pea at all but a bean, and very tender to frost, can also be sown for this purpose. Personally I have had no experience with the cow pea, but praises of its merit come from so many reliable sources that I intend to give it a trial the coming season.

How many seasons will it take for land to pass from the restoration to the maintenance period? I do not know. Very much will depend upon how low the fertility is in the soil when you begin. With fair nursing I have usually been able to get a paying crop on my own fields the second season, and on the third I have put the land to the clover test. Sometimes the catch of clover on the third year has not been satisfactory, and I have had to wait until the fourth, but in case of failure *I never allow the land to remain idle.* I have something growing that will make humus, whatever may be its fertility. On my home farm I always sow rye after taking off a crop of sowed grain, provided the field is not already seeded to clover. Rye sown after potato digging will endure the winter and give something to turn under in May. It usually pays me to sow clover between the rows of corn at the last cultivation. Crimson clover also is much praised for this purpose and I have found it good ; but I am surprised how well the common red clover will do. When sown during the last half of July it does not make as much fall growth as the crimson but it forges ahead in the spring.

These are some of my methods of keeping the soil hustling: always growing a crop for me or for itself. But these are not the only ways of adding humus. Every farmer must judge for himself what will be the best way to imitate nature's way of making soil, by adding humus to stone flour. One point I wish to make emphatic ; that is, the humus should be added only in small quantities. I have told you my experience in plowing under rye after it has headed out. I have heard that if a large green crop is plowed under there is danger that it may make the soil sour, particularly during the hot summers of the South. Of this I have had no experience. I have tried sparingly of lime, plaster and salt. In one of your leaflets you said that these are not direct fertilizers, since none of them supply nitrogen, phosphoric acid or potash to the plant, except indirectly, by making what is already in the soil more easily digested. My idea is that results from their use are not at all uniform, and where marked improvement fellows it is due to local conditions in the soil.

The part that commercial fertilizers play in my experiments is like that of kindling wood in starting a blaze. When planting corn fodder on my worn out fields I used what the manufacturers call a complete fertilizer, supposed to contain the three elements of plant-food which are needed most. When clover becomes a fairly sure crop, I know that the field has passed the restoration period and begun the maintenance period and I do not buy any more fertilizers containing nitrogen. The clover supplies me with that. My opinion is that I do not need to buy much potash either. It may be necessary in orchards, but for field crops I fancy I can unlock enough of the potash already stored in the soil by first class tillage. What I need most and must buy is phosphoric acid. My fields have been under cultivation upwards of forty years and I find that I get best returns from money invested in dissolved phosphate rock. I am speaking from personal experience now, and would not make my practice a general rule for others. Every farmer must cut and try and think out these problems for himself. In my earlier experience in farming, I spent some good money in commercial fertilizer; and when it brought me no returns, I blamed the manufacturer. It was not his fault but my own. That was before I became a tillage crank and put my land in "onion bed" condition.

Stable manure, when well cared for, is a friend that we can count on under nearly all conditions. The chemist tells us that it has only two to four dollars' worth of plant-food per ton. Perhaps that is all it may have in his own laboratory, but it is often worth more than that in the soil laboratory. I think it has value far beyond the plant-food it contains, because it has power to put in motion those "chemical activities" of the soil which we have been talking about. It is the best thing to give clover a start when the soil is near the uncertain line between restoration and maintenance. If I can have from four to eight loads per acre when seeding I can usually get a fair stand of clover. After turning the clover under and following with one hoed crop before seeding to clover again, I feel that I have about reached the top of the divide between restoration and maintenance.

I suppose a man who insists on exact use of words would object to the expression of a "dead" soil, but it means much to a farmer who has stood between the plow handles for many years. By "dead" I mean an absence of mealiness. It is a bad case when two to three crops of humus-makers will not make the soil mealy—I suppose you would say put in a friable condition. As I think of it, this friable condition is but another way of saying that the laboratory has been put in repair so that chemical activities can have full swing. No doubt the humus may have of itself some chemical action, but the repair of the laboratory is the main point with me.

What time of the year would I begin restoration experiments? I think that spring is the ideal time, but as a matter of practice I have begun mine mostly in the fall. It has come about this way. In the springtime I am hopeful, and I am inclined to excuse some of the past failures of a doubtful field as being due to unfavorable seasons. I think I will chance one more crop. But when harvest time comes, the results are the old story, and I find that there is no way but to begin the improvement of *the condition* of the soil laboratories at once. If the land has had a grain crop, I sow Canada peas and oats or barley immediately after harvest, using for kindling wood some commercial fertilizer. The peas and oats will grow until after frost, and perhaps remain green until it is too late for fall plowing; so I allow the vines to mat down under the snow and plow them under in the spring. If the land has had a hoed crop, I use my stand-by—rye; not because I think it the best, but because I can often find nothing else which will fit into the place and season. When my soil has got to the maintenance stage, I begin to feel as if I can think about using more freely of fertilizers.

We have given Peter's story because we believe it contains in simple form three of the first principles of successful farming—good tillage, rotation, humus-producing manures. *We want to start a movement for better tillage.* Try an acre, or a few rows of a potato field or corn field. Keep track of when you till it. Tell us the results in the fall. Of course you will use judgment; one can overdo anything. But tell us whether you think we are right in believing that these three things—tillage, rotation, humus—are the very foundation stones of good agriculture. If we were to add a fourth it would be good business management; but begin this season for a new experience of these three, and let us know the results.

We shall be glad if those farmers who contemplate trying these experiments in improving depleted soils, will write us so that we may register their names. We shall be glad to help them if we can.

L. H. Bailey Chief.
John W. Spencer, Deputy Chief.
Cornell Reading-Course Bureau.

JUNIOR NATURALIST CLUB,
— LESSON I —
OCTOBER 1, 1899.
Prepared by THE BUREAU OF NATURE-STUDY,
College of Agriculture, Cornell University, Ithaca, N. Y.

SEED TRAVELERS.

ALICE G. MC CLOSKEY.

Not many years ago, in a country which lies between the Baltic and North Seas, there dwelt a writer of stories named Hans Christian Andersen. He called his native land a "swan's nest," and I think that he was the most beautiful of all the swans that ever rested there. Junior Naturalists should become familiar with the "Household Tales" written by this Danish author, for by reading them you will learn to take pleasure in some of the common things about you.

How many of you have ever stopped to look at a burdock as you walked along a highway? I fear you think it is only a weed that could not possibly be interesting. Will you read Andersen's story of "The Happy Family" and find out how many delightful things he discovered by observing this common plant? If he had not noticed the burdock, he never would have seen the little white snails that lived beneath its broad leaves.

For the first lesson this year we are going to ask you to study seed travelers. Do not think because they are small and easily found that they will have no interest for you. Some seeds are wonderfully constructed and have remarkable ways of journeying from place to place. They float on the water, are carried by the wind, and slide on the snow. You may find it hard to believe, but many have been shot out of pods and sent long distances. Numberless seeds reach new homes by clinging to the clothing of people and the coats of animals. Do you not wish plants could talk so that we might hear the history of their travels?

Madam Dandelion would speak first, I suppose. You know she never hesitates to go where she pleases and remains as long as she likes, no matter how rudely she may be treated, so I am sure she would not be at all diffident in conversation. She would probably tell us that she had left her home last year in a balloon which her mother had given her. How she must have enjoyed sailing away, away over field and meadow, until she reached a sunny place where she would have plenty of room to grow. I would like to hear her tell how happy she felt when the warm spring days came, and she arose out of the earth clothed in a gay yellow gown, bringing brightness and cheer into the hearts of little children. Many grown folks, as well as the young people, greet her with a smile each spring, and once Lowell wrote a beautiful poem about this bright little blossom in which he said:

My childhood's earliest thoughts are linked with thee ;
The sight of thee calls back the robin's song,
Who from the dark old tree
Beside the door, sang clearly all day long,
And I, secure in childish piety,
Listened as if I heard an angel sing
With news from Heaven, which he did bring
Fresh every day to my untainted ears,
When birds and flowers and I were happy peers.

Yes, she is a pert little thing and is sometimes very annoying to the gardener, but no one would banish her altogether. Will you go out into the fields and find Madam Dandelion, so that you can learn from her how she sends her children abroad in balloons?

I wonder how many boys and girls know what sedges are? They look like coarse grasses and generally grow near ponds and in marshy places. The seeds of most sedges travel by water to reach new homes. Whenever I see them gliding along I feel like saying, "Where are you going, little akenes?" An akene, you know, is a small, dry, one-seeded fruit which does not break open when it ripens. The real seed is inside an outer covering and when there is a space filled with air between the outer covering and the seed, it can sail on quiet waters or drift with the current of running streams. Will you try and find as many sedge akenes as you can and send them to me? Anything that you can tell me of the mother plants will be of interest. I shall enjoy a description of the place in which they grow, and I shall also like to learn something about their neighbors. Do you think the pretty white water lily is one?

A great, burly immigrant which is found in some fields is worth a little study. It has been called a Russian thistle but it is really a tumbleweed. When I tell you that in about twelve years it has traveled from Dakota to New York, you may think it deserves to be spoken of as a "cross country runner." Will you tell me how you think this tumbleweed reached this country from its far away home near the Caspian Sea, and how it has managed to spread so rapidly in the New World?

Not many days ago I saw a Junior-Naturalist who didn't know that "stick tights" are seeds. They have been called "little tramps" and I think they deserve the name, for they wander from place to place, stealing rides on people's clothing or animal's fur whenever they get an opportunity. If you will look closely at one of these seeds, you will be able to see very plainly the tiny hooks with which it fastens itself to moving objects.

Sometime, when wandering along a roadside, you may see a small oak tree struggling to grow tall and strong like its ancestors, those brave old "kings of the forest." You may look for the parent tree, but as far as the eye can reach it is nowhere to be seen. How then did the little acorn travel so far? Keep your eyes open and some day you may discover a way in which this could happen. May be an old crow had started out to carry this acorn to his home. On the way he might have met a congenial friend whom he had not met for a long time. Now in a case like this, children, it seems to me that, on opening his beak the better to say, "Caw," the old chatterer might have dropped the acorn, and being interested in conversation he probably forgot it. If you ever have an opportunity, watch a flock of crows and see whether they might plant an oak tree in some such way as this. You may at the same time come across another little creature that carries acorns, but I shall not tell you his name. I shall just mention, however, that he has a saucy face, very bright eyes, and a warm-gray coat. He runs so rapidly that the most agile Junior-Naturalist would scarcely dare to compete with him in a race, and he can talk faster than any lassie in school. Do you think you will be able to find him and tell me his name?

I earnestly hope, boys and girls, that in studying seed travelers you will try and find many of which I have not spoken. In order to do this you will have to go out into the fields and woods where a great teacher is waiting for you. Patiently will she instruct you over and over again, so that whatever you may fail to learn in one lesson, you will acquire in some other. The work will be so interesting that you will be happy when you learn that in her books there are no last pages. When I read your letters I shall know whether you are really Nature's students. I shall consider that you have done excellent work if you find ten seed travelers and tell me a few facts about them. When your lesson is prepared, suppose you send the seeds to me and I shall give them to boys and girls in large cities who cannot go out into the fields in search of them. Will it not be a pleasure to help other members of the club in this way?

Junior Naturalist Club.

LESSON II.

NOVEMBER, 1899.

Issued under Chapter 430, Laws of 1899.

I. P. ROBERTS, DIRECTOR.

PREPARED BY

THE BUREAU OF NATURE-STUDY,

College of Agriculture, Cornell University,

ITHACA, N. Y.

THE STORY AN APPLE TREE CAN TELL.

It was the morning after All Hallowe'en that I wandered into the orchard and stood beneath the tree where the children had played mimic life during the vacation days. It had been the scene for picnics, high teas, receptions and doll parties, with some of the strife and friction of real society. The soap box, with a board through the middle for a shelf, that was a combination of china closet and pantry, was upset.

The clothes-line swing still hung from a lower limb, but the notched board used as a seat was gone. When the sharp rays of the midsummer sun came down, the wide branches of the tree gave a cool, protecting shade. While the children had their frolics, their bickerings, and "making up," the old tree was hard at work. Every hour of the twenty-four, day in and day out, week in and week out, it worked, not even having a picnic on the Fourth of July.

When you go to a factory and hear the noise of the machinery and see the whirling wheels, the gliding belts, and the army of employees moving briskly about like ants, you think that it is a busy place. Perhaps you are shown the unattractive raw material on one side of the factory and the finished product on the other, and you think what wonderful changes have been made.

The tree has been just as busy a place during all the long summer days. I doubt if the tallest Junior Naturalist could lift and carry the product it has manufactured during that time—I mean the new wood and foliage that has grown since spring.

The idea that a tree works may be a new one to you ; and if so, it is because the tree has made no noise while at work, and you have not yet learned to listen with your eyes. I wish you to look upon this tree as a real living thing having life like yourself, and having a care for its future welfare. It can tell a story about itself that is just as interesting as any old soldier or sailor can tell. When you have made its acquaintance and listened to its story, I am sure that you and the old apple tree will be the best of friends ever after.

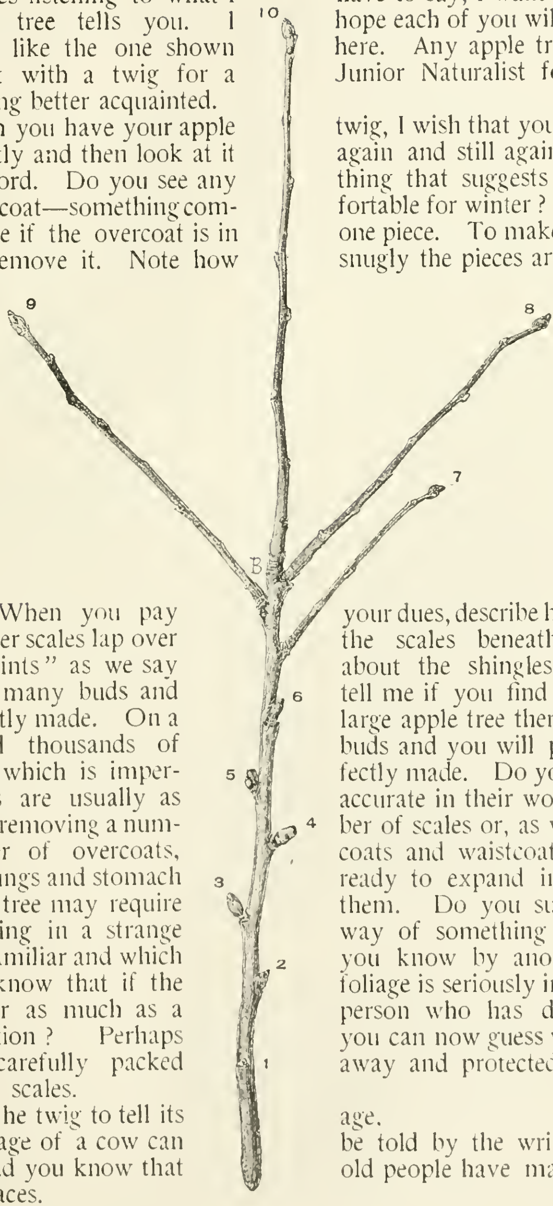
It was raining when I entered the orchard. The drops fell thick and fast, and as some struck pools of water there splashed up cup-shaped waves that settled back in expanding rings. I saw that the tree was no longer at work, but had gone into a profound sleep from which it will not awaken until the warm days of spring. Plain for all eyes to see, however, was the finished product, and I wondered how many of my boys and girls would appreciate the skill shown in the workmanship.

There is a great principle in nature which I wish to impress upon your minds. I hope you will learn it, for if you do you will be able to see the reason for many things when you listen with your eyes. It applies to all forms of life, both animal and vegetable, even to you and me. It is this : *there is a constant struggle for existence.*

Our friend, the apple tree, understands this very well, and all his hard work during the past summer has been expended in preparing for the future. It seems to have known that a cold and trying winter was coming ; that it must stand out there alone many sharp and frosty nights when the snow squeaks beneath the feet and the stars sparkle in the clear sky ; that it must endure many cold rains which will cover its branches with ice for the strong wind to use as whip-lashes.

It also seems to have known that the next spring when it wakens and enters upon another busy summer, its first want will be a breakfast; and that a breakfast will be of no value unless it has a stomach and lungs. Yes, the tree certainly seems to know all these things and after providing them, has given them protection against the hardships of winter.

Besides listening to what I have to say, I want you to hear what the tree tells you. I hope each of you will find a twig something like the one shown here. Any apple tree will willingly part with a twig for a Junior Naturalist for the sake of becoming better acquainted.



When you have your apple twig, I wish that you would look at it intently and then look at it again and still again before you speak a word. Do you see any thing that suggests a tiny wool or fur overcoat—something comfortable for winter ? Look again and tell me if the overcoat is in one piece. To make sure, take a pin and remove it. Note how snugly the pieces are packed together. When you pay your dues, describe how the edges of the outer scales lap over the scales beneath them, or "break joints" as we say about the shingles on a roof. Examine many buds and tell me if you find any that are not perfectly made. On a large apple tree there are thousands and thousands of buds and you will probably not find one which is imperfectly made. Do you think that carpenters are usually as accurate in their work ?

After removing a number of scales or, as we may say, a number of overcoats, coats and waistcoats, you will find the lungs and stomach ready to expand into full size when the tree may require them. Do you suspect that I am speaking in a strange way of something with which you are familiar and which you know by another name ? Do you know that if the foliage is seriously injured, a tree will suffer as much as a person who has dyspepsia or consumption ? Perhaps you can now guess what the tree has so carefully packed away and protected by woolly and furry scales.

Ask the twig to tell its age.

The age of a cow can be told by the wrinkles on her horns, and you know that old people have many wrinkles in their faces.

Look at the picture and note the wrinkles shown at B. Have you ever learned what caused them? That was the location of a terminal bud last winter, and next summer there will be wrinkles where bud 10 now is. All the length of the twig from B to 10 was made by the tree during the past summer when it was so busy.

Now, instead of looking at the picture, will you examine a real twig, begin at the terminal bud, and trace its length until you find some wrinkles? The little twig grew that much longer this year. If you are fortunate enough to have one which has had abundant sunshine, you will probably find another set of wrinkles farther back which will show you the length of growth made the summer before. I have been able to count five or six years of growth on some twigs. If you will compare the one you have with several others, you will find that they have not all grown the same length during the past season. What do you suppose has been the cause of this? It may be that the difference could be explained in many ways, but the most probable one is that the twigs which made the greatest progress had the most sunshine. The leaves, in order to do their work well, must also have abundant sunshine baths—bright light and not shaded light.

All the terminal buds that you see on an apple tree have great ambitions for the future, just as I hope each Junior Naturalist has. The bud hopes to become a twig and grow into a branch, and if it can reach out into the sunshine it usually succeeds; but many buds do not find the full sunlight, and these disappointed ones may become fruit buds. They are short and thick and are borne upon what are known as fruit spurs. Some buds—poor things!—receive so little light that they become completely discouraged and disappear altogether. Look at the picture and carefully note buds numbered 3, 4, 5 and 6. These are probably disappointed buds and in a few years will be only short spurs.

I hope that every Junior Naturalist will visit an apple tree, break off a twig and study it carefully. When you have written the story which it tells, will you send the little twig to me? The story it will tell me is that my boys and girls have studied the thing itself, as real naturalists should, and have not depended on books or leaflets for information which can be obtained directly from nature.

ALICE G. McCLOSKEY.
JNO. W. SPENCER.

December, **1899.**

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VOL. I. CORNELL UNIVERSITY, ITHACA, N. Y. NO. 3

HOW WE SHALL PLEASE ST. NICHOLAS.

SUPPOSE on the eve of the 24th of December, St. Nicholas should pop his head in at my door and say: "Merry Christmas, Uncle John! I have come to find out what your Junior Naturalists have learned about wind and ice and snow and evergreens." Do you not believe that he would be very much disappointed if we had forgotten to study the very things in nature that he enjoys most? Let us work hard during the cold December days, so that Uncle John may be proud of all that his boys and girls have done; for then the jolly old face will be a welcome sight.

The wind is one of Nature's strongest children and many a hard task it accomplishes. Watch carefully and see if you can discover how it works and what are the results of its labors. From your observations from time to time near your own home, let me know what effect you think it might have on the ocean or on a desert. I want you also to learn to love the music of the wind for, as you grow older, you will find that "it is a voice that never sings false. You are never small when you listen to it."

Jack Frost seems to be just a nimble little sprite, so I am sure you have no idea what a strong fellow he is. Perhaps you know that he can break a pitcher or a bottle, which is not a difficult thing to do; but did you ever hear that sometimes he becomes a powerful giant and can pry great rocks apart? How does he do these things? I wonder if you can tell me.

I hope you have seen his marvellous pictures. I read once, and know it is true, that:

"He went to the windows of those who slept,
And over each pane like a fairy crept.
Wherever he breathed, wherever he stept,
By the light of the moon were seen
Most beautiful things. There were flowers and trees
There were bevies of birds and swarms of bees,
There were cities, thrones, temples and towers; and these
All pictured in silver sheen."

Will you look for some of Jack Frost's sketches on your windows and tell me something about them?

Study whenever you can the dainty little snow crystals which fall on your clothing, as

"Silent and soft and slow
Descends the snow."

Do you wonder that the blanket with which nature covers all her sleeping plants is so beautiful, as we see it crossed and recrossed by the shadows of the leafless trees, when you find how pretty are the tiny flakes with which it is made? Jack Frost designed every one, and no two are alike.

How I wish I might be with you when you go in search of evergreens! What a merry party it would be! The smallest Junior Naturalists would be close beside me, so that occasionally I might pat each tiny head, while the older boys and girls discussed with me some of the old-time customs with which evergreens are connected. We would recall how, for many centuries, the youths and maids of England have brought home the yule log* from the forest to cheer the Christmas hearth. It would amuse us to speak of the old-time folks who hung holly wreaths in the windows to scare the witches away; and the queer people who were careful to dispose of all the Christmas greens immediately at the close of the holiday time, because after that the one who stepped on a spray, or even a leaf, would behold a dreadful goblin.

Some rosy cheeked lassie or bright eyed laddie would be sure to ask me why so many trees are leafless in winter, while evergreens are not. You will be unable to understand an explanation of the first question until you are older and can learn, with the aid of the microscope, a little of the mysterious story which Mother Nature has hidden in a leaf. I would

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* Do you know that the burning of the yule or Christmas log grew out of a custom which was established long before the birth of Christ? The custom originated among certain people called Teutons who, during the winter solstice, burned a log of oak. It was their belief that the longer it could be kept burning as the length of the days increased, the greater would be their prosperity. Old time customs are difficult to give up so the burning of the log became a part of the Christmas festivity, and was called the yule log.

probably answer by saying that the material taken in by the roots of the tree, is lifted up into the leaves and other green parts where it is manufactured into starch. Since all the moisture which rises is not needed in these factories, there are little pores in the leaves through which some of it may pass out. In the cold winter weather the tree loses all of its vital activity, so the little unused factories become ruins and tumble to the ground. We may not be able to learn from evergreen trees just why they wear their summer suits all winter. In the distant future, some Junior Naturalist, grown to be a Senior, may find some reason for it.

It certainly would be delightful if I could go with you, for, besides having a jolly time, I believe I might find out something which I am very anxious to know. Maybe you will help me.

In many places in the United States live relatives of two very dear friends of mine. I would like to learn just where I can find them. These friends are pine trees—very old fellows—living close together since Washington took command of the Continental Army. One is a pitch pine and the other is a white pine. They have seemed good comrades since I have known them, the roots of each taking food from the same soil, receiving rain and sunshine from the same skies, and each wearing his own green needles in his own particular way. I have known sleepy boys and girls to put on a stocking in the morning wrong side out, but rarely has the pitch pine failed to put out three needles from a sheath, or the white pine five. All the years that they have lived, they have been counting out needles—one three, the other five,—and one must be very patient in his search if he finds that they have made a mistake in arithmetic. Are we as accurate in our work in numbers—you and I? When I was a youngster I could always remember the difference between the pitch pine and the white pine, because in the latter I could bunch the needles up and make what looked to me like a broom, but in the former the needles stood out so stiffly that they were more like quills on a porcupine's back.

Do you believe pine trees ever shed their leaves? If you look closely along their branches, you will see many places where once the little leaf sheaths rested; and you will then learn where Mother Nature finds material for her thick pine needle carpets.

So many kinds of evergreens are there that if you were to remain in the woods long enough to study them all, I fear Jack Frost would claim you for his own. I am too fond of my Junior Naturalists to give them up to any such mischievous sprite as he; so scamper about as lively as possible, and secure a branch and cone from each green tree.

What kind of pine is this ?

These you can study at home or in school where, if Master Jack does venture in, he will not remain long. You can there learn the names of your specimens by consulting the leaflet, "Evergreens and How They Shed Their Leaves," which we have sent to your teacher.

Before leaving you, my dear boys and girls, I want to wish you a Merry, Merry Christmas. Let the St. Nicholas spirit enter your hearts, bringing with it the knowledge that the highest happiness is found in giving pleasure to others. No greater joy can come to any of us than to feel that the world is a little better—that more brightness and cheer have entered some homes—because we have lived.

ALICE G. MCCLOSKEY.

JNO. W. SPENCER.

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VOL. I. CORNELL UNIVERSITY, ITHACA, N. Y. No. 4

OXYGEN AND CARBON IN PARTNERSHIP.

The stories told of the power of fairies, sprites and elves are the source of never-ending interest to boys and girls. I remember the days when I rejoiced in the victory which Cinderella had over her haughty sisters. How wonderful in my mind was the fairy who transformed the lowly maiden into a beautiful princess, a pumpkin into a chariot and four tiny mice into prancing steeds!

In your study of nature, I want you to learn something of the unseen forces that are about us all the time; forces as great, as powerful and as swift in transformation as could possibly be exerted by a fairy wand. These forces are with us every day. It is true we cannot see or hear them, taste or smell them, nevertheless they are ever present—as strong as the greatest monster, as powerful as the mightiest engine.

This is especially true of a life-giving element with which each Junior Naturalist should become familiar. If an unusual amount of it gets into the blood, it will make it tingle; your eyes will brighten and your cheeks turn red, and sometimes it will send you skipping along the path as though the ground were hot beneath your feet. Without it all animal life would cease to exist; no fires would burn; all things would fade and die.

I fancy if I should call this element "Hokey Pokey," you would be much better pleased than if I should give you the name by which the chemist knows it, for then you might think of it as some amusing little sprite. As you are to be young naturalists, however, you must put on some of the airs of scientists and begin to learn a few things by their true names.

I shall give you but one this time and that is a short one. It is oxygen. I wish you to learn that it belongs to a class called simple substances. A simple substance may be divided into large or small quantities, but each will still be the same substance. There are many substances which we call compounds, that can be taken apart, as milk. A chemist can do it. In one dish he can put the cheese curd, in a very small dish the sugar, and in the largest dish the water—all coming from a quart of milk.

If the subject can be made easy for you to understand, I think you will find pleasure in observing how simple substances go into partnership to make compounds.

Let us begin to make the acquaintance of oxygen. It is a great friend of ours when properly controlled, but if once allowed the opportunity, it is more powerful than all the giants you can imagine. An interesting thing about it is that with all its capacity for power, it can do nothing alone. Without a partner, it is as incapable of accomplishing anything as one-half of a pair of shears. We find as we study oxygen that it seems to revel in partnerships, and with marvellous rapidity it will abandon an old one to enter a new one. This entering into new partnerships and breaking up old ones is something in which I hope you will become interested, for it lies at the foundation of chemistry. The chemist would speak of the partnership as a compound, and to keep him good-natured, we must begin using some of his words.

That you may see with your own eyes oxygen entering into a compound (partnership) with another element, we will try an experiment. The easiest way to obtain oxygen is from the air of which it forms about one-fifth. I think we will make the other partner carbon. Charcoal is one form of carbon, and the wax in a candle contains carbon; as the latter is the handier and the cleaner, we will use the candle. With a lighted match, we will heat the end of the candle, which furnishes the carbon, and the oxygen in the air begins the partnership.

Perhaps you think it is only guess work that there is oxygen in the air. We shall see whether it is or not. Put the lighted candle on a piece of blotting paper and a lamp chimney over it, as you see in Fig. 1, and do not forget to give a little air space at the bottom of the chimney. Notice how the partnership continues the same as before. If anything, the lamp chimney has made the partnership go on a little faster. Why this is so is a good question for all Junior Naturalists to find out for themselves. Perhaps you will observe some reasons for this if you remove the two lead pencils and place the chimney close to the blotting paper. Watch carefully and see the partnership wane, just because the supply of oxygen has been lessened. Next, put a sheet of blotting paper over the top of the chimney, shut off all supply of oxygen and see what will happen.

The light has gone out. The partnership has ceased because the share that oxygen was required to add could not be supplied. In the bottom of the lamp chimney is a com-

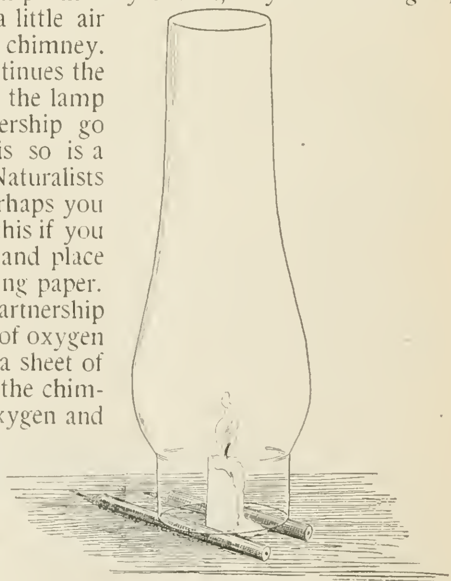

Fig. 1.

pound. It is not oxygen or carbon. A little mouse dropped into this compound would die. It could breathe the compound but it would do no good, and it would die in the same way that it would if it were plunged into a pail of water. The cause of death in each case might be called drowning. Chemists have named this compound carbon dioxid. The word "di" means two, and has been slipped in between the words carbon and oxygen to denote that oxygen put twice the amount into the compound as did carbon. Do you think you can now explain to your parents how a candle burns?

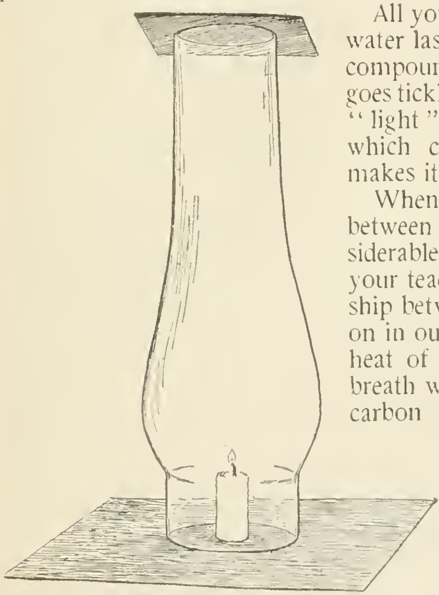

Fig. 2.

All you boys and girls who drank soda water last summer are familiar with this compound carbon dioxid. It sometimes goes tickling up your nose. Bread is made "light" by means of the carbon dioxid which crawls through the dough and makes it full of bubbly holes.

When the partnership was going on between the candle and the oxygen, considerable heat was given off. Perhaps your teacher can tell you if any partnership between oxygen and carbon is going on in our bodies; how it is done; if the heat of our bodies is due to that; if the breath we send out from the lungs is not carbon dioxid, and if a little mouse would die if shut up in it.

Very little people will be unable to understand this lesson, so Uncle John will not expect them to write about oxygen, carbon and carbon dioxid. He knows that they like better to study about real live things, but during the winter weather it is hard to find some of Mother Nature's most interesting children; she has either sent them to warmer lands, or tucked them up cosily in bed where they cannot feel the cold.

"Bob-o'-Lincoln-oh, so wise!*
Goes to sleep 'neath summer skies,
'Mid the leaves.

Mr. Bruin, night and day,
Snoozes all his time away,
In his cave!

Squirrel Red with nuts—a store!
In hollow tree-trunks loves to snore,
In the wood.

Mrs. Woodchuck 'neath some knoll,
Drowses in her bed—a hole!
Deep in earth.

* A. F. Caldwell in Youth's Companion.

Floweret bulbs nestled together,
Doze all through the wintry weather
'Neath the snow.

In the chrysalis hard by,
Dreams the sometime butterfly,
In corner hid."

We shall be patient and not disturb their slumbers, you and I, for if we should they might not be sociable. I learned this once when, digging deep into the earth, I came across an old toad. Months before he had backed down to a place which he thought would make a warm bed. Such a sleepy old fellow as he was! Do you think he would tell me his history? Why, I could not coax him to show the least interest in life. I could hardly be sure that his usual smile was there. For this reason I think we shall wait for Mother Nature to arouse all our old favorites, and in the meantime there is something you can study that will please me very much.

I want you to look for some forsaken birds' nests which I am sure many of you pass on your way to school. You will be surprised to discover how many things can be learned from one of these tiny homes. It will tell you how hard the mother and father bird worked to make a substantial dwelling place for their children. Notice the material used in its construction. Where did the little creatures find it all? How long do you think it took them to build it? Ah, you were not naturalists last year, perhaps, so you cannot answer these questions. Those sweet-voiced friends of ours, now swinging on leafy boughs in southern lands, would be very much surprised if they could only know how eagerly they will be watched next spring by our boys and girls. No harm will come to the little architects and builders because of this interest on your part, I know, for real naturalists are never cruel or thoughtless.

Remember while preparing this lesson that nests are not always built high up in the trees. Robin Redbreast may prefer such a location but many seem to like better a more lowly dwelling place.

Uncle John will be very much pleased if each Junior Naturalist succeeds in finding a deserted bird's nest. He will want to hear all that you can tell him about it, particularly the size, shape, material of which it is made, and where it was found.

ALICE G. MCCLOSKEY.

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WAITING FOR THE BIRDS.

The springtime belongs to the birds and me. We own it. We know when the Mayflowers and the buttercups bloom. We know when the first frogs peep. We watch the awakening of the woods. We are wet by the warm April showers. We go where we will, and we are companions. Every tree and brook and blade of grass is ours; and our hearts are full of song.

There are boys who kill the birds, and girls who want to catch them and put them in cages; and there are others who steal their eggs. The birds are not partners with them: they are only servants. Birds sing for their friends, not for their masters. I am sure that one cannot think much of the springtime and the flowers if his heart is always set upon killing or catching something. We are happy when we are free; and so are the birds.

The birds and I get acquainted all over again every spring. They have seen strange lands in the winter, and all the brooks and woods have been covered with snow. So we run and romp together, and find all the nooks and crannies which we had half forgotten since October. The birds remember the old places. The wrens pull the sticks from the old rail, and seem to be wild with joy to see the place again. They must be the same wrens that were here last year and the year before, for strangers would not make such a noise over an old rail. The bluebirds and wrens look into every crack and corner for a place in which to build, and the robins and chipping-sparrows explore every tree in the old orchard.

If the birds want to live with us, we should encourage them. The first thing to do is to let them alone. Let them be as free from danger and fear as you or I. Take the hammer off the old gun, give pussy so much to eat that she will not care to hunt for birds, and keep away the boys who steal eggs and who carry sling-shots and throw stones.

Bird houses.—For some kinds of birds we can build houses. Although birds may not appreciate architecture, it is well to make the houses neat and tasty by taking pains to have the proportions right. The floor space in each compartment should be not less than five by six inches, and six by six or six by eight may be better. By cutting the boards in multiples of these numbers, one can easily make a house with several compartments; for there are some birds, as martins, tree-swallows and pigeons that like to live in either families or colonies. The size of the doorway is important. It should be just large enough to admit the bird. A larger opening not only looks bad, but it exposes the inhabitants to dangers of cats or other enemies. Birds which build in houses, aside from doves and pigeons, are bluebirds, wrens, tree-swallows, martins and sometimes the chickadee. For the wren and chickadee the opening should be an inch-and-a-half augur hole, and for the others it should be two inches. Only one opening should be provided for each house or compartment. A perch or door-step should be provided just below each door. It is here that the birds often stop to arrange their toilets; and when the mistress is busy with domestic affairs indoors, the male-bird often sits outside and entertains her with the latest neighborhood gossip. These houses should be placed on poles or on buildings in somewhat secluded places. Martins and tree-swallows like to build their nests twenty-five feet or more above the ground, but the other birds prefer an elevation less than twelve feet. Newly made houses, and particularly newly painted ones, do not often attract the birds. Birds do not build in houses made of green lumber. Make the houses in February and March, and let them season.

Watch the Birds.—But if the birds and I are companions, I must know them more intimately. Merely building houses for them is not enough. I want to know live and happy birds, not dead ones. We are not to know them, then, by catching them, nor stuffing them, nor collecting their eggs. Persons who make a business of studying birds may shoot birds how and then, and collect their eggs. But these persons are scientists and they are grown-up people.

Boys and girls should not make collections of eggs, for these collections are mere curiosities, as collections of spools and marbles are. They may afford some entertainment, to be sure, but one can find amusement in harmless ways. Some people think that making collections makes one a naturalist, but it does not. The naturalist cares more for things as they really are in their own home than for museum specimens. One does not love the birds when he steals their eggs and breaks up their homes; and he is depriving the farmer of one of his best friends, for birds keep insects in check.

Then let us go to the fields and watch the birds. An opera-glass or spy-glass will bring them close to you. Try to find out not only what the colors and shapes and sizes are, but what their habits are. What does the bird eat? How much does it eat? Where is its nest? How many eggs does it lay? What color are they? How long does the mother bird set? Does the father bird care for her when she is setting? For how long do the young birds remain in the nest? Who feeds them? What are they fed? Is there more than one brood in a season? Where do the birds go after breeding? Do they change their plumage? Are the mother birds and father birds unlike in size or color? How many birds do you know?

These are some of the things which every boy or girl wants to know; and we can find out by watching the birds! There is no harm in visiting the nests, if one does it in the right way. I have visited hundreds of them and kept many records of the number of eggs and the date when they were laid, how long before they hatched, and when the birds flew away; and the birds took no offense. These are some of the cautions to be observed: watch only those nests which can be seen without climbing, for if you have to climb the tree the birds will resent it. Make the visit when the birds are absent if possible; at least, never scare the bird from the nest. Do not touch the eggs or the nest. Make your visit very short. Make up your mind just what you want to see, then look in quickly and pass on. Do not go too often, once or twice a day will be sufficient. Do not take the other children with you, for then you are likely to stay too long and to offend the birds.

Soon your teacher will receive a leaflet telling the kinds of birds that come with the opening of the spring.

L. H. Bailey.

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THE COMING OF SPRING.

While looking out of my window at the snow-covered fields and frozen stream and listening to the roaring of the wind, I can scarcely believe that spring is near. Spring enters our world so slowly and quietly that rarely are its first footsteps heard. Will our Junior Naturalists listen for them this year? Will they know when the hepatica first lifts its head, when the brook sings its first song, and when the first green leaves unfold? If so, spring will not take them unawares—they will be waiting.

Who in your club will find the first hepatica, I wonder! Will it be John or Tom or Henry or Nell! Nell is a bright little girl and unless the boys look out, she will find one some morning before they are up. These small blue or purple blossoms, which many of you call Mayflowers, sometimes appear before the snow has gone. I was told once that anemones (the little wind flowers) are the first to blossom. I hardly think this possible. They always stand so erect on their slender stalks, that it seems to me they would be injured by the cold more than the lowly hepaticas lying close to the earth. However, I am not sure which is the earlier, and will ask you to find out for me. For your dues, describe the first wild flower you find, and tell us where you found it.

A little plant is a wonderful thing. It takes its place in the world in such a modest way that we usually treat it with indifference, but the commonest flower or plainest weed has a most interesting life story if we only knew it. Begin with the tiny seed which dropped to the ground last fall. Already the little plant inside the seed was prepared to send its root down into the soil, its stem up into the bright world. For days and days it will work. The stem will grow higher and higher, and the leaves will appear. Have you ever looked closely at a leaf? You will not wonder, when you do, that it was not made in a day. Where did these stems and leaves come from?

Occasionally I take the whole plant home with me, having first noticed whether the soil in which it grew is similar to that in my garden. A good many little strangers have entered my gate in this way. They are now thrifty plants, so I think they found their new home comfortable. Can you not make a garden in this way? Try it.

Robert Burns, the poet, loved birds and flowers, and talked to them while working in the fields. One day he was obliged to turn a daisy down with his plow. He did not pass it unnoticed, but has told in a poem "To a Mountain Daisy" something about its life."

> "Cauld blew the bitter, biting north
> Upon thy early, humble birth;
> Yet cheerfully thou glinted forth
> Amid the storm,
> Scarce rear'd above the parent earth
> Thy tender form."

He shows that he appreciated the difficulties under which it had struggled to fill its humble place in the world. It was not shielded as are many plants, put obliged to push its "tender form" up through the stony soil. Notice where a plant grows when you find it.

Another poet says:

> Hast thou named all the birds without a gun?
> Loved the wood-rose, and left it on its stalk?
> * * * * * *
> O, be my friend and teach me to be thine.

Will you then write to Uncle John telling him how your work is progressing and giving as nearly as you can the history of each flower you find in March and April? Where does it grow? In what kind of soil? Tell something about the stem, the leaves and the blossoms. If the flower is scarce near your home, I hope you will tell me that you studied it and "left it on its stalk."

Before next June I hope you will write about some of my old favorites: Jack-in-the-pulpit, columbine, anemone, hepatica, trailing arbutus, wild geranium, Indian pipe, adder's tongue and many others. You cannot find them all at once. In fact it may be several days before you find any. In the meantime I want you to think about another topic for study which I shall suggest.

* * *

Near my home there is a noisy little creek which will soon begin its spring work. Day after day, year after year, I have watched it rushing along on its way to the river; yet it always has something new to tell me, some new song to sing. I have never traced it to its source, but somewhere on the mountain side it began its young life many years ago. It flows through a narrow valley, rather steep banks rising on either side. Do you think Nature made this channel so that it might have a place in which to run easily along? No. Starting on the hillside, the little stream began to work away as if it knew that it must. From the way it rushes onward I cannot help thinking it is ambitious to become a Mississippi some day, or for all I know, it may have aspirations toward being an Amazon.

Young streams sometimes have very hard tasks. If you were with me on a summer day, you would hear my little creek making a great noise about a piece of work it has to do. Standing in its way is a hard layer of rock—so hard that Junior Naturalists would have to hammer with all their strength to break a piece. The stream did not turn back when it found this rock. No; it just tumbled over and is now doing its best to get it out of the way. The more the little waterfall tumbles the better pleased I am. I love to hear it.

Now, I have told you that a stream broadens and deepens its own valley and that it grinds off hard rocks which it finds in the way. Naturally you will think that, in order to grind, it must have tools with which to work. Of course it does, but as a description of the tools used by streams is to be a part of your next lesson, I shall not tell you anything about them. What are they?

I wish you would watch a brook or river at work. You will see it wearing away the land and carrying a load of rock material down stream. Sometimes it will try to carry too much at once and will be obliged to leave some of it along the way. River bars which are so annoying to captains of river steamboats, are formed in this way. They disappear, however, as soon as the stream is strong enough to remove them. The older Junior

Naturalists have probably read and studied about flood plains and deltas. If you care to know how they are formed, any stream near your home will show you. When the water is high in the spring, flood plains are being built and when it recedes new soil will be found on either side.

Do you know how the soil came to be deposited there? If you place a toy village close to a stream in winter, what will happen to it in spring? How could you protect it? A very tiny brook will show you why levees are built along the Mississippi river. Let us know all that you can find out about a stream: whether it flows in a straight line or whether it meanders from side to side; what materials it carries; the tools it uses in carving out its valley. If your father is a farmer or fruit-grower, ask him what he does to prevent soil from being washed away.

* * *

There are some of our boys and girls in large cities who never have an opportunity to walk in the woods or to ask for the story which a meadow brook can tell. I wonder if, for their dues, these children will try egg-shell farming? Secure an egg-shell, nearly fill it with soil, and plant radish seeds. I am sure you will enjoy watching the little plants when they come up. They will have many pretty ways. The one which interests me most is its habit of turning toward the sun. If you make two farms and let one grow in the light and the other in the dark, you will learn why they do this. Tell us two decided differences which you can see in the appearance of your little farms.

ALICE G. McCLOSKEY.

April, 1900.

Junior Naturalist Monthly.

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VOL. I. CORNELL UNIVERSITY, ITHACA, N. Y. NO. 7

THE FOUR CHAPTERS IN AN INSECT'S LIFE.

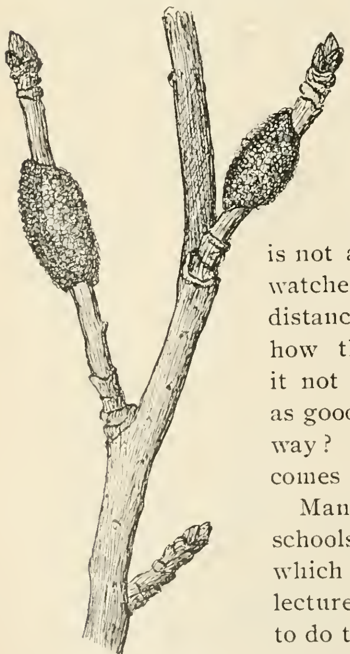
IN April and May is a good time to begin the study of insects. You will not be expected to remember uninteresting facts. I shall not even ask you to learn that in order to be an insect a creature must have six legs, a pair of feelers (antennæ) and usually, when fully grown, one or two pairs of wings. Of course, this knowledge would be valuable to you on many occasions. For instance, when you see a spider you could tell him that he cannot be an insect for he has too many legs; while you would be able to inform any "thousand-legged worm" which you might happen to meet that his case is even more hopeless.

I wish you would write the history of an insect this year; not as you read it in a book, but as the insect tells it to you. Some of the histories can be written in two chapters, but these are not the most interesting. Katydid's is longer. From the way she monopolizes the conversation evenings, one would think she is the only creature in the world that ever existed as an egg, a nymph and a fully grown insect. You probably do not know what a nymph is, but katydid or a grasshopper or a cicada will tell you some day. They are a noisy folk—these three insects—and it is a good thing for us that their history is limited to three chapters. Just imagine how they might chirp and chatter and sing if they had four periods in their life story as the tent-caterpillar has!

The insects which pass through four stages in their lives are so wonderful that I consulted Mother Nature as to the best way in which our Junior Naturalists could learn about them. She told me that a course of lectures is to be given by the apple-tree tent-caterpillars. I can assure you that they are very competent to instruct young naturalists. They give their story in a simple, unaffected manner and have a way of raising their heads as they proceed with their discourse which is very impressive.

I must not neglect to tell you that the lecturers are always accommodating. If you are unable to spend your time in the orchard, they will cheerfully allow you to conduct them to the school-room, where they will entertain you for several days. They always provide their own lodging and clothing, but will, of course, expect board in return for their services.

When you undertake to provide these caterpillars with a daily banquet of apple or wild-cherry leaves, you will find it no easy task. They are very hungry creatures. For this reason the farmer is anxious to get rid of them, and who can blame him? Not I; even though I appreciate how much they can teach young people about insect life. You see these greedy caterpillars are destroying the foliage of the apple trees—the starch factories which you have learned are so important to the welfare of the trees. I think that you and I will have to work hard to prevent them from remaining in the orchards.



The eggs, laid in masses.

Notice the silken thread which the caterpillars spin as they wander away from their tents. I have spoken of this for I think it is one of the points in the lecture which is not always clearly seen. When I have watched the small creatures traveling long distances from their home, I have wondered how they found their way back. Does it not seem as if this silken thread were as good as a foot-path in pointing out the way? See if you can learn where the silk comes from.

Many instructors in colleges and high schools provide the students with notes which aid them in understanding the lectures. The caterpillars will not be able to do this, so I shall give a few suggestions which will help you.

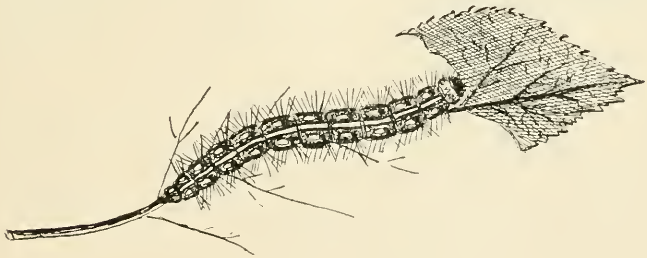
CHAPTER I.

The Eggs.

Where found. When. How protected from cold and storm. Why they should not be taken into the school-room until the leaves appear. Why easily destroyed in this stage.

CHAPTER II.

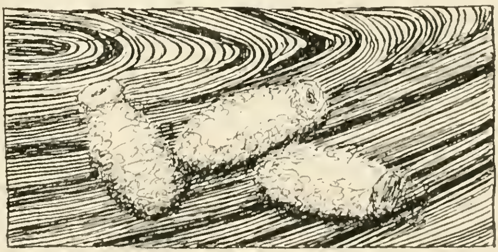
The Larva.



Number of caterpillars which hatch from the egg mass. Size when first hatched. Tent. What will happen if tent is removed. Notice how often they change their coats. Markings and color of coats. The silken thread which they spin as they travel. Where the silk comes from. The time they feed in the school-room. When they eat out of doors.

CHAPTER III.

The Pupa.



How the cocoons are made. Where they are made. Open cocoon. Note changes. Why easily destroyed. Note that the cocoon covers the pupa.

CHAPTER IV.

THE MOTH.

Date of appearance. Size. Color. Markings.

* * *

The full grown insect (*somewhat enlarged*).

If there is any other insect which you can get more easily than the tent-caterpillar, you may write about it for your dues. Perhaps you have already seen the Mourning-cloak butterfly, and it may have an interest for you. I am sure you admired the pretty dark-purple mantle with its cream-colored border. All winter this butterfly lived in some protected nook and it was one of the very first messengers of spring. It lays its eggs in clusters around a twig of an elm, a poplar, or a willow tree as soon as the leaves appear. If you do not find the eggs, you will probably have no difficulty in seeing the larvæ or caterpillars later in the season. You may look for them about the middle or latter part of May. They are black spiny creatures dotted with white and have a row of red spots down the middle of the back. Take some of them home, feed them well and they will, I think, tell you the rest of their story.

* * * * * * * * * *

Are you still looking for wild flowers? A spray of "Shepherd's purse" peeped up at me to-day and I wondered how many Junior Naturalists have seen one in blossom this year. It seems to me that every letter you write should contain one paragraph about spring plants.

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A Children's Garden.

WE want every school child in the state to grow a few plants this summer. We want everyone of them to learn something of why and how plants grow, and the best and surest way to learn is to grow the plants and to watch them carefully. We want everyone to become interested in everything that lives and grows. It does not matter so very much just what kinds of plants one grows, as it does that he grows something and grows it the best that he knows how. We want the children to grow these plants for the love of it,—that is, for the fun of it,—and so we propose that they grow flowers; for when one grows pumpkins and potatoes, and such things, he is usually thinking of how much money he is going to make at the end of the season. Yet, we should like some rivalry in the matter in every school, and we therefore propose that a kind of a fair be held at the school house next September, soon after school begins, so that each child may show the flowers which he has grown. What a jolly time that will be!

Now, we must not try to grow too many things or to do too much. Therefore, we propose that you grow sweet peas and annual phlox. They are both easy to grow, and the seeds are cheap. Each one has many colors, and everybody likes them. Now let us tell you just how we would grow them.

1. *The place.* Never put them—or any other flowers—in the middle of the lawn,—that is, not out in the center of the yard. They do not look well there, and the grass roots run under them and steal the food and moisture. I am sure that you would not like to see a picture hung on a fence-post. It has no background, and it looks out of place. The picture does not

mean anything when hung in such a spot. In the same way, a flower bed does not mean anything when set out in the center of a lawn. We must have a background for it, if possible,—a wall upon which to hang it. So we will put the flower bed just in front of some bushes or near the back fence, or alongside the smoke-house, or along the walk at the side of the house or in the back yard. The flowers will not only look better in such places, but it will not matter so much if we make a failure of our flower bed; there are always risks to run, for the old hen may scratch up the seeds, the cow may break into the yard some summer night, or some bug may eat the plants.

Perhaps some of the children may live so near to the school house that they can grow their plants upon the school grounds, and so have sweet peas and phlox where there are usually docks and smartweeds. Grow them alongside the fence, or against the school house if there is a place where the eaves will not drip on them.

2. *How to make the bed.*—Spade the ground deep. Take out all the roots of docks and thistles and other weeds. Shake the dirt all out of the sods and throw the grass away. You may need a little manure in the soil, especially if the land is either very hard or very loose and sandy. But the manure must be very fine and well mixed into the soil. It is easy, however, to make sweet pea soil so rich that the plants will run to vine and not bloom well.

Make the bed long and narrow, but not narrower than three feet. If it is narrower than this, the grass roots will be apt to run under it and suck up the moisture. If the bed can be got at on both sides, it may be as wide as five feet.

Sow the seeds in little rows crosswise the bed. The plants can then be weeded and hoed easily from either side. If the rows are marked by little sticks, or if a strong mark is left in the earth, you can break the crust between the rows (with a rake) before the plants are up. The rows ought to be four or five inches further apart than the width of a narrow rake.

3. *How to water the plants.*—I wonder if you have a watering-pot? If you have, put it where you cannot find it, for we are going to water this garden with a rake! We want you to learn, in this little garden, the first great lesson in farming,—how to

save the water in the soil. If you learn that much this summer, you will know more than many old farmers do. You know that the soil is moist in the spring when you plant the seeds. Where does this moisture go to? It dries up,—goes off into the air. If we could cover the soil with something, we should prevent the moisture from drying up. Let us cover it with a layer of loose, dry earth! We will make this covering by raking the bed every few days,—once every week anyway, and oftener than that if the top of the soil becomes hard and crusty, as it does after a rain. Instead of pouring water on the bed, therefore, we will keep the moisture in the bed.

If, however, the soil becomes so dry in spite of you that the plants do not thrive, then water the bed. Do not *sprinkle* it, but *water* it. Wet it clear through at evening. Then in the morning, when the surface begins to get dry, begin the raking again to keep the water from getting away. Sprinkling the plants every day or two is one of the surest ways to spoil them.

4. *When and how to sow.*—The sweet peas should be put in just as soon as you get this Monthly. Yet, good results can be had if the seeds are put in as late as the middle of May. If sown very early, they are likely to bloom better, but they may be gone before the middle of September. The blooming can be much prolonged if the flowers are cut as soon as they begin to fade.

Plant sweet peas deep,—two to three or sometimes even four inches. When the plants are a few inches high, pull out a part of them so that they will not stand nearer together than six inches in the row. It is a good plan to sow sweet peas in double rows,—that is, put two rows only five or six inches apart,—and stick the brush or place the chicken-wire support between them.

Phlox may be sown from the middle of May to the middle of June. Phloxes are summer and autumn flowers, and they should be in their prime in August and September.

Sow the seed shallow,—not more than a half inch deep. The plants should stand 6 to 10 inches apart.

5. *What varieties to choose.*—In the first place, do not plant too much. A garden which looks very small when the pussy willows come out and the frogs begin to peep, is big in the hot days of July. A garden four feet wide and twenty feet long,

half sweet peas and half phloxes, is about as big as most boys and girls will take care of.

In the next place, do not get too many varieties. Four or five kinds each of peas and phloxes will be enough. Buy the named varieties,—that is, those of known colors, —not the mixed packets. If you are very fond of reds, then choose the reddish kinds ; but it is well to put in at least three colors.

L. H. BAILEY.