PUBLIC DOCUMENT . . . . No. 31.

~~THIRTY-FIFTH~~ ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

1897-98

~~JANUARY, 18~~98.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
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Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Jan. 1, 1898.

To His Excellency ROGER WOLCOTT.

SIR: — I have the honor to transmit herewith, to Your Excellency and the Honorable Council, the thirty-fifth annual report of the trustees of the Massachusetts Agricultural College.

I am, very respectfully,
Your obedient servant,

HENRY H. GOODELL,
President.

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CALENDAR FOR 1898-99.

1898.

January 5, Wednesday, winter term begins, at 8 A.M.

March 24, Thursday, winter term closes, at 10.15 A.M.

April 6, Wednesday, spring term begins, at 8 A.M.

June 18, Saturday, Grinnell prize examination of the senior class in agriculture.

June 19, Sunday, { Baccalaureate sermon. Address before the College Young Men's Christian Association.

June 20, Monday, { Burnham prize speaking. Meeting of the alumni. Flint prize oratorical contest.

June 21, Tuesday, { Class-day exercises. Military exercises. Reception by the president and trustees.

June 22, Wednesday, Commencement exercises.

June 23-24, Thursday and Friday, examinations for admission, at 9 A.M., Botanic Museum, Amherst; at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; and at Sedgwick Institute, Great Barrington. Two full days are required for examination, and candidates must come prepared to stay that length of time.

September 6-7, Tuesday and Wednesday, examinations for admission, at 9 A.M., Botanic Museum.

September 8, Thursday, fall term begins, at 8 A.M.

December 22, Thursday, fall term closes, at 10.15 A.M.

1899.

January 4, Wednesday, winter term begins, at 8 A.M.

March 23, Thursday, winter term closes, at 10.15 A.M.

ANNUAL REPORT OF THE TRUSTEES

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

His Excellency the Governor and the Honorable Council.

During the thirty years of its existence, the college, in common with all the other land-grant colleges, has passed through many vicissitudes. Heralded at first as the bright morning star, it soon lost popular favor, because it did not at once make itself felt in the agriculture of the State and transform the fields of dock and thistles into broad acres of waving grain. A season of depression ensued, followed again by one of buoyancy and hope, in which it made great strides. This in turn was succeeded by the financial troubles of the last few years, which it was the first to feel and from which it has been the last to recover. Reviewing the past, we cannot but feel that the stage of experiment is over, and we enter upon this the first year of its fourth decade with quickened hope that from a broader, surer foundation the college will continue to rise and fulfil its mission of providing that "liberal and practical education that shall fit the industrial classes for the several pursuits and professions in life." The requirements for entrance have been increased, the average rank has been raised, the courses strengthened and broadened and the faculty increased to meet the increased demands.

To carry out the purpose for which the college was founded, three separate courses have been established. First, to meet the requirements of those whose circumstances forbid a longer stay, a series of ten short winter courses, eleven weeks in length, but covering such practical instruction in agriculture and the allied sciences as will be most helpful to the farmer. For this examinations are not required, and neither degrees nor diplomas are conferred. Elective courses in botany, entomology, floriculture, fruit culture, market gardening and dairying have been thrown open to women, but it is unfortunate that lack of dormitory room practically excludes them from taking advantage of this instruction. Second, a four-years course, leading to the degree of Bachelor of Science. For the first three years a certain definite curriculum is required of all, while the studies of the fourth year, with the exception of English and military science, are entirely optional. Examinations must be passed for this course. Third, post-graduate courses, leading to the degrees of Master of Science and Doctor of Philosophy. Candidates for these degrees are required to choose one major and two minor studies from certain prescribed subjects.

The academic course of four years is divided between nine departments, with the following allotment of hours to the different studies:—

English language and literature,	533
Other languages,	507
Mathematics and drawing,	784
Chemistry and physics,	833
Botany,	519
Entomology, zoölogy and physiology,	559
Economic law and history,	381
Military science and practice,	496
Agricultural in general,	470
Horticulture,	377
Veterinary,	185
Geology and astronomy,	370
Total,	6,014

Briefly, the course in each department may be thus outlined:—

Agriculture.

(*a*) The origin and formation of soils, their physical properties and how to improve them; (*b*) tillage, subsoiling, drainage and irrigation; (*c*) use of fertilizers and manures; (*d*) farm implements and plans of farm buildings; (*e*) animal husbandry, breeds, stock breeding and feeding. As aids to practical instruction, there are models of the domestic animals; a farm of four hundred acres; a barn with one hundred head of stock, types of the leading breeds, and a complete dairy outfit, where the operations of pasteurizing milk and cream, butter making, milk testing and separation of cream are carried on.

Botany.

(*a*) Structural and systematic botany; (*b*) economic botany; (*c*) study of the normal functions and diseases of plants; (*d*) plant physiology and its relation to agriculture. For practical work there is a laboratory abundantly supplied with microscopes, microtomes, histological reagents and numerous appliances for illustration and investigation of the phenomena of plant life.

Chemistry.

The chemical department teaches the composition, the value and the uses of all products of nature and of art. This study is an essential part of the training of the farmer, the manufacturer, the business man, the physician and the advanced student of any subject, for it deals with the ultimate character of all kinds of matter.

The special fields of study are mineral and organic, the latter including vegetable and animal matter. Each of these is studied by analysis and synthesis both qualitative and quantitative. There are three laboratories to suit the varying wants of the students.

Chemical Instruction.

Domains.			*Methods.*	
Mineral.		Each studied by	Analysis,	qualitative.
				quantitative.
Organic,	vegetable.		Synthesis,	qualitative.
	animal.			quantitative.

English.

The aim of this department is to promote: (*a*) ability to give oral and written expression of thought in correct, effective English; (*b*) ability to present in logical form oral and written arguments on questions assigned for debate; (*c*) acquaintance with the masterpieces of English literature. This is secured by constant practice in writing and speaking, and by the study of American literature and rhetoric in freshman and sophomore years and English literature and logic in the junior and senior. Instruction is given partly by text-book and partly by lecture. The course in rhetoric consists of a study of the choice of words, the theory of phraseology, special objects in style, the sentence, the paragraph, the whole composition as regards plan, arrangement and parts. This is followed by a series of lectures on invention, taking up the different elements and underlying principles of literature. The work in American literature is partly by text-book and partly by lecture. The course in the last two years is carried on in the same thorough, practical way, debate taking the place of declamation.

Horticulture.

Instruction is given in: (*a*) fruit culture; (*b*) market gardening; (*c*) floriculture; (*d*) forestry. For practical work there are extensive, well-stocked orchards, nurseries and greenhouses, where the production of fruit, market-garden and greenhouse crops is constantly carried on.

Mathematics and Engineering.

(*a*) Pure mathematics; (*b*) physics; (*c*) drawing; (*d*) engineering. The department is well supplied with the necessary instruments for surveying and engineering, and practical work in the field is required. A laboratory for physics has recently been opened, where the student can solve for himself problems in mechanics, electricity, light and sound. The senior engineering option is designed to give to the student the necessary engineering training to enable him to take up and apply, on the lines of landscape engineering and the development of property, his knowledge of landscape gardening, agriculture, forestry, botany and horticulture. It embraces a course of lectures, recitations and field work on the following subjects: topography, railroad curves, earth work, construction and maintenance of roads, water works and sewerage systems, etc.

Military.

This was established by act of Congress, and all students, unless physically disabled, are required to attend its exercises. Its object is threefold: first, the dissemination of military knowledge throughout the country; second, physical exercise and muscular training; and third, to inculcate respect and obedience to those in authority. There are three hours' drill per week for the whole college, one hour recitation for the senior class and a weekly inspection of the rooms in the dormitory.

Political Economy.

To make a good citizen and a successful man of business is the aim of this department. To realize this aim the course of instruction covers: (*a*) principles of political economy; (*b*) industrial history of England and America; (*c*) discussion of economic problems; (*d*) study of the science of government.

Veterinary.

To give a general idea of the principles of veterinary science in such simple and comprehensive manner as to enable any person to give animals under his supervision the treatment that will tend to prevent the occurrence of disease among them, is the aim of the course of study in this department. (*a*) The hygiene of the stable; (*b*) the anatomy and physiology of the circulatory, respiratory and digestive systems; (*c*) a study of the common diseased processes and the causes, symptoms and effects of disease; (*d*) the nature, action and uses of different drugs. Skeletons of the domestic animals, specimens of diseased bone and tissue, and an Auzoux model of the horse form a part of the equipment. This study is elective.

Zoölogy.

The work in this department commences with the study of human anatomy and physiology. It is followed by a course in zoölogy, taught by lectures and work in the laboratory. In the laboratory each student is required to dissect and study a series of typical animals, making drawings of the different organs. After this preparation the study of insects is taken up, — their classification and habits, and the various methods of destroying those that are injurious. In the senior year an elective course of more technical lectures is given, embracing such subjects as the anatomy, embryology, transformations, duration of life, color and diseases of insects, and the fertilization of plants by them. Each student is required to do original work and prepare a thesis before graduation. The whole is supplemented by a carefully arranged museum, containing, as far as possible, all the native animals of the Commonwealth, and by the extensive entomological collections of the professor in charge.

Faculty.

The faculty number eighteen active resident members, one professor emeritus and one non-resident lecturer. The chair of mathematics and civil engineering made vacant by the resignation of Prof. Leonard Metcalf has been filled by the election of John E. Ostrander, C.E., late professor of civil engineering and mechanic arts in the College of Agriculture of the University of Idaho. Prof. William P. Brooks, after a year's absence spent in study abroad, has resumed his duties at the college. The mechanical and free-hand drawing heretofore conducted by the military officer will this year, as last, be taught by Mr. William H. Armstrong, a member of the junior class.

For a makeshift, until such time as a suitable building can be erected, the recitation room occupied by the president has been altered into a physical laboratory for the use of the junior class. Water and gas have been introduced, a small dynamo run by water motor has been installed, benches accommodating twenty to thirty workers fitted up, and the light regulated by shutters sliding up and down, operated by hydrostatic stop-cocks on the table.

It has been the policy to add each year, as opportunity presented or as there seemed demand, new studies to the optional courses. This year there is offered a course in general history, commencing with the Christian era, a course in geology and a course in astronomy.

The entering class was one-fourth larger this year than last, and there was a number of additions to higher classes. But the same deficiency in preparation still prevails. The applicants for admission represent nearly every county in the State. They come from the hills of Berkshire and the sands of the Cape, from the valley of the Connecticut and the shores of Massachusetts Bay. They are not farmers' sons alone, but come from the homes of mechanics, of nurserymen, of engineers, of those, in fact, who represent the "industrial classes," "to promote the liberal and practical education" of whom "in the several pursuits and professions in life" the Agricultural College was established. These applicants for admission are examined in the following subjects: arithmetic, algebra through quadratic equations, geometry (two books), English grammar and composition, descriptive geography, physical geography, United States history, civil government and physiology. To be successful in this examination an applicant must obtain a mark of 65 per cent. Of the last 247 applicants for admission, 54 failed in arithmetic at the first examination, 93 in algebra, 70 in geometry, 49 in English grammar, 41 in descriptive geography, 37 in physical geography, 39 in history, 38 in civil government and 41 in physiology. The largest number of failures have been in algebra, — $33\frac{1}{5}$ per cent.; the smallest number in physical geography, — 15 per cent.; while the average of failures in the nine subjects specified above is $26\frac{3}{4}$ per cent.

We have, then, an average of more than one-fourth of those who have presented themselves for admission to the college failing in the entrance examinations. It may be urged that too much importance should not be attached to failures in these tests; that examiners are often injudicious in the questions asked; that "Tom is always nervous at such times," and that "Henry can never do justice to himself on an examination." These and other similar excuses may be allowed, yet the deplorable fact remains that so many are "plucked" when the test comes.

As has been intimated, these candidates are fair representatives of the pupils in our public schools. Many are graduates of the high school, many more have had one or two years in the same. The fact of their failure must not, necessarily, be charged to the public school, for these same schools furnish many students who not only pass the entrance examination, but, after a four-years course, graduate with honor and success. The fault, or the limitation rather, is with the student himself or with those who should advise him. *The time devoted to preparation is too short.* A young man suddenly awakes to the idea that he wants to enter the Agricultural College. He fancies that, on the shaky foundation of a possible year in the high school, four or five weeks can build a preparation for college. *The time is too short.* Another, possessed of a similar idea, thinks that a few evenings of study, after the day's work is done, will enable him to "brush up" his mathematics. *The body is too tired.* He falls asleep over those difficult principles of geometry, and there is no time for that practical and repeated solution of problems by which alone the path of algebraic processes becomes familiar. The interests of successful work in any college require time and thoughtful study in the work of preparation.

That each year we are drawing into closer relationship with the agriculture of the State is apparent. The farmers are coming more and more to depend upon the college, and what is true now is just as surely going to increase in the future. In nothing does this more strikingly appear than in the matter of correspondence. During the last twelve months 5,528 letters have been answered in the experiment department alone. What does this mean? It means that at 5,528 points we have touched the interests of the agricultural life of this State. It means that 940 dairymen have wanted to know about butter fats, or the best-balanced ration, or the hundred other matters of vital interest. It means that 750 farmers have had questions to ask concerning fertilizers and fertilizer materials. It means that 316 intelligent men engaged in the practice of agriculture have wanted information respecting rotation of crops, millets and soya beans, or the effects of potash on the growth of corn. It means that 304 fruit growers have come and asked what were the best varieties of fruits, how to cultivate them and how to prevent disease. It means that 113 growers of flowers and vegetables under glass have been attacked by rusts, smuts or nematodes, and have lifted up the Macedonian cry, "Come over and help us." It means that 1,232 sufferers attacked by all kinds of winged, crawling, creeping foes have come to us for relief. It means that 103 good wives have seen the ruin of their household idols effected by the buffalo bug, and have cried out in their anguish, "What shall we do to be saved from these pests?" This is the work of only one department. In addition, there have been written from the office of administration during the same period over 7,000 letters on matters touching college interests.

Expenditure of State Appropriations.

The several amounts appropriated by the Legislature (chapter 15, Acts and Resolves of 1897) have nearly all been expended, and for the purposes indicated. The entire water system of the college has been replaced, furnishing ample protection from fire as well as an adequate amount for domestic supply. An emergency reservoir, with a capacity of 150,000 gallons, has been constructed on the highest point of the college grounds; 7,352 feet of six-inch and 2,172 feet of four-inch cast-iron pipe have been laid, with the necessary gates, hydrants and valves. The fire apparatus has been thoroughly overhauled, and 500 feet of Eureka, U. S., rubber-lined hose, two and five-eighths inches in diameter, with hose play pipes, hose connections and straps have been purchased. The whole work came within the appropriation, though it was found necessary to take down and reconstruct at a large additional expense the culvert through which the pipe was laid at the south end of the pond. It is safe to say that, but for the untiring efforts of Prof. Leonard Metcalf, the supervising engineer, who gave his time and his services without compensation, the college could not have successfully carried through this undertaking. It seems fitting, therefore, in this public manner to place on record our grateful recognition of the work he has done for the college. As a corollary to the change in our water system, we were enabled to place, at slight expense, water-closets and facilities for bathing in the north dormitory, — a much-needed improvement, whether viewed from the stand-point of comfort or sanitation.

The greenhouse for the investigation of plant diseases has been entirely remodelled, but the work is not quite completed. The laboratory for teaching botany has been enlarged to meet the requirements of changes in the course of study and consequent increase of students. It is now well lighted, well ventilated and commodious. The repairs on the two greenhouses have been practically completed and they are both in use.

Accommodations for the Sick.

It may be proper to state that, through the generosity of the donor of Pratt Cottage, Mr. George D. Pratt of Long Island City, those of our students requiring care as the result of accident or sickness may enjoy the advantages of the hospital, on the payment of a fixed sum per diem, subject to the same rules and regulations as students of Amherst College. It is a great satisfaction to feel that in cases of serious illness our students can be removed from the college buildings and receive proper care.

The Military Department.

This department, required by act of Congress and accepted by the Commonwealth of Massachusetts, has received no particular encouragement, although its exhibition parades and drills form one of the most pleasing features of Commencement week. The War Department, as an incentive to good work, publishes each year in the "Army Register" the names of the three graduates in each college recommended by the president and commandant as having stood highest in the military department of the college.

One State, at least, has supplemented this by an act entitling each graduate of the Agricultural and Mechanical College of that State, who may be declared proficient by the United States army officer in charge, to a commission as brevet second lieutenant in the State militia. We would earnestly recommend petitioning the General Court for the passage of an act entitling the three graduates recommended each year for honorable mention in the "Army Register" to a commission as brevet second lieutenant in the Massachusetts State militia. It would be an incentive to the students themselves, and would offer an inducement to the youth of the State to enter an institution where excellent facilities are offered for military training.

Needs of the College.

Commissioner Harris never made a truer remark than when he said, "The laboratory is the pivot on which the Agricultural College is wheeling around to lead in this, the greatest of American education." But what he says of the college as a whole is equally applicable to every department. Instruction, without laboratory work to impress upon the mind the principles learned in the recitation room, is of little value. Precept and practice must go hand in hand, to make the exact scholar. Most of the departments are fairly well equipped for laboratory work. The veterinary is almost the sole exception, and in the present crowded state of the buildings it is impossible to find any adequate quarters. A single room, nine by fourteen feet, with one window, is all the space that can be allotted for practical work with the students in dissection or in the use of the microscope. For lack of other accommodations, the professor in charge is compelled to keep in the cellar of his own house animals on which he desires to experiment, or diseased subjects and carcasses that may be sent in for examination. The value of the domestic animals and their products in this country is something enormous, footing up to nearly two and one-half billions of dollars, distributed as follows: —

United States Statistics.

Dairy Products for 1895 (Estimated).

PRODUCT.	Total Product.	Rate of Value.	Total Value.
Butter (pounds),	1,375,000,000	$0 20	$275,000,000
Cheese (pounds),	280,000,000	08	22,400,000
Milk (gallons),	1,750,000,000	09	157,500,000
Total,	–	–	$454,900,000

Number of fowls,	383,000,000
Number of dozens of eggs produced,	1,141,000,000
Value of both,	$343,000,000
Total value of farm animals,	$1,655,414,612
Total value of dairy products,	454,900,000
Total value of poultry and products,	343,000,000
Total,	$2,453,314,612

In Massachusetts the latest figures give: —

Massachusetts Statistics.

1896.	Number.	Price.	Value.
Horses,	198,568	$64 67	$12,841,392 56
Cows,	174,167	30 78	5,360,860 26
Cattle other than cows,	38,437	16 00	614,992 00
Sheep,	34,091	3 38	115,227 58
Swine,	40,570	8 44	342,410 80
Poultry,	553,970	–	246,703 00
Total,	–	–	$19,521,586 20

Value of Dairy Products.

1890.	Quantity.	Price.	Value.
Milk (gallons), . .	82,571,924	$0 09	$7,431,473 00
Butter (pounds), . .	10,410,300	20	2,082,060 00
Cheese (pounds), . .	385,533	08	30,842 00
Total, . . .	–	–	$9,544,375 00

Prices are from estimates of 1895, made to apply to products in United States. They should be higher for Massachusetts.

Value of farm animals, ...	$19,521,586 20
Value of dairy products, ...	9,544,375 00
Value of poultry products,*	553,970 00
Total, ...	$29,619,931 20

It is estimated that there is an annual loss of 6 per cent. on this valuation, resulting from disease, most of which is preventable. There is not, if I am informed correctly, a single place in this State where the prime object is the study of the diseases of the domestic animals. Other States have already recognized the importance of this subject, and provided means of instruction and study, for the two go hand in hand. Pennsylvania has appropriated $30,000 to the veterinary department of its university. Iowa has furnished the necessary buildings for its college. New York has granted $150,000 for buildings and $25,000 annually for running expenses. Ohio has appropriated large sums, but the exact figures have not been ascertained. In the ordinary business of life, where great capital is invested, the services of experts are sought. In this great industry, in which nearly thirty millions of capital are engaged, provision has not yet been made for the intelligent study of animal diseases, though nearly a million dollars' loss occurs annually through lack of knowledge. The natural place for the dissemination of such knowledge and for the study

* 2,769,850 dozen eggs, at 20 cents.

of the various plagues affecting our domestic animals is the veterinary department of the college, and for this two things are absolutely essential, — a laboratory and hospital-stable connected therewith, and a small annual appropriation for maintenance. The laboratory, with its recitation room, workshop and museum, is both educational and experimental. The stable, while it subserves both purposes, is more especially for investigation. It requires a larger outlay than at first thought may seem necessary. It must be built in a different manner from ordinary stables, to meet the exigencies of the case. Room should be provided for six stalls, each absolutely isolated from the others, cut off by a brick partition, the walls covered with adamant cement and the floors of artificial stone, so as to insure absolute disinfection at the close of each investigation. In this particular the bovine race is in no ways different from the human. Modern science would never think of introducing a patient suffering from typhoid fever into a small-pox or scarlet-fever ward. In like manner, germ-infected timber or earth would never do in stalls in which one week might be an aggravated case of cow-pox and the next one of tuberculosis. To provide for these buildings and their equipment we ask for $25,000 and an annual maintenance fund of $1,000.

The chemical department requires for equipment and material the sum of $1,000 in order to place it in position to offer the educational facilities demanded. Charts, models, material, apparatus and chemicals are needed. With the changes made in the college curriculum, new wants have to be supplied. The senior electives, the post-graduate courses, the short winter courses call for instruction in almost every branch of theoretical and applied chemistry, and demonstrations in a wide range of subjects are made necessary. These include agricultural chemistry, physiological and medical chemistry, assaying, mineral analysis, metallurgy, gas analysis, sugar manufacturing, color chemistry and many other industrial processes. To answer these requirements there should be an abundance of material on hand for demonstration. In no other department is there so great and at the same time so unavoidable a consumption of material and using up of perishable equipment, most of which has to be imported. In almost every other college we find a certain definite sum, ranging from $700 to $1,000, annually appropriated to supply this waste. Lack of means has prevented such annual repair of loss, and at irregular intervals we are compelled to apply for aid.

Among the many unsolved problems confronting the dairyman is the effect of feed stuffs on the consistency and flavor of butter. Experiments in the past have been for the most part confined to the production of quantity. Dairymen are now calling for investigations of quality. Such work requires the erection and equipment of a small dairy building for purpose of experiment alone. A plant of this description would call for an outlay of $2,000 for the following special items: —

(*a*) A building 22 by 44 feet, with ice-house attached, 18 by 20 feet, including floor of artificial stone for creamery.

(*b*) Creamery fittings (boiler, engine, apparatus).

(*c*) Drainage.

(*d*) Heating building and connecting tanks.

In brief, then, the following amounts are asked for: —

Veterinary laboratory and equipment,	$25,000
Chemical equipment,	1,000
Dairy plant,	2,000
	$28,000

and an annual maintenance fund of $1,000, veterinary department.

In accordance with the act of Congress establishing these colleges, and requiring in their annual report the publication of matter of information to the people, an illustrated paper is appended by Prof. Charles H. Fernald on the plume-moths.

Respectfully submitted, by order of the trustees,

HENRY H. GOODELL,
President.

AMHERST, Jan. 1, 1898.

THE CORPORATION.

	Term expires.
WILLIAM H. BOWKER of BOSTON, ...	1899
J. D. W. FRENCH of BOSTON, ...	1899
J. HOWE DEMOND of NORTHAMPTON, . . .	1900
ELMER D. HOWE of MARLBOROUGH, ...	1900
NATHANIEL I. BOWDITCH of FRAMINGHAM, . .	1901
WILLIAM WHEELER of CONCORD, ...	1901
ELIJAH W. WOOD of WEST NEWTON, . . .	1902
CHARLES A. GLEASON of NEW BRAINTREE, . .	1902
JAMES DRAPER of WORCESTER, ...	1903
SAMUEL C. DAMON of LANCASTER, ...	1903
HENRY S. HYDE of SPRINGFIELD, ...	1904
MERRITT I. WHEELER of GREAT BARRINGTON, .	1904
JAMES S. GRINNELL of GREENFIELD, . . .	1905
CHARLES L. FLINT of BROOKLINE, ...	1905

Members Ex Officio.

HIS EXCELLENCY GOVERNOR ROGER WOLCOTT,
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WILLIAM R. SESSIONS, *Secretary of the Board of Agriculture.*

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Vice-President of the Corporation.

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JOHN BURSLEY, . . . of West Barnstable.
C. K. BREWSTER, . . . of Worthington.
WESLEY B. BARTON, . . of Dalton.

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* The president of the college is ex officio a member of each of these committees.

The Faculty.

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Professor of Modern Languages.

LEVI STOCKBRIDGE,
Professor of Agriculture, Honorary.

CHARLES A. GOESSMANN, Ph.D., LL.D.,
Professor of Chemistry.

SAMUEL T. MAYNARD, B.Sc.,
Professor of Horticulture.

CHARLES WELLINGTON, Ph.D.,
Associate Professor of Chemistry.

CHARLES H. FERNALD, Ph.D.,
Professor of Zoölogy.

Rev. CHARLES S. WALKER, Ph.D.,
Professor of Mental and Political Science.

WILLIAM P. BROOKS, Ph.D.,
Professor of Agriculture.

GEORGE F. MILLS, M.A.,
Professor of English and Latin.

JAMES B. PAIGE, D.V.S.,
Professor of Veterinary Science.

GEORGE E. STONE, Ph.D.,
Professor of Botany.

JOHN E. OSTRANDER, M.A., C.E.,
Professor of Mathematics and Civil Engineering.

HERMAN BABSON, M.A.,
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EDWARD R. FLINT, Ph.D.,
Assistant Professor of Chemistry.

FRED S. COOLEY, B.Sc.,
Assistant Professor of Agriculture.

RICHARD S. LULL, M.S.,
Assistant Professor of Zoölogy.

RALPH E. SMITH, B.Sc.,
Instructor in German and Botany.

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Professor of Military Science and Tactics.

ROBERT W. LYMAN, LL.D.,
Lecturer on Farm Law.

HENRY H. GOODELL, LL.D.,
Librarian.

Graduates of 1897.*

Master of Science.

Burgess, Albert Franklin, . . .	Rockland.
Kinney, Asa Stephen, . . .	Worcester.

Bachelor of Science.

Allen, Harry Francis (Boston Univ.), .	Northborough.
Allen, John William (Boston Univ.), .	Northborough.
Armstrong, Herbert Julius (Boston Univ.), ...	Sunderland.
Barry, John Marshall (Boston Univ.),	Boston.
Bartlett, James Lowell (Boston Univ.),	Salisbury.
Cheney, Liberty Lyon (Boston Univ.),	Southbridge.
Clark, Lafayette Franklin (Boston Univ.), ...	West Brattleboro, Vt.

* The annual report, being made in January, necessarily includes parts of two academic years, and the catalogue bears the names of such students as have been connected with the college during any portion of the year 1897.

Drew, George Albert (Boston Univ.),	Westford.
Emrich, John Albert, . . .	Amherst.
Goessmann, Charles Ignatius (Boston Univ.), ...	Amherst.
Leavens, George Davison (Boston Univ.), ...	Brooklyn Heights, N. Y.
Norton, Charles Ayer (Boston Univ.),	Lynn.
Palmer, Clayton Franklin (Boston Univ.), ...	Stockbridge.
Peters, Charles Adams (Boston Univ.),	Worcester.
Smith, Jr., Philip Henry (Boston Univ.), ...	South Hadley Falls.
Howe, Edward Gardnier ('72), . .	Urbana, Ill.
Stone, George Edward ('86), . .	Amherst.
Total, ...	19

Senior Class.

Adjemian, Avedis Garrabet, . .	Kharpoot, Turkey.
Baxter, Charles Newcomb, . .	Quincy.
Clark, Clifford Gay, ...	Sunderland.
Eaton, Julian Stiles, . . .	Nyack, N. Y.
Fisher, Willis Sikes, . . .	Ludlow.
Montgomery, Jr., Alexander, . .	Natick.
Nickerson, John Peter, . . .	West Harwich.
Warden, Randall Duncan, . .	Roxbury.
Wiley, Samuel William, . . .	Amherst.
Wright, George Henry, . . .	Deerfield.
Total, ...	10

Junior Class.

Armstrong, William Henry, . .	Cambridge.
Beaman, Dan Ashley, . . .	Leverett.
Boutelle, Albert Arthur, . . .	Leominster.
Canto, Ysidro Herrera, . . .	Cansahcat, Yucatan.
Chapin, William Edward, . . .	Chicopee.
Chapman, John Chauncey, . .	Amherst.

Courtney, Howard Scholes,	Attleborough.
Dana, Herbert Warner,	South Amherst.
Dutcher, John Remson,	Nyack, N. Y.
Hinds, Warren Elmer,	Townsend.
Hooker, William Anson,	Amherst.
Hubbard, George Caleb,	Sunderland.
Maynard, Howard Eddy,	Amherst.
Pingree, Melvin Herbert,	Denmark, Me.
Sharpe, Edward Hewett,	Northfield.
Smith, Bernard Howard,	Middlefield.
Smith, Carl William,	Melrose.
Smith, Samuel Eldredge,	Middlefield.
Stacy, Clifford Eli,	Gloucester.
Turner, Frederick Harvey,	Housatonic.
Walker, Charles Morehouse,	Amherst.
Wright, Edwin Monroe,	Manteno, Ill.
Total,	22

Sophomore Class.

Atkins, Edwin Kellogg,	North Amherst.
Baker, Howard,	Dudley.
Brown, Frank Howard,	Newton Centre.
Campbell, Morton Alfred,	Townsend.
Crane, Henry Lewis,	Ellis.
Crowell, Jr., Charles Augustus,	Everett.
Crowell, Warner Rogers,	Everett.
Felch, Percy Fletcher,	Worcester.
Frost, Arthur Forrester,	South Monmouth, Me.
Gile, Alfred Dewing,	Worcester.
Halligan, James Edward,	Roslindale.
Harmon, Arthur Atwell,	Chelmsford.
Hull, Edward Taylor,	Greenfield Hill, Conn.
Hunting, Nathan Justus,	Shutesbury.
Kellogg, James William,	Amherst.
Landers, Morris Bernard,	Bondsville.
Lewis, James,	Fairhaven.
March, Allen Lucas,	Ashfield.
Merrill, Frederic Augustus,	Boston.
Monahan, Arthur Coleman,	South Framingham.
Morrill, Austin Winfield,	Tewksbury.

Munson, Mark Hayes,	Huntington.
Otis, Wilbur Corthell,	Beachmont.
Ovalle Barros, Julio Moises,	Santiago, Chili.
Parmenter, George Freeman,	Dover.
Risley, Clayton Erastus,	Plainfield, N. J.
Rogers, William Berry,	Cambridge.
Saunders, Edward Boyle,	Southwick.
Stanley, Francis Guy,	Springfield.
Walker, Henry Earl,	Vineyard Haven.
West, Albert Merril,	Brookville.
Total,	31

Freshman Class.

Ahearn, Michael Francis,	Framingham.
Baker, John Brown,	Amherst.
Barry, John Cornelius,	Amherst.
Boutelle, Clarence Alfred,	Leominster.
Bridgeforth, George Ruffin,	Westmoreland, Ala.
Brooks, Percival Cushing,	Brockton.
Casey, Thomas,	Amherst.
Chickering, James Henry,	Dover.
Clarke, George Crowell,	Malden.
Cooke, Theodore Frederic,	Austerlitz, N. Y.
Curtis, Ernest Waldo,	Canton.
Dana, George Henry,	South Amherst.
Dawson, William Alucius,	Worcester.
Dickerman, William Carlton,	Taunton.
Dorman, Allison Rice,	Springfield.
Gamwell, Edward Stephen,	Pittsfield.
Gordon, Clarence Everett,	Clinton.
Graves, Jr., Thaddeus,	Hatfield.
Gurney, Victor Henry,	Forge Village.
Hemenway, Francis Ellis,	Williamsville.
Henry, James Buel,	Scitico, Conn.
Howard, John Herbert,	Littleton Common.
Jones, Clark Winthrop,	Huntington.
Jones, Cyrus Walter,	Amherst.
Judd, Warren Harold,	South Hadley Falls.
Leslie, Charles Thomas,	Pittsfield.
Macomber, Ernest Leslie,	Taunton.

Moulton, Harry Jackson,	Milford.	
Paul, Herbert Amasa,	Lynn.	
Rice, Charles Leslie,	Pittsfield.	
Root, Luther Augustus,	Deerfield.	
Smith, Ralph Ingram,	Leverett.	
Tashjian, Dickran Bedross,	Kharpoot, Turkey.	
Todd, John Harris,	Rowley.	
Wilson, Alexander Cavassa,	Boston.	
Total,		35

Graduates' Two-Years Course.

Ashley, Henry Simeon,	East Longmeadow.	
Burrington, John Cecil,	Charlemont.	
Colburn, Charles Day,	Westford.	
Dye, Willie Arius,	Sheffield.	
Humphrey, Charles Leonard,	Amherst.	
Merriman, Francis Evander,	Boston.	
Total,		6

Short Winter Courses.

Adams, Charles Moody,	Wayland.	
Charmbury, Thomas Herbert,	Amherst.	
Chiashi, Louie Yeizo,	Imadzumura, Japan.	
Doescher, John Fred,	Cherry Valley.	
Fiske, Charles Daniel,	Hampden.	
Fuller, Herman Kelso,	Lowell.	
Graham, Charles Sumner,	Westborough.	
Holt, Jonathan Edward,	Andover.	
Hopkins, Lemuel Truesdell,	Conway.	
Howes, Albert Lorenzo,	Ashfield.	
Leach, Oliver Herbert,	Florence.	
Moore, George Calvin,	Leverett.	
Pendleton, Charles Bemis,	Willimansett.	
Sherman, Wilbur Gifford,	Haverhill.	
Smith, Charles Atherton,	Buckland.	
Stowell, Herbert Willard,	Leverett.	
Total,		16

Graduate Course.

For Degree of M.S.

Armstrong (B.Sc., M. A. C., '97), Herbert Julius,	Sunderland.
Caudell (B.S., Oklahoma, '96), Andrew Nelson,	Kansas City, Mo.
Goessmann (B.Sc., M. A. C., '97), Charles Ignatius,	Amherst.
Hemenway (B.Sc., M. A. C., '95), Herbert Daniel,	Williamsville.
Kochi (B.S., Sapporo, '91), Chujiro,	Bingo, Japan.
Leavens (B.Sc., M. A. C., '97), George Davison,	Brooklyn Heights, N. Y.
Palmer (B.Sc., M. A. C., '97), Clayton Franklin,	Stockbridge.
Peters (B.Sc., M. A. C., '97), Charles Adams,	Worcester.
Stevens (B.A., Harvard Univ., '95), Waldo Warland,	Groton.
Total,	9

Resident Graduates at the College and Experiment Station.

Cooley, B.Sc., Robert Allen,	South Deerfield.
Drew, B.Sc., George Albert,	Westford.
Hammar, B.Sc., James Fabens,	Swampscott.
Haskins, B.Sc., Henri Darwin,	North Amherst.
Holland, B.Sc., Edward Bertram,	Amherst.
Holt, B.Sc., Jonathan Edward,	Andover.
Jones, B.Sc., Benjamin Kent,	Middlefield.
Kinney, B.Sc., Asa Stephen,	Worcester.
Putnam, B.Sc., Joseph Harry,	West Sutton.
Roper, B.Sc., Harry Howard,	East Hubbardston.
Smith, B.Sc., Frederic Jason,	North Hadley.
Smith, Jr., B.Sc., Philip Henry,	South Hadley Falls.
Smith, B.Sc., Robert Hyde,	Amherst.
Thomson, B.Sc., Henry Martin,	Monterey.
White, B.Sc., Edward Albert,	Ashby.
Total,	15

Special Students.

Cross (Amh. Coll.), Edward Winslow,	Manchester, N. H.	
Howard (Amh. Coll.), Arthur Day,	Glencoe, Ill.	
Kendall (Amh. Coll.), Henry Plimpton,	Walpole.	
Total,		3

Summary.

Graduate course: —		
For degree of M.S.,	9	
Four-years course: —		
Graduates of 1897,	19	
Senior class,	10	
Junior class,	22	
Sophomore class,	31	
Freshman class,	35	
Two-years course: —		
Graduates of 1897,	6	
Winter course,	16	
Resident graduates,	15	
Special students,	3	
Total,		166
Entered twice,		9
Total,		157

FOUR-YEARS COURSE OF STUDY.

Freshman Year.

	Agriculture.	Botany and Horticulture.	Chemistry.	Natural History.	Mathematics.	Latin and English.	French and Social Science.	Drawing and Military.
Fall, . .	- - -	Botany, structural, —5.	- - -	- - -	Advanced algebra, — 5. Book-keeping,—2.	English, — 3.	French, — 4.	Study of tactics, — 1.
Winter, .	History of agriculture, soils and soil formation, — 4.	- - -	- - -	- - -	Advanced algebra and geometry (plane),— 4.	English, — 3.	French, — 4.	Mechanical drawing, — 6.
Summer, .	Soils: — characteristics, improvement of, drainage, etc., — 4.	Botany, analytical, — 4.	Lectures in elementary chemistry, — 3.	- - -	Geometry (solid), — 3.	English, — 3.	French, — 3.	- -

Sophomore Year.

	Agriculture.	Botany and Horticulture.	Chemistry.	Natural History.	Mathematics.	Latin and English.	French and Social Science.	Drawing and Military.
Fall, . .	Irrigation, disposition of sewage, manures and fertilizers, — 4.	Botany, economic, and laboratory work, — 4.	Lectures in elementary chemistry, — 4.	- - -	Trigonometry and surveying, — 5.	English, — 2.	- -	- -
Winter, .	- - -	Laboratory work, — 4.	Lectures and practice, — 4.	Anatomy and physiology,— 4.	Mechanics, — 2. Surveying, — 1.	English, — 3.	- -	- -
Summer, .	Relations of the atmosphere to plant-life, mowings, pastures, grasses, ensilage,—5.	Horticulture, — 5.	Dry and humid qualitative analysis, — 6.	- - -	Surveying, — 4.	English, — 2.	- -	- -

Junior Year.

	Agriculture.	Botany and Horticulture.	Chemistry, Geology and Astronomy.	Zoölogy.	Mathematics.	Latin and English.	French and Social Science.	Drawing and Military.
Fall, . .	Field crops, seed raising, production and improvement of varieties, machines and implements, — 4.	Market gardening, — 3.	Qualitative analysis, — 5.	Zoölogy, laboratory work, — 8.	Physics, — 2.	English literature, — 4.	- -	- -
Winter, .	Breeds and breeding of live stock, poultry farming, — 2.	- - -	Lectures and practice in organic chemistry, — 6.	Zoölogy, — 3.	Physics, — 3. Laboratory physics, — 2.	English literature, — 4.	- -	- -
Summer, .	- - -	Landscape gardening, — 5.	The same continued, — 5.	Entomology, — 6.	Physics, — 4. Laboratory physics, — 2.	English, — 2.	- -	- -

Senior Year (Elective).*

	Agriculture.	Botany and Horticulture.	Chemistry, Geology and Astronomy.	Zoölogy.	Mathematics.	Latin and English.	French and Social Science.	Drawing and Military.
Fall, . .	Dairy farming, — 5.	Botany, cryptogamic, — 8.	Chemical physics and quantitative analysis, — 8. Astronomy, — 5.	Entomology, — 8. Veterinary science, — 5.	Engineering, — 5. Analytical geometry, — 5.	English, — 2. Advanced English, — 5. Latin, — 5.	Political economy, — 5. German, — 5. History, — 5.	Military science, — 1.
Winter, .	Cattle feeding, - 5.	Botany, cryptogamic, — 8.	Advanced work with lectures, — 8. Astronomy, } 5. Geology, } 5.	Entomology, — 8. Veterinary science, — 5.	Engineering, — 5. Differential calculus, — 5.	English, — 2. Advanced English, — 5. Latin, — 5.	Political economy, — 5. German, — 5. History, — 5.	Military science, — 1. Law lectures, — 1.
Summer, .	Experimental work in agriculture, — 5.	Botany, physiological, — 8.	The same continued, — 8. Geology, — 5.	Entomology, — 8. Veterinary science, — 5.	Engineering, — 5. Integral calculus, — 5.	English, — 2. Advanced English, — 5. Latin, — 5.	Constitutional history, — 5. German, — 5. History, — 5.	Military science, — 1.

* English and military science are required; of the other studies three at least must be chosen.

SHORT WINTER COURSES.

[All courses optional.]

AGRICULTURE.

I. General Agriculture.	
1. Soils and operations upon them, drainage, irrigation, etc.,	10
2. Farm implements and machinery,	5
3. Manures and fertilizers,	10
4. Crops of the farm, characteristics, management, etc.,	10
5. Crop rotation,	2
6. Farm book-keeping,	5
7. Agricultural economics,	11
8. Farm, dairy and poultry management,	11
Total hours,	64

II. Animal Husbandry.	
1. Introduction,	1
2. Location and soil,	2
3. Building,	4
4. Breeds of cattle,*	10
5. Breeds of horses,	6
6. Grain and fodder crops,*	11
7. Foods and feeding,*	11
8. Extra,	19
Total hours,	64

* With dairy course.

DAIRYING.

III. Lectures and Class-room Work.	
1. The soil and crops,	22
2. The dairy breeds and cattle breeding,	22
3. Stable construction and sanitation, care of cattle,	11
4. Common diseases of stock, their prevention and treatment,	11
5. Foods and feeding,	11
6. Book-keeping for the dairy farm and butter factory,	22
7. Pasteurization and preparation of milk on physicians' prescriptions,	11
III. Lectures, etc. — Concluded.	
8. Composition and physical peculiarities of milk; conditions which affect creaming, churning, methods of testing and preservation,	22
9. Milk testing,	6
10. Butter making,	12
11. Practice in aeration, pasteurization,	6
Total hours,	156

HORTICULTURE.

IV. Fruit Culture.	
1. Introduction,	1
2. Propagation of fruit trees by seed, budding, grafting, forming the head, digging, planting, pruning, training, cultivation, etc.,	28
3. Insects and fungous diseases,	3
Total hours,	32

V. Floriculture.	
1. Greenhouse construction and heating,	6
2. Propagation of greenhouse and other plants by seed, cuttings, grafting, etc.,	3
3. Cultivation of rose, carnation, chrysanthemum and orchids,	12
4. Propagation and care of greenhouse and bedding plants,	10
V. Floriculture — Concluded.	
5. Insects and fungi which attack greenhouse plants,	2
Total hours,	33

VI. Market Gardening.	
1. Introduction, equipment, tools, manures, fertilizers, etc.,	3
2. Greenhouse construction and heating,	6
3. Forcing vegetables under glass,	3
4. Seed growing by the market gardener,	3
5. Special treatment required by each crop,	10
6. Insects and fungi, with remedies,	2
Total hours,	27

Botany.

VII. Lectures on Injurious Fungi of the Farm, Garden, Greenhouse, Orchard and Vineyard.

1.	Introduction,	2
2.	Nature and structure of rusts,	4
3.	Nature and structure of smuts,	4
4.	Nature and structure of mildews,	4
5.	Nature and structure of rots,	4
6.	Beneficial fungi of roots,	2
7.	Edible mushrooms,	2
	Total hours,	22

VIII. Lectures and Demonstrations on "How Plants Grow."

1.	Introduction,	1
2.	The parts of a plant,	1
3.	Structure of the cell and plant in general,	3
4.	Functions of root, stem and leaves,	3
5.	Food of plant obtained from air,	3
6.	Food of plant obtained from soil,	3
7.	Transference and elaboration of food,	2
8.	Growth of plants,	2
9.	Effects of light, moisture, heat and cold,	2
10.	Root tubercles on pea and clover,	1
11.	Cross fertilization of flowers,	1
	Total hours,	22

Chemistry.

IX. General Agricultural Chemistry.

1.	Introduction,	2
2.	The fourteen elements of agricultural chemistry,	1
3.	Rocks and soils,	8
4.	The atmosphere,	7
5.	The chemistry of crop-growing,	8
6.	Fertilizers,	8
7.	Animal chemistry,	8
	Total hours,	55

X. Chemistry of the Dairy.

1.	Introduction,	2
2.	The fourteen elements of agricultural chemistry,	14
3.	The physical properties of milk,	13
4.	Analysis of milk, butter, cheese and other dairy products,	13
5.	Chemistry of the manufacture of dairy products,	13
	Total hours,	55

Zoölogy.

XI. Animal Life on the Farm.

Total hours, ... 22

XII. Insect Friends and Foes of the Farmers.

Total hours, ... 33

GRADUATE COURSE.

1. Honorary degrees will not be conferred.

2. Applicants will not be eligible to the degree of M.S. until they have received the degree of B.Sc. or its equivalent.

3. The faculty shall offer a course of study in each of the following subjects: mathematics and physics; chemistry; agriculture; botany; horticulture; entomology; veterinary. Upon the satisfactory completion of any two of these the applicant shall receive the degree of M.S. This prescribed work may be done at the Massachusetts Agricultural College or at any institution which the applicant may choose; but in either case the degree shall be conferred only after the applicant has passed an examination at the college under such rules and regulations as may be prescribed.

4. The degree of Doctor of Philosophy may be conferred upon graduates of this college or other colleges of good standing who shall spend three years at this institution, taking chemistry, botany and entomology as their major and minor studies, if in this time the amount and quality of work done be satisfactory to the professors in charge of the above-named departments.

5. Every student in the graduate course shall pay twenty-five dollars to the treasurer of the college before receiving the degree of M.S. or Ph.D.

TEXT-BOOKS.

Gray — "Manual." American Book Company, New York.

Darwin and Acton — "Practical Physiology of Plants." University Press, Cambridge.

Strasburger — "Practical Botany." Swan, Sonnenschein & Co., London.

Sorauer — "Physiology of Plants." Longmans, Green & Co., New York and London.

Campbell — "Structural and Systematic Botany." Ginn & Co., Boston.

Knobel — "Trees and Shrubs of New England." Bradlee Whidden, Boston.

Greiner — "How to make the Garden pay." Wm. Maule, Philadelphia.

Long — "Ornamental Gardening for Americans." Orange Judd Company, New York.

Taft — "Greenhouse Construction." Orange Judd Company, New York.

WEED — "Insects and Insecticides." Orange Judd Company, New York.

WEED — "Fungi and Fungicides." Orange Judd Company, New York.

FULLER — "Practical Forestry." Orange Judd Company, New York.

MAYNARD — "Practical Fruit Grower." Orange Judd Company, New York.

MCALPINE — "How to know Grasses by their Leaves." David Douglas, Edinburgh.

LODEMAN — "The Spraying of Crops." Macmillan & Co., New York.

SAUNDERS — "Insects injurious to Fruits." Lippincott & Co., Philadelphia.

MORROW and HUNT — "Soils and Crops." Howard & Wilson Publishing Company.

AIKMAN — "Manures and the Principles of Manuring." Wm. Blackwood & Son, Edinburgh.

MILES — "Stock Breeding" D Appleton & Co., New York.

CURTIS — "Horses, Cattle, Sheep and Swine." Orange Judd Company, New York.

FARRINGTON and WOLL — "Testing Milk and its Products" Mendota Book Company, Madison, Wis.

VON RICHTER — "A Text-book of Inorganic Chemistry." P. Blakiston, Son & Co., Philadelphia.

MÜTER — "Analytical Chemistry." P. Blakiston, Son & Co., Philadelphia.

ROSCOE — "Lessons in Elementary Chemistry." Macmillan & Co., New York.

BERNTHSEN and MCGOWAN — "Text-book of Organic Chemistry" Blackie & Son, London.

REYNOLDS — "Experimental Chemistry" Longmans, Green & Co., New York and London.

SUTTON — "Volumetric Analysis." J. & A. Churchill, London.

DANA — "Manual of Determinative Mineralogy." John Wiley & Sons, New York.

DANA — "A Text-book of Elementary Mechanics for the Use of Colleges and Schools." John Wiley & Sons, New York.

GAGE — "The Principles of Physics." Ginn & Co., Boston.

FAUNCE — "Mechanical Drawing." Linus Faunce, Boston.

WELLS — "College Algebra." Leach, Shewell & Sanborn, Boston.

MESERVEY — "Meservey's Book-keeping, Single and Double Entry." Thompson, Brown & Co., Boston.

WELLS — "Plane and Solid Geometry." Leach, Shewell & Sanborn, Boston.

WELLS — "Essentials of Trigonometry." Leach, Shewell & Sanborn, Boston

GILLESPIE — "A Manual on the Principles and Practice of Road Making." A. S. Barnes & Co., New York.

MERRIMAN — "A Treatise on Hydraulics." John Wiley & Sons, New York.

MILLER — "A Treatise on Plane and Spherical Trigonometry." Leach, Shewell & Sanborn, Boston.

RAYMOND — "A Text-book on Plane Surveying." American Book Company, New York.

FAUNCE — "Descriptive Geometry." Ginn & Co., Boston.

MERRIMAN — "Text-book on Least Squares." John Wiley & Sons, New York.

MARTIN — "The Human Body" (briefer course). Henry Holt & Co., New York.

WALKER — "Political Economy" (briefer course). Henry Holt & Co., New York.

WALKER — "The Industrial History of England." Methuen & Co., London.

WILSON — "The State." D. C. Heath, Boston.

GIBBINS — "A Short Constitutional History of England" Ginn & Co., Boston.

GENUNG — "Outlines of Rhetoric." Ginn & Co., Boston.

WENTWORTH — "Irving's Sketch Book." Allyn & Bacon, Boston.

LONGFELLOW — "Poems." Houghton, Mifflin & Co , Boston.

PATTEE — "A History of American Literature." Silver, Burdett & Co., Boston.

PANCOAST — "Representative English Literature." Henry Holt & Co., New York.

JEVONS — "Logic." Science Primer Series. American Book Company, New York.

CORSON — "Selections from Chaucer's Canterbury Tales." The Macmillan Company, New York.

ROLFE — "English Classics." Harper & Brothers, New York.

WHITNEY — "French Grammar." Henry Holt & Co., New York.

WHITNEY — "German Grammar." Henry Holt & Co., New York.

SHELDON — "Short German Grammar." D. C. Heath & Co., Boston.

HODGES — "Course in Scientific German." D C. Heath & Co., Boston.

PETTIT — "Elements of Military Science." The Tuttle, Morehouse & Taylor Press, New Haven, Conn.

"Infantry Drill Regulations." Army and Navy Journal, New York.

To give not only a practical but a liberal education is the aim in each department, and the several courses have been so arranged as to best subserve that end. Exercises in composition and declamation are held throughout the course. The instruction in agriculture and horticulture is both theoretical and practical, the lessons of the recitation room being practically enforced in the garden and field. Students are allowed to work for wages during such leisure hours as are at their disposal. Under the act by which the college was founded, instruction in military tactics is imperative, and each student, unless physically debarred,* is required to attend such exercises as are prescribed, under the direction of a regular army officer stationed at the college.

FOUR-YEARS COURSE.

Admission.

Candidates for admission to the freshman class will be examined orally and in writing upon the following subjects: English grammar, geography, United States history, physiology, physical geography, arithmetic, the metric system, algebra (through quadratics), geometry (two books) and civil government (Mowry's "Studies in Civil Government"). The standard required is 65 per cent. on each paper. Diplomas from high schools will *not* be received in place of examination. Examinations in the following subjects may be taken a year before the candidate expects to enter college: English grammar, geography, United States history, physical geography and physiology. Satisfactory examination in a substantial part of the subjects offered will be required, that the applicant may have credit for this preliminary examination.

Candidates for higher standing are examined as above, and also in the studies gone over by the class to which they desire admission.

No one can be admitted to the college until he is sixteen years of age. The regular examinations for admission are held at the Botanic Museum, at 9 o'clock A.M., on Thursday and Friday, June 23 and 24, and on Tuesday and Wednesday, September 6 and 7; but candidates may be examined and admitted at any other time in the year. For the accommodation of those living in the eastern part of the State, examinations will also be held at 9 o'clock A.M., on Thursday and Friday, June 23 and 24, at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; and for the accommodation of those in the western part of the State, at the same date and time, at the Sedgwick Institute, Great Barrington, by James Bird. Two full days are required for examination, and candidates must come prepared to stay that length of time.

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* Certificates of disability must be procured of Dr. Herbert B. Perry of Amherst.

WINTER COURSES.

For these short winter courses examinations are not required. They commence the first Wednesday in January and end the third Wednesday in March. Candidates must be at least sixteen years of age. The doors of the college are opened to applicants from both sexes. The same privileges in regard to room and board will obtain as with other students. Attendance upon general exercises is required. The usual fees for apparatus and material used in laboratory work will be required. Attendance upon military drill is not expected.

ENTRANCE EXAMINATION PAPERS USED IN 1897.

The standard required is 65 per cent. on each paper.

Arithmetic and Metric System.

1. Divide the least common multiple of 7, 42, 6, 9, 10 and 630 by the greatest common divisor of 110, 140 and 680.

2. $\frac{\frac{1}{2} \text{ of } 7\frac{1}{2}}{\frac{3}{8} \text{ of } 15} + \frac{4\frac{3}{4} \times \frac{9}{10}}{11 \times 1\frac{1}{2}} = ?$ Give answer in lowest terms.

3. A speculator bought 48 bales of cotton, and afterward sold the whole for \$2,008.80, losing 7%. What was the cost of each bale?

4. What must be the face of a note at 10 months, interest at 8%, so that the proceeds may be \$448.00?

5. $(2.8)^3 \div \sqrt{.117649} = ?$

6. What will be the weight in grams of the water contained in a rectangular vessel 2 m. $\times$ 9 cm. $\times$ 7 dm.?

7. How many pails of water are there in a tank 10 m. 4 cm. long, 6 m. 2 dm. wide and 9 dm. 4 cm. deep, if the capacity of the pail is 5 litres?

Algebra.

Resolve into prime factors —

1. (*a*) $(5x+8y)^2-(4x-3y)^2$.
   (*b*) $(2x+3y)(3x)-(2x+3y)(2y)$.
   (*c*) (x^2-7x+6).

2. A cistern could be filled with water by means of one pipe alone in six hours and by means of another pipe alone in eight hours, and it could be emptied by a tap in twelve hours if the two pipes were closed. In what time will the cistern be filled if the pipes and tap are all open?

3. $\left.\begin{array}{l} \dfrac{12}{x}+\dfrac{8}{y}=8 \\[2ex] \dfrac{27}{x}-\dfrac{12}{y}=3 \end{array}\right\}$ solve for x and y.

4. Find the square root of

$$9x+10-12x^{\frac{1}{2}}-4x^{-\frac{1}{2}}+x^{-1}.$$

5. Rationalize the denominator of

$$\frac{25\sqrt{3}-4\sqrt{2}}{7\sqrt{3}-5\sqrt{2}}$$

6. Divide $a^{\frac{2}{3}}+b^{\frac{2}{3}}-c^{\frac{2}{3}}+2a^{\frac{1}{3}}\,b^{\frac{1}{3}}$ by $a^{\frac{1}{3}}+b^{\frac{1}{3}}+c^{\frac{1}{3}}$.

7. $\left.\begin{array}{l} x^2-2xy=5 \\ x^2+y^2=29 \end{array}\right\}$ solve for x and y.

Geometry.

1. Each side of an equilateral triangle is two feet; find its altitude.

Prove the following: —

2. The line joining the middle points of two sides of a triangle is parallel to the third side and equal to one-half of it.

3. The perpendiculars at the middle points of the sides of a triangle meet in a common point.

4. In the same circle, or equal circles, two central angles are in the same ratio as the intercepted arcs. Give proof when the arcs are incommensurable.

5. An inscribed angle is measured by one-half its intercepted arc. Give proof when one side of the angle is a diameter.

United States History.

Note. — Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. Contrast the settlement of the Virginia colony at Jamestown and that of the Massachusetts colony at Plymouth. Give dates of each settlement.

2. (*a*) Name the thirteen original States. (*b*) What were the "Articles of Confederation," and what were their weak points? (*c*) When was the Constitution adopted?

3. The causes, principal events and outcome of the French and Indian War.

4. Give brief accounts of the following: (*a*) The Stamp Act. (*b*) The Boston Massacre. (*c*) The Boston Tea Party.

5. Write a short account of the administration of Andrew Jackson.

6. For what were the following men noted in the *legislative* history of our country: (*a*) Benjamin Franklin, (*b*) Patrick Henry, (*c*) John Jay, (*d*) Alexander Hamilton, (*e*) James Monroe, (*f*) Daniel Webster, (*g*) John C. Calhoun, (*h*) Abraham Lincoln, (*i*) Charles Sumner, (*j*) Grover Cleveland?

7–8. The Missouri Compromise. Give the cause, purport of and effect.

9. A few words on the following engagements of the Civil War: (*a*) Farragut's attack on New Orleans. (*b*) The battle of Gettysburg.

10. Name the Presidents that were elected for two terms.

Geography.

Note.— Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. Draw a line from Boston to New Orleans. Through what States would the line pass?

2. Bound the United States of America.

3–4. A careful and comprehensive account of Mexico.

5. Locate: Corea, Amsterdam, Wales, Provincetown, Warsaw, Poland, Calcutta, Sydney, Queenstown, Valparaiso.

6. Describe a journey eastward, by water, from Chicago to Constantinople.

7–8. The East Indies: (*a*) names of the principal islands; (*b*) geographical features; (*c*) people; (*d*) resources and products.

9. Name six republics on the earth.

10. The States bordering upon the Gulf of Mexico, and their capitals.

Physical Geography.

Note.— Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. What are the tides? Where are they greatest, and where least? What causes them? Tell the difference between flood and high tides.

2. What is the Sargasso Sea? What causes it?

3. Name and describe the different kinds of clouds.

4. What is a volcano? What substances are thrown out during an eruption? What probably causes an eruption?

5. Suppose a vessel to sail from North Cape to Cape Horn, through what zones and across what circles would she pass? What ocean currents would she encounter? and state whether they would aid or retard her progress

Civil Government.

Note. — Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. How does the form of the government of the town in which you live differ from that of the government of the United States? Is a town government of the same form as that of a city?

2. Name the three kinds of colonial government found in America prior to the Revolution. Show in what respects they differed from each other, and name the colonies that were under each.

3. Who make the laws for the government of the town or city in which you live? What is the official name of the men whose duty it is to see that these laws are executed? By whom and how often are these men chosen? Does the town have a written constitution?

4. Who make the laws for the government of the State in which you live? Where and how often do these law-makers meet? By whom are they chosen? How long do they hold office? What is the official title of the chief executive officer of the State?

5. What is the Congress of the United States? Of how many bodies does it consist, and what is the name of each? How many men has Massachusetts in each of these bodies? How and for how long a time are these men chosen?

6. What is meant by an *executive* officer? What is the official title of the chief executive officer of the United States? Explain carefully how he is elected. For how long a time is he elected?

7. What is the Constitution of the United States? Who framed it? Where and in what year? In what year did it go into effect? Name any of the objects for which the people of the United States ordained and established the Constitution.

8. What is a tax? a poll tax? a property tax? a direct tax? an indirect tax? For what purposes may a town levy a tax upon its citizens? How is the amount of each citizen's tax determined?

9. Why is an education a necessity in a republican government? Why is it right to tax the citizens of a town for the support of public schools? What provision for the support of public schools in the new States of the Northwest did Congress make? Write briefly about the public schools of the town in which you live.

Physiology.

Note. — Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. Name and locate the cranial bones.

Give a careful description of the skeleton of the trunk.

2. Describe the mechanics of respiration.

How does air once breathed differ from pure air?

3. Give the several functions of the skin.

Tell what you know of the hygiene of the skin.

4. Give the bodily location and the uses of the following organs: the aorta, the optic nerve, the spleen, the larynx and the pharynx.

5. Suppose the hand to touch a hot stove, it is drawn away so quickly as not to be injured; how is this done, and by what means?

English Grammar and Composition.

Note. — Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. Name every word in the following sentence; *i.e.*, give its part of speech: —

"The closing years of the nineteenth century will be remembered by Americans as those in which the business prosperity of the country sunk to a remarkably low level."

2. Select from the above (*a*) all words in the *nominative* case; (*b*) all those in the *objective* case. (*c*) Are there any of the *possessive* case in the sentence?

3. Give the principal parts of: recline, fly, beat, fight, fling.

4. Analyze the following: —

"The tramp who came to our door last evening aroused much curiosity; and next morning my father tried to find out the place from which the man had come."

5. Write a sentence upon college education; one upon agriculture.

Note. — Each sentence must contain at least twenty words.

6. Define the paragraph. How does it differ from the sentence?

7–9. Write three paragraphs upon one of the following subjects: (*a*) Why I come to college; (*b*) Longfellow's "Evangeline;" (*c*) John G. Whittier; (*d*) General Grant.

10. State clearly and fully the work you have done during the past two years, in school and out, in grammar and rhetoric. Where books can be named, do so.

DEGREES.

Those who complete the four-years course receive the degree of Bachelor of Science, the diploma being signed by the governor of Massachusetts, who is the president of the corporation.

Regular students of the college may also, on application, become members of Boston University, and upon graduation receive its diploma in addition to that of the college, thereby becoming entitled to all the privileges of its alumni.

Those completing the prescribed graduate course receive the degree of Master of Science or Doctor of Philosophy.

EXPENSES.

Tuition in advance: —			
Fall term,	$30 00		
Winter term,	25 00		
Summer term,	25 00		
		$80 00	$80 00
Room rent, in advance, $8 to $16 per term,		24 00	48 00
Board, $2.50 to $5 per week,		95 00	190 00
Fuel, $5 to $15,		5 00	15 00
Washing, 30 to 60 cents per week,		11 40	22 80
Military suit,		15 75	15 75
Expenses per year,		$231 15	$371 55

Board in clubs has been about $2.45 per week; in private families, $4 to $5. The military suit must be obtained immediately upon entrance at college, and used in the drill exercises prescribed. The following fees will be charged for the maintenance of the several laboratories: chemical, $10 per term used; zoölogical, $4 per term used; botanical, $1 per term used by sophomore class, $2 per term used by senior class; entomological, $2 per term used. Some expense will also be incurred for lights and textbooks. Students whose homes are within the State of Massachusetts can in most cases obtain a scholarship by applying to the senator of the district in which they live.

THE LABOR FUND.

The object of this fund is to assist those students who are dependent either wholly or in part on their own exertions, by furnishing them work in the several departments of the college. The greatest opportunity for such work is found in the agricultural and horticultural departments. Application should be made to Profs. William P. Brooks and Samuel T. Maynard, respectively in charge of said departments. Students desiring to avail themselves of its benefits must bring a certificate signed by one of the selectmen of the town in which they are resident, certifying to the fact that they require aid.

ROOMS.

All students, except those living with parents or guardians, will be required to occupy rooms in the college dormitories.

For the information of those desiring to carpet their rooms, the following measurements are given: in the new south dormitory the study rooms are about fifteen by fourteen feet, with a recess seven feet four inches by three feet; and the bedrooms are eleven feet two inches by eight feet five inches. This building is heated by steam. In the north dormitory the corner rooms are fourteen by fifteen feet, and the annexed bedrooms eight by ten feet. The inside rooms are thirteen and one-half by fourteen and one-half feet, and the bedrooms eight by eight feet. A coal stove is furnished with each room. Aside from this, all rooms are unfurnished. Mr. Thomas Canavan has the general superintendence of the dormitories, and all correspondence relative to the engaging of rooms should be with him.

SCHOLARSHIPS.

Established by Private Individuals.

Mary Robinson Fund of one thousand dollars, the bequest of Miss Mary Robinson of Medfield.

Whiting Street Fund of one thousand dollars, the bequest of Whiting Street, Esq., of Northampton.

Henry Gassett Fund of one thousand dollars, the bequest of Henry Gassett, Esq., of North Weymouth.

The income of the above funds is assigned by the faculty to worthy students requiring aid.

Congressional Scholarships.

The trustees voted in January, 1878, to establish one free scholarship for each of the congressional districts of the State. Application for such scholarships should be made to the representative from the district to which the applicant belongs. The selection for these scholarships will be determined as each member of Congress may prefer; but, where several applications are sent in from the same district, a competitive examination would seem to be desirable. Applicants should be good scholars, of vigorous constitution, and should enter college with the intention of remaining through the course.

State Scholarships.

The Legislature of 1883 passed the following resolve in favor of the Massachusetts Agricultural College: —

Resolved, That there shall be paid annually, for the term of four years, from the treasury of the Commonwealth to the treasurer of the Massachusetts Agricultural College, the sum of ten thousand dollars, to enable the trustees of said college to provide for the students of said institution the theoretical and practical education required by its charter and the law of the United States relating thereto.

Resolved, That annually, for the term of four years eighty free scholarships be and hereby are established at the Massachusetts Agricultural College, the same to be given by appointment to persons in this Commonwealth, after a competitive examination, under rules prescribed by the president of the college, at such time and place as the senator then in office from each district shall designate; and the said scholarships shall be assigned equally to each senatorial district. But, if there shall be less than two successful applicants for scholarships from any senatorial district, such scholarships may be distributed by the president of the college equally among the other districts, as nearly as possible; but no applicant shall be entitled to a scholarship unless he shall pass an examination in accordance with the rules to be established as hereinbefore provided.

The Legislature of 1886 passed the following resolve, making perpetual the scholarships established: —

Resolved, That annually the scholarships established by chapter forty-six of the resolves of the year eighteen hundred and eighty-three be given and continued in accordance with the provisions of said chapter.

In accordance with these resolves, any one desiring admission to the college can apply to the senator of his district for a scholarship. Blank forms of application will be furnished by the president.

EQUIPMENT.

Agricultural Department.

The Farm. — Among the various means through which instruction in agriculture is given, none exceeds in importance the farm. The part which is directly under the charge of the professor of agriculture comprises about one hundred and fifty acres of improved land and thirty acres of woodland. Of the improved land, about thirty acres are kept permanently in grass.

The rest of the farm is managed under a system of rotation, all parts being alternately in grass and hoed crops. All the ordinary crops of this section are grown, and many not usually seen upon Massachusetts farms find a place here. Our large stock of milch cows being fed almost entirely in the barn, fodder crops occupy a prominent place. Experiments of various kinds are continually under trial; and every plat is staked, and bears a label stating variety under cultivation, date of planting, and manures and fertilizers used.

Methods of land improvement are constantly illustrated here, tile drainage especially receiving a large share of attention. There are now some nine miles of tile drains in successful and very satisfactory operation upon the farm. Methods of clearing land of stumps are also illustrated, a large amount of such work having been carried on during the last few years.

In all the work of the farm the students are freely employed, and classes are frequently taken into the fields; and to the lessons to be derived from these fields the students are constantly referred.

The Barn and Stock.—Our commodious barns contain a large stock of milch cows, many of which are grades; but the following pure breeds are represented by good animals, viz., Holstein-Friesian, Ayrshire, Jersey, Guernsey, Aberdeen-Angus and Shorthorn. Experiments in feeding for milk and butter are continually in progress. We have a fine flock of Southdown sheep. Swine are represented by the Chester White, Poland China, Cheshire, Berkshire and Tamworth breeds. Besides work horses, we have a number of pure-bred Percherons, used for breeding as well as for work; and a fine pair of French Coach colts.

The barn is a model of convenience and labor-saving arrangements. It illustrates different methods of fastening animals, various styles of mangers, watering devices, etc. Connected with it are commodious storage rooms for vehicles and machines. It contains silos and a granary. A very large share of the work is performed by students, and whenever points require illustration, classes are taken to it for that purpose.

Dairy School. — Connecting with the barn is a wing providing accommodation for practical and educational work in dairying. The wing contains one room for heavy dairy machinery, another for lighter machinery, both large enough to accommodate various styles of all prominent machines; a large ice-house, a cold-storage room and a room for raising cream by gravity methods, a class room and a laboratory. The power used is an electric motor. This department is steam heated and piped for hot and cold water and steam. In this department has been placed a full line of modern dairy machinery, so that we are able to illustrate all the various processes connected with the creaming of milk, its preparation for market and the manufacture of butter. Special instruction in such work is offered in the dairy course.

Equipment of Farm. — Aside from machines and implements generally found upon farms, the more important of those used upon our farm and in our barn which it seems desirable to mention are the following: reversible sulky plough, broadcast fertilizer distributer, manure spreader, grain drill, horse corn planter, potato planter, wheelbarrow grass seeder, hay loader, potato digger and fodder cutter and crusher. It is our aim to try all novelties as they come out, and to illustrate everywhere the latest and best methods of doing farm work.

Lecture Room. — The agricultural lecture room in south college is well adapted to its uses. It is provided with numerous charts and lantern slides, illustrating the subjects taught. Connected with it are two small rooms at present used for the storage of illustrative material, which comprises soils in great variety, all important fertilizers and fertilizer materials, implements used in the agriculture of our own and other countries, and a collection of grasses and forage plants, grains, etc.

A valuable addition to our resources consists of a full series of Landsberg's models of animals. These are accurate models of selected animals of all the leading breeds of cattle, horses, sheep and swine, from one-sixth to full size, according to subject. We are provided with a complete collection of seeds of all our common grasses and the weeds which grow in mowings, and have also a large collection of the concentrated food stuffs. All these are continually used in illustration of subjects studied.

Museum. — A beginning has been made towards accumulating materials for an agricultural museum. This is to contain the rocks from which soils have been derived, soils, fertilizer materials and manufactured fertilizers, seeds, plants and their products, stuffed animals, machines and implements. It is expected to make this collection of historical importance by including in it old types of machines and implements, earlier forms of breeds, etc. For lack of room the material thus far accumulated is stored in a number of scattered localities, and much of it where it cannot be satisfactorily exhibited.

Botanical Department.

Course of Study. — This department is well equipped to give a comprehensive course in most of the subjects of botany. The course aims to treat of all the more important features connected with the study of plants which have a close bearing upon agriculture, without at the same time deviating from a systematic and logical plan. Throughout the entire course the objective methods of teaching are followed, and the student is constantly furnished with an abundance of plant material for practical study, together with an elaborate series of preserved specimens for illustration and comparison. In the freshman year the study of structural and systematic botany is pursued, with some observation on insect fertilization. This is followed in the first term of the sophomore year by the systematic study of grasses, trees and shrubs, and this during the winter term by an investigation into the microscopic structure of the plant. The senior year is given up entirely to cryptogamic and physiological botany. This includes a study of our common plant diseases, and the simple functions of the plant which it is essential for the agriculturist to become familiar with.

The Botanical Museum contains the Knowlton herbarium, of over ten thousand species of phanerogamous and the higher cryptogamous plants; about five thousand species of fungi, and several collections of lichens and mosses, including those of Tuckerman, Frost, Denslow, Cummings, Müller and Schaerer. It also contains a large collection of native woods, cut so as to show their individual structure; numerous models of native fruits; specimens of abnormal and peculiar forms of stems, fruits, vegetables, etc.; many interesting specimens of unnatural growths of trees and plants, natural grafts, etc.; together with models for illustrating the growth and structure of plants, and including a model of the squash which raised by the expansive force of its growing cells the enormous weight of five thousand pounds.

The Botanical Lecture Room, in the same building, is provided with diagrams and charts of over three thousand figures, illustrating structural, systematic and physiological botany.

The Botanical Laboratory has provision for thirty-four students to work at one time. Each student is provided with a locker, wherein he can dispose of his equipment necessary for study. The laboratory is equipped with Leitz', Reichert's, Bausch and Lomb's, Beck's, Queen's and Tolles' compound microscopes, with objectives varying from four inch to one-fifteenth inch focal length. It also contains four induction coils, including a Du Bois-Reymond induction apparatus and rheocord, a Lippmann capillary electrometer, and various other forms of electrical appliances especially devised for studying the influence of electricity upon the growth of plants. There are also Thoma, Minot and Beck microtomes, a self-registering thermometer and hygrometer, a Wortmann improved clinostat and also one of special construction, an Arthur centrifugal apparatus with electric motor, various forms of self-registering appliances for registering the growth of plants, including a Pfeffer-Baranetsky electrical self-registering auxanometer, a Sach's arc-auxanometer, a horizontal reading microscope (Pfeffer model), various kinds of dynamometers of special construction, respiration appliances, mercurial sap and vacuum gauges, manometers, gas and exhaust chambers, besides various other appliances for work and demonstration in plant physiology. The laboratory is also provided with an Eastman landscape camera, a Bausch and Lomb micro-photographic camera, and a dark closet equipped for photographic and other kinds of work.

Horticultural Department.

Greenhouses. — To aid in the instruction in botany, as well as in floriculture and market gardening, the glass structures contain a large collection of plants of a botanic and economic value, as well as those grown for commercial purposes. They consist of two large octagons, forty by forty feet, with sides twelve feet high and a central portion over twenty feet high, for the growth of large specimens, like palms, tree ferns, the bamboo, banana, guava, olive, etc.; a moist stove twenty-five feet square; a dry stove of the same dimensions; a rose room, twenty-five by twenty feet; a room for aquatic plants, twenty by twenty-five feet; a room for ferns, mosses and orchids, eighteen by thirty feet; a large propagating house, fifty by twenty-four feet, fitted up with benches sufficient in number to accommodate fifty students at work at one time; a vegetable house, forty-two by thirty-two feet; a large propagating house, thirty-six by seventy-five feet, for the growing of carnations, violets and bedding plants; a cold grapery, eighteen by twenty-five feet. To these glass structures are attached three work rooms, equipped with all kinds of tools for greenhouse work. In building these houses as many as possible of the principles of construction, heating, ventilation, etc., have been incorporated for the purposes of instruction.

Orchards. — These are extensive, and contain nearly all the valuable leading varieties, both old and new, of the large fruits, growing under various conditions of soil and exposure.

Small Fruits. — The small-fruit plantations contain a large number of varieties of each kind, especially the new and promising ones, which are compared with older sorts, in plots and in field culture. Methods of planting, pruning, training, cultivation, study of varieties, gathering, packing and shipping fruit, etc., are taught by field exercises, the students doing a large part of the work of the department.

Nursery. — This contains more than five thousand trees, shrubs and vines in various stages of growth, where the different methods of propagation by cuttings, layers, budding, grafting, pruning and training are practically taught to the students.

Garden. — All kinds of garden and farm-garden crops are grown in this department, furnishing ample illustration of the treatment of market-garden crops. The income from the sales of trees, plants, flowers, fruit and vegetables aids materially in the support of the department, and furnishes illustrations of the methods of business, with which all students are expected to become familiar.

Forestry. — Many kinds of trees suitable for forest planting are grown in the nursery, and plantations have been made upon the college grounds and upon private estates in the vicinity, affording good examples of this most important subject. A large forest grove is connected with this department, where the methods of pruning trees and the management and preservation of forests can be illustrated. In the museum and lecture room are collections of native woods, showing their natural condition and peculiarities; and there have been lately added the prepared wood sections of R. B. Hough, mounted on cards for class-room illustration.

Ornamental trees, shrubs and flowering plants are grouped about the grounds in such a way as to afford as much instruction as possible in the art of landscape gardening. All these, as well as the varieties of large and small fruits, are marked with conspicuous labels, giving their common and Latin names, for the benefit of the students and the public.

Tool House. — A tool house, thirty by eighty feet, has been constructed, containing a general store-room for keeping small tools; a repair shop with forge, anvil and work-bench; and a carpenter shop equipped with a large Sloyd bench and full set of tools. Under one-half of this building is a cellar for storing fruit and vegetables. In the loft is a chamber, thirty by eighty feet, for keeping hot-bed sashes, shutters, mats, berry crates, baskets and other materials when not in use.

Connected with the stable is a cold-storage room, with an ice-chamber over it, for preserving fruit, while the main cellar underneath the stable is devoted to the keeping of vegetables.

All the low land south of the greenhouses has been thoroughly underdrained and put into condition for the production of any garden or small fruit crop.

Department of Zoölogy.

The work in this department begins in the winter term of the sophomore year with human anatomy and physiology, the study of which not only serves as an introduction to zoölogy and veterinary science, but also gives the student a knowledge of the structure and uses of the different organs of the human body and the laws of health. In the fall and winter terms the members of the junior class take zoölogy, which is taught by means of lectures and laboratory work. In the laboratory each student is required to dissect and study a series of typical animals, making drawings of the various organs. During the spring term of this year a course of lectures is given on insects in general, their classification and habits and the various methods of destroying those that are injurious, and more or less time in this connection is devoted to laboratory and field work.

There is a most excellent and carefully arranged museum connected with this department, in which are exhibited, as far as possible, all the native animals of this Commonwealth, together with such species from other parts of the world as are necessary to give completeness or for the instruction of the students. This museum furnishes specimens for illustration in the lectures before the classes, and also for general information to visitors as well as members of the college.

During the senior year such members of this class as elect advanced entomology take a course of more technical lectures, in which the following subjects relating to insects are considered quite at length: external and internal anatomy, embryology, transformations, duration of life, luminosity of insects, the color of insects, parasitic insects, diseases of insects, number of insects in existence, geographical and geological distribution of insects, insect architecture, fertilization of plants by insects, economic entomology, bee-keeping and the literature of insects. The laboratory work of this year consists in part of dissections of the caterpillar, pupa and imago stages of insects, and a critical study of the external anatomy of species of each of the orders of insects, followed by the exercise of determining a group of insects in each order; and, finally, each student is required to prepare a thesis on some insect or group of insects pertaining to the business in which he intends to engage. He is asked at the beginning of the year what business he intends to follow after graduation, and is then advised to prepare his thesis on those insects with which he will most have to deal in the business he has selected. In the preparation of this thesis the work is carried on in the most approved methods, so that he may obtain the most scientific and at the same time practical knowledge of the subject; in fact, the is taught such methods of investigation that, if new insec pests appear on his crops, he will know how to properly investigate them and discover the best and cheapest methods for their destruction. If this thesis when completed contains information of public interest, whether of an economic character or otherwise, it is published, with whatever illustrations are necessary.

This course is primarily for the student of agriculture or horticulture, but, when taken in connection with botany and chemistry, is especially adapted to one wishing to fit himself as a teacher of science in our public schools, or to one intending to study medicine, but in this case his laboratory work would be devoted mainly to histology.

This department is now prepared for and is receiving graduates from this and other colleges, who wish to continue the study of entomology beyond what they were able in their undergraduate course. These advanced studies will fit them for positions in the experiment stations or as State entomologists, and also give them most excellent training as teachers in our high schools and colleges.

Veterinary Department.

This department is well equipped with the apparatus necessary to illustrate the subject in the class room.

It consists of an improved Auzoux model of the horse, imported from Paris, constructed so as to separate and show in detail the shape, size, structure and relations of the different parts of the body; two *papier-maché* models of the hind legs of the horse, showing diseases of the soft tissues, — wind-galls, bog spavins, etc., also the diseases of the bone tissues, — splints, spavins and ringbones; two models of the foot, one according to Bracy Clark's description, the other showing the Charlier method of shoeing and the general anatomy of the foot; a full-sized model of the bones of the hind leg, giving shape, size and position of each individual bone; thirty-one full-sized models of the jaws and teeth of the horse and fourteen of the ox, showing the changes which take place in these organs as the animals advance in age.

There is an articulated skeleton of the famous stallion, Blackhawk, a disarticulated one of a thoroughbred mare, besides one each of the cow, sheep, pig and dog; two prepared dissections of the fore and hind legs of the horse, showing position and relation of the soft tissues to the bones; a *papier-maché* model of the uterus of the mare and of the pig; a gravid uterus of the cow; a wax model of the uterus, placenta and fœtus of the sheep; showing the position of the fœtus and the attachment of the placenta to the walls of the uterus.

In addition to the above there is a growing collection of pathological specimens of both the soft and osseous tissues, and many parasites common to the domestic animals. A collection of charts and diagrams especially prepared for the college is used in connection with lectures upon the subject of anatomy, parturition and conformation of animals.

Through the kindness of Mr. Henry Adams of Amherst the department has received a large sample collection of the various drugs used in the treatment of the diseases of the domestic animals.

For the benefit of the students, sick or diseased animals are frequently shown them, and operations performed in connection with the class-room work. For the use of the instructor of this department a laboratory has been provided in the old chapel building. It has been equipped with the apparatus necessary for the study of histology, pathology and bacteriology, consisting in part of four improved Zeiss microscopes with one-eighteenth and one-twelfth inch oil immersion objectives, together with the lower powers; a Lautenschlager's incubator and hot-air sterilizer; an Arnold's steam sterilizer and a Bausch and Lomb improved laboratory microtome. This apparatus is used for the preparation of material for the class room and for general investigation.

Mathematical Department.

At first glance it might appear that mathematics would play a very small part in the curriculum of an agricultural college, and, while it is true that its chief object is of a supplementary nature, it is equally true that, entirely aside from its value as a means of mental discipline, mathematics has a well-defined and practical object to accomplish. In this day of scientific experiment, observation and research on the farm, the advantages of a thorough knowledge of the more elementary branches of mathematics, general physics and engineering must be more than ever apparent; and it is to meet the needs of the agricultural college student in these lines that the work in the mathematical department has been planned.

The mathematics of the freshman, sophomore and junior years are required, those of the senior year elective.

A glance at the schedule of studies will show the sequence of subjects: book-keeping, algebra, geometry and mechanical drawing in the freshman year; trigonometry, mechanical drawing and plane surveying — the latter embracing lectures and field work in elementary engineering, the use of instruments, computation of areas, levelling, etc. — in the sophomore year; general physics with work in laboratory — including mechanics, electricity, sound, light and heat — and descriptive geometry or advanced mechanical drawing in the junior year; and, finally, two electives in the senior year, — mathematics and engineering, respectively.*

The mathematical option includes the following subjects: fall term, plane analytic geometry, embracing a study of the equations and properties of the point, line and circle, and of the parabola, ellipse and hyperbola; winter term, differential calculus; and summer term, integral calculus.

The senior engineering option is designed to give to the student the necessary engineering training to enable him to take up and apply, on the lines of landscape engineering and the development of property, his knowledge of landscape gardening, agriculture, forestry, botany and horticulture. It embraces a course of lectures, recitations and field work on the following subjects: topography, railroad curves, earth work, construction and maintenance of roads, water works and sewerage systems, elementary structures, elementary mechanism, etc.

It is believed that the engineering elective will equip the student to enter a comparatively new field, that of landscape engineering, which is coming more and more prominently before the public attention; for, with the increasing consideration which is being paid to the public health and the development and beautifying of our towns and cities, come fresh needs and opportunities.

Chemical Department.

Instruction in general agricultural and analytical chemistry and mineralogy is given in the laboratory building. Thirteen commodious rooms, well lighted, ventilated and properly fitted, are occupied by the chemical department.

The lecture room, on the second floor, has ample seating capacity for seventy students. Immediately adjoining it are four smaller rooms, which serve for storing apparatus and preparing material for the lecture table.

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* While these two electives are entirely distinct, the student electing engineering is strongly advised to elect mathematics also.

The laboratory for beginners is a capacious room on the first floor. It is furnished with forty working tables. Each table is provided with sets of wet and dry re-agents, a fume chamber, water, gas, drawer and locker, and apparatus sufficient to render the student independent of carelessness or accident on the part of others working near by; thus equipped, each worker has the opportunity, under the direction of an instructor, of repeating the processes which he has previously studied in the lecture room, and of carrying out at will any tests which his own observation may suggest.

A systematic study of the properties of elementary matter is here taken up, then the study of the simpler combinations of the elements and their artificial preparation; then follows qualitative analysis of salts, minerals, soils, fertilizers, animal and vegetable products.

The laboratory for advanced students has tables for thirty workers, with adequate apparatus. This is for instruction in the chemistry of various manufacturing industries, especially those of agricultural interest, as the production of sugar, starch, fibres and dairy products; the preparation of plant and animal foods, their digestion, assimilation and economic use; the official analysis of fertilizers, fodders and foods; the analysis of soils and waters, of milk, urine and other animal and vegetable products.

The balance room has four balances and improved apparatus for determining densities of solids, liquids and gases.

Apparatus and Collections. — Large purchases of apparatus require to be made. Deficiencies caused by the wear and breakage of several years need to be supplied and the original outfit increased. The apparatus includes balances, a microscope, spectroscope, polariscope, photometer, barometer and numerous models and sets of apparatus. The various rooms are furnished with an extensive collection of industrial charts. A valuable and growing collection of specimens and samples, fitted to illustrate different subjects taught, is also provided. This includes rocks, minerals, soils, raw and manufactured fertilizers, foods, including milling products, fibres and other vegetable and animal products and artificial preparations of mineral and organic compounds. Series of preparations are used for illustrating the various stages of different manufactures from raw materials to finished products.

Library.

This now numbers 18,497 volumes, having been increased during the year, by gift and purchase, 687 volumes. It is placed in the lower hall of the chapel-library building, and is made available to the general student for reference or investigation. It is especially valuable as a library of reference, and no pains will be spared to make it complete in the departments of agriculture, horticulture, botany and the natural sciences. It is open a portion of each day for consultation, and an hour every evening for the drawing of books.

PRIZES.

Burnham Rhetorical Prizes.

These prizes are awarded for excellence in declamation, and are open to competition, under certain restrictions, to members of the sophomore and freshman classes.

Flint Prizes.

Mr. Charles L. Flint of the class of 1881 has established two prizes, one of thirty dollars and another of twenty dollars, to be awarded, at an appointed time during commencement week, to the two members of the junior class who may produce the best orations. Excellence in both composition and delivery is considered in making the award.

Grinnell Agricultural Prizes.

Hon. William Claflin of Boston has given the sum of one thousand dollars for the endowment of a first and second prize, to be called the Grinnell agricultural prizes, in honor of George B. Grinnell, Esq., of New York. These two prizes are to be paid in cash to those two members of the graduating class who may pass the best written and oral examination in theoretical and practical agriculture.

Hills Botanical Prizes.

For the best herbarium collected by a member of the class of 1898 fifteen dollars is offered, and for the second best a prize of ten dollars; also a prize of five dollars for the best collection of dried plants from the college farm.

The prizes in 1897 were awarded as follows: —

Burnham Rhetorical Prizes: Edwin M. Wright (1899), first; Warren E. Hinds (1899), second; Allen L. March (1900), first; Francis G. Stanley (1900), second.

Flint Oratorical Prizes: Randall D. Warden (1898), first; John P. Nickerson (1898), second.

Grinnell Agricultural Prizes: Liberty L. Cheney (1897), first; Philip H. Smith, Jr. (1897), second.

Hills Botanical Prizes: John M. Barry (1897), first; Clayton F. Palmer (1897), second.

Prize in Drawing, given by William H. Armstrong, '99; Edwin K. Atkins (1900).

Senior Prizes, given by Charles S. Crocker, '89, and Henry L. Russell, '90; best thesis, James L. Bartlett; best appearance, Charles I. Goessmann.

RELIGIOUS SERVICES.

Students are required to attend prayers every week-day at 8 A.M. and public worship in the chapel every Sunday at 10.30 A.M. Further opportunities for moral and religious culture are afforded by a Bible class taught by one of the professors during the hour preceding the Sunday morning service and by religious meetings held on Sunday afternoon and during the week, under the auspices of the College Young Men's Christian Association.

LOCATION.

Amherst is on the New London Northern Railroad, connecting at Palmer with the Boston & Albany Railroad, and at Miller's Falls with the Fitchburg Railroad. It is also on the Central Massachusetts Railroad, connecting at Northampton with the Connecticut River Railroad and with the New Haven & Northampton Railroad.

The college buildings are on a healthful site, commanding one of the finest views in New England. The large farm of three hundred and eighty-three acres, with its varied surface and native forests, gives the student the freedom and quiet of a country home.

REPORTS.

GIFTS.

From Massachusetts Society for Promoting Agriculture, one hundred dollars to be distributed in prizes in the Dairy School.

J. D. W. French of Boston, seven volumes Hough's "American Woods."

John A. Cutter (M. A. C., '82) of New York, forty-five volumes medical works.

Frederick W. Morris (M. A. C., '72) of New York, forty-four volumes miscellaneous works.

Creamery Package Manufacturing Co., of Chicago, Ill., Disbrow combined churn and butter worker.

F. B. Fargo & Co. of Lake Mills, Wis., Fargo combined churn and butter worker.

I. S. Johnson & Co. of Boston, two large cans Sheridan's condition powders.

L. H. Reed of Grand Rapids, Mich., seed of Panicum crus-galli gigantic.

Rogers & Hubbard Company of Middletown, Conn., one hundred pounds raw knuckle bone flour.

Bradley Fertilizer Company of Boston, two hundred pounds extract fine-ground South Carolina rock, five hundred pounds soft Florida rock, two hundred pounds hard Florida rock, two hundred pounds dissolved bone meal, one hundred pounds steamed bone meal and two hundred pounds acid phosphate.

Barteledes & Co. of Lawrence, Kansas, seed of Idaho field pea, white Kaffir corn, red Kaffir corn, black chaff Kaffir corn or African millet, yellow millo maize, black rice corn, Jerusalem corn, brown Dourha, Brazilian stooling flour corn.

United States Department of Agriculture of Washington, D.C., seed of many varieties of grasses and alfalfa.

Herbert Myrick (M. A. C., '82) of Springfield, "Sugar, a New and Profitable Industry in the United States."

From SAMUEL B. GREEN (M. A. C., '79) of St. Anthony Park, Minn., "Vegetable Gardening."

HERBERT S. CARRUTH (M. A. C., '75) of Ashmont, "George Washington;" "True George Washington."

Hon. GEORGE F. HOAR of Washington, D.C., fifteen volumes government reports.

J. WILLARD BROWN of Boston, "Signal Corps of the United States in the War of the Rebellion."

JOHN F. WINCHESTER (M. A. C., '75) of Lawrence, "Bovine Diphtheria."

RIEHLÉ Co. of Pennsylvania, "Digest of Physical Tests."

JAMES C. HOUGHTON of Montpelier, Vt., "Cambridge of 1896."

CHARLES I. GOESSMANN (M. A. C., '97) of Amherst, "Introduction to General Chemistry;" "True Atomic Weight of the Chemical Elements;" "Literary History of the American Revolution."

Miss ELEANOR A. ORMEROD of Spring Grove, England, "Twentieth Report of Observations on Injurious Insects."

JOSEPH E. POND, Esq., of North Attleborough, four volumes bee journals.

WILLIAM H. CALDWELL (M. A. C., '87) of Peterboro, N.H., "Herd Register American Guernsey Cattle Club."

CHARLES L. FLINT (M. A. C., '81) of Brookline, "Reports Boston Transit Commission."

TREASURER'S REPORT.

Report of George F. Mills, *Treasurer of Massachusetts Agricultural College, from Jan. 1, 1897, to Jan. 1, 1898.*

	Received.	Paid.
Cash on hand Jan. 1, 1897,	$4,309 98	–
State treasurer,	15,333 33	–
Term bill,	3,213 48	$757 28
Salary,	250 00	26,987 40
Horticultural department,	4,495 85	6,366 70
Farm,	5,810 00	11,352 98
Expense,	1,410 00	9,163 19
Endowment fund,	11,791 97	–
State scholarship fund,	15,000 00	–
Labor fund,	5,000 00	5,849 65
Botanical laboratory,	65 00	48 46
Chemical laboratory,	585 04	478 17
Entomological laboratory,	30 00	5 76
Zoölogical laboratory,	32 00	45 95
Grinnell prize fund,	40 00	35 00
Gassett scholarship fund,	42 50	80 00
Whiting street fund.	51 05	30 00
Mary Robinson fund,	38 84	55 00
Burnham emergency fund,	129 04	80 00
Hills fund,	356 16	292 36
Library fund,	421 98	221 06
Extra instruction,	–	288 00
Advertising,	–	677 38
Dairy school,	558 78	1,241 58
Electric equipment,	754 92	3,132 33
Insurance,	–	478 57
Investment, N. Y. C. & H. R. R. R.,	4 00	–
Burnham emergency fund,	2,000 00	–
Cash on hand Jan. 1, 1898,	–	4,054 10
	$71,720 92	$71,720 92

This is to certify that I have this day examined the accounts of George F. Mills, treasurer of Massachusetts Agricultural College, from Jan. 1, 1897, to Jan. 1, 1898, and find the same correct, properly kept, and all disbursements vouched for, the balance in the treasury being four thousand and fifty-four dollars and ten cents ($4,054.10), which sum is shown to be in the hands of the treasurer.

CHARLES A. GLEASON, *Auditor.*

Amherst, Dec. 27, 1897.

CASH BALANCE, AS SHOWN BY THE TREASURER'S STATEMENT, BELONGS TO THE FOLLOWING ACCOUNTS:

Hills fund,	$254 14
Burnham emergency fund,	49 04
Grinnell prize fund,	25 00
Gassett scholarship fund,	23 52
Whiting Street fund,	10 46
Mary Robinson fund,	4 76
General fund of the college,	3,687 18
	$4,054 10

BILLS RECEIVABLE JAN. 1, 1898.

Term bill,	$737 14
Horticultural department,	335 34
Farm,	898 22
Expense,	69 02
Labor fund,	7 23
Electric equipment,	145 95
Botanical laboratory,	32 50
Chemical laboratory,	294 00
Entomological laboratory,	6 00
Zoölogical laboratory,	68 00
	$2,593 40

BILLS PAYABLE JAN. 1, 1898.

Term bill,	$43 23
Horticultural department,	438 44
Farm,	2,405 24
Expense,	567 69
Chemical laboratory,	89 08
Zoölogical laboratory,	27 45
Hills fund,	45 81
Insurance,	18 00
	$3,634 94

INVENTORY — REAL ESTATE.

Land (Estimated Value).

College farm,	$37,000 00	
Pelham quarry,	500 00	
Bangs place,	1,750 00	
Clark place,	4,500 00	
		$43,750 00

Buildings (Estimated Value).

Drill hall,	$5,000 00	
Powder house,	75 00	
Gun shed,	1,500 00	
Stone chapel,	30,000 00	
South dormitory,	35,000 00	
		71,575 00
Amount carried forward,		$115,325 00

Amount brought forward,		$115,325 00
North dormitory,	$25,000 00	
Chemical laboratory,	8,000 00	
Entomological laboratory,	3,000 00	
Farm house,	2,000 00	
Horse barn,	5,000 00	
Farm barn and dairy school,	33,000 00	
Graves house and barn,	2,500 00	
Boarding house,	2,000 00	
Botanic museum,	5,500 00	
Botanic barn,	2,500 00	
Tool house,	2,000 00	
Durfee plant house and fixtures,	13,000 00	
Small plant house, with vegetable cellar and cold grapery,	4,700 00	
President's house,	6,500 00	
Dwelling houses, purchased with farm,	5,000 00	
		119,700 00
		$235,025 00

PERSONAL PROPERTY.

Electric equipment,	$6,000 00
Electric supplies,	88 59
N. Y. C. & H. R. R. R. stock,	100 00
Botanical department,	3,610 00
Horticultural department,	8,668 20
Farm,	15,933 20
Chemical laboratory,	1,986 00
Botanical laboratory,	2,056 53
Zoölogical laboratory,	1,894 75
Natural history collection,	5,278 85
Veterinary department,	1,615 66
Physics and mathematics,	4,513 00
Agricultural department,	3,267 58
Library,	18,050 00
Fire apparatus,	665 00
Furniture,	550 00
Books in treasurer's office,	241 16
Tools and lumber,	209 57
	$74,728 09

SUMMARY.

Assets.

Total value of real estate, per inventory,	$235,025 00
Total value of personal property, per inventory,	74,728 09
Bills receivable,	2,593 40
	$312,346 49

Liabilities.

Bills payable,	3,644 94
	$308,711 55

Maintenance Fund.

Technical educational fund, United States grant,	$219,000 00	
Technical educational fund, State grant,	141,575 35	
	$360,575 35	
Two-thirds of the income from these funds is paid to the treasurer of the college and one-third to the Institute of Technology. Amount received by the college treasurer from Jan. 1, 1897, to Jan. 1, 1898,		$11,791 97
Morrill fund, in accordance with act of Congress, approved Aug. 30, 1890. Amount received in 1897,		15,333 33
Hills fund, the gift of Messrs. L. M. and H. F. Hills of Amherst, now amounts to $8,542. By conditions of the gift the income is used for the maintenance of a botanic garden. Income from Jan. 1, 1897, to Jan. 1, 1898,		356 16
Annual State appropriation, $10,000. This sum was appropriated for four years by the Legislature of 1889, continued for another four years by the Legislature of 1892, and again by the Legislature of 1896, for the endowment of additional chairs of instruction and for general expense. Five thousand dollars of this sum was set apart as a labor fund, to be used in payment of labor performed by needy and worthy students. Amount received from annual State appropriation for college expense from Jan. 1, 1897, to Jan. 1, 1898,		5,000 00
Amount received as labor fund,		5,000 00

Scholarship Funds.

State scholarship fund, $10,000. This sum was appropriated by the Legislature of 1896, and is paid to the college treasurer in quarterly payments. Amount received from Jan. 1, 1897, to Jan. 1, 1898,	10,000 00
Whiting Street fund, $1,000. This fund is a bequest without conditions. To it was added, by vote of the trustees, in January, 1887, interest accrued on the bequest, $260. Amount of the fund Jan. 1, 1897, $1,260. Income from Jan. 1, 1897, to Jan. 1, 1898,	51 05
Gassett scholarship fund, $1,000. This sum was given as a scholarship by Hon. Henry Gassett. Income from Jan. 1, 1897, to Jan. 1, 1898,	42 50
Mary Robinson fund, $858. This fund was given without conditions. The income from it has been appropriated for scholarships to needy and worthy students. Income from Jan. 1, 1897, to Jan. 1, 1898,	35 84
Amount carried forward,	$47,610 85

Amount brought forward, ...	$47,610 85

PRIZE FUNDS.

Grinnell prize fund, $1,000. This fund is the gift of Ex-Gov. William Claflin, and is called Grinnell fund in honor of his friend, George B. Grinnell, Esq. The income from it is appropriated for two prizes to be given to the two members of the graduating class who pass the best examination in agriculture. Income from Jan. 1, 1897, to Jan. 1, 1898, ...	40 00

MISCELLANEOUS FUNDS.

Library fund for the benefit of the library. Amount of fund, Jan. 1, 1898, $10,046.12.	
Burnham emergency fund, $5,000. This fund is a bequest of Mr. T. O. H. P. Burnham, late of Boston, and was made without conditions. The trustees have voted that this fund be kept intact, and that the income from it be used by the trustees for such purposes as they believe to be for the best interests of the college. Income from Jan. 1, 1897, to Jan. 1, 1898, ...	129 04
Income from Jan. 1, 1897, to Jan 1, 1898, ...	$47,779 89

To this sum should be added amount of tuition and room rent and receipts from sales from farm and from botanic gardens. These amounts can be learned from treasurer's statement, tuition and room rent being included in term bill account.

REPORT OF THE PRESIDENT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE TO THE SECRETARY OF AGRICULTURE AND THE SECRETARY OF THE INTERIOR, AS REQUIRED BY ACT OF CONGRESS OF AUG. 30, 1890, IN AID OF COLLEGES OF AGRICULTURE AND THE MECHANIC ARTS.

I. Condition and Progress of the Institution, Year ended June 30, 1897.

The college has begun to recover from the effects of the hard times experienced during the past two years, and it is evident, from the improved tone and numbers in the entering classes, that the tide has passed its ebb and begun to flow back. In the regular course descriptive geometry has been dropped, and practical work in laboratory physics substituted. In the elective studies, courses in geology and modern history are offered. The dairy and short winter courses were opened for the first time this year, seventeen availing themselves of their advantages. The twenty acres purchased by the State and added to the college domain have been utilized by the horticultural department, and the ground broken up and prepared for orchards and nurseries.

This year closes the thirtieth of the existence of the college. Excluding those at present pursuing their studies, 1,093 have been admitted to its benefits. Of these, 1,001 are living, distributed as follows: 503 in agriculture and the mechanic arts, 498 in business and the various professions in life.

II. Receipts for and during the Year ended June 30, 1897.

1. Balance on hand July 1, 1896,	$578 96
2. State aid: (*a*) Income from endowment,	3,820 23
(*b*) Appropriations for building or other special purposes,	12,000 00
(*c*) Appropriation for current expenses,	15,000 00
3. Federal aid: (*a*) Income from land grant, act of July 2, 1862,	7,300 00
(*b*) For experiment stations, act of March 2, 1887,	15,000 00
(*c*) Additional endowment, act of Aug. 30, 1890,	14,666 66
4. Fees and all other sources,	3,000 00
Total receipts,	$71,365 85

III. *Expenditures for and during the Year ended June 30, 1897.*

1. *Instruction* in the subjects specified in section 1, act of Aug. 30, 1890,	$23,000 00
2. *Instruction* in all other subjects, if any, not mentioned in Question 1 of this series,	1,000 00
3. Administrative expenses (president's, secretary's, treasurer's, librarian's salary, clerical service, fuel, lights, etc.),	7,500 00
4. Experiment Station,	15,000 00
Total expenditures,	$46,500 00

IV. *Property, Year ended June 30, 1897.*

Value of buildings,	$189,275 00
Value of other equipment,	$73,872 78
Value of above property not used for instruction in the subjects specified in section 1 of act of Aug. 30, 1890,	$102,275 00
Total number of acres,	404
Acres under cultivation,	260
Acres used for experiment,	60
Value of farm lands,	$45,000 00
Amount of all endowment funds,	$360,575 35
Number of bound volumes in library,	18,080
Number of pamphlets,	–

V. *Faculty during the Year ended June 30, 1897.*

	Male.	Female.
1. College of Agriculture and Mechanic Arts, collegiate and special classes,	18	–
2. Number of staff of Experiment Station,	21	1
Total, counting none twice,	32	1

VI. *Students during the Year ended June 30, 1897.*

1. College of Agriculture and Mechanic Arts, collegiate and special classes,	129
2. Graduate courses,	4
Total, counting none twice,	132

FARM REPORT.

The farm operations of the past year have followed the general lines of the past few years. The work has been mainly confined to the cultivation and securing of our usual crops, and the caring for our rapidly increasing herd.

The peculiarities of the past season have rendered the results less satisfactory than usual. The four months, May, June, July and August, brought a total of about thirty-seven inches rainfall, about twenty-two inches coming in the months of June and July and nearly fifteen inches in the single month July.

This excessive rainfall largely increased the cost of caring for our field crops and securing the hay. It greatly decreased the yield of corn, ruined completely fields of carrots and mangels, caused a considerable portion of the potatoes upon about one-half our total area to rot, and decreased materially our crops of millet and soya beans. On the other hand, it gave us a large rowen crop, which serves in part to offset the losses in other directions.

The number of acres in the various crops of the year were as follows: hay, 78; corn for the silo and for fodder, 23½; field corn, 7; potatoes, 12; oats and pease, 1; soya beans, 3; Japanese barn-yard millet, 4½; beets, ½; carrots, 1; celery, 1¼; and turnips as a second crop, 1⅚.

The several fields and products were as follows: —

Hay. — Old fields (between college buildings and the county road, and including building site of old barn and farm-house), 42 acres: hay, 55 tons, 156 pounds; rowen, 36 tons, 1,289 pounds; total, 91 tons, 1,445 pounds, an average per acre of 2 tons, 368 pounds; fields where grass is grown in rotation, 36 acres: hay, 110 tons, 1,687 pounds; rowen, 34 tons, 1,800 pounds; total, 145 tons, 1,487 pounds, average per acre, 4 tons, 98 pounds. The total hay and rowen crops amount to 237 tons, 952 pounds, an average of a little over 3 tons per acre for the entire farm.

Corn for the Silo. — South flat, 15½ acres: 230 tons; north flat, 7 acres: 57 tons.

Field Corn. — South flat, 7 acres: grain, 281 bushels; stover, 9½ tons. Fodder put into the silo: 5 tons.

Potatoes.— Hatch slope, 6 acres: marketable tubers, 903 bushels; south flat, 6 acres: marketable tubers, 463 bushels.

Japanese Barn-Yard Millet. — North flat, 4½ acres: 29.7 tons.

Soya Beans. — North flat, 3 acres: 17⅗ tons.

Oats and Vetch. — North flat, 1 acre: 12½ tons.

Carrots. — One acre: failure on account of weather, and ploughed up.

Mangels. — One-half acre: failure on account of weather, and ploughed up.

Turnips as a Second Crop. — One and five-sixths acres: 405 bushels.

Celery. — North flat, 1¼ acres: crop estimated to be worth $400.

The system of manuring followed with the several crops is shown in the following table: —

Application per Acre.

	Old Mowings.	Field Corn.	Potatoes.	Onion Land, Potatoes.	Oats and Pease.	Japanese Millet.	Beets and Carrots.	Beans.	Celery.
Manure (cords),	-	5	-	-	4	1	-	3	16
Nitrate of soda (pounds),	150	100	240	120	250	175	200	-	450
Plain superphosphate (pounds),	-	200	400	400	400	150	300	250	550
South Carolina rock phosphate (pounds),	-	-	-	-	-	-	200	-	-
Dried blood (pounds),	-	-	100	50	-	-	-	-	250
Tankage (pounds),	-	-	240	120	-	-	150	-	400
Bone meal (pounds),	-	-	-	-	-	-	175	-	-
Muriate of potash (pounds),	-	140	-	-	300	100	250	-	350
High-grade sulphate of potash (pounds),	-	-	250	250	-	-	-	250	350
Armour's fertilizer (pounds),	-	-	-	-	-	-	-	-	2,000

Corn for the Silo. — Our principal field of ensilage corn was planted upon land most of which was tile-drained about six years ago. The soil was heavy, and the care of the crop was rendered very expensive on account of the frequent and heavy rains. The total area of this field is 15½ acres. The total labor cost (crop in the silo) was $342. One-half the manure and three-fourths of the fertilizer used are charged to the crop, at $190. The product, 230 tons, is valued at $805 in the silo, leaving the balance of $273 in favor of the crop. The average yield per acre was 15 tons. A small portion of this field which was not tile-drained furnished a most instructive object lesson. This portion of the field was not originally wetter than other portions. The crop, however, upon this part of the field was at the rate of only 4 tons per acre. The variety of corn cultivated in this field was the Leaming Field.

Field Corn. — The area devoted to this crop comprised 7 acres in the large field known as the south flat. The land had produced corn the previous year. This portion of the field is not tile-drained. It apparently needed this improvement much less than other parts of the field, but the past season has given us so much rain that the crop of corn this year was seriously injured. Upon a portion of the field it was so poor that it was cut and put into the silo, 5 tons of fodder being secured. The balance of the field gave us 281 bushels of grain, an average of about 40 bushels per acre, which is not much more than one-half our usual crop. The crop is to be charged with manure and fertilizer to the amount of $102, and labor $155.13, — a total cost of $257.13. The crop is worth about $200, leaving a balance of about $57 against the crop.

Potatoes. — Of the total area of 12 acres, one-half had a thoroughly drained medium loam and gave a fair crop. This portion of our potato land produced grass and clover in 1896. It is to be charged with fertilizer, $62.46 (three-fourths of the total used); seed, $42; Paris green, $2.56; labor, $201. The crop was dug before the vines were dead, and the work was done by hand. We obtained 903 bushels of marketable potatoes, which sold at 80 cents per bushel, amounting to $722.40, leaving a balance in favor of the crop of $414.38. The other 6 acres of potato land was upon soil which suffered from the excessive rainfall. One-half this land was in onions in 1896 and the balance in root crops. The fertilizer used is charged against the crop at $28.80; seed, $42; Paris green, $2.52; labor, $183.91; total, $257.23. A portion of the crop, as it was found to be rotting, was dug early by hand and disposed of at once; but the greater part of the field was left until the rotting had ceased, when it was dug by machine. That part of the field dug as soon as the rot was noticed gave a larger yield than the portion which was allowed to remain. The total yield of the 6 acres was only 463 bushels of sound, marketable tubers. These were sold for $372.40, leaving a balance in favor of the crop of $113.17.

Soya Beans. — These were grown on the north flat, occupying land that produced potatoes in 1896. The crop suffered seriously from the unfavorable season. The yield was only 17⅗ tons of green fodder, most of which was put into the silo. The crop is charged for manure and fertilizer, $66.35; for labor, $55.95; a total of $122.30, leaving a balance against the crop of $51.90.

Japanese Millet. — Four and one-half acres of the barn-yard variety of Japanese millet were grown upon the north flat. The crop is charged for manure and fertilizer, $24.45; for labor, $51.25; a total of $75.70. The crop was cut green and put into the silo, two parts of this millet to one of soya beans. The yield of millet was 297 tons, estimated to be worth in the silo $89.90, leaving a balance of $13.40 in favor of the crop.

Oats and Pease. — This crop occupied 1 acre on the north flat, and was grown at a cost for manure and fertilizers of $16.30 and labor $14.67; a total of $30.97. The yield was 12½ tons of fodder, which was fed green. This was estimated at $3 per ton, giving a total value of $37.50; leaving a balance of $6.53 in favor of the crop.

Celery. — This crop occupied 1¼ acres upon the north flat. The total cost of producing it and putting into the pit that portion not marketed from the field was $216. The crop is charged with manures and fertilizers, $71.75; labor, $144.25 (the last item including harvesting and preparing for market of the Dwarf Paris Golden variety, which was grown between the rows of the Pascal variety). The Dwarf Paris Golden was of fairly good quality, but sold at a low price, bringing in only $100. The Pascal celery was of remarkably fine quality, and is now about ready for market. It is estimated to be worth about $300, thus making the total probable returns from the field about $400.

Live Stock.

Horses. — Our horses and colts have all gone through the year in perfect health. We now own the following animals: Percherons, 1 stallion, 1 mare and 1 stallion colt; Percherons three-quarters blood, 2 mares; Percheron one-half blood, 1 mare; French Coach, 1 stallion colt, 1 mare colt; ordinary work horses, 1 stallion, 2 geldings, 2 mares; total, 13.

Neat Cattle. — Shorthorn, 1 male and 1 female; Ayrshire, 2 males, 2 females; Holstein-Friesian, 1 male, 2 females; Guernsey, 1 male, 2 females; Aberdeen-Angus, 1 female; grade Hereford, 1 female; Dakota cows and heifers, 39; grades (Jersey, Guernsey, Holstein-Friesian, Ayrshire and Shorthorn), 2-year-old, 7 females; 1-year-old, 18 females; grade (Jersey and Guernsey) cows, 17; grade Hereford, 1 heifer; total 101.

Southdown Sheep. — Thirty-one breeding ewes, 4 ewe lambs, 1 breeding buck, 1 yearling buck, 3 buck lambs; total, 40.

Swine. — Tamworth, 1 boar, 1 sow, 5 pigs; Chester White, 1 boar, 1 sow; Cheshire, 1 boar; Berkshire, 1 boar, 1 sow; Poland-China, 1 sow; Berkshire and Poland-China, cross-bred, 6 pigs, 2 fat hogs; Chester White and Cheshire, cross-bred, 2 fat hogs; common stock, 11 pigs; total, 34.

The general health of the cattle, sheep and swine has been good throughout the year and the breeding increase satisfactory.

Improvements.

The chief improvement of the year has been the moving and fitting up for a quarantine stable of the sheep shed formerly connected with the State Experiment Station barn. This shed is about twenty by forty feet, and has been moved to the foot of the Hatch slope and joined to the quarantine sheds which we already had there. It has been conveniently fitted up to accommodate fifteen cows.

The roads, bridges and drains of the farm have required an unusual amount of attention, on account of the excessively heavy rains. The roads have been badly washed and gullied, bridges have been washed out, streams have made for themselves new courses, and numerous breaks and washouts have occurred in the lines of drains. The repairing of damages of this description has involved much work and considerable expense.

No extensive land improvements have been made during the year.

Cash Receipts of the Year.

The total receipts for the year for products sold and labor performed amounted on December 10 to $5,775.06. The leading items were the following: milk and cream, $2,664.44; potatoes, $865.27; hay, $518.82; beef, $250.10; live stock, $227.75; labor, $191.73; and celery, $149.97. There is now due to the farm for products sold to date this year $902.18, making a total of receipts of $6,677.24.

In conclusion, I desire to testify to the continued faithful services of the farm superintendent, Mr. E. A. Jones. Amid circumstances in many respects difficult and in my absence during the greater part of the year, he has devoted himself, with an eye single to its interests, to the management of the farm. In a season when on every hand farmers abandoned crops, leaving fields to grow to weeds, he has given all fields clean culture, and succeeded in most instances in securing fair crops where others failed.

WM. P. BROOKS,
Professor of Agriculture.

AMHERST, Dec. 24, 1897.

MILITARY DEPARTMENT.

AMHERST, MASS., Dec. 20, 1897.

To President H. H. GOODELL, *Massachusetts Agricultural College.*

SIR: — In compliance with instructions from your office, I have the honor to submit the annual report of the military department of the college for the year 1897.

The organization of the battalion last year was faulty in that the officers were more numerous than the number of privates warranted, with the result that there was little interest taken in the drill. At the commencement of the fall term the cadets were reorganized, with a cadet major, cadet adjutant, cadet sergeant major, cadet quartermaster sergeant, a drum and trumpet corps and two companies of thirty-five privates and non-commissioned officers each. The effects of this step are seen in the increased interest of the cadet officers and efficiency of the battalion.

Drills commenced on September 13, and have been held on Monday, Tuesday and Thursday of each week.

The seniors have received instruction in signalling with flag and heliograph, and, with one exception, are proficient.

The juniors and sophomores have been instructing the freshmen in squad drill, and the sophomores have received some instruction in target practice at one, two, three and four hundred yards.

Companies have been drilled by their company officers under my supervision, and a good knowledge of company drill has been obtained up to platoon movements. The battalion is well instructed in the new manual of arms, as modified by the War Department, for the Springfield rifle, and is also very efficient in the bayonet exercise.

The attendance at drill has been very good. The average of daily absentees for this fall term is 3.7, against 5 for the same time last year.

The drum corps is efficient and interested in its work, but the trumpet corps is not up to a proper standard, owing to lack of proper instruction. I recommend that a good drum and trumpet instructor be engaged to give instruction in the field music once a week during the winter term.

The dormitories are in better condition than last year. North college has been provided with a bath-room and lavatories, which makes the building much more comfortable and convenient. I recommend that the painting of the bath-rooms and lavatories in south college be completed. This work was commenced about a year ago, and has never been finished. The place needs painting very much, and should not be left half done.

It would be economy to give the drill hall a thorough painting on the outside, and I renew my recommendations of last year relative to making the present armory a locker room where the students can keep their athletic clothes and equipments. The gun shed would be suitable for an armory and gun shed combined.

The college fire department has been reorganized and partially re-equipped, and is in efficient condition. The new water system of the college gives excellent fire protection.

The new target pit and butt is entirely satisfactory, and affords ample protection to the cadets working there.

The following three members of the class of '97 were reported to the Adjutant-General of the Army and the Adjutant-General of the State of Massachusetts as having shown the greatest proficiency in the art and science of war: —

Cadet First Lieutenant and Adjutant, . .	G. D. Leavens.
Cadet First Lieutenant and Fire Marshal, .	H. J. Armstrong
Cadet Second Lieutenant, ...	H. F. Allen.

The following is a list of the United States property now on hand: —

Ordnance.

2 3.2-inch B. L. field guns.
2 8-inch mortars, with implements.
2 gun carriages
2 gun caissons with spare wheels.
2 mortar beds
147 Springfield cadet rifles.
147 sets in infantry accoutrements.
51 headless shell extractors.
4,250 metallic ball cartridges.
2 mortar platforms.
2,0C0 pasters.
75 paper targets.
30,000 cartridge primers.
20,000 round balls.
1 set reloading tools.
75 pounds small arms powder
2 sets implements and equipments for 3.2-inch B. L. field guns.

Signal.

2 heliographs, complete.
6 2-foot white flags.
6 2-foot red flags.
6 canvas cases and straps.
12 joints of staff.

The following are the officers of the battalion: —

Commandant.

First Lieut. W. M. Wright, ... Second U. S. Infantry.

Field and Staff.

Cadet Major, ... R. D. Warden.
Cadet Adjutant, ... W. S. Fisher.

Company A.

Cadet Captain, ... A. Montgomery, Jr.
Cadet First Lieutenant, ... J. P. Nickerson.
Cadet Second Lieutenant, ... C. G. Clark.

Company B.

Cadet Captain, ... G. H. Wright.
Cadet First Lieutenant, ... C. N. Baxter.
Cadet Second Lieutenant, ... J. S. Eaton.

Respectfully submitted,

WM. MASON WRIGHT,
First Lieutenant Second U. S. Infantry.

THE PTEROPHORIDÆ OF NORTH AMERICA.

C. H. FERNALD, A.M., PH.D.

Massachusetts Agricultural College.

January, 1898.

THE PTEROPHORIDÆ OF NORTH AMERICA.

The species of moths taken up in this work are known by the common names of plume-moths and feather-wings. They have been studied but very little, and our knowledge of the early stages and habits of a large proportion of our native American species is very imperfect, but it is hoped that our entomologists will give more attention to them hereafter.

Geographical Distribution.

The Pterophoridæ are distributed very widely over the globe, but appear to be most numerous in the temperate regions, particularly in Europe, North America and Australia; yet, when other parts of the globe have been as carefully explored, it is probable that many additional species will be discovered, and that they may be more evenly distributed than at present appears to be the case.

Geological Distribution.

I am indebted to Mr. S. H. Scudder, our highest authority on fossil insects, for the information that no Pterophoridæ have yet been recognized among the fossils, not even in amber.

Economic Importance.

A few species of the Pterophoridæ are injurious to plants of economic importance, and the larvæ of several others feed on plants raised for ornamental purposes or for flowers.

Natural Enemies.

While it is probable that the species of this family are preyed upon not only by insect enemies but also by birds, yet I have been able to find but few recorded observations with regard to them. Ashmead has described *Pimpla pterophori* and *Limneria pterophoræ* from Pterophorids in California, and the latter species has also been taken in Texas. Prof. Kellicott bred *Ichneumon humilis* Prov. from *Platyptilia carduidactyla.*

History.

Linnæus, in the tenth edition of his "Systema Naturæ," Vol. 1, page 542, published in 1758, established the genus *Alucita* for the plume-moths with the following six species under it in order: *monodactyla*, *didactyla*, *tridactyla*, *tetradactyla*, *pentadactyla* and *hexadactyla*, — all placed under the heading Alucitæ. Some of these insects had been figured and described more or less fully by authors previous to the time of Linnæus, as Aldrovandus, 1602; Madam Merian, 1679; Petiver, 1702; Ray, 1710; Frisch, 1721; Reaumur, 1736; and Rosel, 1746; but, as Linnæus in the above work first consistently used the binomial nomenclature, it has been decided almost universally by zoölogists to adopt this edition of the "Systema Naturæ" as the starting-point in zoölogical nomenclature.

In 1761, Poda published his "Insecta Musei Graecencis," in which, on page 94, he adopted the generic name *Alucita* with *pentadactyla* L. the only species under it, and this species is therefore regarded as the type of the genus *Alucita* by Lord Walsingham and other eminent authorities. Geoffroy, in 1762, published the first edition of his "Histoire abrégée des Insectes," in two volumes. In the second volume this author, rejecting the genus *Alucita* of Linnæus, established the genus *Pterophorus*, a name which he stated was given to these insects by some naturalist in former times, and placed under it *pentadactyla* L. *didactyla* L. and *hexadactyla* L. From his description of *didactyla*, there can be no doubt that, instead of this species, he had *monodactyla* L. before him, and therefore we must consider *didactyla* Geoff. the same as *monodactyla* L. As Poda had already used *pentadactyla* as the type of *Alucita*, only the species *monodactyla* L. and *hexadactyla* L. could be considered as belonging under *Pterophorus*.

Scopoli, in his "Entomologia Carniolica," published in 1762, gives five species of plume-moths under Phalæna, which he appears to have used in a generic sense. In 1775, Fabricius, in his "Systema Entomologiæ," page 667, very improperly made use of the genus *Alucita* for *xylostella* L. and nineteen other Tineids, and followed Geoffroy in using *Pterophorus* for the plume-moths. This use of these generic names he continued through all his writings. The authors of the "Systematische Verzeichniss der Schmetterlinge der Wienergegend," 1776, page 144, adopted the genus *Alucita* in the strict Linnæan sense.

Latreille, in his "Precis des Caracteres generique des Insectes," published in 1796, page 148, separated *hexadactyla* from the group and established for it the genus *Orneodes*, but retained the rest of the plume-moths under Pterophorus. Latreille repeated this use of these generic names in his "Histoire naturelle des Crustaces et Insectes," Vol. XIV., page 255 (1805), and used the generic name *Alucita* in the Fabrician sense. This action of Latreille in removing *hexadactylus* from *Pterophorus* left only the species *monodactylus* L. under it which must now be regarded as the type, while *Orneodes* must be recognized with *hexadactyla* L. as the type.

In 1806 Hübner published his "Tentamen," in which these insects are placed in Phalanx 9; Alucitæ, in Tribus 1: *indubitate*. There are two divisions under this, the first of which is Pterophoræ with *Pterophora pentadactyla*, and the second is Ripidophoræ with *Ripidophora hexadactyla*. The "Tentamen" has caused a great deal of controversy as to whether it was a true publication, and whether its generic names should be recognized. No question can arise in case of the plume-moths, as Poda had long before adopted *pentadactyla* as the type of *Alucita*, and Latreille had very properly separated *hexadactyla* from the group and established for it the genus *Orneodes*. Schrank, in the second part of Vol. II. of his "Fauna Boica" (1802), page 139, adopted the Linnæan genus *Alucita* for these insects.

In 1811 Haworth published the third part of his "Lepidoptera Britannica," in which he adopted the genus *Alucita* in the Linnæan sense for the plume-moths. In 1815, Leach published his article "Entomology" in the "Edinburgh Encyclopædia," in which, under Tribe VII, Alucitides, the genus *Pterophorus* Geoff. is adopted with *pentadactylus* and *didactylus* under it, and the genus *Alucita* with *hexadactyla* under it. In 1819 Samoulle published his "Entomologist's Useful Compendium," in which he adopted the classification of Leach.

Hübner, in his "Verzeichniss bekannter Schmetterlinge," adopted the term Alucitæ for his ninth phalanx, the plume-moths. This part of the "Verzeichniss" was published between Aug. 27, 1825, and the time of Hübner's death, which occurred Sept. 13, 1826. This author divided these insects into three tribes: the first including those with unfissured wings, for which he established the genus *Agdistis;* the second with those having one fissure in the fore wings and two in the hind wings. This tribe was further divided into two families, each containing two genera. The first family, Obtusæ, contained the genera *Platyptilia* and *Amblyptilia*, and the second family, Cuspides, contained the genera *Stenoptilia* and *Aciptilia*. The third tribe included those species in which each wing is divided into six parts, and these were all placed under the genus *Euchiradia*, which is of course synonymous with *Orneodes*.

In 1827 Curtis published Vol. IV. of his "British Entomology," in which he adopted the genus *Pterophorus* and names *pentadactyla* L. as the type. In Vol. X. of the same work (1833), he established the genus *Adactylus* with *adactyla* Hüb. for the type. In Vol. XV., published in 1838, he adopted the genus *Alucita* and named *hexadactyla* as the type. Curtis, in 1829, in his "Guide to an arrangement of the British insects," had taken the genus *Adactylus* for the species with undivided wings, *Alucita* for "*hexadactyla* and its allies" and *Pterophorus* for the remainder. In the same year Stephens published his "Catalogue of British insects," in which he adopted the genus *Agdistis* Hüb. for the species with undivided wings, and *Pterophorus* and *Alucita* in the same sense as Curtis had used them. This same classification was used by Stephens in 1834, in his "Illustrations of British Entomology."

Treitschke, in Vol. IX., Part 2, of his "Schmetterlinge von Europa," published in 1833, adopted the generic name *Alucita* for the species placed by Stephens under *Agdistis* and *Pterophorus*, while he used *Orneodes* for *hexadactylus* and its allies. In 1836, Duponchel, in his "Histoire naturelle des Lepidopteres," Vol. IX., adopted the classification of Latreille, but in his "Catalogue Methodique," published in 1844, he used the genus *Adactyla* Zell. for *hübneri* Curt., *Orneodes*, for *hexadactyla* and its allies, and *Pterophorus* for the remaining species. Westwood, in Vol. I. of his "Classification of insects," page 115, published in 1839, adopted the classification of Stephens.

Zeller, in 1841, published his monograph of the plume-moths in "Isis," Vol. X. This author adopted the name *Pterophoridæ* for the group, and divided them into the *Pterophoridæ proprii*, and *Alucitina*. Under the first division he established the genus *Adactyla*, apparently unconscious of the fact that Curtis had already used the same name. Under this same division Zeller adopted the genus *Pterophorus* Geoff., which he divided into groups or subgenera as follows: *Platyptilus* (*Platyptilia* Hüb.), *Oxyptilus* (*Amblyptilia* Hüb.), *Pterophorus* (*Stenoptilia* Hüb.), *Aciptilus* (*Aciptilia* Hüb.). The division *Alucitina* contained the genus *Alucita* with *hexadactyla* and allies under it. In 1852, Zeller published his "Revision of the Pterophoridæ" in "Linnæa Entomologia," Vol. VI., page 319, in which he sinks his genus *Adactyla* and adopts Hübner's *Agdistis*, and established the genus *Deuterocopus* for the species *tengstrœmi* of Java.

In 1840, Zetterstedt, in his "Insecta Laponica," placed all his plume-moths under the genus *Alucita*, but in a note refers to *Orneodes hexadactyla* indicating his adoption of this generic name. Herrich-Schæffer, in his "Schmetterlinge von Europa," Vol. V., published in 1853–55, follows the classification of Zeller. Stainton, in his "Manual of British Butterflies and Moths" (1859), adopted the generic name *Adactyla* for *bennetii*, *Pterophorus* for *rhododactylus* and its allies and *Alucita* for *polydactyla*.

In 1859, Wallengren published his work on the Scandinavian plume-moths, which, like Zeller's works, marked an era in the classification of these insects. Wallengren followed Zeller in dividing them into the *Pterophoridæ* and *Alucitina*, under the first of which he established four new genera, and used, in addition to these, five genera established by earlier authors. Under *Alucitina* he adopted the genus *Alucita* for *hexadactyla*.

In 1864, Walker published Part 30 of his "List of the Lepidopterous Insects in the British Museum," in which he refers to all the described species of the plume-moths, and added thirty-five new species and two new genera founded on new species from Ega, South America. In this work Walker followed the classification of Zeller.

In 1869, Dr. Jordan, in the "Entomologist's Monthly Magazine," Vol. VI., pages 119 and 149, gave a review of Wallengren's work, referred to above, which contains valuable information. Mr. South has given a most interesting and valuable series of illustrated papers on the early stages, habits and food plants of the British plume-moths in the "Entomologist," Vol. XIV. and following volumes. Tutt's "Monograph of the Pterophorina of Britain" is also a valuable paper on the British plume-moths. In 1877, Dr. Wocke, in "Die Schmetterlinge Deutschlands und der Schweiz," Vol. II., Part 2, followed very closely the classification of Wallengren. In 1886, Leech, in his "British Pyralides," including the Pterophoridæ published in 1886, uses the super family Pterophori with the families *Pterophoridæ* and *Alucitidæ* under it.

Meyrick, in his paper "On the Classification of the Pyralidina of the European Fauna," published in 1890, in the "Transactions of the Entomological Society of London," placed these insects as families under the super family Pyralidina. Mr. Meyrick had already made critical studies on these insects in his researches on the Lepidoptera of Australia and New Zealand and in the paper above referred to he gave most excellent characters to the families and genera. He adopted the family names *Pterophoridæ* and *Orneodidæ* with the genus *Orneodes* under the last for *hexadactyla* and its allies. In his "Handbook of British Lepidoptera" (1895), Meyrick retains substantially the same classification. The latest and one of the most valuable works that I have seen is "Die deutschen Pterophoriden" by Dr. O. Hofmann (1895). In this work we are given for the first time a very good account of the genitalia, and all stages are described in full so far as known.

The first writer on the North American plume-moths, so far as I am able to learn, was Fitch, in his first "Report on the Insects of New York," page 145 (1856), where he published eight species, placing them under the genus *Pterophorus*. In 1864, Walker published two species from this country under the same genus, in the "Catalogue of the Lepidoptera Heterocera," Part 30, page 940. In 1869, Riley, in his first "Report on the Insects of Missouri," published one new species and gave a more complete description of one of the species of Fitch. In 1873, Packard described three species from California under the genus *Pterophorus*, in the "Annals of the Lyceum of Natural History," Vol. X., page 265. In the same year Zeller, in his "Beitrage," described six new species of the North American plume-moths, and in the same paper established a new genus (*Scoptonoma*) with two new species from Texas. This genus, however, proved to be the same as *Lineodes* of Guenee, a Pyralid genus. The next year Zeller described his *Leioptilus Mathewianus* in his "Lepidoptera der Westkuste Amerika's," page 23. Chambers published *Pterophorus lacteodactylus* in the "Canadian Entomologist," Vol. V., page 265 (1873).

The most important contribution to our knowledge of the North American species of these insects was given by Lord Walsingham in his "Pterophoridæ of California and Oregon," published in 1880. This work contains full descriptions of forty-one species, many of them here published for the first time, and all of the species are illustrated in colors. Lord Walsingham was so generous as to give me co-types of nearly all of his species. In this same year Miss Murtfeldt described two new species with their early stages in the "American Entomologist," Vol. III., page 235. In 1881, Mr. Charles Fish described ten species of these moths in the "Canadian Entomologist," Vol. XIII., pages 70 and 140. This gentleman made extensive studies of the Pterophoridæ, and secured the types of Fitch's species and all of his notes on them; but, having abandoned the work because of other engagements, I obtained his entire collection of these insects, including all of his own types as well as those of Fitch. Valuable notes by other writers have also been made, which will be referred to under the various species on following pages.

Structure.

The Pterophoridæ are small, slim insects, with long, slender legs and long, narrow fore wings, cut by a fissure extending in from the middle of the outer margin between veins 4 and 7, from a fourth to one-half of the length of the wing (plates II. and III.). The parts on each side of the fissure are called lobes, the anterior one being called the first lobe and the other the second lobe. In some of the genera these lobes are narrow and pointed, while in others they are well developed and present two well-marked angles on each, which are called the apex and anal angle (Plate II., fig. 1). The normal number of veins in the fore wings is twelve, but this number is reduced in many of the species. Vein 1 is feebly forked at the base, at least in some of the species, and the cross vein and veins 5 and 6 are very weak, often entirely invisible; 5 and 6 at equal distances from each other and from 4 and 7, extending to the fissure which ends between them. Veins 8 and 9 are stalked and 10 sometimes arises from the same stalk, but is occasionally wanting.

The hind wings have two fissures, the first extending in from the outer margin between veins 4 and 7 to about the middle of the wing; the second, between the inner margin veins and vein 2, extends to about the basal fourth. These divisions are called feathers, the anterior one being called the first feather, the middle one the second feather and the posterior one the third feather (Plate II., fig. 2).

The first feather in some species is somewhat spoon-shaped, rounded at the outer end, widest near the middle and narrower near the base. The costal vein bends down near the middle of its course, approaching very near to the subcostal. The costal vein ends in the costa when this feather tapers gradually to a point and vein 7 ends in the point. When this feather is broad at the outer end and has two angles corresponding to the apex and anal angle, the costal vein usually ends in the apex and vein 7 in the anal angle. The frenulum is single in the male and divided in the female.

The second feather in some species is widest towards the outer end, which is very oblique, but in others it is of the same form as the third feather. The median vein runs into this feather, giving off vein 2 which ends in the hind margin, vein 3 which ends in the anal angle of this feather and vein 4 which ends in the apex. In the narrow, tapering forms vein 4 is wanting and 3 runs to the end of the feather. The cross vein and also veins 5 and 6 are exceedingly fine and scarcely visible under the most favorable circumstances.

The third feather tapers gradually to the more or less blunt outer end, but in some species it has a very obtuse and rounded angle on its hind margin, which represents the anal angle of the wing (Plate II., fig. 2). This feather has a strong vein running through the middle to the end, which is undoubtedly vein 1b. In some species a weak vein may be seen above lying very near the edge of the feather, and in others a shorter vein below running to the hind margin of the feather a little beyond the anal angle. This, without doubt, is vein 1a, and therefore the three internal veins are represented in the Pterophoridæ, but all three do not occur in any one species.

The fringes are long and arranged along both sides of the feathers, giving them a strong resemblance to the feathers of a bird, thus making more complete organs of flight. In some species there are clusters of dark spatulate scales in the hind fringe of the third feather, and similar scales occur along the median vein on the under side of the wing. The basal part of the median vein on the upper side of the hind wings is not provided with a row of fine hairs, as in some families of moths.

The head is of medium size, with the front smooth and vertical in some species but more or less conical in others. The labial palpi are either porrect or curved upward and closely scaled, or more or less bushy. The maxillary palpi are entirely wanting. The proboscis is about as long as the head and thorax, and not clothed with scales at the base. The eyes are nearly hemispherical, naked and without lashes or cilia. The ocelli are absent. The scales of the head lie smooth over the surface, giving it an even appearance; but in some species they form a more or less cone-shaped tuft, extending forward from the front. The antennæ are fine filiform, and about two-thirds as long as the costa of the fore wings. The basal segment is much larger than those beyond, and covered with scales which sometimes form a pointed tuft at the end. The remaining segments are finely ciliated, those in the males being stronger than in the females.

The thorax is of medium size, and its covering of scales smooth without any indication of tufts or other characters. The tegulæ are of medium length, without long scales, hairs or other unusual characters. The abdomen is long and slim, of nearly uniform size throughout in the male, but somewhat fusiform in the female.

The genitalia of the male consist of a pair of long, comparatively thin and broad exserted claspers and a prominent uncus.

The legs are long and slim with cylindrical segments, except the femora, which are somewhat compressed. The coxæ are about as long as the thorax and stouter than the remaining segments of the legs. The fore tibiæ have a tibial epiphysis on the inside near the end, the middle tibiæ have a pair of unequal spurs at the end, while the hind tibiæ have a pair of unequal spurs at the end and a similar pair at the outer third. The tarsi consist of five segments with a pair of claws at the end. There are no spines on any of the segments of the legs, but they are covered by scales that lie smooth and close to the surface. In some species, however, the scales are raised, forming an enlarged ring around the middle and hind legs at the base of the spurs, and a similar ring occurs around the end of the fore tibiæ. In one species (*monodactylus*) there is a small tuft of scales on the hind tibiæ, opposite and within the middle spurs (Plate I., figs. 11, 12). This character is very useful in determining this exceedingly variable and common species.

The ground color of the Pterophoridæ is generally white, yellowish white or some shade of brown, occasionally without darker markings, though the fore wings most frequently have a dark triangular spot resting on the costa and extending down to a point just within the end of the fissure. One or two light lines cross the lobes obliquely, and there is a dark spot on the cell a little before the middle of the wing and another on the fold still nearer the base of the wing. The hind wings are of one uniform color, and seldom have spots or lines of other colors.

Habits.

The usual time of flight is on warm, calm evenings, when they are occasionally attracted to light and rarely to sugar. They may, however, be easily "flushed" in the day time from the shrubbery, when they fly a short distance and alight. When at rest they hold their wings nearly horizontal and at right angles with the body, but the feathers of the hind wings are folded over each other and drawn under the fore wings.

Early Stages.

I am not aware that anything is known of the egg-stage of any of our North American plume-moths, and if any thing has been published on this stage, I have overlooked it. In the European species, so far as I have seen any descriptions, they are more or less oval in outline, smooth and of a pale-green color.

The larvæ are short and stout, pale green, with longitudinal stripes of other colors in some species, and one or more coarse or fine hairs arise from tubercles on the segments. The pupæ are formed above ground, and attached by the anal extremity. Some species are hairy, while others are naked; and they sometimes have a pair of prominent tubercles arising from the back.

It is not known positively whether any of our North American species have more than one generation in a season; but so little is known about them that we cannot speak with any certainty on this point. *Acanthodactyla* and *monodactyla* are said to have two generations in a year in Europe, and very likely this is true here, at least in some parts of the country.

Systematic Position.

Linnæus placed these insects at the end of the Lepidoptera, after the Tineina, and he was followed by later writers till a little more than twenty-five years ago, when it began to dawn upon those who were working upon these insects that they were out of place. At first the matter was talked over, but it was some time before any one seemed to be willing to express such an apparent heterodox opinion in print. Dr. Jordan, however, in 1869 (Ent. Mon. Mag., Vol. VI., p. 152), expressed the opinion that these insects form "an aberrant group of the Pyralidæ." A few years ago, entomologists, both in this country and England, in making critical studies on the early stages as well as on the imago of the Lepidoptera, quite revolutionized the order, not only with regard to the position of the families, but also with regard to the names. I am heartily in sympathy with this movement, and, if I do not always adopt the changes at once, it is because I have not had time to study them carefully and convince myself that they are right.

The genus *Chrysocorys* has been placed among the Pterophoridæ by several of the English entomologists, and Zeller established the genus *Scoptonoma* for two Texan species, placing it in this family; but this genus is identical with *Lineodes* Guen., which both he and Lederer very properly placed among the Pyralids. If these two genera be removed, we have rather a compact group, which may be placed in the vicinity of the Pyralids, in my opinion.

Characters of the Pterophoridæ.

Long, slim insects, with long legs. Fore wings usually with one fissure and hind wings with two. The North American species, so far as known, have fissured wings. Proboscis and labial palpi well developed. Maxillary palpi and ocelli absent.

Fore wings with vein 1 b either simple or with a short fork at the base; 1 c present, 4 and 5 remote at the base, 8 and 9 stalked or fused. Hind wings above without a row of hairs along the basal part of the median vein; 1 a usually absent, 4 and 5 remote at the base, 6 and 7 remote, 7 and 8 approach very near each other near the middle of the wing.

Synopsis of the Genera.

1.	Hind wings with a cluster of black scales in the fringe of the third feather, ...	2.
	Hind wings without a cluster of black scales in the fringe of the third feather, ...	4.
2.	Anal angle present in second lobe of fore wings, ...	3.
	Anal angle absent in second lobe of fore wings, .	*Trichoptilus.*
3.	Anal angle absent in first lobe of fore wings, . .	*Oxyptilus.*
	Anal angle present in first lobe of fore wings, .	*Platyptilia.*
4.	Feathers of hind wings similar and tapering uniformly, .	*Alucita.*
	Feathers of hind wings unlike in form, ...	5.
5.	Anal angle present on first lobe of fore wings, .	*Stenoptilia.*
	Anal angle absent on first lobe of fore wings, . .	*Pterophorus.*

Genus TRICHOPTILUS Wlsm., Pter. Cal. and Ore. (1880).

Front neither extended nor tufted, vertex smooth. Antennæ pubescent; palpi slightly ascending; second and third segments nearly equal in length, the former a little thickened with scales, especially towards the outer end, the latter filiform. Tibiæ thickened with scales at the origin of the spurs. Fissure of the fore wings extending in a little more than half their length, the lobes being very slender, diverging, and without the anal angle on either. Hind wings with the fissure between the first and second feathers reaching within one-fourth of their base, while the second fissure reaches nearly to the base of the wing. All the feathers are very slender, almost filiform, and there is a cluster of black scales in the fringe near the middle of the hind margin of the third feather.

This genus was established by Lord Walsingham on a single species, *pygmæus*, of which his lordship took three specimens near Milville, in Shasta County, California, on the 11th of July, 1871, one of which with his characteristic generosity he gave me. As this single co-type is all I have, I do not feel like injuring it to study the venation or genitalia. Mr. Meyrick, in his "Handbook of British Lepidoptera," has given the venation of the fore wings probably of *T. paludum* Z. as follows: 2 out of 4 or absent, 3 absent, 7 and 9 absent, 10 from near 8 or absent, 11 from near 8.

Hofmann gives a description of the male genitalia and a figure of a paramere of *T. paludum.* He states that the genitalia of the male are distinguished by the remarkable form of the claspers, which are long and narrow, hollow within, and with a broad, bell-shaped, bristly appendage. The tenth dorsal plate is obtusely triangular, arched and bent down at the end. The ninth dorsal and ventral plates offer nothing especially worthy of remark.

Synopsis of the Species.

Expanse of wings, 10 mm. or less, . . . *pygmæus.*
Expanse of wings, 17 mm., ... *ochrodactylus.*
Expanse of wings, 20 mm., ... *lobidactylus.*

Trichoptilus pygmæus.

Trichoptilus pygmæus Wlsm., Pter. Cal. and Ore., p. 64, Plate 3, fig. 15 (1880).

Expanse of wings, 10 mm. Head and thorax pale fawn color; antennæ slightly pubescent, marked above with fawn brown and white alternately; palpi whitish touched with fawn color. Abdomen whitish, with a tinge of fawn color on the sides and above posteriorly. Legs white, dotted and barred above with fawn brown; spurs white, and at their origin the legs are thickened with fawn brown scales, among which project some which are white and almost erect. Fore wings very pale fawn color, dusted with fuscous brown scales along the costa, especially above the base of the fissure and near the base of the hind margin. Two indistinct white stripes cross the lobes of the fore wings, one beyond and the other before the middle, cutting the fawn-colored fringes on each side. Hind wings pale grayish brown, with cinereous fringes interrupted with white behind and at the apex. The third feather has long cinereous fringes interrupted with white at the apex, and there is a cluster of dark scales slightly beyond the middle in the fringe of the hind margin.

Habitat. — Shasta County, California. Early stages and food plant unknown.

Trichoptilus ochrodactylus.

Trichoptilus ochrodactylus Fish, Can. Ent., Vol. XIII., p. 142 (1881).

Expanse of wings, 17 mm. Head and anterior part of the thorax pale ochreous. Antennæ with a longitudinal brown line above, bordered by a fine white line on each side, pale ochreous beneath. Posterior part of thorax and abdomen light cream color, the latter nearly pure white beneath. Legs white, striped longitudinally with pale brownish ochreous; posterior tibiæ with a band of raised ochreous scales before each pair of spurs. Fore wings pale ochreous, approaching to cream color, with a very light brownish tinge on the first lobe. A minute brown spot at the base of the first lobe reaches from the end of the fissure half way to the costa. Costal fringe of the first lobe brownish ochreous, with a longitudinal white spot at the basal third, another at the outer third and a smaller one just before the apex. Fringe of the fissure ochreous and tinged with brown just beyond the middle, and there are some white hairs near the apices. Fringe of hind margin pale ochreous, with a white patch near the middle of the second lobe, beyond which the fringe is rather dark brownish, with a streaklet of white near the apex. Hind wings pale brown, with the fringes slightly paler. The third feather has a cluster of dark-brown scales in the hind fringe, just beyond the middle, and a row of club-shaped white scales extends from this to the base of the wing.

Habitat. — Texas. Early stages and food plant unknown.

TRICHOPTILUS LOBIDACTYLUS.

Pterophorus lobidactylus Fitch, N. Y. Rep., Vol. I., p. 848 (1854).
Aciptilus californicus Wlsm., Pter. Cal. and Ore., p. 60, Pl. II., fig. 9 (1880).

Expanse of wings, 17-20 mm. Head grayish brown, with a while line over each eye; palpi whitish, touched with brown on the outside of the second segment, with a long, slim tuft at the outer end beneath; of nearly the same size and length as the slim outer segment, which is dark brown, as is also the tuft at the end of the second segment. Antennæ grayish beneath, blackish above and dotted with white. Thorax brown, much lighter posteriorly. Abdomen dark brown, with diverging white lines on some of the segments. Legs striped with dark brown and white, with a tuft of dark scales at each pair of spurs; tarsal segments white at the base and brown at the outer end.

Fore wings with the fissure extending in one-half of the length of the wing, dark cinnamon brown. An oblique stripe of pale yellow or white crosses the basal third of the first lobe, cutting the brown fringe on each side of the lobe. Traces of this stripe are sometimes seen on the second lobe, especially in the fringe on the hind margin. There are also indications of a second stripe on the outer third of the lobes, as shown by a few light scales and the white in the fringes, which are dark elsewhere except on the apical end of the costa. Hind wings and fringes dark brown, with a cluster of black scales in the hind fringe a little beyond the middle, preceded by white, and the fringe at the apex is also white.

I have carefully compared four examples of *californicus*, given me by Lord Walsingham, with seven eastern examples of *lobidactylus* Fitch, and can see no difference except in the ground color, which is considerably lighter in the former; but, as the genitalia are absolutely alike in both, I must consider *californicus* only as a variety. Lord Walsingham doubtfully referred this species to the genus *Aciptilus*, but it seems to me to agree better with the characters of *Trichoptilus*.

Habitat. — Massachusetts, Connecticut, New York, Colorado, California. Food, *Solidago canadensis*.

I have been informed by Mr. Fish that Mr. N. Coleman of Berlin, Conn., has bred this insect from this plant.

Genus OXYPTILUS Zeller, Isis, Vol. X., p. 765 (1841).

Front smooth, without projection; labial palpi longer than the head, ascending, the second segment with appressed or projecting scales beneath, sometimes forming a short tuft at the apex, terminal segment filiform. Legs long and slim, the anterior and middle tibiæ thickened with scales at the middle and end. Fore wings fissured nearly to the middle, the first lobe narrow, curved somewhat at the end and terminating in a point without a defined anal angle. Second lobe with the apex somewhat produced, and with a more or less prominent anal angle. Feathers of the hind wing narrow and pointed, linear and without anal angles. Vein 2 arises from the median vein, a little before the outer end of the cell, while 3 and 4 arise from a short stalk, 9 and 10 arise one after the other from 8, and 11 arises near 8 from the upper angle of the cell. In the hind wing the costal vein terminates near the outer third of the costa; the continuation of the subcostal runs through the middle of the first feather and ends in the apex. The median vein has three branches the third of which ends in the apex of the second feather. The third feather with a single strong vein through the middle, terminating in the apex. This feather has a cluster of dark scales in the hind fringe beyond the middle. The characters of the male genitalia are represented in Plate VI., figs. 1–8.

Synopsis of the Species.

General color tawny yellow, ...	*periscelidactylus.*
General color light reddish brown, . .	*delawaricus.*
General color dull grayish brown, . . .	*ningoris.*
General color dark brown, ...	*tenuidactylus.*

Oxyptilus periscelidactylus.

Pterophorus periscelidactylus Fitch, N. Y. Rep., Vol. I., p. 843 (1854).
Pterophorus periscelidactylus Riley, Mo. Rep., Vol. I., p. 137 (1869).
Pterophorus periscelidactylus Riley, Am. Ent., Vol. II., p. 234 (1870).
Oxyptilus periscelidactylus Zell., Ent. Zeit., Vol. XXXII., p. 178 (1871).
Pterophorus periscelidactylus Pack., Guide, p. 356 (1872).
Oxyptilus periscelidactylus Zell., Beitr., Part 2, p. 119 (1873).
Pterophorus periscelidactylus Saund., Can. Ent., Vol. V., p. 99 (1873).
Oxyptilus periscelidactylus Wlsm., Pter. Cal. and Ore., p. 25, Pl. II., fig. 5 (1880).
Oxyptilus periscelidactylus Saund., Ins. Inj. Veg., p. 268 (1889).
Oxyptilus periscelidactylus Comst., Manual, p. 238 (1895).
Oxyptilus periscelidactylus Smith, Econ. Ent., p. 318 (1896).

Expanse of wings, 14 to 29 mm. Head, thorax and fore wings tawny yellow. Palpi slim, porrect or ascending, reaching as high as the top of the head, white touched on the outside of second and third segments with tawny yellow. Antennæ dark brown beneath, white above and dotted with white along each side. Posterior part of the thorax marked in some specimens with white on the top of the tegulæ, the sides and two longitudinal stripes on the top of the metathorax. Abdomen tawny yellow, marked more or less imperfectly with a white stripe along each side and also on each side of the dorsal stripe, except on the third segment, which is entirely dark tawny brown. Underside white, striped with tawny brown. Fore legs white, with longitudinal brown lines on the femora and tibiæ; middle and hind femora white, striped with tawny; middle tibiæ tawny on the outside, also a tuft of scales on the middle and at the end tawny; hind tarsi tawny at the middle and end, and all the tarsi are marked more or less with this color at the end of the segments.

Fore wings fissured nearly to the middle, tawny yellow, with two oblique white stripes crossing the lobes, dividing them into nearly equal parts, the space between these stripes often rusty brown, a transverse white spot just within the end of the fissure is edged on its inner side with rusty brown, the posterior end often extending outward and fusing with the first cross line. There is usually a very oblique white spot on the cell near the middle of the wing, with a dark dot at the basal end of it, and a second white spot rests on the hind margin at the basal fourth of the wing. The fringes of the two lobes are whitish, cut by blackish at the apex and anal angle, this latter on the second lobe extending along nearly half the hind border. Hind wings rusty brown, the third feather white in the middle and dark brown at the end, with large dark scales in the fringes on both sides of this part of the feather.

Thirty-five specimens examined.

Habitat. — Maine to Missouri, Ontario, Quebec, Texas. Food, leaves of the grape vine.

Larva. — Length, about 12 mm. Head yellow, with the mouth parts brown. Body pale greenish yellow, deeply constricted between the segments. Each segment has a transverse row of ten moderately sized tubercles, from each of which arises a cluster of from six to twelve long, whitish, diverging hairs, besides which, scattered over the surface, are short hairs which are enlarged at the tip. Legs yellow, long and slender.

Pupa. — Length, 11 mm. Diameter, 2 mm. Front obliquely truncated, with two irregular ridges extending up over the truncate part and along the dorsum on either side of the median line, diverging towards the metathorax, where they terminate in a pair of flattened, sharp-pointed projections, about as high as two-thirds of the diameter of the pupa. The ridges are higher, and toothed on the top of each segment. On the first five abdominal segments there is a row of short spines on each side, in line with the abdominal projections. These spines incline forward, and on the posterior side is a small tooth and two short diverging club-shaped bristles. The pupæ attach themselves by a cluster of fine hooks at the end of the abdomen to a button of silk spun by the caterpillar before pupating. The pupal stage lasts about a week.

So far as I can learn, nothing is known of the egg and early larval stages. Both Fitch and Riley expressed the opinion that there were two generations in a year, but it has not been observed. The moths are on the wing here in Amherst during the latter part of June.

Oxyptilus delawaricus.

Oxyptilus Delawaricus Zell., Verh. z.-b. Ges. Wien, XXIII., p. 318 (1873).

Oxyptilus delawaricus Wlsm., Pter. Cal. and Ore., p. 29, Pl. II., fig. 7 (1880).

Expanse of wings, 17 to 18 mm. Head, thorax and fore wings light reddish brown. Palpi projecting forward about the length of the head, acuminate, lighter beneath and at the tip, the second segment tufted beneath at the end. Antennæ fuscous, dotted with white above. Abdomen reddish brown at the base, yellowish white beyond and indistinctly marked with whitish scales and lines, but not so conspicuously marked as *tenuidactylus*. Legs white, barred with dark brown.

Fore wings with a few whitish scales scattered along the costa, which is slightly shaded with fuscous beyond the middle. There is a faint brown spot on the cell before the middle, and an indistinct pale spot on the basal fourth of the hind margin. Two oblique white stripes cross the first lobe, dividing it into thirds, the outer stripe appearing again on the second lobe, while only a trace of the inner stripe is occasionally seen on the second lobe, extending along to the inner end of the fissure, which is edged with white and dark brown. The ground color of the lobes is often darker than the rest of the wing. The costal fringe from the outer white stripe to the apex is white, that within the fissure is brown, while the fringe on the rest of the second lobe is white, cut with brown at the apex, and from the anal angle along the hind margin to the middle of the lobe, beyond which in one or two places black scales are seen in the white fringe. Hind wings darker brown than the fore wings, and with the usual cluster of black scales in the fringe, near the apex of the third feather. Nine specimens examined.

Habitat. — Canada, New Hampshire, Massachusetts, California. Early stages and food plant unknown.

Oxyptilus ningoris.

Oxyptilus ningoris Wlsm., Pter. Cal. and Ore., p. 26, Pl. II., fig. 6 (1880).

Expanse of wings, 15 to 20 mm. Head and thorax dark grayish brown. Palpi clothed with close scales, second segment untufted. Antennæ brownish, dotted with white above. Abdomen grayish white at the base, brownish fuscous beyond, with three pairs of slender white streaks diverging from the front to the back of each of the anterior segments; beyond them crossed by lines of whitish scales. Legs white and banded with brownish fuscous.

Fore wings dull grayish brown, sprinkled with whitish scales along the costa, with two oblique white stripes across the lobes and a small white spot at the end of the fissure, connected with the first oblique stripe by the white of the fringes, which beyond this are brownish, except on the outer end of the costa of the first lobe and in the concave outer border of the second lobe, where they are white. There is also an inconspicuous white spot on the basal fourth of the hind margin, and a similar ill-defined spot near the middle of the wing. Hind wings brownish fuscous, the first feather barred with white beneath and the third feather widely barred with white and with blackish scales in the fringe on both sides towards the outer end. Six specimens examined.

Habitat. — California, Oregon. Early stages and food plant unknown.

Oxyptilus tenuidactylus.

Pterophorus tenuidactylus Fitch, N. Y. Rep., Vol. I., p. 848 (1854).
Oxyptilus nigrociliatus Zeller, Verh. z.-b. Ges. Wien, XXIII., p. 322 (1873).
Oxyptilus nigrociliatus Wlsm., Pter. Cal. and Ore., p. 31, Plate II., fig. 8 (1880).
Oxyptilus delavaricus Forbes, 3d Ill. Rep., p. 91, Plate X., fig. 2 (1885).
Oxyptilus nigrociliatus Saund., Inj. Ins., p. 314, figs. 326-7 (1889).

Expanse of wings, 12 to 15 mm. Head and thorax dark tawny brown, with a tinge of coppery red; posterior part of the thorax white. Palpi ascending, reaching above the top of the head, slender, not tufted. Antennæ black, dotted with white above. Abdomen of the same color as the wings, with two diverging white lines on the top of the third segment, and the fifth strongly marked with white above except in the middle line. Legs white and banded with dark brown.

Fore wings dark tawny brown, with a tinge of coppery red in certain lights. Two oblique white stripes cross the lobes, the inner one being the wider, and both more or less indistinct or wanting on the second lobe. There is a faint indication of a white spot near the middle of the wing and a similar one at the inner end of the fissure. Fringes white on the apical part of the costa and on the outer margin, cut with blackish at the apex and anal angle of each lobe, and also blackish in the fissure and on the outer part of the hind margin of the second lobe. Hind wings of the same color as the fore wings, with the first feather barred with white beneath and the third feather white in the middle, beyond which the fringe on both sides is thickened by heavy black scales. Fifty-eight specimens examined.

I have before me one specimen from the National Museum, labelled, in Zeller's handwriting, "Oxyptil. nigrociliatus Z., N.

Am." It also has a printed label, "Collection C. V. Riley," and therefore it is probable that this specimen was determined by Zeller himself. I also have two specimens given me by Lord Walsingham which he took in California. Although Professor Zeller declared Lord Walsingham's Californian specimens to be identical with his *nigrociliatus*, yet, because of the lighter color of the Californian specimens, his lordship wrote: "It is open to question how far the two forms may be entitled to be considered distinct; but I must leave it to be decided by some one who has a more extended series of the undoubted *tenuidactylus* to refer to." I have the types of Fitch in my possession, and there are two specimens of *tenuidactylus*, one of which is a male, from which the figures of the genitalia on Plate VI. were drawn. I have carefully compared this with the genitalia of the Californian specimens, as well as other eastern specimens, and find that there is absolutely no difference. There is, therefore, no doubt that Lord Walsingham was correct in considering *nigrociliatus* the same as *tenuidactylus*, and that his Californian specimens are light varieties of the same species. I have a specimen from Philadelphia as light as any of my Californian specimens received from Lord Walsingham, and one taken in South Abington, Mass., which is as light in color as the lightest specimen from California. This, with many others, was taken July 19, 1881, by Mr. J. Elwyn Bates, who found them flying around blackberry bushes in large numbers.

Habitat. — Massachusetts, New York, Delaware, Maryland, West Virginia, Illinois, Ontario, Colorado, California. Food, blackberry. This species has been bred from blackberry by Prof. William Saunders and also by Prof. S. A. Forbes.

"About the middle of June the larva reaches full growth, when it is about four-tenths of an inch long, of a pale greenish-yellow color, streaked with pale yellow, and with transverse rows of shining tubercles, from each of which arise from two to six spreading hairs of a yellowish-green color. The head is small, pale green, with a faint brown dot on each side.

"When the larva is about to change to a chrysalis, it spins a loose web of silk on a leaf or other suitable spot, to which the chrysalis is attached. This is less than three-tenths of an inch long, pointed behind, enlarging gradually towards the front, where, near the end, it slopes abruptly to the tip. Its color is pale green, with a line along the back of a deeper shade, margined on each side with a whitish ridge; it is also more or less hairy. In about a week or ten days the chrysalis changes to a darker color, shortly after which the perfect insect escapes." (Saunders.)

Genus PLATYPTILIA Hüb., Verz. bek. Schm., p. 429 (1826).

Front with a conical projection, covered by a longer or shorter tuft of scales. Labial palpi long, slim, porrect or slightly ascending, closely scaled, the third segment filiform and shorter than the second. Legs long and slim, the tibiæ with darker scales and sometimes thickened at the end and also in the middle of the hind tibiæ.

Fore wings fissured about one-third of their length, the lobes, especially the second, wider at the outer end than at the base, each with a distinct anal angle, the first falcate and the second convex on the outer margin. The cell is nearly rectangular at the outer end, and veins 5 and 6, as well as the cross vein, are very weak. Two internal veins are present. Vein 2 arises from the outer third of the median vein and ends in or near the anal angle of the second lobe, while vein 3 ends in the middle and 4 in the apex of the same lobe. Vein 7 arises a little below the anterior angle of the cell and ends in or near the anal angle of the first lobe; 8 and 9 are from a stalk which arises from the anterior angle of the cell, and 8 ends in the apex, while 9 ends in the costa; 10 and 11 are somewhat remote from each other and from the stalk of 8 and 9. The first feather of the hind wings has a blunt apex, and is wider towards the outer end than at the base. Veins 7 and 8 arise separately from the base of the wing, approach very near to each other at the basal third and end at the widest part of the feather, one in the costa a little before the apex, and the other in the outer margin behind the apex. The second feather has an acute apex and a distinct anal angle; and vein 3, arising a little before the end of the cell, ends in the anal angle, while 4 arises from the end of the cell and ends in the apex of this feather. The third feather is narrow and tapers gradually to the apex, but there is usually a slight enlargement indicating the anal angle near the middle of the hind margin. A cluster of black scales more or less pronounced occurs in the fringe of the hind margin. One internal vein runs through the middle of this feather and a second terminates at the end of the second fissure.

The characters of the genitalia are represented in plates V., VII. and VIII.

Synopsis of the Species.

1.	Palpi and frontal tuft much longer than head,	*marginidactyla.*
	Palpi and frontal tuft not longer than head,	2.
2.	With a dark triangle on the outer third of costa,	3.
	Without a dark triangle on the outer third of costa,	13.
3.	Cluster of dark scales in the middle of fringe of third feather,	4.
	Cluster of dark scales beyond the middle,	10.
4.	Hind tibiæ white, banded with dark near middle and end,	5.
	Hind tibiæ without these characters,	6.
5.	More than half the space between spurs white,	*carduidactyla.*
	Less than half the space between spurs white,	*percnodactyla.*
6.	Ground color of fore wings pale fawn,	7.
	Ground color of fore wings whitish,	8.
7.	Expanse of wings 36 mm.,	*grandis.*
	Expanse of wings 20 mm.,	*fragilis.*
8.	Expanse of wings 30 mm.,	*albidorsella.*
	Expanse of wings 20 mm.,	*shastæ.*
	Expanse of wings 25 mm.,	9.
9.	Costa black between stripes on first lobe,	*orthocarpi.*
	Costa not black between stripes on first lobe,	*albida.*
10.	Fore wings reddish fuscous,	11.
	Fore wings pale gray marked with black,	12.
11.	Markings dark brown,	*acanthodactyla.*
	Markings light brown,	*edwardsii.*
12.	Thorax white,	*pica.*
	Thorax gray,	*cosmodactyla.*
13.	First lobe with two light cross lines or stripes,	14.
	First lobe without cross lines or stripes,	15.
14.	Costa cinnamon brown, hind margin white,	*albicans.*
	Fore wings white shaded with brownish scales at base and costa,	*petrodactyla.*
	Fore wings brownish gray,	*tesseradactyla.*
15.	Fore wings cinereous,	*modesta.*
	Fore wings cinnamon brown,	16.
16.	Second segment of palpi enlarged with scales,	*albiciliata.*
	Second segment of palpi not enlarged with scales,	*adusta.*

Platyptilia pica.

Amblyptilus pica Wlsm., Pter. Cal. and Ore., p. 21, Plate II., fig. 1 (1880).

I have never seen this species, and therefore repeat Lord Walsingham's description: —

"Head and palpi cinereous, dusted with white scales. Antennæ cinereous, faintly dotted with whitish above. The thorax white touched with cinereous above and at the sides, with two black spots behind.

"Fore wings white, dusted with cinereous along their costal half before the fissure; the costa fuscous, dotted with white; a blackish spot before the middle of the wing touching the costal shade; another nearer to the base below it; a blackish fuscous, triangular, costal patch before the fissure, followed by a conspicuous white space, beyond which is a fuscous shade, crossing both lobes, divided by a white line running parallel to the apical margin, on which the cilia are white, dotted with some fuscous. The dorsal half of the wing is less shaded or dusted than the costal, and contains two short, oblique, blackish dashes near the middle, the second being followed by a straight streak of brownish fuscous scales running parallel to the dorsal margin. The cilia on the dorsal margin are white, with two distinct tooth-like tufts of black scales; the cilia within the fissure are fuscous.

"Hind wings fuscous brown, with cilia of all the lobes the same color, except on the dorsal margin of the third, where they are white, irrorated with black scales along the basal half, and bearing a conspicuous projecting triangular tuft of black scales beyond the middle, and a few more below the apex of the lobe.

"The abdomen is white above and beneath, with a fuscous line along each side, which also crosses it above near the base, and again below the middle. The third pair of legs are annulated with white and fuscous brown, the bases of the white spurs being also fuscous. Expanse, 23 mm.

"It is allied to *A. acanthodactylus* and *A. cosmodactylus* of Huebner."

Habitat. — California. Early stages and food plant unknown.

Platyptilia cosmodactyla.

Alucita Cosmodactyla Hüb., Aluc., Plate VII., figs. 35, 36 (1825).
Amblyptilus cosmodactylus Wlsm., Pter. Cal. and Ore., p. 23, Plate II., figs. 2–4 (1880).

Expanse of wings, 18–21 mm. Head, thorax and fore wings pale gray, finely striated with black; a triangular black spot on the outer third of the costa, followed by a small white costal spot, which is in turn followed by a broad black band edged on the outside with white, which crosses the lobes diagonally. On the second lobe the white cuts a dark basal portion twice at equal distances; costa of the wing dark gray with a series of white dots. Fringes blackish basally, white externally. Hind wings dark grayish brown, with a large cluster of black scales beyond the middle of the fringe of the third feather, and a small black cluster on the apex.

Habitat.— Europe, California, Oregon. Food, *Stachys*, *Aquilegia*, *Geranium*, *Orthocarpus*. "Larva, from pale green to purplish pink; dorsal line dark gray; subdorsal white, conspicuous; lateral and spiracular whitish, interrupted; head dark reddish fuscous, almost black." (Meyrick.)

Platyptilia acanthodactyla.

Alucita Acanthodactyla Hüb., Aluc., Plate V., figs. 23, 24 (1825).

Expanse of wings, 18–21 mm. Head, thorax and fore wings reddish fuscous, marked very similarly to *cosmodactyla*, but may be separated by the ground color of the fore wings.

Habitat. — Europe, South Africa, New York. Food, *Stachys*, *Mentha*, *Ononis*, *Calamintha*, *Pelargonium* and *Euphrasia*.

I have a single specimen of this species, taken at West Farms, N. Y., by Mr. James Angus.

"Larva, from pale green to deep purple; dorsal line dark gray; subdorsal, lateral, and sometimes spiracular whitish, interrupted; head yellowish gray or yellowish brown, blackish-marked." (Meyrick.)

Platyptilia edwardsii.

Platyptilus Edwardsii Fish, Can. Ent., Vol. XIII., p. 72 (1881).

Expanse of wings, 22–27 mm. Head and thorax ochreous brown; frontal tuft short and blunt, brown above, whitish beneath. Palpi ascending, extending beyond the frontal tuft; antennæ finely ciliated, dotted above with dark scales, cinereous beneath. Abdomen ochreous, slender. Legs ochreous brown, hind tibiæ and all the tarsi paler.

Fore wings reddish brown, darker on the costa; triangular costal spot dark brown, bordered on the outside by whitish scales. A small brown spot occurs near the hind margin at the basal fourth, another near the costa at the basal third, and a transverse white line at the apical third of the lobe. The first lobe with a dark longitudinal spot half way between the costa and hind margin; second lobe dark at the anal angle. Fringes whitish, with a patch of dark scales before and another just behind the apex of the costal triangle. Hind wings reddish brown; fringes brown, whitish at base of hind margin and bearing a small patch of dark scales just before the apex.

Habitat. — Maine, Massachusetts. Early stages and food plant unknown.

PLATYPTILIA CARDUIDACTYLA.

Pterophorus carduidactylus Riley, Mo. Rep., Vol. I., p. 180, Plate II., figs. 13, 14 (1869).
Platyptilus cardui Zell., Stett. Ent. Zeit., Vol XXXII., p. 179 (1871).
Platyptilia cardui Zell., Beitr., p. 118 (1873).
Platyptilus cardui Wlsm., Pter. Cal. and Ore., p. 7, Plate I., fig. 6 (1880).
Platyptilus cardui Riley, Gen. Index Ent. Rep. Mo., p. 83 (1881).

Expanse of wings, 23 mm. Head, thorax and abdomen tawny yellow. Legs tawny yellow, except the tarsi, which are nearly white, spotted with dark brown; spurs brown, with darker tips.

Fore wings tawny yellow, fissure extending in about one-fourth of the length of the wing; triangular spot dark brown, its outer margin slightly concave; three dark diffuse longitudinal spots, one on the basal third of the wing near the costa, one near the hind margin, nearer the base than the latter, and one on the outer third of the hind margin. Two paler transverse lines cross the outer portion of the wing, one bordering the triangular spot behind and curving across the lower lobe towards the anal angle, the other very near and parallel to the outer margin. The space between these two lines usually darker than the ground color. Fringes dark basally, whitish outwardly except three brown patches of scales, one in the middle of hind margin, one on the anal angle and a smaller one half-way between. Hind wings ashy brown. Fringes concolorous, with a patch of very dark scales about half way on hind margin of third feather, and a few scattering scales about half-way between that and the base.

Habitat. — New York, Pennsylvania, Illinois, Missouri, Texas, California, Washington. Food, Thistle (*Cirsium lanceolatum*).

"*Larva.* — Average length, 0.60. Largest in the middle of the body, tapering thence each way. Color light straw yellow, greener when young. Somewhat darker, partly translucent, dorsal, subdorsal, and stigmatal lines. Two lateral rows of black spots, the lower spots rather smaller and placed behind the upper ones. A third row above these, and others along the back, but so small that they are generally imperceptible with the naked eye, except on the thoracic segments, being especially distinct on segment 2. Head small, black, sometimes inclining to brown. Cervical shield black, divided longitudinally in the middle by a lighter line. Caudal plate also black. Segment 11, besides the spots above mentioned, has two transverse black marks, the posterior one the largest. Thoracic legs black, the others of the same color as the body.

"*Pupa.* — Average length, 0.45. Soft, dull yellow, with a lateral dusky line each side of dorsum, and another, less distinct, each side of venter. Also dusky about the head and wing-sheaths." (Riley.)

Platyptilia percnodactyla.

Platyptilus percnodactylus Wlsm., Pter. Cal. and Ore., p. 8, Plate I., fig. 7 (1880).

Expanse of wings, 22 mm. Head and thorax pale brown; antennæ spotted on the upper side with white and brown. Abdomen brownish, paler at the base. Legs whitish, slender, slightly enlarged, and tinged with brownish at the end of the segments. Spurs pale.

Fore wings pale brown with much paler blotches, one reaching from the base of the fissure to the costa, another below the dark-brown costal triangle and another at the base of the costal margin; a pale streak crosses the wing, parallel to the outer margin, which is brownish; a brown line at the base of the fringes, which are brown except within the fissure and near the anal angle; a few brown scales near the middle of the hind margin. Hind wings brown, the third feather paler than the others, and with a few fuscous scales in the fringe of the hind margin of the third feather.

Habitat. — California. Early stages and food plant unknown.

Platyptilia shastæ.

Platyptilus shastæ Wlsm., Pter. Cal. and Ore., p. 14, Plate I., fig. 11 (1880).

As I have no example of this species, I quote Lord Walsingham's description: —

"Head white; palpi white, touched with cinereous at the sides; antennæ dotted above. Thorax dusted with cinereous.

"Fore wings narrow, whitish, dusted with cinereous atoms, especially along the costa; the triangular costal patch brown, followed by the usual pale space; a brown line along the base of the white fringes; a very slender whitish line, running parallel to the apical margin, terminates in a white dash on the costa, reaching to the extreme apex; the antemedian dots scarcely indicated. Hind wings pale cinereous, the third lobe perhaps slightly the lightest in color; fringes nearly unicolorous, pale cinereous, scarcely paler at their bases. Abdomen yellowish white. The third pair of legs cinereous, slightly whitish below each joint and on the spurs and feet. Expanse 20 mm."

Habitat. — California.

"This species may be distinguished by its slender appearance and narrow fore wings, which are so delicately dusted as to be of almost the same shade as the pale cinereous hind wings, which separate it at once from any of its allies now described."

PLATYPTILIA FRAGILIS.

Platyptilus fragilis Wlsm., Pter. Cal. and Ore., p. 16, Plate I., fig. 12 (1880).

Expanse of wings, 19 mm. Head and thorax white, sprinkled with yellowish scales; palpi slightly cinereous; abdomen yellowish; legs yellowish white, brownish at the joints.

Fore wings fawn color with yellowish tinge; the two antemedian spots and the triangular costal patch brown; outer margin brownish. Fringe white with a fine brown line at its base. Two brown dashes in the fringes of the hind margin before the anal angle. Hind wings very pale brownish white with paler fringes.

Habitat. — California. Early stages and food plant unknown.

PLATYPTILIA ORTHOCARPI.

Platyptilus orthocarpi Wlsm., Pter. Cal. and Ore., p. 11, Plate I., fig. 9 (1880).

Expanse of wings, 25 mm. Head and thorax whitish, slightly tinged with ochreous; frontal tuft short. Hind legs whitish, marked with fuscous on the outside, with white annulations below each segment; spurs and feet white.

Fore wings dusted with ochreous and brown scales, especially on the costa; triangular costal patch and a dash at the end of the first third of the wing very dark fuscous, and more produced toward the apex than in *albida;* space beyond the triangular patch and a streak parallel to the outer margin white, with the space between them brown. Hind wings fuscous brown; fringes fuscous with a white line at the base.

Habitat. — Oregon. Food, *Orthocarpus.*

Platyptilia albida.

Platyptilus albidus Wlsm., Pter. Cal. and Ore., p. 10, Plate I., fig. 8 (1880).

Expanse of wings, 24 mm. Head and thorax white, with a bluish tinge. Antennæ white dotted with brown above. Abdomen white streaked with fuscous. Hind legs dark ashy in color; spurs and feet slightly paler on the inner side.

Fore wings bluish white, with brownish scales, especially along the costa to the brown triangular spot, beyond which is a pale stripe running parallel to the outer margin across both lobes of the wing; another pale line near the outer margin; the space between these pale lines is grayish brown except near the costa, where it is brownish; a brown stripe between this and the fringes. Two indistinct brown spots on the inner half of the wing, the lower one much nearer the base than the upper one; a brown line at the base of the fringe, which is white except at the anal angle. Hind wings brown; fringes brown, a little paler on the hind margin of the third feather.

Habitat. — Southern Oregon, California. Early stages and food plant unknown.

Platyptilia albidorsella.

Platyptilus albidorsellus Wlsm., Pter. Cal. and Ore., p. 13, Plate I., fig. 10 (1880).

Expanse of wings, 30 mm. Head and thorax white, with a few scattered fuscous scales; frontal tuft short. Legs whitish tinged with cinereous; feet and spurs paler.

Fore wings white, thickly sprinkled with brown, forming a widening streak from the base of the wing to the triangular patch, beyond which it is paler and crossed by a white costal patch and a white line near the outer margin and parallel to it. Fringes ashy, with a brown line at the base. Hind wings white, thickly dusted with brown. Fringes paler brown, much paler at the base.

Habitat. — California. Early stages and food plant unknown.

Platyptilia grandis.

Platyptilus grandis Wlsm., Pter. Cal. and Ore., p. 6, Plate I., fig. 5 (1880).

Expanse of wings, 36 mm. Head and thorax pale fawn color; antennæ brownish fawn color, spotted with white above; frontal tuft fawn color, shorter than in allied species. Legs very pale, the hind tibiæ with their extremities darker.

Fore wings pale fawn color, with the costa and triangular blotch fuscous; two brownish, elongated dots near the middle of the wing, the larger one nearer the base. The lobes are crossed by a pale wavy streak parallel and near to the outer margin; a brown line at the base of the fringes, which are dark fuscous except near the anal angle, where they are pale. Hind wings brownish fawn color. Fringes pale except on the hind margin of the third feather, where they are brownish.

Habitat. — California. Early stages and food plant unknown.

Platyptilia modesta.

Platyptilus modestus Wlsm., Pter. Cal. and Ore., p. 18, Plate I., fig. 14 (1880).

As I have no example of this species, I give a copy of Lord Walsingham's description: —

"Head and palpi cinereous; antennæ slightly dotted above.

"Fore wings very narrow, cinereous, with a slight ochreous tinge towards the dorsal margin. The costa sprinkled and shaded with fuscous, the fuscous shade widening towards the fissure, forming an elongate but indistinct triangular costal blotch. The apical portion of the wing more or less shaded with fuscous, and a fuscous line along the base of the cilia on the apical margin, which are whitish at their points. The cilia within the fissure and those along the dorsal margin before the anal angle white, the latter containing a few dark scales. Hind wings cinereous; the cilia slightly paler, especially along their bases. Posterior legs cinereous; the feet slightly paler. Expanse 22 mm."

Habitat. — California. Early stages and food plant unknown.

Platyptilia petrodactyla.

Pterophorus petrodactylus Walk., Cat. Lep. Het., Vol. XXX., pp. 940, 941 (1864).

Platyptilus petrodactylus Wlsm., Pter. Cal. and Ore., p. 20, Plate II., fig. 15 (1880).

Expanse of wings, 23 mm. Head, thorax and abdomen shaded cinereous. Legs cinereous, slightly thickened at the joints; the spurs apparently of equal length.

Fore wings white, shaded with cinereous or ashy brown; costa brownish beyond the middle; an oblique brownish fuscous line, starting from the costa before the apex, extends inward more obliquely than the outer margin, but does not reach the fissure. This line is widest on the costa, tapering to a point inwardly, and is darker at its lower end. Fringes white within the fissure, with a cinereous line near their bases, shaded with fuscous at the anal angle. Hind wings pale cinereous; fringes slightly darker towards the end of the feathers.

Habitat. — Arctic America. Early stages and food plant unknown.

Platyptilia adusta.

Platyptilus adustus Wlsm., Pter. Cal. and Ore., p. 5, Plate I., fig. 4 (1880).

Expanse of wings, 23 mm. Head, frontal tuft, thorax and abdomen fawn color, with a brownish tinge. Legs pale fawn color, with the feet and anterior parts of the tibiæ slightly paler.

Fore wings fawn color, somewhat streaked with a paler tint; the costa much darker. Fringes but little paler than the wings, but with a fine brown basal line. Hind wings fawn color, the first and second feathers slightly darker than the fore wings.

Habitat. — California. Early stages and food plant unknown.

Platyptilia albiciliata.

Platyptilus albiciliatus Wlsm., Pter. Cal. and Ore., p. 17, Plate I., fig. 13 (1880).

Expanse of wings, 24 mm. Head cinnamon brown; frontal tuft short. Thorax grayish brown. Hind legs cinereous; feet and spurs paler.

Fore wings cinnamon brown, with a slight grayish tinge on the costa and outer margin. Fringes whitish except at the base, where they are of the same color as the wing. Hind wings pale brown, with the fringes paler at the base.

Habitat. — California. Early stages and food plant unknown.

Platyptilia albicans.

Platyptilia albicans Fish, Can. Ent., Vol. XIII., p. 71 (1881).

Expanse of wings, 22 mm. Head and thorax cream color, frontal tuft short and blunt. Palpi extending beyond frontal tuft, slightly ascending. Antennæ cinnamon brown, dotted above with white. Abdomen ochreous, lighter at base. Legs whitish, anterior and middle femora and tibiæ cinnamon brown, sprinkled with whitish scales; tarsi cinereous, first two segments whitish interiorly; posterior tibiæ cream color, brownish just before the spurs.

Fore wings creamy white along the hind margin, on the costa cinnamon brown; costal triangular spot cinnamon brown, bordered outwardly above the fissure by a broad white line; below the fissure its apex is continuous with the brownish color of the second lobe. Both lobes cinnamon brown, with a transverse white line not reaching the hind margin of the second lobe. Fringes cream color, sprinkled with cinnamon brown. Hind wings cinnamon brown, with fringes concolorous.

Habitat. — Nevada. Early stages and food plant unknown.

Platyptilia tesseradactyla.

Alucita tesseradactyla Linn., Fn. Suec., p. 370 (1761).

Expanse of wings, 16–20 mm. Head, palpi and frontal tuft grayish brown. Antennæ whitish, dotted above with dark brown. Thorax gray in front, white behind.

Fore wings whitish, heavily dusted with brownish gray. The somewhat indistinct brownish triangle on the outer third of the costa is followed by a whitish spot, and a subterminal white line crosses both lobes.

Habitat. — Europe, Massachusetts. Food, *Gnaphalium dioicum*, *G. arenarium*.

"The egg is pale green, smooth and somewhat elongated, and the larva in its earliest stage is clear white with isolated hairs. Head, thoracic and anal shields black. Later (in September) the dorsal and lateral rows of rust-brown points appear, and in March, after hibernating, it becomes stout without increasing very much in length. The head, thoracic and anal shields are dark brown; dorsal stripe is crimson rust color; the subdorsal and lateral lines are of the same color but finer. The ground color of the body is yellowish above and rust red beneath. The adult larva is a little smaller at each end and cylindrical in the middle. The head is small and black, the thoracic shields small, black divided by a light line. The color of the body is dark ferruginous brown. On the back stand whitish flecks with two pairs of black tubercles on each segment, of which the hinder are placed farther from each other than those in front; similar tubercles occur on the sides, from which arise long light hairs. The anal shield and legs are dark brown. These larvæ frequently vary in the tone of the color." (Gartner.)

PLATYPTILIA MARGINIDACTYLA.

Pterophorus marginidactylus Fitch, N. Y. Rep., Vol. I., p. 848 (1854).
Pterophorus nebulædactylus Fitch, N. Y. Rep., Vol. I., p. 849 (1854).
Platyptilus Bertrami Roessl., Wien. Mts., Vol. VIII., p. 54 (1864).
Platyptilus Bischoffii Zell., Stett. Ent. Zeit., Vol. XXVIII., p. 333 (1867).
Platyptilia Bertrami Zell., Stett. Ent. Zeit., Vol. XXXIV., p. 135 (1873).
Platyptilia Bischoffii Zell., Verh. z.- b. Ges., p. 317 (1873).
Pterophorus cervinidactylus Pack., Ann. Lyc. N. Y., Vol. X., p. 266 (1873).
Platyptilus bertrami Wlsm., Pter. Cal. and Ore., p. 3., Plate I., fig. 3 (1880).
Platyptilia bertrami Tutt, Mon., p. 31 (1891).
Platyptilia Bertrami Mey., Brit. Lep., p. 434 (1895).
Platyptilia Bertrami Hof., Deut. Pter., p. 55 (1895).

Expanse of wings, 22–28 mm. Head, palpi, frontal tuft, thorax and abdomen pale ochre yellow, the collar and outside of the palpi sometimes a little darker. Palpi and frontal tuft of nearly equal length, extending forward of the head a distance equal to the length of the head. Antennæ whitish, dotted above with dark brown. All the coxæ, femora, anterior and middle tibiæ brownish yellow on the outside, whitish within. Hind tibiæ whitish at the base, dull brown on the outer half. All the tarsi whitish, except in some examples the segments of the hind tarsi are touched with dull brown. Fore wings somewhat falcate at the end of the first lobe, pale ochre yellow, fuscous along the costal edge, broken by an oblique light shade above and a little beyond the end of the fissure, within which a darker shade extends from the costa across the cell containing two brownish dots, one on each angle of the cell. The anterior dot is seldom present and often both are absent. An elongated ochre yellow spot rests on the cell halfway between the discal dots and the base of the wing, a second elongated spot on the hind margin at the base and another near the middle of the wing. The lobes are somewhat darker at the outer end, sometimes with an indication of a pale subterminal line. Fringes whitish, with a darker shade outwardly, and with a dark-brown basal line which extends a little into the fissure. The darker ochre yellow spots are often extended so that nearly the whole surface of the wing is of this color. Hind wings dark ochreous fuscous, with a more or less distinct cluster of dark scales near the middle of the hind fringe of the third feather.

The genitalia are represented on Plate III., figs. 4 and 5. For the sake of comparison the genitalia of *P. ochrodactyla* are represented on the same plate, figs. 14 and 15. These were made from specimens received from Professor Zeller, and labelled in his own handwriting.

The above description was drawn up from one hundred and thirteen American specimens.

Habitat. — Europe; Canada, Maine, New Hampshire, Massachusetts, New York, Pennsylvania, Colorado, California, Oregon. Food, Yarrow (*Achillea millefolium*).

In some unpublished notes received from Mr. Charles Fish, I find the following statement: "Received from Mr. J. Elwyn Bates, on June 30, 1881, some eggs of *Plat. bischoffii*, which were laid June 24, to the number of twenty-four. They were elliptical in outline and somewhat flattened. The longer diameter was three-sevenths of a millimeter and the shorter diameter was three-tenths of a millimeter, and the surface was irregularly corrugated. When first deposited they were of a light cream color or almost hyaline with a glossy surface, but after two days they turned to a deep flesh color." There was no note made as to whether these eggs hatched, or not.

Different stages of the larva have been described by several writers in Europe, and the mature larva is briefly described as follows: "Larva green; dorsal line darker or somewhat brownish tinged; subdorsal and lateral gray whitish; subspiracular white; head whitish yellowish." (Meyrick.)

"The pupa is a little over half an inch long, with a longish beak in front, projecting at a slight angle downwards from the head; pointed at the tail; the wing cases of moderate length, well developed, and the ends of the leg cases projecting free from the abdomen. The color is bright pale green, dorsal line dark green, edged on the thorax with white; beak white above, rust color on the sides; there is a conspicuous streak on this rust color on the hind part of the thorax, and the same color also appears (but more faintly) on the abdominal point and at the tip of the leg cases; subdorsal line dark green, lateral line white. Ventral surface pale green, with darker green lines, and the wing-cases with whitish rays." (Porritt.)

The insects before me, so far as the labels indicate, were on the wing in Maine, June 24; Massachusetts, from the 10th to the 27th of June; New York, from June 23 to July 17; Missouri, in May; Colorado, from the 11th to the 16th of June; California, June 1 to 18.

I have seven European species of *Platyptilia* in my collection, all named by Professor Zeller. Five of these are males, and an examination of the genitalia proves that one which Zeller named *bertrami* is *ochrodactyla* and one named *ochrodactyla* is *bertrami*. They approach each other so closely in form and coloration that it is not surprising that they should have been considered conspecific for so long a time, and that there should have been so much discussion about the matter in the European journals. Mr. Tutt has given an excellent resumé of this discussion in his "Monograph of the Pterophorina of Britain." Mr. Tutt suggests that Haworth's *pallidactyla* is identical with *bertrami*, and in that case it should take precedence, but until this is adopted we must accept the name *marginidactyla* Fitch, which is ten years older than *bertrami*.

The types of Fitch now belong to my collections; and I have made a critical examination of the genitalia, and they agree perfectly with the genitalia of *bertrami*.

Genus ALUCITA Linn., Syst. Nat., Ed. 10, p. 542 (1758).

Vertex smooth; front smooth or a little swollen, closely scaled; antennæ with a thickened basal segment. Palpi slim, porrect or somewhat ascending, the third segment shorter than the second, pointed and sometimes bent down a little. Anterior and middle tibiæ very slightly thickened at the end; hind tibiæ without thickening of scales. Abdomen moderately slim, the second and third segments not much longer than the others. Fore wings fissured half their length or a little more, the lobes running to a point and bent backward somewhat, especially the second lobe. Feathers of the hind wings all of the same form, linear and pointed, without a cluster of dark scales in the fringe of the third feather.

Synopsis of the Species.

Ground color of fore wings gray, ... *belfragei*.
Ground color of fore wings white, ... *montana*.
Ground color of fore wings yellowish white, . . . *cinerascens*.

Alucita belfragei.

Aciptilus Belfragei Fish, Can. Ent., Vol. XIII., p. 142 (1881).

Expanse of wings, 18 mm. Head brownish gray. Palpi brown above, whitish beneath. Antennæ whitish, dotted with pale brown above. Thorax pale ochreous gray in front; hind portion and abdomen pale grayish ochreous, striped longitudinally with fine white lines and marked with dark streaks. Legs pale grayish; fore and middle femora striped longitudinally with whitish and dark brown lines; tarsi pale ochreous, with shadings on the outer side; hind tibiæ and tarsi pale ochreous; spurs tipped with brown.

Fore wings pale ochreous gray, dusted with brown scales; an oblique dark-brown patch at the base of the fissure, bordered posteriorly with white; a small brown spot midway between this and the base of the wing; two longitudinal brown spots on the outer third of the costa of first lobe and one or two brown dots on the outer margin of the same lobe near the apex. Fringes pale brown except at the apex of the second lobe, where they are white. Hind wings brownish cinereous. Fringes pale brown.

Habitat. — Texas. Early stages and food plant unknown.

Alucita montana.

Aciptilus montanus Wlsm., Pter. Cal. and Ore., p. 59, Plate III., fig. 14 (1880).

Expanse of wings, 16 mm. Head white, antennæ faintly dotted above with brownish. Thorax, abdomen and legs snow white; the fore and middle legs brownish on the inner side.

Fore wings snow white, sprinkled with ferruginous-brown scales, especially on the outer half of the costa; a spot of these scales before the base of the fissure runs obliquely to a darker spot on the costa, and this is nearly connected by a dark shade with another brown costal spot near the apex; a dark-brown fine streak on the outer half of the costa of the second lobe extends through the fringe under the apex; all of the rest of the fringe is snow white. Hind wings dusted with cinereous brown.

Habitat. — California, New York.

"The larva feeds upon different species of *Solidago*. The first examples were noticed on May 30. At this time they were found only on the under side of the leaves, later they occur on the upper as well. As a rule, they lie close to and parallel with the midvein. At least while young they eat out the parenchyma, leaving the epidermis.

"May 30 the larvæ were .1 of an inch and less in length; entirely white, except claws and mandibles. The body is not flattened at this stage. The first ring is broad, and the head may be well withdrawn into it. The tubercular hairs are spined, plainly seen under a moderate magnifying power.

"June 3 the largest had evidently moulted, length then .2 of an inch; pale green, eighth and ninth rings yellow. Lateral tufts more conspicuous. Dorsal line faint. Subsequent changes not noted until full-grown larva was described the latter part of June. Length .34 to .4 of an inch. Pale pea green, head paler; dorsal stripe of three white lines, the middle one the finest and most clearly defined. The seventh, eighth and ninth rings yellow. The posterior subdorsal papilla of the body rings bears two unequal hairs, the anterior but one; above the spiracles and in front of them also is a papilla; below the same there are two, from which arise long hairs, five from posterior and ten or twelve from anterior, these are spread out fan-like; below these a prominent longitudinal fold. From the first ring proceed long hairs reaching over and beyond the head. Hairs all unbranched and plumose. The body is considerably flattened, so when looking down upon it the spiracles from either side may be seen at once, spiracles conical, rings black.

"The *pupa* is .3 of an inch in length; light green, some of them have a reddish stripe along dorsal part of the abdomen, the conical spiracles of such have the same hue. The upper part of the rings well clothed, especially at extremities and along the lateral ridges. Pupa fastens to a tuft of silk by means of the hooks of the last ring. Moth appears through greater part of July." (Kellicott.)

Alucita cinerascens.

Aciptilus cinerascens Wlsm., Pter. Cal. and Ore., p. 57, Plate III., fig. 13 (1880).

Expanse of wings, 19 mm. Head slightly ochreous; palpi very short; antennæ pubescent, pale ochreous. Thorax whitish, especially in front, where two indistinct dark lines run forward to the head. Abdomen pale ochreous. Legs whitish, the fore and middle pairs tinged with brown on the inner side.

Fore wings very pale ochreous, dusted thickly with brownish, forming a large spot before the base of the fissure; a subcostal spot before the middle and two small costal spots on the outer half of the first lobe. Fringes below the apex of first lobe and on the apex of the second lobe dark brown; pale subochreous within the fissure, with a brownish spot on the hind margin. Hind wings and fringes pale cinereous; under side pale brownish.

Habitat — California. Early stages and food plant unknown.

Genus PTEROPHORUS Geoff., Hist. Ins., Vol. II., p. 90 (1764).

Vertex and front smooth; palpi short, not reaching beyond the head or but very slightly; porrect, or slightly ascending, the third segment short and sometimes bent down a little; antennæ with a thickened basal segment. Anterior and middle tibiæ only slightly thickened at the end; hind tibiæ without a thickening of scales.

Fore wings fissured about one-third of their length; both lobes pointed, the hind lobe in some species with a scarcely perceptible anal angle. Feathers of the hind wings unlike in form, with long fringes and without a black scale cluster. The upper angle of the cell is very acute, formed by the very oblique cross vein.

Synopsis of the Species.

1.	Ground color of the fore wings snow white,	2.
	Ground color of the fore wings pale sulphur yellow,	*sulphureodactylus.*
	Ground color of the fore wings pale straw color,	4.
	Ground color of the fore wings cream white,	5.
	Ground color of the fore wings very pale brownish gray,	6.
	Ground color of the fore wings ochre yellow,	7.
	Ground color of the fore wings brown or dark gray,	13.
2.	Expanse of wings less than 21 mm.,	*fishii.*
	Expanse of wings more than 21 mm.,	3.
3.	Expanse of wings between 23 and 25 mm.,	*elliottii.*
	Expanse of wings more than 25 mm.,	*homodactylus.*
4.	Costa of first lobe of fore wing indistinctly brownish,	*stramineus.*
	Costa of first lobe of fore wing not marked with brown,	*angustus.*
5.	Expanse of wings 24 mm.,	*helianthi.*
	Expanse of wings 28 mm.,	*lacteodactylus.*
6.	Fore wings with a brown spot at the end of the fissure,	*paleaceus.*
	Fore wings unspotted,	*inconditus.*
7.	With three or four terminal brown spots on outer margin of second lobe,	*kellicottii.*
	Without this character,	8.
8.	Pale ochre yellow without any markings,	*grandis.*
	With more or less markings,	9.
9.	An oblique reddish brown shade from costa to fissural spot,	*cretidactylus.*
	Without this character,	10.
10.	Second lobe of a brighter yellow than the rest of the wing,	*baroni.*
	Without this character,	11.
11.	A brown costal streak over the end of fissure,	12.
	Without this character,	*guttatus.*
12.	Expanse of wings 28 mm.,	*cineraceus.*
	Expanse of wings 22 mm.,	*gratiosus.*
13.	With tuft of scales near middle of hind tibiæ,	*monodactylus.*
	Without this character,	14.
14.	Expanse of wings less than 20 mm.,	*inquinatus.*
	Expanse of wings more than 20 mm.,	15.
15.	Costal region light yellowish brown,	*eupatorii.*
	Costal region dark,	16.
16.	Outer fourth of costa mostly white,	*grisescens.*
	Outer fourth of costa with but little white,	*lugubris.*

PTEROPHORUS FISHII.

Alucita fishii Fern., Can. Ent., Vol. XXV., p. 95 (1893).

Expanse of wings, 20 mm. Thorax and abdomen white. Legs white slightly tinged with brownish.

Fore wings white with a few brown scales scattered over the costal portion before the fissure, forming a faint costal triangular patch, beyond which are two equidistant brown spots on the costa. Fringes pure white. Hind wings and fringes pure white. Described from one specimen with the head wanting.

Habitat. — Nevada. Early stages and food plant unknown.

PTEROPHORUS HOMODACTYLUS.

Pterophorus homodactylus Walk., Cat. Lep. Het., Vol. XXX., p. 941 (1864).

? *Leioptilus hololeucos* Zell., Lep. Westk. Am., p. 23 (1874).

Lioptilus homodactylus Wlsm., Pter. Cal. and Ore., p. 50, Plate III., figs. 8, 9 (1880).

Expanse of wings, 22–27 mm. Head white, palpi and antennæ whitish. Thorax and abdomen white. Legs white, slightly tinged with cinereous.

Fore wings white, very slightly dusted on the costa with brownish scales; a brownish spot before and slightly below the base of the fissure; a group of indistinct brownish scales between this and the base of the wing; a faint indication of two brownish dots on the outer margin. Hind wings and fringes pure white, with a silky lustre. In some specimens the brownish spots are absent.

A variety of this species has the head brown behind and in front, the palpi brownish and antennæ dingy white. Fore wings more heavily dusted with brown scales, fringes tinged at the tips around the obsolete anal angle with pale cinereous. Hind wings and fringes very pale cinereous. Legs white, first two pairs touched with brownish on their inner sides.

A specimen of this species was sent by Lord Walsingham to Professor Zeller, who remarked: "Only larger, otherwise agreeing with *Lioptilus hololeucos* Zeller; on the right anterior wings it has also two dots."

Habitat. — South America, California, Oregon. Food, *Solidago*, *Eupatorium purpureum.*

"*Larva.* — Length, .55 of an inch; pale yellowish green; dorsal line sharply defined, white; subdorsal and stigmatal lines similar; the top of each ring from the second to the tenth bears a minute circle of white interrupting the dorsal line. The dorsal spaces of each ring from the fourth to the eleventh bear a pair of tubercles on either side of the middle line, from these proceed rather long, stiff, hoary, smooth hairs; the thoracic and terminal rings have a single papilla in place of the pairs. These tubercles stand in a light stripe. Below them a single tubercle with similar appendages; below the spiracles a larger one with a minute one back of it bearing three or four hairs, also one above the line of the feet. Legs and ventral surface hairy. The anterior half of the first ring bears many hairs, which hang over the head somewhat. Spiracles round, rim white; back of each there is a short, stiff hair. Head almost colorless, except mouth organs and ocelli; epicranial suture deep; cranial lobes hemispherical, with scattered hairs.

"The pupa measures .45 of an inch. It is light pea green, turning white before the moth escapes. There is a clear dorsal space with an interrupted white line in the middle; also white lines on the lateral faces. The tubercles are set with hairs exactly as in the larva, so the pupa is quite conspicuously clothed; the head and thorax support shorter hairs arising singly from the surface; short, dusky hairs stand in rows on the wing covers, apparently outlining the veins; there is a similar row on the antennæ covers. The pointed cremaster ends with many hooklets, which fasten the pupa securely to the leaf, on which a tuft of silk has been spun by the larva. The thorax is quite obliquely truncated; seen from below, it is slightly bilobed, rendered so by the prominent origin of the antennæ covers; between the lobes there is a slight tufted tubercle." (Kellicott.)

Pterophorus elliottii.

Alucita elliottii Fern., Can. Ent., Vol. XXV., p. 95 (1893).

Expanse of wings, 23–25 mm. Head very pale fuscous. Thorax and abdomen whitish fuscous. Legs white.

Fore wings white, tinged more or less with ochre yellow near the base and on the apical third of the costa; a very oblique streak of brown scales on the costa near the apex and a dark-brown spot before the fissure; a streak of irregular brown scales extends from the base of the wing to the fissure. Fringes white. Hind wings pure white, with a few ochre yellow scales scattered over the surface in some specimens. Fringes white.

Habitat. — New York. Early stages and food plant unknown.

PTEROPHORUS SUBOCHRACEUS.

Lioptilus subochraceus Wlsm., Pter. Cal. and Ore., p. 53, Plate III., fig. 10 (1880).

? *Pterophorus lacteodactylus* Cham., Can. Ent., Vol. V., p. 73 (1873).

Having no example of this species from California, I copy Lord Walsingham's description: —

"Head whitish above; face and neck brownish; palpi very short, not projecting as far as the front of the head; antennæ whitish ochreous, with the basal joint brown.

"Fore wings pale subochreous, without spots or markings, except a rather oblique delicate ferruginous shade above the base of the fissure, reaching the costa before the apex; the cilia about the dorsal margin of the second lobe are slightly tinged with brownish. Hind wings very pale brownish straw color. Legs whitish.

"Expanse, 28 mm."

Habitat. — California. Early stages and food plant unknown.

I have the type of *lacteodactylus* before me, and the head and palpi agree perfectly with the above description, but the wings are somewhat worn. Without seeing an authentic specimen of *subochraceus*, I do not feel prepared to pronounce them identical. I have two specimens from Massachusetts which were supposed to be *subochraceus*, by Mr. Fish, and from which the drawings of the genitalia on Plate IV. were made. In these specimens the palpi are longer than in *lacteodactylus*, and I do not think they are the same.

PTEROPHORUS HELIANTHI.

Lioptilus helianthi Wlsm., Pter. Cal. and Ore., p. 54, Plate III., fig. 11 (1880).

Expanse of wings, 24 mm. Head and thorax whitish; palpi brownish; antennæ white, dotted with brown above. Abdomen whitish. Legs whitish, dotted with brown on the under side of the segments.

Fore wings cream white, with a few scattered brown scales; a brown spot before the base of the fissure and another between that and the costa, upon which is a brown line; the apex of each lobe sprinkled with brown, and on the apex of the first lobe are two or three small brown spots or dashes. Fringes cream white, tinged with brown on the outer margin. Hind wings very pale cinereous; fringes slightly darker about the ends of the feathers.

Habitat. — Southern Oregon. Food plant, *Helianthus*.

Pterophorus stramineus.

Lioptilus stramineus Wlsm., Pter. Cal. and Ore., p. 41, Plate III., fig. 3 (1880).

Expanse of wings, 19 mm. Head yellowish brown above and in front, yellowish white between the antennæ; palpi and antennæ pale straw color above, brownish beneath. Thorax, abdomen, legs and spurs pale straw color. Fore wings straw color, with a slightly brownish streak extending from the base along the lower half of the wing, and one running obliquely on the costa, pointing inward toward a brown spot at the base of the fissure. Fringes grayish, slightly tinged with brown. Hind wings and fringes pale grayish brown.

Habitat. — Southern Oregon. Early stages and food plant unknown.

Pterophorus angustus.

Lioptilus angustus Wlsm., Pter. Cal. and Ore., p. 43, Plate III., fig. 4 (1880).

Expanse of wings, 18 mm. Head very pale straw color; palpi straw color above, tinged with brownish on the sides; antennæ whitish, with indistinct ochreous spots above. Thorax and abdomen pale straw color. Legs whitish.

Fore wings narrow, very pale straw color tinged with ochreous; a dark fuscous dot at the base of the fissure. Fringes very pale straw color except at the outer end of the fissure above and below where they are grayish. Hind wings pale cinereous; fringes paler.

Habitat. — California. Early stages and food plant unknown. It differs from *stramineus* in having no costal streak.

Pterophorus sulphureodactylus.

Pterophorus sulphureodactylus Pack., Ann. Lyc. Nat. Hist., N. Y., Vol. X., p. 266 (1873).

Lioptilus sulphureus Wlsm., Pter. Cal. and Ore., p. 48, Plate III., fig. 7 (1880).

Expanse of wings, 25 mm. Head ochreous. Palpi whitish yellow, streaked with ochreous; antennæ long, yellowish, tinged with fuscous. Thorax and abdomen sulphur yellow, streaked with ochreous scales. Legs whitish ochreous, streaked with brown.

Fore wings with the first lobe produced into a very acute point, the second lobe broad halberd-shaped, unspotted, clear sulphur yellow, slightly tinged with brownish on the outer fourth of the costa. A minute brown dot before the base of the fissure.

Fringes pale yellowish white, cinereous on the hind margin. Hind wings whitish, thickly dusted with cinereous. Fringes concolorous.

Habitat. — California. Early stages and food plant unknown.

Pterophorus mathewianus.

Leioptilus Mathewianus Zell., Lep. Westk. Am., p. 23 (1874).

Expanse of wings, 24 mm. Head brownish gray behind; palpi whitish gray; antennæ dust gray, faintly annulated on the basal third with whitish. Thorax and abdomen whitish gray. Legs light gray, all the femora and tibiæ brownish ochre, lightest on hind legs.

Fore wings pale reddish gray, sprinkled with black scales, especially on the margin. A diffuse brown dot on the cell, nearer to the base of the wing than to the fissure. Before this is a more distinct dot, variable in form and size, and sometimes a pale dot at the base of the second lobe. A white longitudinal spot under the first-named dot, and before the same an almost pure white stripe runs to the fold, where it widens and sends out a slender line through the middle of the second lobe to its outer margin. A dark-brown line bordered with white on each side runs to the dot on the fissure, and a brown indistinct dot rests on the middle of the first lobe; two brown spots on the apex of the second lobe and a short brown cross line at the base of the fringes of the outer margin. Hind wings clear brownish gray, with a silky luster.

Habitat. —Vancouver Island. Early stages and food plant unknown.

Pterophorus paleaceus.

Leioptilus paleaceus Zell., Beitr., p. 126 (1873).
Lioptilus paleaceus Wlsm., Pter. Cal. and Ore., p. 41, Plate III., fig. 2 (1880).
Leioptilus sericidactylus Murtf., Am. Ent., Vol. III., p. 235 (1880).

Expanse of wings, 21-25 mm. Head yellowish brown, pale between the antennæ; antennæ whitish. Thorax dull yellowish white. Abdomen dull yellowish, with fine longitudinal brownish lines. Legs yellowish white, with fuscous shadings on the under side.

Fore wings very pale brownish gray, with a brownish spot before the fissure. Fringes concolorous with the lobes. Hind wings of the same color as the fore wings. Fringes paler, except at the apices.

Habitat.—Ohio, Illinois, Missouri, Texas, California, Oregon. Food, Iron Weed (*Vernonia noveboracensis*).

An examination of the genitalia of the types of *paleaceus* and also of *sericidactylus* proves them to be identical.

"*Larva.*—Length, 0.55 inch; diameter, 0.10 inch; form, subcylindrical. Color when young, dingy white, with a tinge of green, becoming at maturity pale glaucous, often varying, especially in the late fall brood, to dull salmon. Dorsal hairs proceeding from prominent tubercles, and of two sizes in each tuft, each of the shorter ones tipped with a minute pellucid bead of viscid fluid, to which pollen and bits of leaves often adhere. Lateral ridge well defined. Prolegs long and narrow. When mature, the larva weaves a dense mat of silk, upon which it extends itself, remaining quiescent for two or three days, the dorsal surface acquiring, meanwhile, a translucent lilaceous hue, with three greenish-white longitudinal stripes, of which the medio-dorsal is most distinct and continuous.

"*Pupa*, with ventral surface closely appressed to the mat of silk, to which the anal hooks are firmly attached. An upright or inverted horizontal position seems to be preferred, although there is no thoracic band or other support for the anterior part of the body.

"Average length, 0.45; diameter, same as larva, tapering rather abruptly from seventh abdominal segment backward. Wing sheaths narrow, free at the blunt tips. Dorsum with prominent subdorsal ridges. Color and markings quite variable. In the spring brood commonly dull green, with indistinct lateral yellow stripes. In the fall brood the dorsum is pale yellow or flesh color, with two fine, indistinct, medio-dorsal lines of lilac color; subdorsal ridge pale, inclining to lilac on outer side. In subdorsal space are two nearly continuous, quite heavy, black or fuscous lines, separated by a broad pale stripe, from two narrow, interrupted dark lines, one beneath, the other above, the stigmata. On the thorax the dark stripes are represented by two slightly diverging dashes on each side. Situated in the subdorsal ridge, at the posterior edge of each segment, are a pair of small, geminate, piliferous warts, each bearing a sparse tuft of light sprangling hairs. The last larval skin, rolled into a little hairy ball, is often supported over the back of the chrysalis, raised above it on the hairs of the sub-dorsal ridges. The pupa is quite active and irritable, striking about in all directions when meddled with." (Murtfeldt.)

Pterophorus agraphodactylus.

Pterophorus agraphodactylus Walk., Cat. Lep. Het., Vol. XXX., p. 94 (1864).
Lioptilus agraphodactylus Wlsm., Pter. Cal. and Ore., p. 46, Plate III., fig. 6 (1880).

I have not seen this species, and therefore quote Lord Walsingham's description: —

"Head whitish in front, touched with brownish ochreous towards the thorax and in front; antennæ whitish, browner beneath; palpi very short. Thorax yellowish white.

"Fore wings remarkably narrow, dirty white, with a faint yellowish tinge, streaked longitudinally with faint slender lines of brownish gray, apparently following the neuration; the widest and most conspicuous of these runs parallel to the costa from the base of the wing to the middle of the anterior lobe, where it is diffused in a faint shade towards the costa, sending two slender and scarcely discernible lines to the apex and inner margin. There are two slender brownish-gray lines on the dorsal half of the wing, the upper one, coming from the base, passing below the cleft, where it throws off a branch beneath and running along the upper edge of the second lobe to its apex; the lower coming also from the base, and attaining the dorsal margin below the base of the cleft. The costa pale; the cilia tinged with gray. Hind wings and fringes pale cinereous. Abdomen and legs slightly yellowish white. Underside uniformly pale cinereous, except the costa and the fringes of the anterior lobe within the fissure which are whitish.

"Expanse, 25 mm."

Habitat. — St. Domingo, Southern Oregon. Early stages and food plant unknown.

Pterophorus inconditus.

Lioptilus inconditus Wlsm., Pter. Cal. and Ore., p. 44, Plate III., fig. 5 (1880).

Expanse of wings, 19 mm. Head pale brownish gray, paler between the antennæ; palpi brownish gray; antennæ pubescent, whitish, the basal segment enlarged and with a few erect scales on its inner side; thorax and abdomen slightly tinged with yellowish. Legs yellowish white.

Fore wings very pale brownish gray or bone color, without any markings except faint traces of darker lines upon some of the veins. Fringes slightly paler than the wings. Hind wings and fringes very slightly darker, with a more decided cinereous tinge.

Under side of all the wings brownish gray, with the costal margin of the fore wings slightly paler.

Habitat. — California, Washington, D. C. Early stages and food plant unknown.

Pterophorus parvus.

Lioptilus ?parvus Wlsm., Pter. Cal. and Ore., p. 55, Plate III., fig. 12 (1880).

As I have no example of this species, I quote Lord Walsingham's description: —

"Head grayish white, a scarcely paler frontal tuft projecting slightly above the long, well clothed but sharply pointed palpi, which are about twice the length of the head; antennæ pubescent, grayish.

"Fore wings cleft to scarcely one-third of their length, with no posterior angle to the the upper lobe, which is rather narrow, acuminate and appressed at the apex, dusty grayish, sprinkled with fuscous scales, which form an elongate shade, extending from an ill-defined antemedian fuscous dot to the base of the anterior and to the apex of the posterior lobe; a small fuscous dot lies immediately before and slightly below the base of the fissure; there is a slight fuscous shade along the posterior margin of the upper lobe, of which the costal portion is rather pale ochreous; the costa itself whitish. The cilia along the apical margin of both lobes are grayish, spotted along their base with four or five groups of fuscous scales, of which one is at the extreme apex of the upper lobe. The anal angle appears to be slightly more defined in the second lobe of the fore wings, and the fissure rather wider at the base than is usual in this genus. Hind wings cinereous. Abdomen grayish white; the legs whitish, first two pairs touched at the sides with grayish fuscous. The first pair of spurs on the hinder tibiæ are unequal in length; the second pair equal to the longest of the other two.

"Expanse, 15 mm."

Habitat. — California. Early stages and food plant unknown.

Pterophorus kellicottii.

Lioptilus Kellicottii Fish, Can. Ent., Vol. XIII., p. 141 (1881).

Expanse of wings, 28–30 mm. Head ochreous brown, whitish between antennæ. Palpi rather long and slender, second segment with a small tuft of raised scales on the upper side at the extremity. Antennæ pale ochreous, brownish beneath; thorax and abdomen pale brownish ochreous, the latter striped longitudinally with pale brown lines. Fore and middle legs brownish ochreous; hind legs whitish ochreous, tarsi paler.

Fore wings pale ochreous, dusted more or less with brownish scales, which in some examples form longitudinal streaks on the costa and basal half of the median space; a dark-brown dot on the base of fissure; two brown dashes on the costa near the apex, one on the hind margin of first lobe near the apex, usually four at the end of the second lobe on veins 2, 3, 4 and 5. Fringes concolorous. Hind wings, also under side of all the wings, cinereous brown, with a silky lustre. Fringes darker.

Habitat. — New York. Food, *Solidago.*

"The larva, when first examined, August 22, was .3 of an inch long; color light yellow, head and shield darker, the oblique anal plate almost black, bearing hairs and hooks; dorsal and subdorsal lines pinkish. By the middle of September it abandons the branches, being then .45 of an inch in length, and bores into the stalk a few inches above the ground; it makes its way down the pith into the roots, well under the ground, where it passes the winter. I fetched several examples from the fields in January for examination; they were then .58 to .6 of an inch in length, lighter in color, with the longitudinal lines of pink brighter than in autumn, the eighth segment conspicuously marked on the back by pink. There are few hairs over their smooth bodies; on the last ring, however, there is a brown or black chitinous disc, with a circle of long brown hairs about its circumference; in the centre of this disc there is a small papilla, with two stout, straight black teeth, pointing rearwards; these teeth are hooked upward in the autumn stage. The hairs render the plate sensitive to touch, and help to brush fragments from their long, narrow galleries, while the teeth assist in backward motion in them. The mature larvæ obtained in May differ but slightly from these, except that they are then .7 of an inch long, and the pink stripes and marks are brownish. The fourth, fifth and sixth segments are smaller than those preceding or following them. They are quite active, moving up and down their burrows rapidly.

"By the middle of May the caterpillar has worked its way back to the place of entrance in autumn, enlarging its way to accommodate its increased size, and, after loosely stopping the upper part with a few chips, retires and changes to the pupa. It is then .6 of an inch in length, slender, cylindrical. Color white, except the oblique disc or plate terminating the head, which is made dark by many teeth-like elevations on its surface. The abdominal segments are clothed with hairs, and the last four segments have each a transverse row of teeth on the dorsal part, reminding one of a Tortrix or Cossus pupa. The conical tip of the abdomen has many teeth; these teeth, together with the roughness on the head, enable the pupa to worm its way up and down the burrow with readiness. When removed from the stem to the table, it travels about, rolling and worming its way very much as do the pupæ of certain stem-boring beetles. The wing and limb covers are free for a considerable distance from their tips." (Kellicott.)

Pterophorus grandis.

Lioptilus grandis Fish, Can. Ent., Vol. XIII., p. 141 (1881).

Expanse of wings, 34 mm. Head, palpi, antennæ, thorax and abdomen of nearly a uniform pale brownish-ochreous color. Legs brownish ochreous, with tarsi somewhat lighter.

Fore wings pale brownish ochreous, in some species with a few scattered faint brownish dots on the second lobe. Fringes slightly darker. Hind wings very slightly browner than fore wings, with the fringes still darker.

Habitat.—California. Early stages and food plant unknown.

Pterophorus monodactylus.

Alucita monodactyla Linn., Syst. Nat., Ed. X, Vol. I., p. 542 (1758).
Pterophorus cineridactylus Fitch, N. Y. Rep., Vol. I., p. 848 (1854).
Pterophorus nævosidactylus Fitch, N. Y. Rep., Vol. I., p. 849 (1854).
Pterophorus pergracilidactylus Pack., Ann. Lyc. N. Y., Vol. X., p. 265 (1873).
Pterophorus monodactylus Wlsm., Pter. Cal. and Ore., p. 39, Plate II., fig. 16; Plate III., fig. 1 (1880).

Expanse of wings, 22–26 mm. Head and thorax pale gray, sprinkled with brown scales. Palpi short, tipped with brown; antennæ grayish white, spotted with fuscous above. Abdomen grayish ochreous, striped with fuscous and brown scales on the sides; a dorsal row of brown dots, one at the base of each segment. Legs grayish, with the joints enlarged and covered with brownish hairs; a tuft of scales near the middle of the hind tarsi on the side opposite the spurs.

Fore wings varying from pale grayish to pale reddish brown, often mixed with white and sometimes with a few black scales; stripes or streaks of dark brown or blackish scales on the costa and hind margin; before the fissure a brown spot, sometimes tapering to a point toward the base; an elongated spot of brown scales on the costa, half-way between the latter and the apex, with two smaller ones between it and the apex; one or more small blackish dots on one or both lobes near the apex. Fringes grayish, tinged with fuscous on the outer third of fissure. Hind wings gray or fuscous, with a silky lustre; fringes slightly darker.

This species is exceedingly variable both in color and markings, some examples being very light with but few spots, while others are reddish brown.

Habitat. — Europe; Maine to California. Food, *Convolvulus sepium*, *Convolvulus arvensis*, *Chenopodium album*, *Atriplex patula*.

"*Larva.* — Length, when at rest, about five-eighths of an inch, and stout in proportion. Head polished and rather small, narrower than the second segment. Body uniform and cylindrical, tapering a little posteriorly. Segmental divisions well defined and deeply cut ventrally; each tubercle emits a tuft of short but rather strong hairs. Ground color bright yellowish green, more decidedly green on the back; head pale yellow, the mandibles light brown. A fine but clear yellowish white line forms the dorsal stripe; there is a much broader stripe of the same color along the spiracular region, and the space between it and the spiracles is prickled with streaks and spots of the same color. Spiracles black, hairs grayish. Ventral surface, legs and prolegs uniformly pale green. The pupa, although attached by the tail, was laid flat along the top of the cage." (Porritt.)

Pterophorus cretidactylus.

Pterophorus cretidactylus Fitch, N. Y. Rep., Vol. I., p. 849 (1854).
Œdematophorus occidentalis Wlsm., Pter. Cal. and Ore., p. 37, Plate II., figs. 13, 14 (1880).
Pterophorus cretidactylus Fern., Can. Ent., Vol. XXV., p. 96 (1893).

Expanse of wings, 26 mm. Head whitish ochreous, slightly tinged with fawn color on the front; palpi fawn color; antennæ whitish, faintly spotted with fawn color; thorax whitish ochreous. Abdomen fawn color. Fore and middle legs white, with dark, brush-like tufts on the joints; hind legs tinged with fawn color, whitish on the inner sides; segments slightly thickened, not annulated.

Fore wings whitish ochreous, the costa, apex and hind margin tinged with fawn color; a dark fawn-colored spot before the base of the fissure, more or less connected obliquely with an elongated spot of the same color on the costa; a light space on each side of the costal spot. Fringes whitish ochreous, tinged with pale fawn color. Hind wings and fringes lustrous, pale fawn color.

Habitat. — New York, California. Early stages and food plant unknown.

Pterophorus eupatorii.

Œdematophorus cretidactylus Zell., Lep. Westk. Am., p. 22 (1874).
Œdematophorus cretidactylus Wlsm., Pter. Cal. and Ore., p. 35 (1880).
Œdematophorus cretidactylus Kell., Bull. Buf. Soc., Vol. IV., p. 2 (1882).
Alucita eupatorii Fern., Can. Ent., Vol. XXV., p. 96 (1893).

Expanse of wings, 22–24 mm. Head dull reddish brown; thorax pale brown; legs brown, darker at the middle and ends of the tibiæ; segments of the tarsi white at the base and brown at the tips; spurs white in the middle and brown at the tips.

Fore wings pale ochre yellow, whitest on the costal portion, and sprinkled with dark-brown scales to such an extent as to give them a wood-brown color. These dark-brown scales form an antefissural spot, which in some specimens is concave on the outside and extended obliquely up and out, nearly reaching a dark-brown costal streak over the end of the fissure, beyond which are two costal dark-brown spots, the first of which is the smaller. The brown on the second lobe sometimes gives this part of the wing a streaked appearance. Fringes smoke brown, cut with whitish once on the first lobe and twice on the outer margin of the hind lobe. Hind wings and fringes brownish cinereous.

Habitat. — New York, California, Vancouver Island. Food, *Eupatorium purpureum.*

"*Larva.* — Length, 0.55 of an inch; color of skin greenish, striped with wine color and white; hairs dusky, lighter laterally. Dorsal line white, interrupted with circles and bordered laterally with wine color. That part of the dorsal space in which the tubercles stand, much lighter in hue; subdorsal and stigmatal lines white, bounded by the same shade as the dorsal. Head light green, spiracles ringed with brown.

"*Pupa.* — Color, green, ornamented with wine-colored and white lines. It has the same size and habits as *homodactylus;* the tubercles are similar. It is a little thicker, the anterior end more obtusely truncated and less bilobed. The hairy clothing similar to *homodactylus*, but the hairs not so smooth as in that pupa." (Kellicott.)

Pterophorus guttatus.

Œdematophorus guttatus Wlsm., Pter. Cal. and Ore., p. 36, Plate II., fig. 12 (1880).

Expanse of wings, 25 mm. Head and palpi whitish, sprinkled with cinereous, the palpi fuscous at the sides; thorax and abdomen whitish cinereous. Hind legs white, with two slightly fuscous annulations.

Fore wings whitish cinereous, paler at the base, dusted with fuscous scales toward the costa and hind margin; a white spot, generally bordered on the inner edge by two fuscous scales, lies at the base of the fissure; another similar spot is sometimes indicated before the middle of the hind margin. Fringes of the outer margin and fissure cinereous fuscous, slightly interrupted with whitish. Hind wings pale cinereous. Fringes paler.

Habitat. — California. Early stages and food plant unknown.

Pterophorus cineraceus.

Œdematophorus cineraceus Fish, Can. Ent., Vol. XIII., p. 73 (1881).

Expanse of wings, 28 mm. Front of head dark grayish brown, vertex pale cinereous. Palpi grayish brown, ascending, third segment short. Antennæ cinereous, dotted above with dark brown. Abdomen cinereous, marked with reddish-brown scales. Legs brownish cinereous, sprinkled with dark-brown scales; a band on the middle and on the end of the middle tibiæ dark grayish brown, spurs tipped with dark brown; tarsi whitish cinereous, slightly brownish at extreme end of segments.

Fore wings cinereous, tinged with brownish, and very thinly sprinkled with dark-brown scales. These scales form a median spot before the base of the fissure, bordered on the outside with white. A longitudinal brown spot occurs on the costa opposite the base of the fissure, and two smaller ones toward the apex. Fringes brownish cinereous. Hind wings and fringes brownish cinereous.

Habitat. — Washington. Early stages and food plant unknown.

Pterophorus baroni.

Œdematophorus Baroni Fish, Can. Ent., Vol. XIII., p. 73 (1881).

Expanse of wings, 30 mm. Front of head brownish cinereous, vertex lighter. Palpi rather stout, third segment very short and blunt. Antennæ pale cinereous, dotted above with dark brown.

Thorax and abdomen pale brownish cinereous, the latter marked dorsally by a row of fine black dots on each segment beyond the third. Anterior and middle femora brownish cinereous, tibiæ grayish, tarsi whitish cinereous. Hind femora and tibiæ pale brownish cinereous, spurs short, tipped with black.

Fore wings brownish cinereous, ochreous on the inner margin and second lobe, the whole surface sprinkled with fine black scales. Fringes concolorous with the wings. Hind wings and fringes dark cinereous.

Habitat. — California. Early stages and food plant unknown.

Pterophorus gratiosus.

Œdematophorus gratiosus Fish, Can. Ent., Vol. XIII., p. 73 (1881).

Expanse of wings, 22 mm. Head and palpi dark brown; antennæ pale brownish, dotted above with white and dark-brown scales. Thorax grayish brown, anterior portion lighter. Abdomen fawn brown. Legs grayish brown, tarsi pale cinereous, slightly darker on the extremities of segments.

Fore wings pale cinereous, dusted with dark brown; an oblique brown spot occurs before the base of the fissure and a longitudinal brown costal line nearly opposite the base of fissure. Fringes concolorous with wings. Hind wings and fringes brownish cinereous, third feather whitish.

Habitat. — California. Early stages and food plant unknown.

Pterophorus lugubris.

Œdematophorus lugubris Fish, Can. Ent., Vol. XIII., p. 140 (1881).

Expanse of wings, 27–29 mm. Head and palpi dark smoky brown. Antennæ dotted above with white and blackish scales. Thorax light smoky brown. Abdomen slender, dark smoky brown, thickly sprinkled with very dark scales. Legs grayish brown, the middle tibiæ whitish just before the middle and end; all the tarsi whitish at base of joints; spurs whitish at base.

Fore wings dark smoky gray, dusted with dark brown scales; a longitudinal black dash on the costa, opposite the base of fissure; an obscure blackish spot before the base of fissure, bordered outwardly by gray scales. Faint indications of two smaller blackish spots on the costal margin of anterior lobe. Fringes smoky gray, with a few whitish hairs on the hind margin of anterior lobe near the apex. Hind wings and fringes, as well as under side of wings, cinereous.

Habitat. — California. Early stages and food plant unknown.

Pterophorus grisescens.

Œdematophorus grisescens Wlsm., Pter. Cal. and Ore., p. 34, Plate II., fig. 11 (1880).

Expanse of wings, 29 mm. Head and palpi gray, with a fuscous tinge on the apex of the palpi. Antennæ spotted with gray and fuscous. Thorax and abdomen grayish, sprinkled with fuscous. Legs grayish white, tinged on the segments and on the tips of the spurs with fuscous.

Fore wings gray, slightly spotted with white and dusted with fuscous scales, the hind portion touched with ferruginous. A white space on the costa before the base of the fissure, and another beyond and obliquely connected by whitish scales with the base of fissure; a whitish spot before the middle of the hind margin and an indistinct fuscous spot above it. Fringes mottled with white and grayish fuscous. Hind wings cinereous; fringes whitish mixed with gray.

Habitat. — Southern Oregon. Food, *Artemisia*.

Pterophorus inquinatus.

Œdematophorus inquinatus Zell., Beitr., p. 125 (1873).
Œdematophorus ambrosiæ Murtf., Am. Ent., Vol. III., p. 236 (1880).

Expanse of wings, 19 mm. Head and thorax gray, spotted with white; palpi small, porrect, acute, whitish, touched with brown outwardly. Antennæ whitish, spotted with brownish, white at the base on the under side. Abdomen gray.

Fore wings dust gray, thickly dusted with white and brown scales, forming scattered flecks or blotches, one of which is generally present on the middle of the space between the base of the wing and the fissure; a larger one before the fissure and separated from it by a whitish space, against which its oblique outer margin is excavated; below this is a longitudinal streak of scales, bordered basally by a white spot and separated from the spot before the fissure by a whitish space. Two blackish streaks or spots occur on the costa, the larger one above the base of fissure, the other half-way between it and the apex of the wing. Fringes grayish, cut with white under the apices of the lobes and on the anal angles, where there is a white wisp. A similar wisp before the apex and on the anal angle of the second lobe. A brown dot sometimes rests on the base of each of the three wisps. Hind wings brownish gray, a diffuse brown dot on the apex of each feather or at least on the first. Fringes brighter.

Habitat. — Alabama, Texas, Missouri, Colorado, Arizona. Food, Rag-weed (*Ambrosia artemisiæfolia*).

"*Larva.* — Length, 0.35; diameter, 0.09. Form depressed. Color, pale greenish gray, with very characteristic dark markings and lateral tufts of long, white silken hairs. Head small, light brown, corneous, retractile. Segment 1 with a dilated, partially free shield-like collar, covering top and projecting over the head. The ornamentation of this collar consists of five central minute brown dots, with four still smaller black ones on each side, from each of which proceeds a short curving bristle. The projecting edges fringed with soft light hairs. Segments 2 and 3 gradually broadening backward, ornamented on dorsum with two oblong, pale, brown spots on either side of a triangle of very minute black dots, and having a larger black dot on each outer side. Two short bristles arise from each of the more conspicuous spots. Abdominal segments each with four somewhat elevated brown spots, from which proceed single, short, backward-curving bristles. Between the posterior pair of brown spots are two smaller black ones, each of which forms the base of a very short clubbed piliferous process, which turns backward, resting flat upon the surface.

"The stigmata are annulated with black, and obliquely above and forward of each are two small brown dots. The lateral tufts are below the stigmata, and each is composed of from seven to nine long hairs, which under the lens are remotely pectinate. A little above and back of each of these tufts is a semicircle of fine, scale-like bristles. The prolegs are very short.

"*Pupa.* — Length, 0.25. Swollen and blunt anteriorly. Color, pale fulvous, with a roseate hue on dorsum. Dorsal surface beset with tufts of dingy hairs, with a lateral fringe of single straight hairs, which serve to secure it more firmly to the mat of silk upon which it rests. Dorsum marked near the head with two large, dull-brown spots, and an indistinct longitudinal stripe of the same color on the abdomen. On either side of the thorax is a small, velvety dark-brown dot." (Murtfeldt.)

Genus STENOPTILIA Hüb., Verz., p. 430 (1826).

Vertex smooth; front cone shaped, smoothly scaled; palpi extending beyond the frontal projection, the second segment somewhat triangular, with projecting scales above at the end, the third segment very small and cylindrical. Fore wings fissured about one-third of their length, the lobes narrow and with very oblique outer margins, but with more or less distinctly visible anal angles. The feathers of the hind wings are dissimilar in form: the first is the widest; the second is smaller, and has a long, produced apex; the third is linear, without dark scales in the hind fringe. The venation is complete, as shown on Plate III., figs. 1 and 2.

Synopsis of the Species.

1. { Expanse of wings less than 15 mm., ... *pumilio.*
   { Expanse of wings more than 15 mm., ... 2.
2. { With a dark-brown streak on the middle of first lobe, . . 3.
   { Without a dark streak on the middle of first lobe, . *pterodactyla.*
3. { Second lobe without any trace of a brown streak, . *exclamationis.*
   { Second lobe with a more or less complete brown streak, *semicostata.*

Stenoptilia pumilio.

Mimeseoptilus pumilio Zell., Beitr., p. 124 (1873).

Expanse of wings, 12 mm. Head reddish gray, front whitish; palpi very thin, filiform, horizontal, whitish. Antennæ pale gray, white towards the base on the outside. Thorax reddish gray. Abdomen yellowish white at the base and end. Legs slender, white, the first pair of spurs on hind tibiæ unusually long.

Fore wings unusually short and broad, very bright fawn color, darkest on the costal margin of the anterior lobe; costal vein white for two thirds of its length; a long blackish streak on the fold at the basal fourth of the wing; a long, conspicuous point in the middle between this and the fissure, and before these one or two long, confused flecks. Fringe of anterior lobe white or gray, with scattered black scales, with two black, somewhat commingled dots on the outer margin near the anal angle. Fringe of the second lobe gray, thickly sprinkled with deep black scales, which are united with three black spots on the hind margin; at the apex it is whitish, and marked with a row of unequal, somewhat commingled dots, which do not reach to the base of the fringe. Hind wings brownish gray, with much lighter fringes. On the apex of the first and second feathers a small black dot may be seen in certain lights, most distinct on the under side, where the apex of the third feather is dark brown.

Habitat. — Texas. Early stages and food plant unknown.

STENOPTILIA PTERODACTYLA.

Alucita pterodactyla Linn., Faun Suec., p 371 (1761).

Expanse of wings, 21–24 mm. Head ashy brown; palpi long, acuminate, whitish at the tips; antennæ brownish above, whitish beneath. Thorax ashy brown, with a few darker scales. Abdomen fuscous, striped with pale ochreous lines and with a few dark-brown dots at the ends of the segments. Legs ochreous brown on the outside, whitish on the inner sides, tarsi very pale ochreous.

Fore wings reddish brown, the entire costa and the apex of the second lobe heavily sprinkled with dark-brown scales; a dark-brown reniform spot at the base of the fissure. Fringes ashy brown, with a very pale line at their bases. Hind wings fuscous with ashy brown fringes.

Habitat. — New York. Food, Speedwell (*Veronica chamædrys*).

"*Larva.* — Length, about five-eighths of an inch, and scarcely so stout as seems usual in the genus. Head small, and narrower than the second segment; it is polished, rather flat in front, but rounded at the sides. Body cylindrical, of fairly uniform width, but tapering a little at the extremities; segmental divisions well defined; the skin, with a soft and half-transparent appearance, is sparingly clothed with short hairs. There are two varieties, which are perhaps about equally numerous. In one of them the ground color is a bright grass green; in the other it is equally yellow green; in both forms the head is pale yellowish brown, very prettily reticulated with intense black. The dark-green, or, in some of the specimens, dark-brown alimentary canal forms the dorsal stripe; subdorsal lines rather indistinct, grayish white; below there is a still more indistinct waved line of the same color; there is, again, a similarly colored faint line along the spiracular region, and the segmental divisions are also of this pale color. In some specimens the hairs are gray; in others, brown. Ventral surface uniformly of the same color as the ground of the dorsal area; the legs reticulated and the prolegs tipped with black.

"*Pupa.* — The pupa is attached by the tail only, is rather long, but slender. The head, which is the thickest part, is abruptly rounded, and has the snout very prominent; thorax and abdomen rounded above, rather flattened beneath, and attenuated strongly to the anal point; eye, leg and wing cases fairly prominent, the last prolonged a considerable distance over the abdominal segments." (Porritt.)

Stenoptilia exclamationis.

Mimeseoptilus exclamationis Wlsm., Pter. Cal. and Ore., p. 32, Plate III., fig. 10 (1880).

Expanse of wings, 22 mm. Head and palpi above, gray, with brown scales on the sides and beneath the palpi; thorax gray, with a brown spot on the top. Antennæ brownish gray. Abdomen ochreous brown. Legs brownish above, whitish beneath; feet white.

Fore wings gray, sprinkled with fuscous; costa fuscous; a row of fuscous spots runs from the base along under the cell for one-third the length of the wing; a small fuscous dash under the costa before the middle. Two fuscous spots before the end of the fissure, and beyond them, on the first lobe, a fuscous dash, pointing toward the upper spot, both together forming an exclamation point; above, the costa is spotted with fuscous. Fringes around the fissure white; along the outer margin cinereous, with a fuscous line at their base, but interrupted with white on the middle of the anterior and at the upper angle of the posterior lobe. Hind wings fuscous, with brownish scales. Fringes brownish.

Habitat. — California, Oregon. Early stages and food plant unknown.

Stenoptilia semicostata.

Mimeseoptilus semicostatus Zell., Beitr., p. 123 (1873).

Expanse of wings, 18 mm. Head grayish, with a fine white line above the eyes. Antennæ grayish, white toward the base. Thorax dusted with brown in front, whitish behind. Abdomen slender, pale yellowish, with two black dots on the end of each of the three segments before the last. Legs whitish.

Fore wings brownish gray, shading into pale reddish ochre along the hind margin and upon both lobes. In the middle of the space, between the base and the fissure, is a black dot. At the fissure, at the beginning of the second lobe, is a similar dot, and above it, in one example, is a larger but very distinct wisp-like mark. One example has in the middle of each lobe a fine, brown longitudinal streak; upon the first lobe it is short and in the middle, upon the second it is long and reaches quite to the hind margin. Fringes of hind margin of first lobe whitish at the base, gray outwardly; fringe of outer margin pure white with two black dots, one behind the other. Fringes of second lobe gray, dark outwardly except at the apex, where they are white with two black dots. Hind wings brownish gray; fringes dark gray, with a clear fine line at their base and around the apex of the first two feathers.

Habitat. — Texas. Early stages and food plant unknown.

ORNEODIDÆ.

This family is not so closely related to the Pterophoridæ as was supposed by the early entomologists, and is introduced here merely because there is only a single species known in this country; and, as it is placed near the Pterophoridæ in collections, generally, it may be convenient to treat of it here.

Mr. Meyrick has given the following characters: —

Ocelli distinct. Tongue developed. Maxillary palpi obsolete. Fore wings six-cleft, cell very short, vein 5 absent, 7 separate, 8 and 9 coincident. Hind wings six-cleft, cell very short, 5 absent, 7 out of 6 near origin, 8 free.

GENUS ORNEODES Latr., Prec. d. Car., p. 148 (1796).

Labial palpi long, obliquely ascending, second segment tufted, third segment long and slim. Veins 5, 6, 9 and 10 wanting in the fore wings.

The following well-known European species occurs in the western part of this country: —

ORNEODES HEXADACTYLA.

Alucita hexadactyla Linn., Syst. Nat., Ed. XII., Vol. II., p. 542 (1758).

Alucita montana Ckll., MS., Ent. Mon. Mag., Vol. XXV., p. 213 (1889).

Expanse of wings, 13–16 mm. Head and thorax dark gray on the outside, whitish beneath and within.

Fore wings ochreous gray, with two dark-gray bands edged with whitish crossing them; the first on the middle of the wing and wider on the costa, where it is interrupted in the middle by a white-edged gray spot; the second is subterminal, and wider on the middle of the wing. A dark spot on the costa between the bands, and two others before the first band. A dark-brown or black dot on the apex of each of the feathers of both wings; feathers of the hind wings whitish and dotted with dark gray.

Habitat. — Europe; Missouri, California, Oregon, Canada, Manitoba. Food, *Lonicera.*

The eggs are laid in the early spring, on the flower-buds of the honey-suckle, and the larvæ, when hatched, feed inside of the buds and flowers.

Explanation of Plate I.

External Anatomy of Pterophorus monodactylus.

[All the drawings enlarged.]

Fig. 1. Side view of denuded body of male.

Fig. 2. Top view of denuded body of male.

Fig. 3. Top view of head.

Fig. 4. Front view of head.

Fig. 5. Labial palpus.

Fig. 6. Base of tongue and labrum.

Fig. 7. Antenna of male.

Fig. 8. Fore leg.

Fig. 9. Tibial epiphysis.

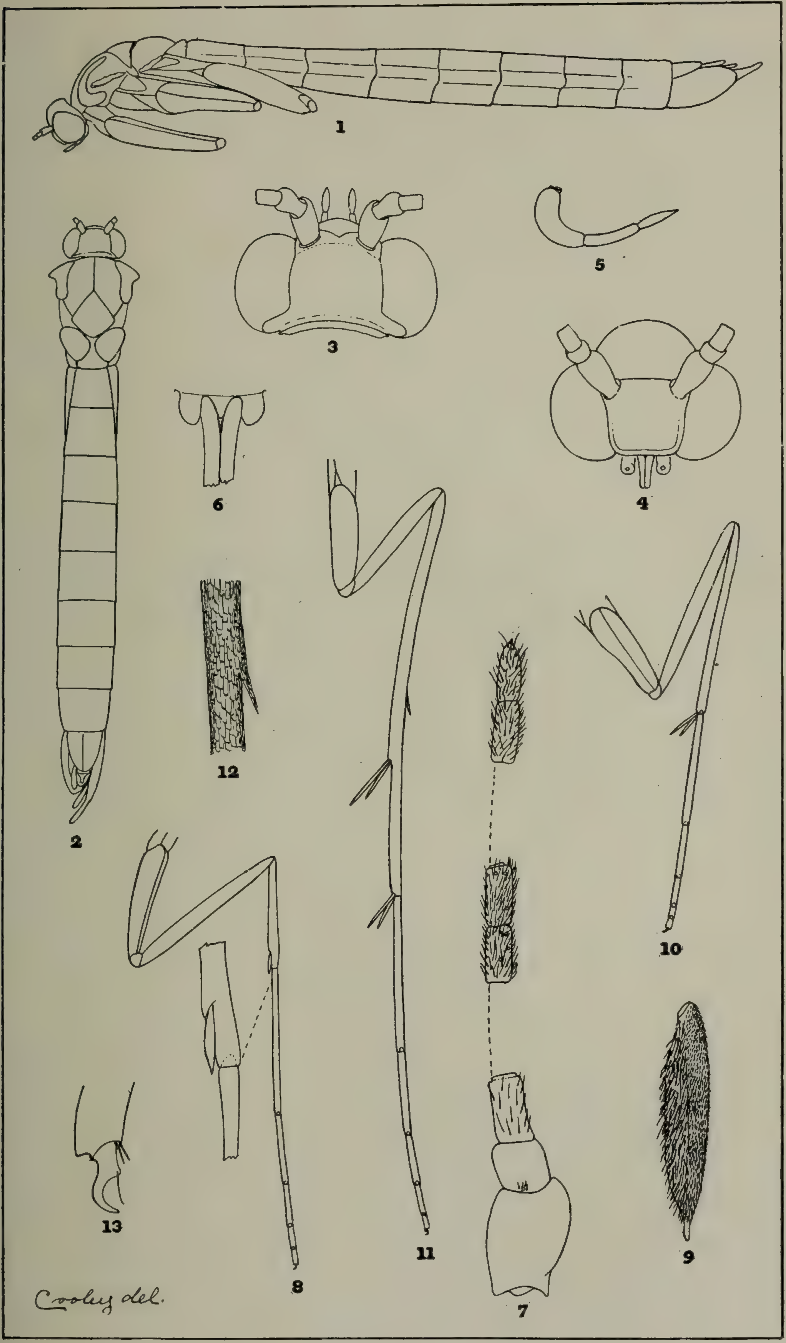
Fig. 10. Middle leg.

Fig. 11. Hind leg.

Fig. 12. Portion of hind tibia, showing tuft of scales.

Fig. 13. Claw from the hind leg.

Plate I.



Explanation of Plate II.

Fig. 1. Fore wing of Platyptilia carduidactyla, showing veins numbered. *A*, apex of first lobe; *B*, anal angle of first lobe; *C*, apex of second lobe; *D*, anal angle of second lobe.

Fig. 2. Hind wing of Platyptilia carduidactyla, showing veins numbered.

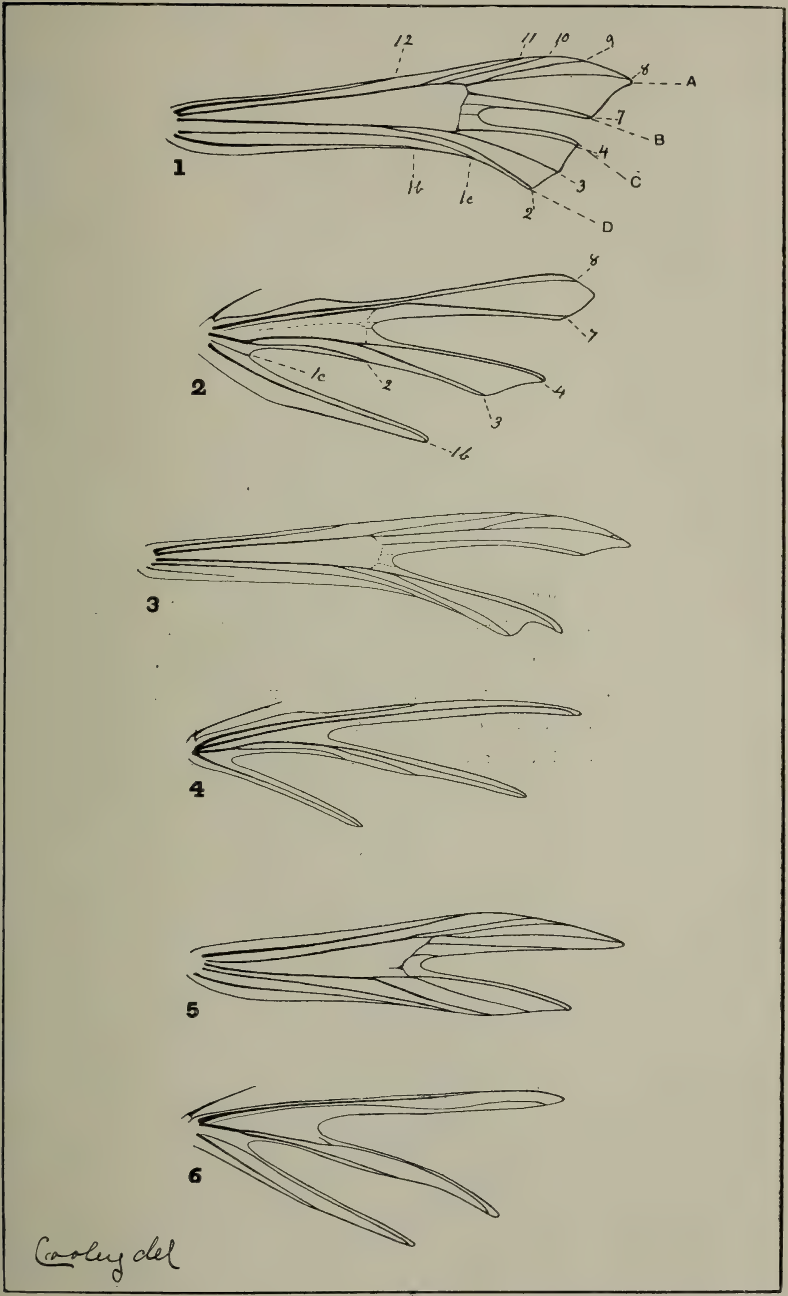
Fig. 3. Fore wing of Oxyptilus periscelidactylus.

Fig. 4. Hind wing of Oxyptilus periscelidactylus.

Fig. 5. Fore wing of Alucita cinerascens.

Fig. 6. Hind wing of Alucita cinerascens.

Plate II.



Explanation of Plate III.

Fig. 1. Fore wing of Stenoptilia exclamationis.

Fig. 2. Hind wing of Stenoptilia exclamationis.

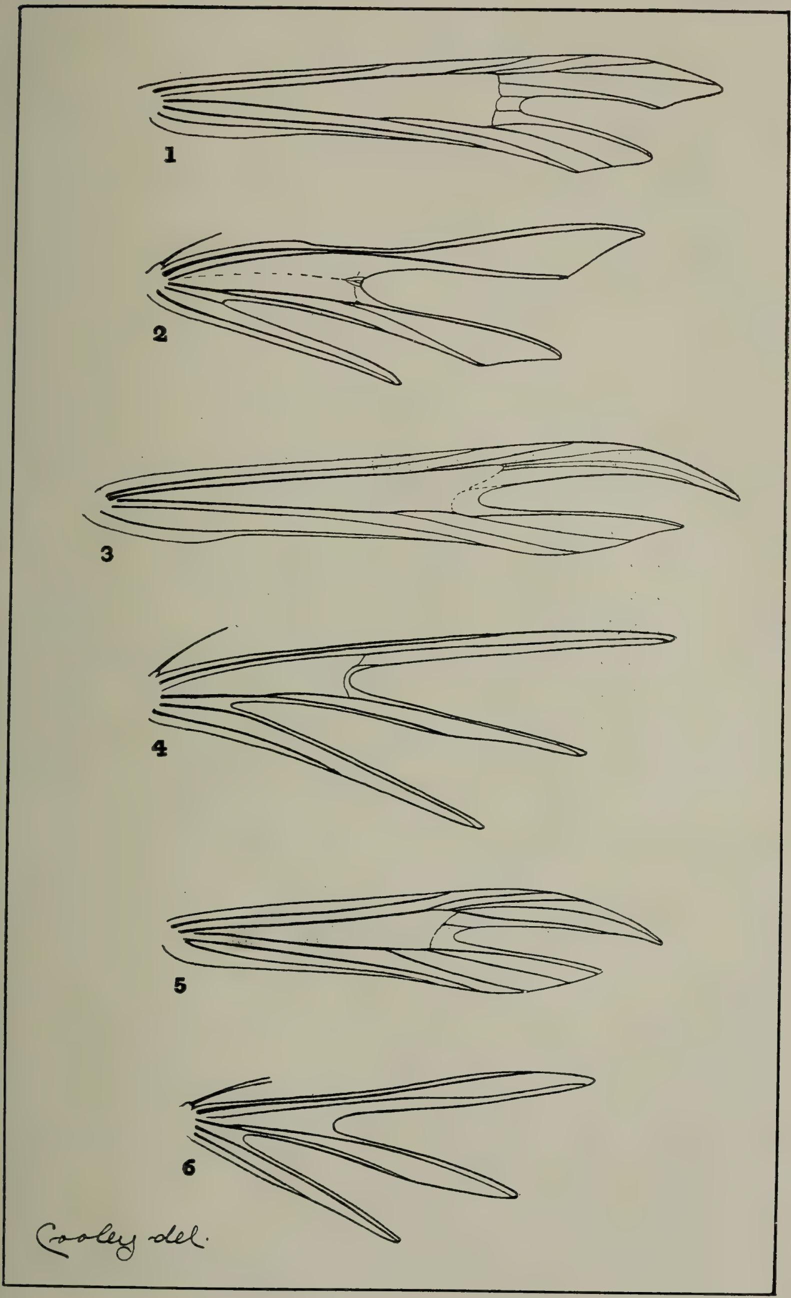
Fig. 3. Fore wing of Pterophorus monodactylus.

Fig. 4. Hind wing of Pterophorus monodactylus.

Fig. 5. Fore wing of Pterophorus inquinatus.

Fig. 6. Hind wing of Pterophorus inquinatus.

Plate III.



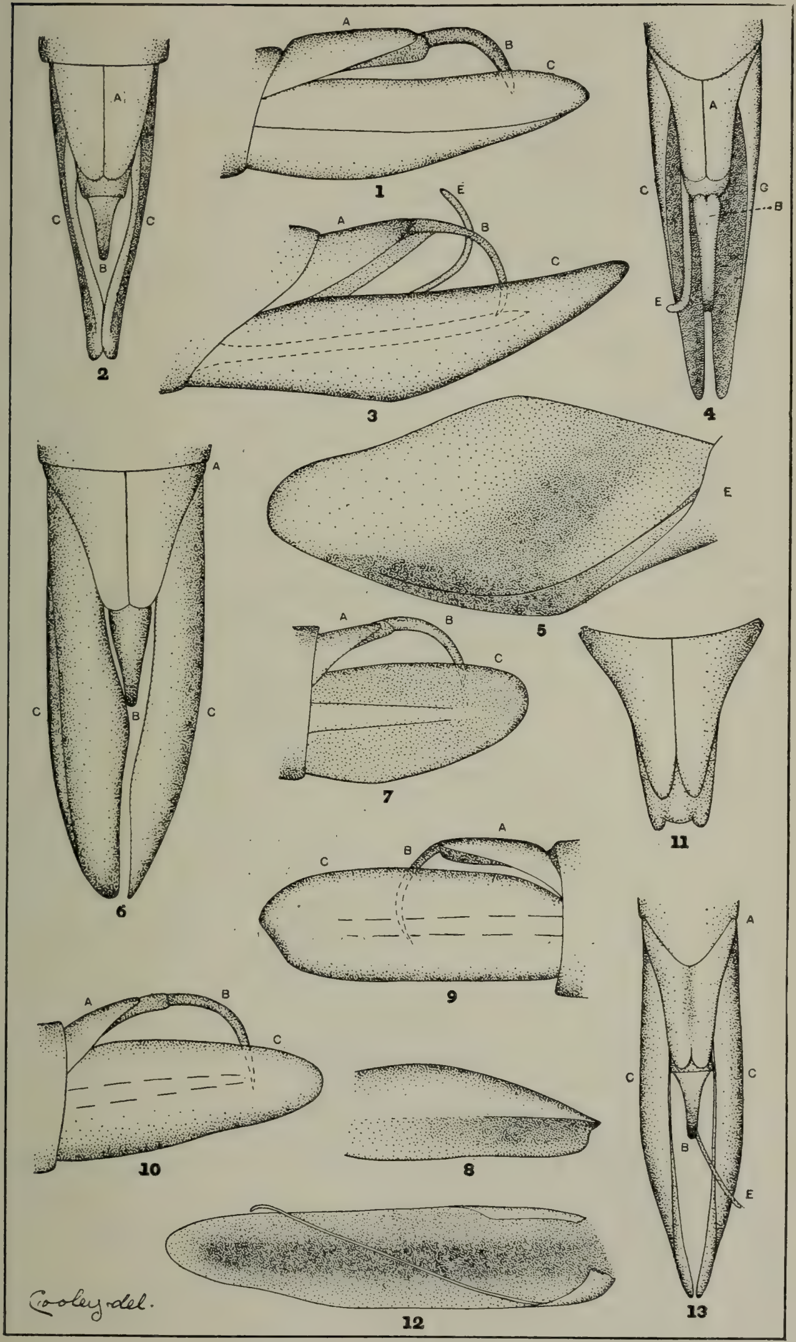
Explanation of Plate IV.

MALE GENITALIA OF PTEROPHORIDÆ.

[Parts of the genitalia: *A*, dorsal plate; *B*, uncus; *C*, clasp; *D*, ventral plate; *E*, elongated internal chitinous appendage.]

Fig. 1. **Pterophorus homodactylus**, side view.
Fig. 2. **Pterophorus homodactylus**, top view.
Fig. 3. **Pterophorus inquinatus**, side view.
Fig. 4. **Pterophorus inquinatus**, top view.
Fig. 5. **Pterophorus kellicottii**, view of inside of left clasper.
Fig. 6. **Pterophorus kellicottii**, top view.
Fig. 7. **Pterophorus stramineus**, side view.
Fig. 8. **Pterophorus stramineus**, outside of left clasper.
Fig. 9. **Pterophorus subochraceus**, side view.
Fig. 10. **Pterophorus sulphureodactylus**, side view.
Fig. 11. **Pterophorus sulphureodactylus**, dorsal plate.
Fig. 12. **Pterophorus lugubris**, view of inside of left clasper.
Fig. 13. **Pterophorus lugubris**, top view.

Plate IV.



Explanation of Plate V.

Male Genitalia of Pterophoridæ

Fig. 1. **Oxyptilus periscelidactylus**, side view.

Fig. 2. **Oxyptilus periscelidactylus**, view from beneath.

Fig. 3. **Pterophorus sulphureodactylus**, side view.

Fig. 4. **Pterophorus sulphureodactylus**, top view of dorsal plate.

Fig. 5. **Pterophorus cineraceus**, side view.

Fig. 6. **Pterophorus cineraceus**, top view of dorsal plate.

Fig. 7. **Platyptilia adusta**, side view.

Fig. 8. **Platyptilia adusta**, top view.

Fig. 9. **Pterophorus grandis**, side view.

Fig. 10. **Pterophorus grandis**, top view.

Fig. 11. **Alucita montana**, side view.

Fig. 12. **Alucita montana**, top view.

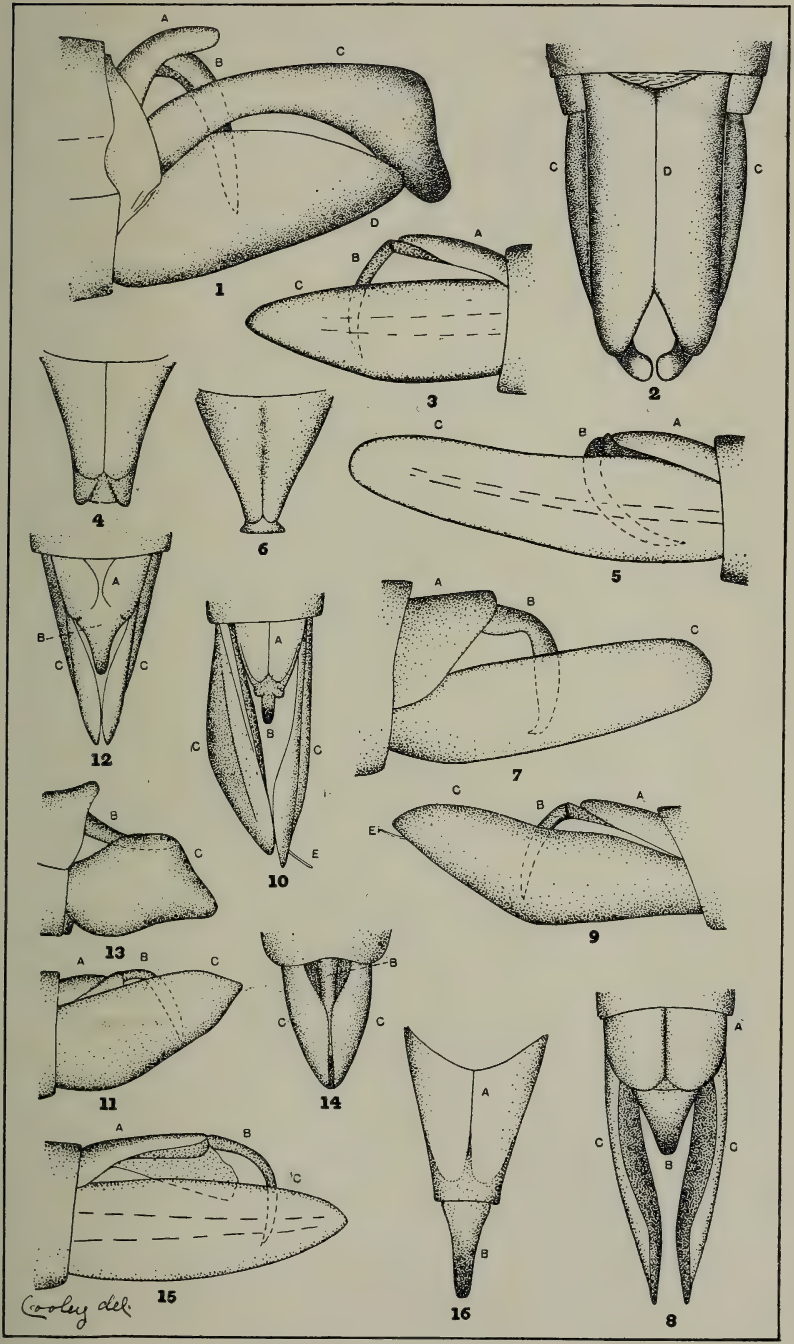
Fig. 13. **Trichoptilus ochrodactylus**, side view.

Fig. 14. **Trichoptilus ochrodactylus**, top view.

Fig. 15. **Pterophorus eupatorii**, side view.

Fig. 16. **Pterophorus eupatorii**, top view of dorsal plate and uncus.

Plate V.



Explanation of Plate VI.

MALE GENITALIA OF PTEROPHORIDÆ.

Fig. 1. **Oxyptilus ningoris,** side view.

Fig. 2. **Oxyptilus ningoris,** top view.

Fig. 3. **Oxyptilus ningoris,** view from beneath.

Fig. 4. **Oxyptilus tenuidactylus,** side view.

Fig. 5. **Oxyptilus tenuidactylus,** top view.

Fig. 6. **Oxyptilus tenuidactylus,** view from beneath.

Fig. 7. **Oxyptilus delawaricus,** side view.

Fig. 8. **Oxyptilus delawaricus,** top view.

Fig. 9. **Pterophorus cretidactylus,** side view.

Fig. 10. **Pterophorus cretidactylus,** top view of dorsal plate and uncus.

Fig. 11. **Orneodes hexadactyla,** side view.

Fig. 12. **Orneodes hexadactyla,** top view.

Fig. 13. **Orneodes hexadactyla,** view from beneath.

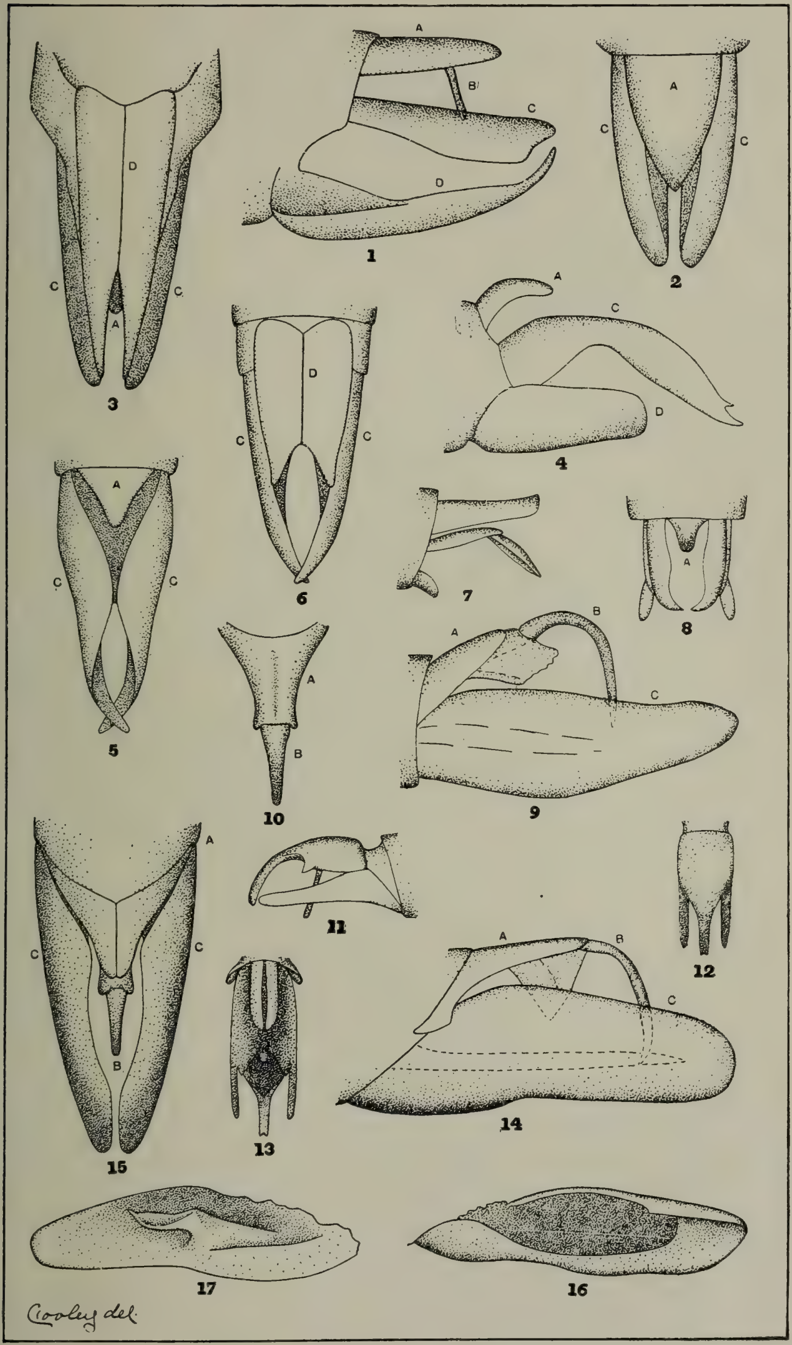
Fig. 14. **Pterophorus ambrosiæ,** side view.

Fig. 15. **Pterophorus ambrosiæ,** top view.

Fig. 16. **Pterophorus ambrosiæ,** view of inside of right clasper.

Fig. 17. **Pterophorus ambrosiæ,** view of inside of left clasper.

Plate VI.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Explanation of Plate VII.

GENITALIA OF PTEROPHORIDÆ.

Fig. 1. **Pterophorus monodactylus**, side view.

Fig. 2. **Pterophorus monodactylus**, top view.

Fig. 3. **Pterophorus monodactylus**, inside view of right clasper.

Fig. 4. **Pterophorus monodactylus**, inside view of left clasper.

Fig. 5. **Pterophorus monodactylus**, female.

Fig. 6. **Platyptilia edwardsii**, side view.

Fig. 7. **Platyptilia edwardsii**, top view.

Fig. 8. **Platyptilia carduidactyla**, side view.

Fig. 9. **Platyptilia carduidactyla**, top view.

Fig. 10. **Platyptilia carduidactyla**, view of inside of left clasper.

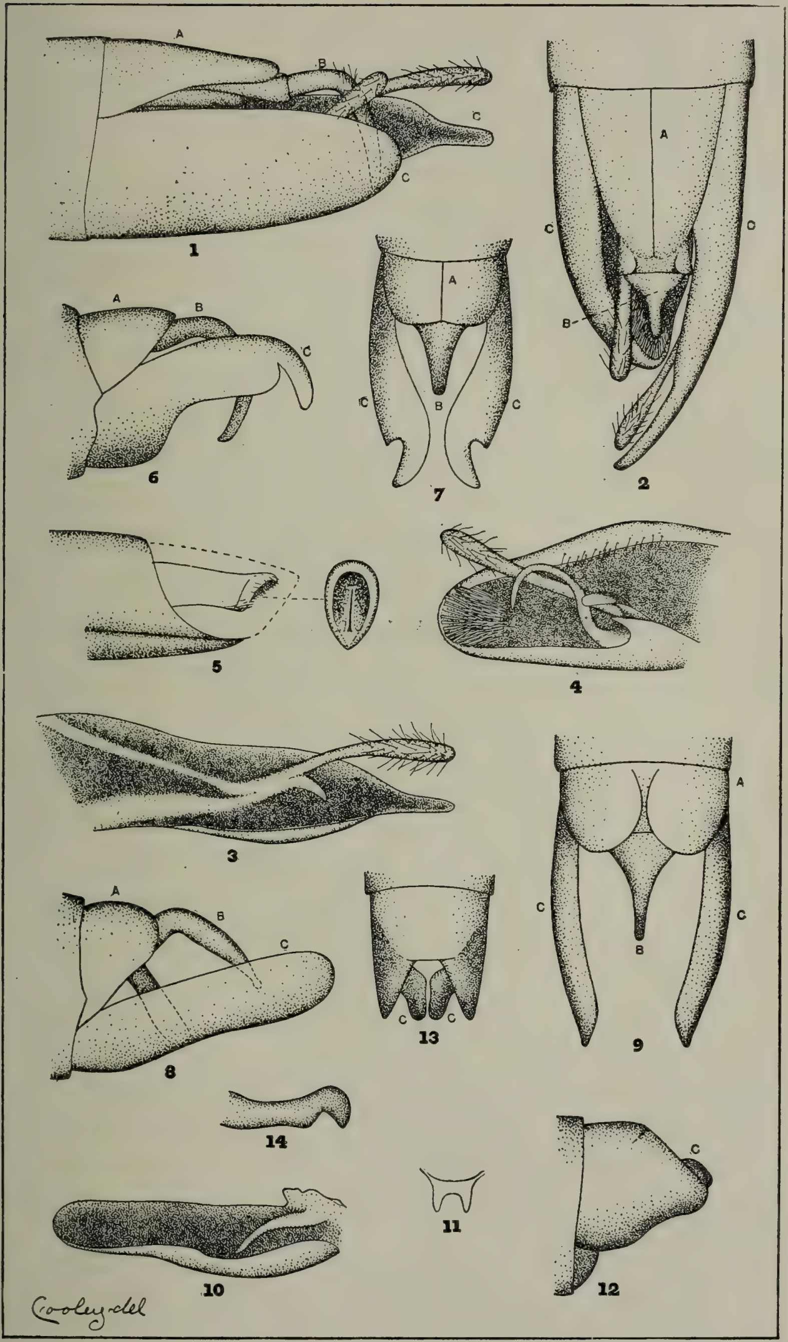
Fig. 11. **Platyptilia carduidactyla**, ventral plate.

Fig. 12. **Trichoptilus lobidactylus**, side view.

Fig. 13. **Trichoptilus lobidactylus**, top view.

Fig. 14. **Trichoptilus lobidactylus**, outside view of left clasper.

Plate VII.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Explanation of Plate VIII.

MALE GENITALIA OF PTEROPHORIDÆ.

Fig. 1. Pterophorus elliottii, side view.
Fig. 2. Pterophorus elliottii, top view.
Fig. 3. Stenoptilia exclamationis, side view.*
Fig. 4. Stenoptilia exclamationis, top view.*
Fig. 5. Platyptilia albidorsella, side view.
Fig. 6. Platyptilia albidorsella, top view.
Fig. 7. Platyptilia albidorsella, end view of uncus.
Fig. 8. Platyptilia tesseradactyla, side view.
Fig. 9. Platyptilia tesseradactyla, top view.
Fig. 10. Platyptilia albida, side view.
Fig. 11. Platyptilia albida, top view.
Fig. 12. Platyptilia albicans, side view.
Fig. 13. Platyptilia albicans, top view.
Fig. 14. Platyptilia percnodactyla, side view.
Fig. 15. Platyptilia percnodactyla, top view.

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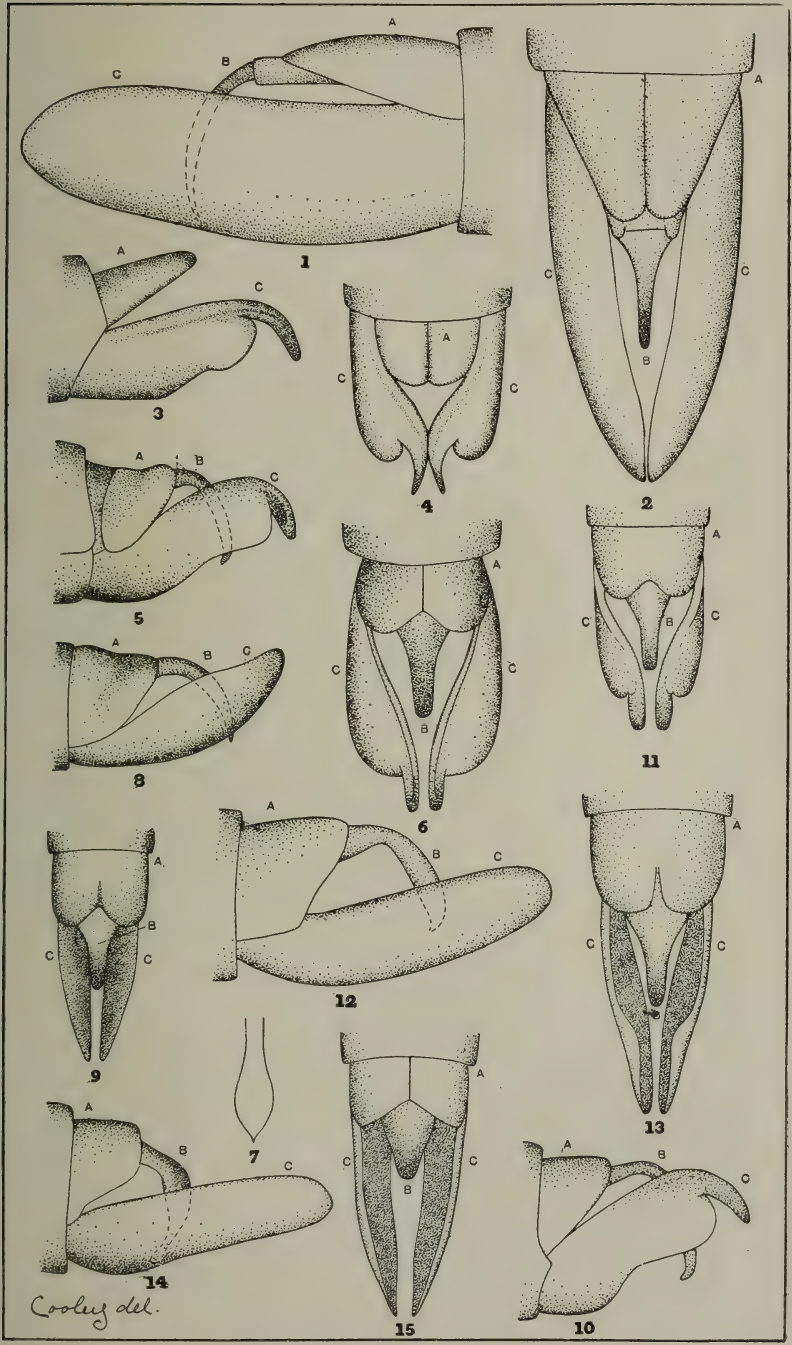
* The uncus is wanting in the specimens from which these drawings were made.

Plate VIII.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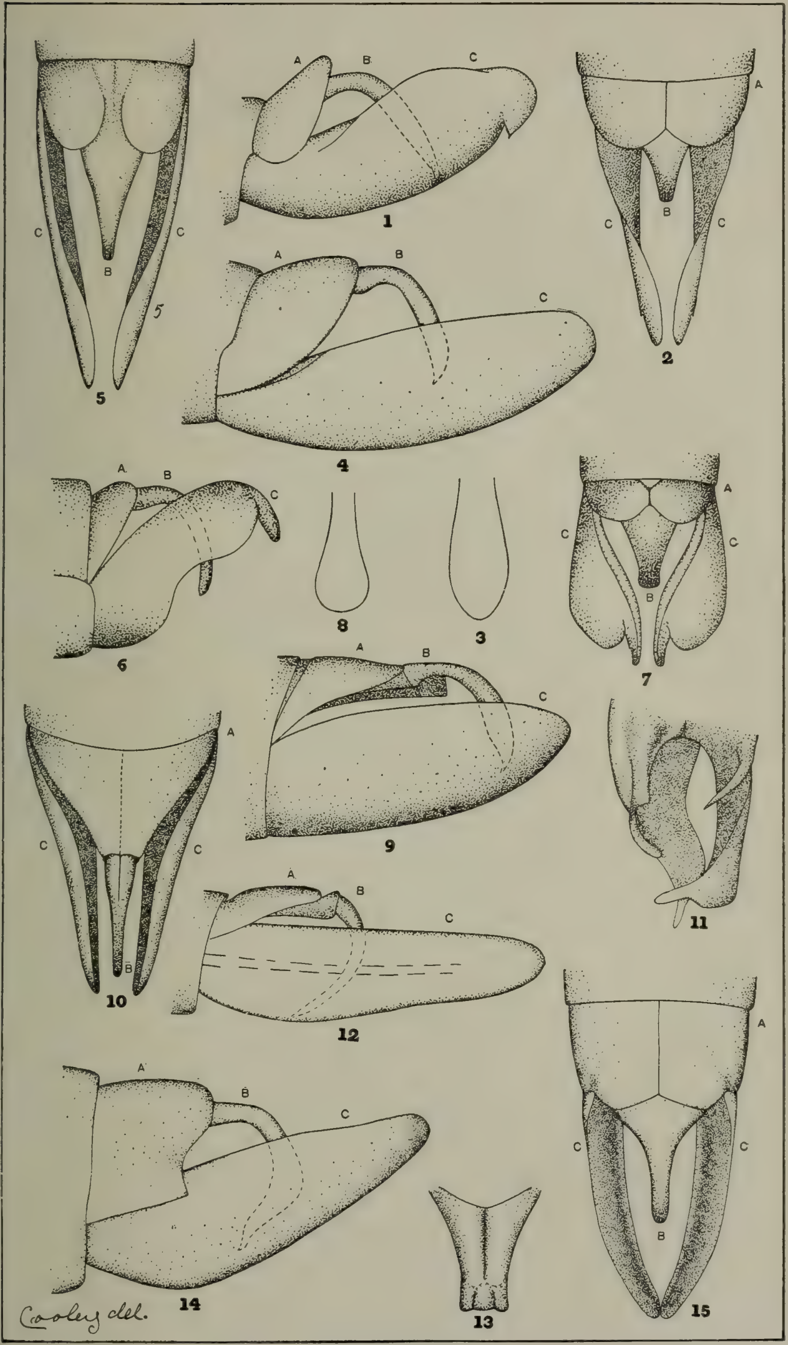
Explanation of Plate IX.

Male Genitalia of Pterophoridæ.

Fig. 1. **Platyptilia cosmodactyla**, side view.
Fig. 2. **Platyptilia cosmodactyla**, top view.
Fig. 3. **Platyptilia cosmodactyla**, end of uncus.
Fig. 4. **Platyptilia marginidactyla**, side view.
Fig. 5. **Platyptilia marginidactyla**, top view.
Fig. 6. **Platyptilia albiciliata**, side view.
Fig. 7. **Platyptilia albiciliata**, top view.
Fig. 8. **Platyptilia albiciliata**, end of uncus.
Fig. 9. **Alucita cinerascens**, side view.
Fig 10. **Alucita cinerascens**, top view.
Fig. 11. **Alucita cinerascens**, view of an internal chitinous piece.
Fig. 12. **Pterophorus guttatus**, side view.
Fig. 13. **Pterophorus guttatus**, top view of dorsal plate.
Fig. 14. **Platyptilia ochrodactyla**, side view.
Fig. 15. **Platyptilia ochrodactyla**, top view.

Plate IX.



INDEX OF GENERA.

INDEX OF SPECIES.

TENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1898.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are : —

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, Ph.D.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LL.D.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Samuel T. Maynard, B.Sc.,	*Horticulturist.*
J. E. Ostrander, C.E.,	*Meteorologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Charles I. Goessmann, B.Sc.,	*Assistant Chemist* (fertilizers).
George D. Leavens, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, B.Sc.,	*Assistant Chemist* (foods and feeding).
Fred W. Mossman, B.Sc.,	*Assistant Chemist* (foods and feeding).
Benjamin K. Jones, B.Sc.,	*Assistant in Foods and Feeding.*
Robert A. Cooley, B. Sc.,	*Assistant Entomologist.*
G. A. Drew, B. Sc.,	*Assistant Horticulturist.*
H. D. Hemenway, B.Sc.,	*Assistant Horticulturist.*
H. H. Roper, B.Sc.,	*Assistant in Foods and Feeding.*
A. C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins are still in stock and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 28. Canker, army and corn worms; red-humped apple-tree caterpillar; antiopa butterfly; currant stem girdler; imported elm-bark louse; greenhouse orthezia.
No. 29. Fungicides and insecticides; new spraying pump; spraying calendar.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 36. Imported elm-leaf beetle; maple pseudococcus; abbot sphinx; San José scale.
No. 37. Report on fruits, insecticides and fungicides.
No. 38. Fertilizer analyses; composition of Paris green; action of muriate of potash on the lime resources of the soil.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 42. Fertilizer analyses; fertilizer laws.
No. 43. Effects of electricity on germination of seeds.
No. 44. Variety tests of fruits; tests of vegetable seeds.
No. 45. Commercial fertilizers; fertilizer analyses; fertilizer laws.
No. 46. Habits, food and economic value of the American toad.
No. 47. Field experiments with tobacco.
No. 48. Fertilizer analyses.
No. 49. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Index, 1888–95.

Of the other bulletins, a few copies remain, which can only be supplied to complete sets for libraries.

The work during the year has been unusually diversified in its character and importance, a result of the numerous problems sent in for solution. In the agricultural division, soil tests with corn and potatoes grown in several localities have been continued; a comparison of different fertilizers has been made; "Nitragin" has again been tried, with negative results; and an interesting test has been carried on of twenty varieties of corn, eighty-one of potatoes, sixty of grasses, twenty-one of millets and four of clover.

In the division of chemistry (fertilizers), aside from the six hundred analyses of licensed fertilizers and manurial substances, valuable work has been done for the tobacco-growers of the Connecticut valley in the analyses of tobacco leaves grown with different fertilizers, testing of the quality of ash and burning quality, and suggestions as to methods of planting, fertilizers to be employed and mechanical preparation of the soil.

In the botanical division, investigations have been carried on of the brown rot of stone fruit, the chrysanthemum rust, the leaf blights of certain native trees, as the sycamore, butternut, chestnut and black cherry, with recommendations of treatment for the brown rot and chrysanthemum rust.

The horticultural division has continued its work of testing varieties of fruit and seeds of vegetables, and has entered upon an investigation of the use of hydrocyanic acid as an insecticide.

From the entomological division have issued two important bulletins on the habits, food and economic value of the American toad and the brown-tail moth. A monograph on the plume-moths (some varieties of which attack plants of economic value and those raised for ornamental purposes) has been completed. The superiority of spraying for the canker worm over ink bands and oil troughs has been demonstrated, and investigations carried on of new insecticides with which to assail the gypsy moth.

A series of observations for the electrical determination of moisture in the soil, in connection with the growth of corn, were undertaken by the meteorological division. Owing to breaks in the circuit and other causes that made the instrument fail to work, and the abnormally wet weather of the summer, the results were not entirely satisfactory, and the observations will be repeated the coming season.

Three investigations in the division of foods and feeding are worthy of special note: (*a*) On the comparative values of corn meal and hominy and cerealine feeds for pork production, when fed in combination with skim-milk. It was found that the pigs did quite as well on these feeds as on an equal amount of corn meal. (*b*) On salt-marsh hay. It was found to possess less feeding value than English hay, but, combined with grain and ensilage, produced nearly as much milk and butter as an equal amount of English hay thus combined. (*c*) On cotton-seed feed as a hay substitute for milch cows. More energy was used up in its digestion than in hay, and it was concluded that Massachusetts farmers would derive no benefit from feeding this material in place of hay.

Reports of the different divisions, giving in detail the work of the year, accompany this brief summary.

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Hatch Experiment Station of Massachusetts Agricultural College,

For the Year ending June 30, 1897.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$5,087 75	
for labor,	3,312 26	
for publications,	2,354 06	
for postage and stationery,	264 11	
for freight and express,	245 78	
for heat, light and water,	193 31	
for seeds, plants and sundry supplies,	600 55	
for feeding stuffs,	185 11	
for library,	1,139 85	
for tools, implements and machinery,	272 21	
for furniture and fixtures,	33 43	
for scientific apparatus,	226 83	
for live stock,	125 45	
for travelling expenses,	352 32	
for contingent expenses,	42 73	
for building and repairs,	564 25	
		$15,000 00

Cash on hand July 1, 1896,	$1,042 92	
Received from State treasurer,	10,000 00	
from fertilizer fees,	4,087 75	
from farm products,	1,934 15	
from miscellaneous sources,	1,022 19	
		$18,087 01
Cash paid for salaries,	$10,784 83	
for labor,	1,075 81	
for publications,	175 03	
for postage and stationery,	156 18	
for freight and express,	187 48	
for heat, light and water,	361 64	
Amount carried forward,	$12,740 97	

Amount brought forward,	$12,740 97	
Cash paid for chemical supplies,	592 48	
for seeds, plants and sundry supplies,	515 54	
for fertilizers,	1,074 41	
for feeding stuffs,	559 24	
for library,	61 82	
for tools, implements and machinery,	28 62	
for furniture and fixtures,	176 12	
for scientific apparatus,	357 48	
for live stock,	359 45	
for travelling expenses,	72 72	
for contingent expenses,	273 03	
for building and repairs,	1,255 40	
Cash on hand June 30, 1897,	19 73	
		$18,087 01

AMHERST, MASS., Aug. 30, 1897.

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1897; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $33,087.01, and the corresponding disbursements $33,067.28. All the proper vouchers are on file and have been by me examined and found to be correct, there being a balance of $19.73 on accounts of the fiscal year ending June 30, 1897.

CHARLES A. GLEASON,
Auditor.

REPORT OF THE AGRICULTURIST.

WILLIAM P. BROOKS.

Soil Tests.

Four soil tests upon the plan heretofore followed were attempted during the past year; viz., with corn in Norwell and Montague, with potatoes and with onions (and later cabbages) upon our home grounds. Only the tests in Norwell and with potatoes upon our home grounds were successfully carried through.

Unfavorable weather conditions destroyed the onions and cabbages upon our south soil-test acre. The field was sown to white mustard late in July. But four plots furnished sufficient growth to cut and weigh; viz., lime plot, 1 pound; manure plot, 425 pounds; nitrate and dissolved bone-black, 45 pounds; potash and dissolved bone-black, 25 pounds; nitrate, dissolved bone-black and potash plot, 255 pounds,—all green weights.

The field has now been used nine years in soil-test work, and we have a high degree of one-sided exhaustion on most of the plots. The close dependence of the mustard upon a supply of phosphoric acid (furnished by the bone-black) is brought out, as was the case in 1895; but phosphoric acid alone can no longer produce any growth of mustard upon this soil. The addition of either nitrogen or potash helps it, the former most; but not much growth is produced unless all three are supplied.

The soil test with corn in Montague was ruined by wire and cut worms. As nearly as could be determined from the portion of the crop left, nitrogen seemed the most necessary element upon this soil.

1. *Soil Test with Corn. Norwell.*

This is the second year of soil-test work in this field, the crop last year also being corn. Last year potash was the controlling element; the result this year is the same. Muriate of potash, at the rate of 160 pounds per acre, gives an average increase at the rate of 36.3 bushels of grain and 2,203 pounds of stover; nitrate of soda, at the same rate per acre, gives an average increase of 8.3 bushels of grain and 325 pounds of stover; dissolved bone-black, at the rate of 320 pounds per acre, gives an average increase of 15.3 bushels of grain and 455 pounds of stover. Five cords of manure increase the crop by 26.4 bushels of grain and 3,450 pounds of stover per acre; complete fertilizer (nitrate, dissolved bone-black and potash at above rates) gives an increase of grain 52.5 bushels and stover 2,455 pounds; lime and plaster both produce apparent small increases.

2. *Soil Test with Potatoes. Amherst.*

The field upon which this test was carried out lies upon our own grounds. It has a medium, well-drained loam, and has been seven years in soil-test experiments. The crops in order of succession have been potatoes, corn, soya beans, oats, grass and clover (two years), and cabbages and Swedish turnips. This year the phosphoric acid gives the largest average increase in crop, viz., at the rate of 26.6 bushels of merchantable tubers per acre; nitrogen gives an increase of 11.3 bushels merchantable tubers and potash an increase of 7.2 bushels. The soil, however, is very generally exhausted, and no single fertilizer or combination of either two or all three gave a good crop. The apparent superiority of the phosphoric acid and nitrogen is chiefly due to the fact that the plot to which those two elements alone were applied was for some reason (not believed to be the effect of the fertilizer alone) nearly twice as great as that upon any other plot. Had the crop where the potash was added to the nitrogen and phosphoric acid been better or even as good as that where the phosphoric acid and nitrogen alone were used, we should be justified in the conclusion that the nitrogen and phosphoric acid are the elements chiefly required. The crop where all three elements were combined was, however, much inferior to that where the nitrogen and phosphoric acid were used without potash. We must therefore conclude that some disturbing factor, at present unknown, influenced the results; and we are, therefore, unable to draw practical conclusions which throw light upon the proper practice to be followed in manuring the potato crop.

Manure Alone v. Manure and Potash.

An experiment in continued corn culture for the comparison of an average application of manure with a small application of manure used in connection with muriate of potash was begun in 1890. A full account of the results will be found in the annual reports of 1890–95, and in the latter year a general summary of the results is given.

The land used in this experiment was seeded with a mixture of timothy, red-top and clover in the standing corn in July of last year. A good stand of grass and clover was secured, although the latter was rather unevenly developed in different parts of the field, suggesting a possible lack of thoroughness in mixing the seeds.

No manure or potash has been used this year. The field includes four plots of one-fourth of an acre each. The results for 1897 are shown below: —

Plot 1 (1½ cords of manure alone, 1890–96): hay, 1,420 pounds; rowen, 783 pounds.

Plot 2 (1 cord manure and 40 pounds of muriate of potash, 1890–96): hay, 885 pounds; rowen, 483 pounds.

Plot 3 (manure alone, as for Plot 1): hay, 1,380 pounds; rowen, 785 pounds.

Plot 4 (manure and potash, as for Plot 2): hay, 1,037½ pounds; rowen, 590 pounds.

The averages are as follows: —

Plots 1 and 3 (manure alone, 1890–96): hay, 1,403½ pounds; rowen, 784 pounds.

Plots 2 and 4 (manure and potash, 1890–96): hay, 961¼ pounds; rowen, 536½ pounds.

Combining the figures showing the averages of hay and rowen, we find that plots 1 and 3 have produced an average of 2,187 pounds per plot, which is at the rate of 4 tons, 748 pounds, per acre. Plots 2 and 4 have produced an average of 1,497¼ pounds per plot, which is at the rate of 9 pounds less than 3 tons per acre. The larger quantity of manure, then, produced this year about 1⅓ tons more per acre than the manure and potash. This is a large difference, but a difference which was to be anticipated, in view of the much larger quantity of plant food which has been applied to these plots. It remains to be seen whether the clover on plots 2 and 4 will be capable of so enriching the soil in nitrogen as to remove or lessen this difference in succeeding years.

"Special" Corn Fertilizer v. Fertilizer richer in Potash.

This experiment was begun with a view of comparing the results obtained with a fertilizer proportioned like the average of the "*special*" *corn fertilizers* found upon our markets in 1891 with those obtained with a fertilizer richer in potash but furnishing less nitrogen and phosphoric acid.

Corn was grown during each of the years from 1891 to 1896 inclusive. From 1891 to 1895 it was found that the fertilizer richer in potash gave the more profitable results. In 1896 there was no practical difference. It was decided during the season of 1896 that it might be possible to derive a greater benefit from the larger quantity of potash applied to two of the four plots if grass and clover should be grown in rotation with the corn. Accordingly the land was seeded with a mixture of timothy, red-top and clover in the standing corn in July, 1896. The field is divided into four plots, of one-fourth of an acre each. The materials applied to the several plots are shown in the following table : —

FERTILIZERS.	Plots 1 and 3 (Pounds each).	Plots 2 and 4 (Pounds each).
Nitrate of soda,	20	18
Dried blood,	30	30
Dry ground fish,	30	20
Plain superphosphate,	226	120
Muriate of potash,	22.5	60
Cost of materials per plot,	$3 23	$3 10

Fertilizers were applied evenly broadcast on April 11.

The yields the past year are shown below: —

Plot 1, "special" fertilizer: hay, 795 pounds; rowen, 130 pounds.

Plot 2, fertilizer richer in potash: hay, 810 pounds; rowen, 129 pounds.

Plot 3, "special" fertilizer: hay, 725 pounds; rowen, 97 pounds.

Plot 4, fertilizer richer in potash: hay, 617 pounds; rowen, 165 pounds.

The average yield on plots 1 and 3 is: hay, 760 pounds; rowen, 113½ pounds. On plots 2 and 4: hay, 713½; rowen, 147 pounds. Putting the crops of hay and rowen together, we have an average from 1 and 3 of 873½ pounds, and from 2 and 4 of 860½ pounds. The difference, 13 pounds, is too small to be regarded as of much significance. The greater rowen crop produced by plots 2 and 4 is perhaps to be attributed to the larger amount of potash which has been applied to these plots, which favors especially the growth of the clovers. Inequality of moisture conditions, however, has been the apparent cause of a very uneven development of clover on different parts of the field, and the influence of the potash does not show as clearly as was anticipated.

Natural Phosphates compared with Each Other and with Acid Phosphate. (Field F.)

This series of experiments was begun by Dr. Goessmann in 1890, with a view of determining whether it is not more profitable to employ one of the cheaper natural phosphates than to use the more costly acid phosphate. A full account of the experiment and the results obtained up to the end of 1896 is given by Dr. Goessmann in our ninth annual report. It is only necessary to restate the following points: —

The field was at first divided into five plots, containing about 6,600 square feet each. These plots received equal money's worth (on the basis of prices in 1890) of the phosphates used, as follows: Plot 1, phosphatic slag; Plot 2, Mona guano; Plot 3, at first, apatite; later, Florida phosphate; Plot 4, South Carolina phosphate; Plot 5, dissolved bone-black. Plot 3, as above stated, received an application of ground apatite in 1890. In 1891 it was found impossible to obtain this material, and no phosphate of any kind was applied to this plot. In 1892 and 1893 ground hard Florida phosphate was applied to this plot. It is not believed, however, that it is fair to this phosphate to compare it with the others, since it has been used only two years, while the others have been applied for four years.

From the beginning, each of these five plots has received the same application of nitrate of soda and potash-magnesia sulphate. The quantities of these applied per plot during the first four years were about 44 pounds of the former and 66 pounds of the latter.*

Since 1894 no phosphate of any kind has been applied to these plots, but the quantity of nitrate of soda and of potash-magnesia sulphate has been used in one-half greater quantities.

At first Dr. Goessmann included no plot on which phosphate was not used for comparison with others. Later such a plot was added, but it was left entirely unmanured until 1896. During 1896 and 1897 it has received the nitrate of

* The plots in this experiment differ from each other by a few square feet in size, and the fertilizers have from the beginning varied in proportion as the size varied.

soda and potash-magnesia sulphate at the same rate as the other plots.

The yield of the plots receiving phosphate for each of the years 1890–96 inclusive will be found in our ninth annual report. This report also contains a statement showing the amounts of phosphoric acid applied and removed from each plot during each of these years. This statement shows an excess added over and above that removed from each of the plots at the end of the season of 1896 as follows: where phosphatic slag had been used, the amount of phosphoric acid remaining was 65.6 pounds; where Mona guano had been used, 44.2 pounds; where apatite and Florida phosphate had been used, 141.7 pounds; where South Carolina rock phosphate had been used, 115.0 pounds; and where acid phosphate had been used, 21.8 pounds.

The crop during the past year was Swedish turnips. The field had been sown with rye for winter protection in the fall of 1896. The growth of the rye was characterized as poor. It was ploughed on June 1, the land was harrowed on the 2d, and on the 3d of June, Laing's Swedes were sown in drills two feet apart. The seed germinated promptly and evenly, but the season was much too wet for the best growth of the crop. It was, however, kept free from weeds by frequent cultivation. The crop was thinned on June 20 to eight inches. It was harvested November 2–4. The turnips were poor in quality, small, and a few of them decayed.

The yields of the several plots were as follows: —

	Roots (Pounds).	Tops (Pounds).
Plot 0, no phosphate,	830	185
Plot 1, phosphatic slag,	1,870	480
Plot 2, Mona guano,	3,655	800
Plot 3, Florida hard phosphate,	820	400
Plot 4, South Carolina rock phosphate,	1,965	560
Plot 5, dissolved bone-black,	1,619	370

It will be noticed that the crop on the phosphatic slag, Mona guano and South Carolina rock surpasses that where dissolved bone-black was used, and that the Mona guano gives nearly twice the product obtained by either the slag or the South Carolina rock. It will be further noticed that the Florida phosphate yields practically the same amount of roots as the plot receiving no phosphate. None of the crops secured this year can be regarded as good. The largest yield, that on the Mona guano plot, is at the rate of rather less than 12 tons per acre. A good crop should be about 20 tons per acre. The results of this year, therefore, although showing marked differences, are not regarded as decisive. The peculiarities of the season produced an unhealthy condition, which interfered with the full action of the fertilizers employed.

Comparison of Different Phosphates.

The results of the experiments inaugurated by Dr. Goessmann for the comparison of different phosphates with acid phosphate having proved so interesting and valuable, it was decided to inaugurate another series of experiments, including a greater number of materials supplying phosphoric acid. It was further thought best to apply these materials upon the basis of equal quantities of phosphoric acid to each plot, rather than on the basis of equal money's worth, as in the experiments planned by Dr. Goessmann.

The land selected for the experiment was fairly level, with a medium heavy loam. It had been in grass for many years. In April, 1896, it received an application of 600 pounds of ground bone and 200 pounds of muriate of potash per acre. The season was very dry, and the grass derived little benefit from the fertilizers. The grass was cut about the middle of June, and the field was ploughed on June 24 and 25, 1896, and planted to Longfellow corn. The corn was cut when in the milk, September 26, and weighed as put into the silo. The field had been divided into 13 plots, of one-eighth of an acre each, separated by suitable unmanured strips. The yields of corn in 1896 were as follows: —

Plot 1, 2,640 pounds; Plot 2, 2,990 pounds; Plot 3, 2,915 pounds; Plot 4, 3,555 pounds; Plot 5, 2,885 pounds; Plot 6, 2,905 pounds; Plot 7, 2,850 pounds; Plot 8, 3,020 pounds; Plot 9, 3,160 pounds; Plot 10, 3,095 pounds; Plot 11, 3,000 pounds; Plot 12, 3,090 pounds; Plot 13, 3,440 pounds.

These weights were taken with a view to determining whether these plots were fairly even in fertility. It will be noticed that with three exceptions, plots 1, 4 and 13, this appears to be the case. Plot 1 is apparently poorer than the average, while plots 4 and 13 are better.

In 1897 the soil was thoroughly prepared by the use of the wheel harrow. Fertilizers were applied May 11. Each plot in the field received the following materials: potash-magnesia sulphate, 50 pounds; nitrate of soda, 30¼ pounds; sulphate of potash, high grade, 12½ pounds. These materials supplied the potash and nearly all the nitrogen estimated to be required. Some of the phosphates to be employed (the bone meals), however, contained nitrogen as well as phosphoric acid, and, to equalize conditions on all the plots, sufficient hoof meal was applied to those not receiving bone to make the quantity of nitrogen applied to each plot throughout the field the same.

The plots contained, as stated, one-eighth of an acre each, and the materials used furnished to each plot phosphoric acid, 12 pounds; nitrogen, 6½ pounds; potash, 19 pounds.

The fertilizers used per plot (in addition to nitrate of soda and sulphate of potash which were used alike on each as stated above) are shown below: —

Plot 1: hoof meal, 11¾ pounds. Plot 2: hoof meal, 11¾ pounds; apatite, 32 pounds. Plot 3: hoof meal, 11¾ pounds; South Carolina rock phosphate, 47 pounds. Plot 4: hoof meal, 11¾ pounds; Florida soft phosphate, 45½ pounds. Plot 5: hoof meal, 11¾ pounds; slag, 67¼ pounds. Plot 6: hoof meal, 11¾ pounds; Navassa phosphate, 49 pounds. Plot 7: hoof meal, 11¾ pounds. Plot 8: hoof meal, 11¾ pounds; dissolved bone-black, 70 pounds. Plot 9: hoof meal, $\frac{6}{16}$ pound; raw bone meal, 45 pounds. Plot 10: hoof meal, 1$\frac{3}{16}$ pounds; dissolved bone meal, 73¼ pounds. Plot 11: steamed bone meal, 48¼ pounds. Plot 12: hoof meal, 11¾ pounds; acid phosphate, 90½ pounds. Plot 13: hoof meal, 11¾ pounds.

The variety of corn raised was Sibley's Pride of the North, which was planted on May 17, replanted as far as necessary on June 1, and thinned to one plant per foot in the drill early in June. The extraordinary precipitation of the season kept the soil too wet the greater part of the time during the month of July, and the crop was prevented from doing its best. It was cut and stooked September 21, and husked about the last of October.

The yield per plot and the calculated rates per acre are shown below: —

NAMES.	Corn (Pounds).	Stover (Pounds).	Corn per Acre (Bushels).	Stover per Acre (Pounds).
Plot 1, no phosphate, . . .	585	580	58.500	4,640
Plot 2, apatite, ...	565	475	56.500	3,800
Plot 3, South Carolina rock phosphate	645	535	64.500	4,280
Plot 4, Florida soft phosphate, .	725	620	72.500	4,960
Plot 5, phosphatic slag, . .	620	620	62.000	4,960
Plot 6, Navassa phosphate, . .	678¼	610	67.825	4,880
Plot 7, no phosphate, . . .	643¼	542	64.325	4,336
Plot 8, dissolved bone-black, .	618¼	548	61.825	4,384
Plot 9, raw bone meal, . . .	673¼	570	67.325	4,560
Plot 10, dissolved bone meal, .	633¼	550	63.325	4,400
Plot 11, steamed bone meal, . .	503¼	450	50.325	3,600
Plot 12, acid phosphate, . .	628¼	540	62.825	4,320
Plot 13, no phosphate, . . .	673¼	590	67.325	4,720

It will be noticed that one of the best crops in the field was produced where no phosphate was used, and that the yield on the plots to which phosphates were applied varies without apparent relation to the availability of the phosphoric acid in the materials used. Under these circumstances, extended discussion of the results is not called for.

The unfavorable influence of the season and possible differences in natural fertility of the soil serve to obscure the action of the phosphates employed.

Leguminous Crops (Clover, Pea and Bean, or "Pod" Family) as Nitrogen Gatherers. (Field A.)

A full history of the field since 1884 is given by Dr. Goessmann in our ninth annual report. The years 1884–88 were preparatory; the experiment proper began in 1889. The objects in view have been: —

1. To determine the extent to which plants of the clover family are capable of enriching the soil in nitrogen taken by them from the air through the agency of the nodular bacteria found upon their roots.

2. To compare nitrate of soda, sulphate of ammonia, dried blood and barn-yard manure as sources of nitrogen.*

The field is divided into eleven $\frac{1}{10}$ acre plots, numbered from 0 to 10. Three plots, 4, 7 and 9, have received no application of nitrogen-containing manure or fertilizer since 1884. One (0) has received barn-yard manure; two (1, 2), nitrate of soda; three (5, 6, 8), sulphate of ammonia; and two (3, 10), dried blood every year since 1889. These materials have been used in such amounts as to furnish nitrogen at the rate of 45 pounds per acre each year. All the plots have received, yearly, equal amounts of phosphoric acid and potash. The quantities applied have furnished, per acre, phosphoric acid 80 pounds, and potash 125 pounds, from 1889 to 1894 and the past season. In 1895 and 1896 double these quantities were used. Dr. Goessmann reports: † —

> The total yield of crops on the plots receiving no nitrogen, as compared with those receiving nitrogen, was in the several years as follows: —
>
> With corn in 1889, one-fifth less.
> With oats in 1890, one-fifth to one-sixth less.
> With rye in 1891, one-fifth to one-sixth less.
> With soya beans in 1892, one-third to one-fourth less.

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* Only such details are given here as are necessary to a general understanding of the subject; full information is found, as stated above, in our ninth annual report.

† Ninth annual report, Hatch Experiment Station, page 175.

In 1893 the crop was oats, and the yield of grain was from one-seventh to one-eighth less on the plots receiving no nitrogen than the average of those receiving nitrogen. Here the interposition of a leguminous crop (soya bean in 1892) appears to have lessened the proportional inferiority of the plots which received no nitrogen. In 1894 the crop was again the soya bean. The plots without nitrogen give a yield about one-third less than the average of the others. Thus far it will be seen that the soya bean has not shown that degree of independence of soil nitrogen of which it is supposed to be capable. To an even greater degree than the grain crops it is benefited by nitrogen manuring. This fact may perhaps be accounted for because of conditions unfavorable to bacterial life in this soil; but as to the nature of such unfavorable conditions we are at present ignorant.

In 1895 the crop was oats, and results showed no improvement in proportional yield on the plots receiving no nitrogen which could be attributed to the preceding bean crop. This may be in part due to the fact that the bean has a rather limited root system, and leaves behind but little stubble.

In 1896 the crop was again the soya bean, which once more showed marked inferiority on the no-nitrogen plots. An attempt to seed the land to clover in the standing beans proved a failure, on account of the dry season and the too dense shade made by the crop of beans.

The crop the past season has been oats. The yield per plot of straw and grain, the rate per acre and remarks upon the quality of the grain are given below. In this table the no-nitrogen plots are italicised.

Nitrogen Experiment.

PLOT.	Weight per Plot One-tenth Acre.		Yield per Acre.		Remarks on Grain.
	Straw (Pounds).	Oats (Pounds).	Straw (Pounds).	Oats (Bushels).	Kernels.
Nitrate of soda, . .	500	159	5,000	49.68	Light.
Nitrate of soda, . .	400	147	4,000	45.93	Light.
Dried blood, . .	215	122	2,150	38.12	Good.
No nitrogen, . .	*120*	*69*	*1,200*	*21.56*	Good.
Sulphate of ammonia, .	340	137	3,400	42.81	Poorer than No. 3.
Sulphate of ammonia, .	275	97	2,750	30.31	Good.
No nitrogen, . .	*120*	*77½*	*1,200*	*24.21*	Good.
Sulphate of ammonia, .	350	127	3,500	39.68	Good.
No nitrogen, . .	*130*	*75*	*1,300*	*23.43*	Good.
Dried blood, . .	220	126	2,200	39.37	Fair.
Barn-yard manure, .	220	125	2,200	39.06	Fair.

Calculation shows that the average total weight of crop is a little less than one-half as great on the plots not manured with nitrogen as the average of the other plots. The crop of grain is a little more than one-half as great. We find, then, not the least evidence of any ability on the part of the soya bean when grown before a grain crop (and harvested) to make nitrogen manuring of the grain crop unnecessary. On the contrary, the proportional yield of the no-nitrogen plots is this year the lowest it has ever been in these experiments.

The Relative Value of the Different Manures furnishing Nitrogen.

The nitrate of soda gives the largest crop. Next in order of yield come the barn-yard manure, dried blood and sulphate of ammonia; but between these there is not much difference. On plots 2, 3, 4, 6, 7, 8 and 9 the source of potash is the muriate; on all others it is double sulphate of potash-magnesia. The yield of oats is in every instance greater where the sulphate is used under otherwise similar manuring. The superiority is most marked when sulphate of ammonia is the source of nitrogen.

Muriate compared with Sulphate of Potash in connection with Sulphate of Ammonia for Corn.

Results obtained with different crops in the special nitrogen tests on Field A during previous years having indicated an injurious effect, due to the combination of muriate of potash and sulphate of ammonia,* it was decided to undertake experiments upon a larger scale, with the view of bringing out more clearly the significance or importance of this effect. Accordingly two plots of land of one-half acre each, lying on the east side of the highway, were set apart for this experiment. This land had previously been used in experiments to determine the relative value of phosphatic slag and ground bone as sources of phosphoric acid. These experiments were begun in 1894 and continued until 1896. The crops had been oats, corn and millet. An account of these experiments will be found in the annual reports covering the years named.

The following fertilizers were applied this year, broadcast, after ploughing, and harrowed in: —

North plot: sulphate of ammonia, 152 pounds; muriate of potash, 120 pounds; acid phosphate, 160 pounds.

South plot: sulphate of ammonia, 152 pounds; sulphate of potash, 120 pounds; acid phosphate, 160 pounds.

The fertilizers were applied May 11. The crop was planted in drills three and one-half feet apart, May 17. The variety was Sibley's Pride of the North.

The soil throughout the season was too wet for the best growth of the corn crop. The crop was harvested on September 6, and put into the silo. The yield was as follows:

* For a full discussion of this subject see Dr. Goessmann's paper in the annual report of the Hatch Experiment Station for 1897, pages 222 and 223.

north plot, 5,760 pounds; south plot, 5,255 pounds. The difference is too small to afford a basis for a positive judgment as to the merits of the two forms of potash applied.

Fertilizers for Garden Crops.

In 1891 Dr. Goessmann began a series of experiments for the comparison of sulphate of ammonia, nitrate of soda and dried blood as sources of nitrogen for various garden crops. Sulphate of potash was employed to furnish potash. In 1892 the scope of the experiment was enlarged by including three additional plots, comparing the same materials as sources of nitrogen with muriate of potash used as a source of potash. The results of these experiments are fully discussed in Dr. Goessmann's reports. The following table shows the different fertilizers applied to the several plots: —

PLOTS.	Annual Supply of Manurial Substances.	Pounds.
Plot 1,	Sulplate of ammonia,	38
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 2,	Nitrate of soda,	47
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 3,	Dried blood,	75
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 4,	Sulphate of ammonia,	38
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plot 5,	Nitrate of soda,	47
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plot 6,	Dried blood,	75
	Sulphate of potash,	30
	Dissolved bone-black,	40

The area of the plots is about one-eighth of an acre each. The fertilizers used supply at the rates per acre: phosphoric acid, 50.4 pounds; nitrogen, 60 pounds; potash, 120 pounds.

The crops raised during the past year were garden peas, beets, squashes and celery.

Garden Peas. — The land was ploughed April 19, fertilizers applied and harrowed in April 21, and the seed planted on April 22. On June 7 it was noticed that the growth of the vines on Plot 1 was distinctly inferior to that on the other plots, and it so continued throughout the season. The pods produced by the vines upon this plot were short, but well filled, as were they also upon Plot 4. The growth of vines upon plots 3 and 6 may be characterized as medium; upon plots 2 and 5 the growth was rank. The pods upon these two plots were large, but not well filled. Three pickings of peas were made. The yield of green peas, as well as of vines, is shown in the following table: —

Green Peas (Pounds).

DATE.	Muriate of Potash.			Sulphate of Potash.		
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
July 12, ...	100	93	99½	165	179	195
July 19, ...	66	150	132	143	134	91
July 23, ...	11	60	49	40	30	21
	177	203	280½	348	343	307

Green Vines (Pounds).

July 23, ...	102½	210	240	240	205	180

The average yield of green peas produced by the different fertilizers is shown in the following table: —

	Pounds.
Average of muriate plots, ...	220⅙
Average of sulphate plots, ...	332⅔
Average of sulphate of ammonia plots, . . .	262½
Average of nitrate of soda plots, ...	273
Average of dried blood plots, ...	293¾

It will be noticed that the sulphate of potash appeared to be distinctly superior to the muriate, that the dried blood gives a larger crop than either of the other sources of nitrogen, but that there is not a great difference between the three materials used to supply this element. The best crop is produced where sulphate of ammonia and sulphate of potash are used. The crop where nitrate of soda and sulphate of potash are used is not, however, materially inferior.

Beets. — The variety raised was the Eclipse. Fertilizers were applied as stated above, seed planted April 22, vacancies filled May 20. The growth of the beets upon Plot 1 was noticed early in the season to be distinctly inferior to that on the other plots, and before the close of the season most of the plants upon this plot were dead. On July 27 the crop was harvested. The yield of the several plots was as follows: Plot 1, 133 pounds; Plot 2, 711 pounds; Plot 3, 358 pounds; Plot 4, 448 pounds; Plot 5, 793½ pounds; Plot 6, 478 pounds.

The averages of the different fertilizers are shown below: —

	Pounds.
Average of muriate plots,	400⅔
Average of sulphate plots,	573⅙
Average of sulphate of ammonia plots,	290½
Average of nitrate of soda plots,	752¼
Average of dried blood plots,	418

It will be noticed that the sulphate of potash appears to be greatly superior to the muriate, and nitrate of soda is far ahead of sulphate of ammonia as a source of nitrogen for this crop. The best yield is produced where nitrate of soda and sulphate of potash are used together.

Squashes and Celery. — Both of these crops were failures, on account of the unfavorable weather. The celery plants, it is true, lived, but many of them made no growth. The plants were cut close to the ground on October 18, many of them being, if anything, smaller than when set. The cuttings were weighed, with the following results: Plot 1, 28½ pounds; Plot 2, 57 pounds; Plot 3, 35½ pounds; Plot 4, 28 pounds; Plot 5, 92 pounds; Plot 6, 24 pounds.

It is noticeable that here again Plot 5, where nitrate of soda and sulphate of potash were used, is the best; but even this did not produce a crop with any marketable value.

Injurious Effect of Sulphate of Ammonia and Muriate of Potash used together. — Particular attention is called to the fact that upon Plot 1, where sulphate of ammonia and muriate of potash are used together, the growth was, in the case of the peas and beets, decidedly inferior to that upon the other plots. This inferiority may undoubtedly be ascribed to the poisonous effect of the chloride of ammonia formed where these fertilizers are used together, to which Dr. Goessmann has called especial attention.

Experiments on Grass Land.

The system of manuring grass lands, planned by Dr. Goessmann and described by him in previous reports, has been continued. According to this system, the land receives one year a dressing of barn-yard manure at the rate of 8 tons per acre; the next year, wood ashes at the rate of 1 ton per acre; and the third year, ground bone 600 pounds, and muriate of potash 200 pounds, per acre.

Plot 1, which this year received ashes, gave a yield at the rate of 5,775 pounds of hay and 3,204 pounds of rowen per acre, — a total of 4 tons 979 pounds. Plot 2, which received manure applied in the fall of 1896, produced at the rate of 5,784 pounds of hay and 2,627 pounds of rowen per acre, — a total of 4 tons and 411 pounds. Plot 3, which this year received bone and potash, produced at the rate of 6,183 pounds of hay and 2,755 pounds of rowen per acre, — a total of 4 tons 938 pounds.

This system of using these different manures for grass lands in rotation has much to recommend it. It is simple, and has certainly given remarkably good crops. I believe, however, that the system would be improved by the use of a little nitrate of soda, say 150 pounds per acre, with the ashes as well as with the bone and potash.

Experiments with Nitragin, a Germ Fertilizer.

Nitragin, prepared according to the directions of Professor Nobbe, was imported at my suggestion from Germany in the summer of 1896. The material was fully described by Dr. Goessmann in our last annual report, and full directions for its use are quoted by him.

The nitragin has been tried in accordance with directions, as stated elsewhere in this report, upon crimson clover and alfalfa, without apparent benefit. It has also been tried upon common red clover. On this crop, as with the others, no difference in growth attributable to the nitragin has been noticed; and, so far as can be judged at the present time, the use of this germ fertilizer for our common clovers is not to be advised. Nitragin undoubtedly contains the germs of the appropriate nodular bacteria, — the name of Professor Nobbe is sufficient guarantee of this. The failure of the material to benefit the crop appears to be due to the fact that our soils contain the nodular bacteria of the common leguminous crops in sufficient numbers so that the addition of a few more by the use of nitragin counts for nothing. Experience in the open field in most parts of Germany and England has been similar to our own, and I believe that we may safely conclude that only when we are about to begin the culture of a leguminous crop new to a particular locality will it be found advantageous to employ nitragin. In such cases the soil lacks the appropriate nodular bacteria; nitragin furnishes these, and the result is a better growth, because the crop is enabled to make use of the free nitrogen of the air from the first, which it could not do in the absence of the proper bacteria.

Sulphate of Iron as a Fertilizer.

Sulphate of iron has been tried during the past season upon the same plots as in 1896, but this year with corn as a crop. The sulphate of iron is used at the rate of 80 pounds per acre. The crop where it was employed was a little inferior to that on the plots where it was not used. Without sulphate of iron the average yield of the plots was 58¼ pounds of corn and 163¼ pounds of stover; with sulphate of iron, 50¾ pounds of corn and 160 pounds of stover.

Variety Tests.

1. Corn.

Twenty of the more promising varieties of corn tried for the first time last year have been given a further trial during the past season. Nine of these varieties were flint corns, as follows, named in the order of productiveness: Sanford, Longfellow, Waushakum, Giant Long White, Rhode Island White Cap, Early Canada, King Philip, Angel of Midnight, Compton's Early. The varieties of dent corn, named in order of productiveness, were Early Butler, Leaming Field, Champion White Pearl, Queen of the Prairie, Iowa Gold Mine, King of the Earlies, Sibley's Pride of the North, South Dakota White, Huron Extra Early, Wisconsin Yellow and White Cap Yellow.

Varieties the ears of which were very moist when husked are Queen of the Prairie and Huron Extra Early. Varieties which were moist are White Cap Dent, Leaming Field, Iowa Gold Mine and Champion White Pearl.

All of the varieties in these two classes are too late for culture as grain crops in this locality, though they would do for the silo.

2. Potatoes.

Eighty-one varieties of potatoes were cultivated for purposes of comparison upon the general plan described in our last report (ninth). The soil was a well-drained medium loam. The fertilizers used per acre were as follows: —

	Pounds.
Nitrate of soda,	240
Acid phosphate,	400
Sulphate of potash (high grade),	250
Tankage,	240
Dried blood,	100

These materials were mixed and scattered broadly in the furrows before dropping the seed. The seed was planted April 30. May 5 the crop was somewhat injured by washing of the soil between the rows and by the excessive rainfall. The potatoes were dug September 26 to October 6. The yield was at the rate of from 115.7 to 282.4 bushels per acre. The eleven largest yields of merchantable tubers, in the order of productiveness, were given by the following varieties: Rose No. 9, Restaurant, Woodbury's White, Bliss's Triumph, Prolific Rose, Empire State, Early Maine, Dakota Red, Sir William, Early Rose and Beauty of Hebron. All of these gave a product at the rate of more than 220 bushels of merchantable tubers per acre. Again, as last year, we find the two old standard sorts, Early Rose and Beauty of Hebron, ranking among the very best. It appears doubtful whether any among all those tried are truly superior to these varieties.

Twenty-three varieties have given yields of merchantable tubers at the rate of less than 175 bushels per acre. These, in the order of inferiority, are the following: Minister, Bill Nye, Harbinger, Peerless, Jr., Livingston Banner, Burpee's Extra Early, Carmen No. 3, Dandy, Early Market, Crown Jewel, Merriman, White Star, Irish Daisy, Chance, Six Weeks, Alliance, Sunlit Star, World's Fair, Freeman, Ohio, Jr., Great Divide, Wise Seedling and Early Norther.

All of the varieties grown this year are to be examined for determination of dry matter and starch, but this work could not be completed in season for this report. Full details as to the varieties cultivated are therefore reserved until these analytical results can be published.

3. *Grasses.*

Sixty species and varieties of grasses have been under trial. Most of them occupied plots containing one square rod. About one-half of these grasses were sown in the spring of 1896. Among those so sown the following varieties winter-killed: English rye grass, Italian rye grass, crested dog's-tail and meadow fescue. Among comparatively little-cultivated varieties which appear promising may be mentioned the following: tall oat grass, tall fescue, red fescue, fowl meadow, Canada blue-grass, water-spear grass and wood-meadow grass.

The yield of the dry matter in the hay and rowen (where any was secured) of those varieties sown in the spring of 1896 during the past season, with date of cutting of both the first and the second crops, is shown in the following table. The area in each variety was one square rod.

KINDS.	Date of cutting Hay.	Dry Matter in Hay (Pounds).	Date of cutting Rowen.	Dry Matter in Rowen (Pounds).
Timothy (*Phleum pratensis*), .	July 1,	19.36	Sept. 11,	6.44
Awnless Broom (*Bromus inermis*),	June 25,	14.71	Sept. 11,	6.44
Yellow Oat (*Avena flavescens*), .	July 1,	–	Sept. 11,	4.41
Sweet Vernal (*Anthox anthum odoratum*).	June 4,	2.98	Sept. 11,	4.41
Meadow Foxtail (*Alopecurus pratensis*).	May 17,	5.70	June 25,	7.87
Red-top (*Agrostis vulgaris*),. .	July 6,	31.12	Sept. 11,	8.44
Rhode Island Bent (*Agrostis Canina*).	July 6,	30.81	Sept. 11,	6.41
Fall Oat (*Arrhenatheum avenaceum*).	June 25,	22.85	Sept. 11,	11.86
Glyceria fluitans, ...	July 1,	–	Sept. 11,	–
Meadow soft (*Holcus lanatus*), .	June 25,	10.25	Sept. 11,	6.42
Slender Fescue (*Festuca tennuifolia*).	June 15,	21.43	–	–
Meadow Fescue (*Festuca pratensis*).	Sept. 11,	4.36	–	–
Sheep's Fescue (*Festuca ovina*), .	June 15,	27.85	Sept. 11,	6.61
Tall Fescue (*Festuca elatior*), .	June 25,	27.20	Sept. 11,	17.81
Hard Fescue (*Festuca durinscula*),	June 15,	27.42	Sept. 11,	–
Orchard (*Dáctylis glomerata*), .	June 15,	16.41	Sept. 11,	11.96
Red Fescue (*Festuca rubra*), .	June 25,	27.47	Sept. 11,	–
Fowl Meadow (*Poa serotina*), .	July 6,	43.00	Sept. 11,	14.27
Rough-stalked Meadow (*Poa trivialis*).	July 1,	9.87	Sept. 11,	–
Kentucky Blue (*Poa pratensis*), .	June 15,	14.73	Sept. 11,	18.93
Canada Blue (*Poa compressa*), .	July 10,	43.68	Sept. 11,	6.17
Water Spear (*Poa aquatica*), .	July 1,	31.97	Sept. 11,	8.04
Canary Reed (*Phalaris arundinaria*).	June 25,	23.18	Sept. 11,	21.09
Wood Meadow (*Poa nemoralis*), .	July 1,	31.07	Sept. 11,	12.88
Creeping Rent (*Agrostis stolonifera*).	July 6,	15.27	Sept. 11,	–

4. *Millets.*

Twenty-one varieties of millet, occupying one square rod each, were grown for purposes of comparison on medium loam, manured at the rate of 600 pounds of ground bone and 200 pounds of muriate of potash per acre. These were of three species, *Panicum crus galli*, *P. miliaceum* and *P. italicum*. The varieties grown, with particulars concerning amount of seed sown, date of heading, height of plants, and the weight per plot and acre of hay produced, are shown in the table below: —

KINDS.	Ounces Seed Sown.	Date of Heading.	Date When Cut.	Height of Plants (Feet).	Weight, Air Dry, Square Rod (Pounds).	Weight per Acre (Pounds).
Panicum crus galli.						
Japanese barn-yard, . . .	1	Aug. 2,	Aug. 17,	6	65	10,400
Japanese barn-yard, loose headed.	1	Aug. 2,	Aug. 17,	6	63	10,080
Panicum miliaceum.						
Common broom corn, . .	3	July 19,	Aug. 2,	4	51	8,160
Japanese broom corn, red seed,	3	Aug. 2,	Aug. 21,	4 -6	83	13,280
Japanese broom corn, white seed.	5	Aug. 10,	Aug. 29,	5½-6	92	14,720
California, ...	4	July 19,	Aug. 2,	4	62	9,920
Chinese, ...	4	July 23,	Aug. 5,	4	69	11,040
French, ...	4	July 23,	Aug. 5,	4	66	10,560
White French, ...	4	July 19,	Aug. 2,	3½-4	65	10,400
Red French, ...	4	July 19,	Aug. 2,	-	65	10,400
Hog, ...	4	July 19,	Aug. 2,	3 -3½	63	10,080
Panicum italicum.						
Canary bird seed, ...	4	Aug. 7,	Aug. 2,	-	40	6,400
Dakota, ...	4	July 23,	Aug. 12,	3½-4	60	9,600
Early Harvest, ...	4	July 19,	Aug. 2,	3 -3½	57½	9,340
Golden, ...	3	Aug. 21,	Sept. 4,	5	100	16,000
Golden Wonder, ...	4	Aug. 10,	Sept. 4,	5	95	15,200
Japanese Glutenous Hokkaido,	3	Aug. 12,	Aug. 26,	4½	63	10,080
Japanese Glutenous Mukodamashi.	3	-	Sept. 15,	2 -4	100	16,000
Japanese common Millet, .	3	Aug. 12,	Aug. 26,	4¾	88	14,080
New Siberian, ...	4	July 28,	Aug. 12,	3 -4	55	8,800

The differences in yield are large, but the scale upon which the varieties were grown is small, — too small, in my judgment, to justify sweeping conclusions as to the relative merits of the several sorts.

The "Dakota" closely resembles the "Early Harvest;" the "loose-headed" variety of the "barn-yard" millet is much less leafy and less valuable than the common form. The so-called "Golden Wonder" cultivated appeared to be like the "Golden." The "Japanese Glutenous," from "*Mukodamashi*," is very late, and does not mature with us. The variety of glutenous millet from *Hokkaido* appears to be a valuable sort. Moisture tests which are being made will very likely change the relative position of some varieties.

5. *Japanese Millets for Seed.*

A small area of each of our three leading varieties of Japanese millets was grown for seed. The soil was fertilized for each variety at the following rate per acre, the fertilizer being sown broadcast and harrowed in: —

Manure, ...	4 cords.
Nitrate of soda, ...	125 pounds.
Dried blood, ...	100 "
Tankage, ...	200 "
Superphosphate, ...	250 "
Muriate of potash, ...	200 "

The season was not very favorable for these crops, and they were somewhat injured on several occasions by the washing of the soil, due to excessive rain-fall.

Barn-yard Variety (*Panicum crus galli*). — The area sown to this variety was .633 acres. The seed was sown May 27, in drills, and was cultivated and hand-weeded. It yielded 1,370 pounds of seed and 4,360 pounds of straw, which is at the rate of 40 bushels of seed and 3 tons 888 pounds of straw per acre.

Japanese Broom-corn Millet (*Panicum miliaceum*). — The area of this variety was .248 acres. It was planted and cultivated like the preceding variety. The yield was 535 pounds of seed and 1,620 pounds of straw, which is at the rate of 40 bushels of seed and 3 tons 532 pounds of straw per acre.

Japanese Millet (Panicum italicum). — The area of this variety was .138 acres. It was planted and managed in all respects like the preceding varieties. The yield was 305 pounds of seed and 519 pounds of straw, which is at the rate of 41 bushels of seed and 1 ton 1,761 pounds of straw per acre.

6. *Soya Beans.*

A small area of each of the three leading varieties of Japanese soya beans was cultivated for seed. The yield was at the following rates per acre: early white, 18.7 bushels; medium black, 16 bushels; medium green, 34.5 bushels. The last-named variety thus once more demonstrates its great superiority as a crop-producer over either of the other sorts under trial.

7. *Clovers.*

Tests were begun in 1895 for the purpose of comparing four of our prominent clovers, viz., medium red, mammoth, alsike and crimson. The result of the first year's test will be found in our ninth annual report (pages 27 to 29). As stated in that report, our results indicate that the crimson will not prove valuable as a fodder crop in this locality.

Medium Red Clover. — The crop of this variety compared very favorably with that of the mammoth clover in the season of 1896, but during the winter of 1896 and 97 the plants of this variety were nearly all killed. The plots were accordingly ploughed and sown with oats and vetch.

Mammoth Clover. — This variety was somewhat injured by the winter, but was allowed to stand. Bad weather prevented its being harvested at the proper time, and it was much damaged before it could be secured. It yielded at the rate of about 1½ tons per acre at the first cutting. The second growth was much mixed with weeds. It was cut and weighed green, yielding at the rate of about 2,800 pounds per acre.

Alsike Clover. — This variety, like the preceding, was much injured by rain. It, like the mammoth, was found to have suffered much during the winter. The crop cut was much mixed with weeds, yielding at the rate of $2\frac{1}{4}$ tons per acre for the first cutting. The second growth was mostly weeds, and was weighed green, amounting to about 5 tons per acre.

Conclusion. — The mammoth clover under the conditions of our experiment has shown greater vitality and productive capacity than either of the other sorts. It is worthy more extensive cultivation.

Sulphate v. Muriate of Potash for Clovers. — As stated in our ninth annual report, there were two plots of each of the varieties of clover under comparison, one fertilized with muriate of potash, the other with sulphate of potash. The results in 1896 showed no material difference in yields which could certainly be ascribed to the nature of the potash salts used. The same is true this year.

The sulphate plots, both of the mammoth and the alsike clovers, yielded most at the first cutting; the muriate plots, in both cases, yielded most at the second cutting; but, as stated, the crops secured at the second cutting were largely mixed with weeds. The results, therefore, must be regarded as without especial significance.

8. Sweet Clover (Melilotus alba).

This crop occupied two plots of two-fifteenths of an acre each, in Field B. The same crop was grown upon these plots in 1896, and the results are fully discussed in our ninth annual report. The growth during that season was for the most part small and unsatisfactory, owing apparently to the fact that the appropriate nodular bacteria were not present in sufficient numbers to enable the crop to make use of free atmospheric nitrogen. A few of the plants in 1896 were found to have abundant nodules upon their roots. These showed a deep-green color and made a vigorous growth. It was judged that, if the land should be thoroughly worked in various directions, the nodular bacteria would be scattered throughout the soil, and that the second crop upon the same land would be better than the first. The soil was accordingly thoroughly prepared, and the seed for the crop of this year sown at the rate of 10 pounds per acre on July 30, 1896.

The growth was very much superior to that of the previous year, and upon examination in the early part of the season it was found that the roots of about one-half the plants were abundantly supplied with nodules. These plants were making a vigorous growth, and had a deep-green color, indicative of an abundant supply of nitrogen. They were at this time evidently able to draw upon the atmosphere for this element. Later the other plants in the field seemed also to gain this ability.

On July 8 the crop averaged 6 feet in height. A portion was cut and fed to the cows kept in the department of foods and feeding. This portion yielded at the rate of about 12½ tons per acre. Dr. Lindsey reports that the cows ate it readily and appeared to be fond of it. It was, however, rather coarse for feeding when allowed to stand until the latter part of July. If to be fed, the crop should be cut early. In average seasons it would be at its best condition during the first half of the month of July. It is not, however, as a fodder crop that I am inclined to recommend a trial of sweet clover, but rather as a crop for green manuring. I believe it may serve here a similar purpose to that served by crimson clover in localities where it is hardy.

Miscellaneous Crops.

Alfalfa. — One-quarter of an acre of light soil was sown on April 17 with alfalfa. The fertilizer applied to the quarter acre was as follows: fine-ground bone, 100 pounds; nitrate of soda, 50 pounds; phosphatic slag, 50 pounds; muriate of potash, 50 pounds. One-half the seed used was treated with nitragin. All the seed germinated quickly, no difference being noticed between the treated and the untreated. The small plants were, however, injured by the heavy rains, and up to date the crop has made but a feeble growth.

Saccaline. — Our trial of this crop has been carried out upon two small plots, the one having a heavy, moist soil, the other a light, drier soil. One-year-old plants were set in the spring of 1896. The growth during that season was feeble. In August of that year each plot was given a good dressing of manure. In the spring of 1897 it was found that a considerable number of the plants had been winter-killed. On the heavy soil 36 out of 408, and on the lighter soil 71 out of 129, were dead; of 451 plants left in a nursery, 258 were dead. Plants which lived through the winter were well started by April 20, but the new growth was killed by a frost. On July 16 the growth, which ranged from 1 to 7 feet in height, the average being about 3 feet, was cut. The plants were large and woody. The yield on the heavy soil, 408 plants, was 295 pounds; on the lighter soil, 129 plants, 132 pounds. The leaves only were eaten by cows, — horses would not eat it at all. A second crop was not cut, but on October 1, when the plants were killed by frost, the second growth averaged about 18 inches in height. As a result of our trial of this crop, I am convinced that it is without value as a fodder crop for us.

Crimson Clover. — A further trial of this crop has been made upon a rather light soil. The seed was sown July 3 with equal parts of winter rye. Nitragin, not received in season to apply with the seed, was mixed with water, according to directions, and applied to the clover August 31, the plants then standing about 2 inches high. The crop was a complete failure, every plant being winter-killed.

Winter Vetch. — A small plot of this crop has been grown upon a light soil. It was sown August 20, equal parts of vetch and rye. This vetch proved perfectly hardy and grew vigorously, reaching a greater height than the rye. This vetch will prove valuable as a green fodder when sown with winter rye.

Besides the above, we have cultivated a few rows each of a large variety of fodder plants, some 39 in number. In this variety are included a large number that have been mentioned in previous reports, and they do not require further notice at this time.

Among those cultivated for the first time this year are the *Idaho field or coffee pea* (*Cicer arietinum*). This appears to be the same as the gram or chick pea, which we have had under cultivation for two years. The growth is too small to make it valuable for a fodder crop.

Another new fodder crop for this year was the *Brazilian stooling flour corn.* The plants made a vigorous growth, but are judged to be too coarse and woody to prove of much value for fodder.

Black chaff or African millet is another crop under trial this year for the first time. It appears to be the same as Kaffir corn, and, as reported last year, our experience leads us to regard this fodder crop as inferior to maize for our climate.

A Reputed Method for Destroying Stumps.

A correspondent in one of our agricultural papers during the summer of 1895 reported that he had found it possible to destroy stumps in the following manner: —

A hole one or two inches in diameter according to the size of the tree, and eighteen inches deep, is to be bored in the stump. Into this put from one and one-half to two ounces of saltpetre, fill with water and plug tightly. Six months later, put into the same hole about one gill of kerosene oil, and set fire to it. The correspondent stated: "The stump will smoulder away without blazing, even down to every part of the roots, leaving nothing but ashes."

On Nov. 4, 1895, fifty stumps of trees cut in 1894, including the following varieties, maple, hickory, hemlock, white pine, yellow birch and elm, were bored according to directions. On December 11 saltpetre and water were put into the holes, according to directions, and the holes plugged. During July, 1896, the plugs were removed, the holes were filled with kerosene, and an attempt made to burn the stumps. It was found that not even the oil would burn. A portion of the stumps were left until June, 1897, when another attempt was made to burn them, using a low-test oil, called paraffine gas oil. The stumps are still in the field. The method has been given a thorough trial, but must be regarded as a complete failure.

Poultry Experiments.

Experiments with poultry were carried out during the winter of 1896 and 1897. Our attention was confined to three points: —

1. Effect upon egg-production of the use of condition powders.

2. Comparative value for egg-production of dry-ground animal meal and cut fresh bone.

3. Comparative value for egg-production of cut clover and fresh cabbage.

General Conditions.

In all of these experiments pullets purchased in Plymouth County and sent to us in December were used. A few had laid before we received them, and production was stopped by the move, as is generally the case. Some of the pullets moulted after reception here, which served to reduce the egg yield. Each of the six lots of fowls occupied a house, with roosting and laying room ten by twelve feet, and scratching shed eight by twelve feet in size. Each had the liberty of a large yard, which furnished a little grass after April 15, but in all alike. Each of the feeding trials began January 1 and continued until May 2, — 122 days.

Soft foods were mixed for the morning mash with boiling water the night before using. Sufficient of the materials for a fortnight were mixed dry at one time. Oats were always scattered in the straw in the shed at noon. At night the wheat was fed in the same manner. As a rule, a little cut bone was fed once a week, in place of the noon ration of oats. About twice a week cabbage was hung up in each coop except the one where cut clover was under comparison with this vegetable. Clear water, shells and grit were before the fowls all the time. Occasionally salt was added to the morning mash. At the conclusion of the experiment the dressed fowls were sent to G. M. Austin & Son, Boston, who reported upon the quality of the several lots.

1. Effect of Condition Powder upon Egg-production.

This experiment was carried out in most respects in the same manner as last year. Light Brahmas were selected for this test, 20 in the coop receiving condition powders and 19 in the other. The food of the two lots was the same in kind, with the exception that the fowls in House No. 6 received daily condition powder in the morning mash, in accordance with directions furnished with the powder.

The kinds and amounts of food used are shown in the table: —

KINDS.	AMOUNTS (POUNDS).	
	No Condition Powder.	Condition Powder.
Wheat,	209	220
Oats,	150	150
Bran,	27	28
Middlings,	27	28
Animal meal,	27	28
Clover,	27	28
Cabbage,	28	29
Corn meal,	28	29¼
Bones,	9	9

About three pounds of condition powders were used in the experiment.

The weights of the fowls were taken at intervals, and were as follows: —

Average Weights (Pounds).

	No Condition Powder.	Condition Powder.
January 4,	4.868	4.650
February 4,	5.260	4.950
March 9,	5.360	5.343
April 26,	5.310	5.470
May 3 (after fasting twelve hours),	5.160	5.180
Dressed weight,	4.605	4.657

The results and leading details are shown below: —

Condition Powder for Egg-production.

Experiment January 1 to May 2.	Number of Hen Days.	Gross Cost of Food.	Cost per Hen Day.	Cost of Food per Egg.	Number of Eggs.	Weight of Eggs.		Weight per Egg (Ounces).
						lbs.	oz.	
No condition powder,	2,318	$6 61	$0 00285	$0 0124	532	65	1½	1.958
Condition powder, .	2,354	6 68	00280	0125	540	67	4	1.993

The nutritive ratio was 1 : 5.16 for the fowls not receiving condition powder; for the others, 1 : 5.14,—practically identical. The total dry matter in food consumed for each egg produced was: without condition powder, 0.8349 pounds; with powder, 0.8688 pounds. Besides the perfect eggs as shown in above table, the fowls receiving no condition powders laid three soft-shelled eggs; the others, one. There were five sitters in the first lot, eleven in the second.

Samples of the eggs were analyzed, and those from the condition-powder fowls were found somewhat richer in dry matter, protein and fat. The eggs were also tested in two families by careful house-keepers. The reports did not agree in all particulars; but one of the two found the eggs from the fowls which had received condition powders superior in flavor of yolk, flavor of white, in beating qualities and in consistency; the eggs from the other fowls better in color and size of yolks. The other reported the condition-powder eggs strong in flavor and the yolks small. This discrepancy is probably to be accounted for from the fact that the number tested was small. Individual as well as class differences would almost certainly be found in the eggs.

The fowls which had received condition powder were reported as dressing rather better than the other lot.

One fowl in the condition-powder house died during the test; there were no losses in the other house.

In conclusion, I have to say that the differences found in this experiment are too small to be considered decisive. On the side of the condition powder we have size of eggs and weight and quality of the dressed fowls; against the powder, we have the food cost per egg, the weight of dry matter in food per egg, and the loss of one fowl. We are warranted simply in the statement that the powder does not appear to have paid for its use.

2. *Cut Bone v. Animal Meal for Egg-production.*

Each of the two houses contained twenty Plymouth Rock pullets in this experiment. The bone and animal meal were each mixed in the morning mash. The foods used are shown below: —

KINDS.	Cut-bone House (Pounds).	Animal-meal House (Pounds).
Wheat,	213	196
Oats,	149	149
Bran,	27	28
Middlings,	27	28
Buffalo gluten,	–	28
Animal meal,	–	28
Clover,	28	27
Cabbages,	26½	29⅛
Chicago gluten,	27	–
Cut bone,	28	–

The nutritive ratios in the two houses were 1 : 5.05 and 1 : 4.45 respectively.

The average weights of the fowls were as follows: —

	Cut-bone House (Pounds).	Animal-meal House (Pounds).
January 4,	4.75	4.89
February 6,	5.10	5.00
March 9,	5.86	5.28
April 27,	5.44	5.15
May 3 (after fasting twelve hours),	5.28	4.88
Dressed weight,	4.83	4.43

The dressed fowls which had received the cut bone were reported slightly better than the other lot. The leading details and results are shown in the following table: —

Cut Bone v. Animal Meal.

Experiment January 1 to May 2.	Number Hen Days.	Gross Cost of Food.	Cost per Hen Day.	Cost of Food per Egg.	Number of Eggs.	Weight of Eggs.		Weight per Egg (Ounces).
						lbs.	oz.	
Cut-bone house, .	2,279	$6 61	$0 0028	$0 0130	508	64	9	2.0034
Animal-meal house, .	2,440	6 24	0025	0097	639	80	15	2.0270

There was, in addition to the eggs as shown by the table, one soft-shelled egg in each house. Two hens in the cut-bone house died during the experiment, from diarrhœa; those in the other house were healthy throughout the experiment.

The dry matter per egg was, where cut bone was fed, 0.877 pounds; on animal meal, 0.69 pounds. The number of sitters was 6 in the cut-bone house, 12 in the other.

A sample of eggs from each house was subjected to analysis. Those produced on the cut bone contained rather more protein but less fat than the other. A test for cooking quality was indecisive; one of the two house-keepers having preferred one lot; the other the opposite lot.

The advantage in this trial is, then, clearly with the animal meal as a food for egg-production. It has given more eggs of a greater average weight and at considerably less cost than the bone; and it is, moreover, a more convenient food to use, as well as safer. The results this year are thus the opposite of those of last year. We have now repeated this experiment four times, with results twice favorable to the bone and twice to the animal meal, but have not before found so decisive a difference as this year. We repeat the experiment again this winter.

3. *Clover Rowen v. Cabbage for Egg-production.*

Plymouth Rock pullets were used in this experiment; but they were later-hatched fowls than those in the experiments already described. There were twenty fowls in each of the two houses, at the beginning. One fowl died in each house during the experiment, from unknown causes. The cut clover was fed in the morning mash. Instead of the clover, a fresh cabbage was kept before the fowls in the other house.

The foods used are shown in the table : —

KIND.	Clover House (Pounds).	Cabbage House (Pounds).
Wheat,	223	212
Oats,	150	149½
Bran,	28	36
Middlings,	28	36
Animal meal,	28	34¾
Clover,	26	–
Cabbage,	–	46¾
Cut bone,	8½	8½
Oat meal,	28	36

The nutritive ratio was practically the same in both houses : viz., in the clover house, 1 : 4.99 ; in the other, 1 : 4.838.

The average weights of the fowls were as follows : —

DATES.	Clover House (Pounds).	Cabbage House (Pounds).
January 4,	4.560	4.530
February 4,	5.480	4.800
March 8,	5.420	5.350
April 27,	5.470	5.394
May 3 (after twelve hours fasting),	5.289	5.184
Dressed weights,	4.780	4.890

The leading results and details are shown in the table : —

Clover Rowen v. Cabbage for Egg-production.

EXPERIMENT JANUARY 1 TO MAY 2.	Number of Hen Days.	Gross Cost of Food.	Cost per Hen Day.	Cost of Food per Egg.	Number of Eggs.	Weight of Eggs.		Weight per Egg (Ounces).
						lbs.	oz.	
Clover house, . .	2,356	$7 033	$0 0029	$0 0150	466	59	10	2.0472
Cabbage house, . .	2,423	6 988	0028	0118	588	75	1	1.9880

In addition to these, the fowls in each house laid one soft-shelled egg.

The advantage lies most decidedly with the fowls fed cabbages, in so far as numbers, weight and cost of eggs are concerned. The eggs from the clover house were, however, much superior in cooking and eating quality to those from the other. Both house-keepers reporting are most emphatic in the expression of their preference for the eggs from the fowls fed the clover. One reports: "The eggs from the clover lot are in every way superior." The other says: "They are superior in color, size of yolk and flavor;" and adds that "they have the finest flavor of any eggs" she ever ate.

Analysis showed the eggs from the fowls fed cabbages to contain higher percentages of dry matter, protein and fat than the others. The superior richness of these eggs apparently renders them strong in flavor.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

The work of the meteorological department during the past year has been in the main a continuation of that of previous years, with such minor changes as, after due consideration, have seemed advisable. The observations for temperature are now all taken in the ground shelter on the campus. The publication of the maximum and minimum temperatures taken in the observatory shelter was discontinued last year, owing to their unreliable character. For the same reason, the observations themselves were discontinued early in April the present year.

The usual bulletins, giving a summary of the records and weather for each month, have been published. An annual summary will be issued as soon as the records for the year are completed.

No material additions have been made to the equipment of the department during the year.

Arrangements have been made to furnish the New England Weather Bureau with the weekly snow reports, as was done last year.

In co-operation with Professor Whitney of the Division of Soils, United States Department of Agriculture, this department installed one of his instruments (kindly loaned by the Department at Washington) for the electrical determination of moisture in the soil. Observations were taken from the latter part of June until early in November. The records, however, are incomplete for the period, owing to breaks in the circuit and other causes which made the instruments fail to work at times. The readings taken were sent weekly to the Department at Washington. The Division of Foods and Feeding of this station made some independent determinations of moisture for standardizing the instrument, and the Division of Botany kept a record of the growth of the crops where the electrodes were buried. Owing to the unusually wet weather during the summer and the incomplete records of the instrument, the results of the experiment were not entirely satisfactory. The department expects to repeat the observations next year under more favorable conditions, and an outfit for that purpose has been ordered.

It is hoped that arrangements may be made to put the electrometer in the tower in working order, so that observations on atmospheric electricity may be undertaken.

REPORT OF THE BOTANISTS.

GEORGE E. STONE, RALPH E. SMITH.

Our work during the past year has been in general a continuation of that of the year preceding. In this, as in other departments of the station, the work falls under two classes: first, examination of material sent in for determination and answering of inquiries; second, investigations of problems connected with plant physiology and pathology.

For the purpose of investigation the greenhouse has been remodelled and enlarged during the past summer, so as to admit of carrying on experiments under more desirable conditions. It is quite essential, in experimenting with plants, that the number employed should be large enough to make it possible to draw deductions from the results with a reasonable degree of certainty that errors arising from individual variation have been counterbalanced. It is also essential that the heat, light and moisture conditions should be equal upon each series of plants under consideration, and that these conditions should compare as closely as possible with the best method of cultivation. In the construction of the experiment house these details have been considered as carefully as possible. The house as now arranged consists of several sections, in which different temperatures can be maintained, for growing tomatoes, cucumbers, lettuce and other important plants subject to destructive diseases. The amount of money invested in the production of greenhouse crops is large and continually increasing, and no small part of our work consists in the study of the various diseases which affect them.

For the last three years we have been investigating methods of controlling the gall-forming nematode worm, which affects cucumbers, tomatoes, English violets, roses, cyclamens and many other greenhouse plants. The results of the investigation are nearly ready for publication, but it seems desirable to first clear up a few remaining points upon the habits of the worm, which are not well known.

Experiments are also being made upon the different methods of pruning tomatoes, and upon the best light conditions for assimilation in greenhouse cucumbers.

With regard to lettuce we are studying the mechanical conditions of the soil as affecting the crop, and the various fungous diseases to which it is subject, more especially the disease known as the "drop."

In addition to these experiments, it may be mentioned that there are incidentally being carried on investigations upon the influence of electrical currents on the growth of plants. Bulletin 43 of this station embodied the most careful and extensive series of experiments ever made upon the subject. They were carried out by Mr. Asa S. Kinney, while a student at the college, and did not necessarily fall under station work. The results obtained by him were of such a promising nature that it has seemed well worth our time to carry the investigation further. It should be stated that any costly method of using electricity as an accelerator of plant development is not to be recommended. If, however, any simple and cheap means of using electric currents can be used, which will give an acceleration in the growth of a crop equal to 30–40 per cent., it might be worthy of consideration by practical agriculturists.

We have in progress a series of experiments with various gaseous substances, with a view to developing a treatment of this sort for combating fungous diseases of greenhouse plants. This method of treatment has been suggested by the extensive application which it has reached in exterminating insects. While we are as yet unable to present any results of great practical value, it is hoped that these experiments may lead to the development of an effective treatment for greenhouse plant diseases by the use of a gaseous substance. The great superiority of such method over that of spraying, which is in many cases inapplicable, needs no exposition. Our experiments thus far have been carried on with two gases, hydrocyanic and formaldehyde. Neither of these appears to answer the purpose. The former, which has been found to be of considerable value as an insecticide, cannot be made effective as a fungicide without using a strength which will prove fatal to the plant. This we have determined by parallel exposures of various fungous spores and plants to the gas, and also by the fact that spores of the carnation rust, taken from plants which had been almost killed by over-exposure, germinated freely. Formaldehyde has a well-marked fungicidal effect, and is much less harmful to plants; but we cannot at present recommend it as a general fungicide, on account of the difficulty of producing it in sufficient strength.

The past year has been an exceedingly abnormal one for vegetation, and as a result this division has had many inquiries concerning plant diseases, different from those of ordinary years. The excessive and long-protracted rains and the lack of sunshine gave rise to a multiplicity of plant diseases such as we have not had for some years. This was the case not only in regard to our various crop plants, but our introduced ornamental species and even our wild plants were unusually affected by fungi. An unusual number of the so-called spot diseases made their appearance, and defoliated to a greater or less extent more than one species of tree. These spot diseases were especially disastrous to the sycamore and butternut, both of which in many instances lost all their foliage; while other trees, such as the chestnut and wild cherry, were more or less affected. The fungi causing these diseases are not new to these trees in this locality, but the abnormal conditions to which all vegetation was subjected proved amply sufficient to accelerate their growth and development.

Whenever the normal conditions surrounding the plant are disturbed, we must expect to find irregularities in its functions; and any serious irregularities in the plant's functions are most likely to manifest themselves by the presence of some insect, fungous or bacterial organism. Abnormal functions, or, in other words, physiological disorders, are in a majority of instances the basis of many plant diseases with which gardeners have to contend; and, since we are liable to observe only the effects of the fungus or bacteria preying upon the plant, we too often think that they are the primary causes of the disease, when, as a matter of fact, they are purely secondary.

This leads us to the subject of spraying as a preventive of plant diseases. From the hap-hazard manner in which it is often resorted to, one would gain the idea that it is intended as a curative rather than as a preventive remedy. This idea is erroneous, inasmuch as spraying is intended as a prevention rather than a cure. This misconception of the proper use of spraying solutions gives rise to the practice of using the Bordeaux mixture as a panacea for every plant disease. Upon this point we wish to state that it must be distinctly borne in mind that spraying under any condition is only a temporary means of preventing certain diseases. The ultimate aim of all progress connected with gardening should be not only to improve the marketable product, but to improve the stock and increase our knowledge pertaining to proper cultivation, so that spraying will be unnecessary. Many experienced gardeners recognize this, and we find experts in almost every line of gardening who have had eminent success in controlling diseases without resorting to the use of fungicides. Some of the most experienced growers of carnations claim that they can control the many diseases which have of late years affected this plant, by simple, judicious methods in the management of the greenhouse.

To expect that spraying is going to save plants that are improperly cared for, or to act as a cure for those already diseased, is absurd. There are many instances where spraying produces beneficial results, and at the present time it appears to be essential, in some instances, to the production of good crops; but there are also many instances where it is entirely useless. This applies especially to the diseases having their origin in improper care or in abnormal conditions surrounding the plant. The condition of the potato crop in Massachusetts during the past summer affords an illustration of how any amount of spraying would not save it from disease, when the soil was soaked with water and the plants in some instances practically submerged for days at a time. Every plant is surrounded by a host of parasitic organisms, which, given the proper conditions, will manifest their distinctive properties. The healthy, vigorous plant is always less susceptible to the attacks of fungi than the weakly, abnormally developed one, — a fact which every practical gardener readily understands. We have seen this illustrated so many times in our work in the greenhouse that it may be well to give an example of it here. Certain species of non-parasitic nematode worms, which are always present in greenhouse soil, although apparently doing no harm as long as the plants are vigorous, will, as soon as the plant becomes weakened or abnormal from any cause, penetrate the tissues and cause rapid decomposition of the same. What is true in regard to nematodes applies also to fungi and bacteria, and, indeed, these various forms of organisms are most frequently to be found together in the decayed tissues of the plant.

Before any attempt is made to spray diseased plants, it is well worth while to find out something about the nature of the disease with which the plants are affected. It is, for example, unwise to spray roses for the black spot or mildew when the roots are half decayed by the action of parasitic gall-forming nematode worms; and for the same reason it would be unwise to treat the spot disease of the English violet, when the roots are covered with hundreds of minute galls, and when the supply of nutriment from the root is greatly interfered with.

On the other hand, spraying the apple, grape, potato and plum is at the present time justifiable and necessary; and there are many diseases common to greenhouse cucumbers and tomatoes which can be largely controlled by spraying, although it must be said here that by judicious management of the various conditions surrounding the plants these diseases can be checked.

The Causes of the Failure of the Potato Crop of 1897.

The disastrous effect upon agricultural crops of the excessive rainfall of the past season has been especially marked upon the potato. The small yield and large amount of rotting of this staple may be easily attributed to this source. In all sections of the State, as well as beyond our borders, the report has been general of a small potato crop and excessive rotting. This rotting has been generally regarded as resulting from the well-known and ordinary "potato rot" fungus, Phytophthora infestans. In fact, however, we have to describe a series and variety of agents, which, under the favorable influence of the excessive rainfall, — an influence unfavorable to the vitality of the plant, — have brought about the diminution and destruction of the crop.

At planting time the ground was extremely wet. The crop, however, started well, and the plants appeared above ground in a promising manner. Continuous rains kept the soil saturated with moisture, and before the plants had reached a height of more than six inches it was noticed in many places — usually the lowest and wettest portions of the field — that many of them were dying. Such plants did not collapse suddenly, but gradually turned yellow and faded away, most of them dying eventually, though here and there one would be seen which maintained a feeble, stunted growth through the season. This was the case not only in this vicinity, but it was also reported from various parts of the State.

Investigation of affected plants showed that the trouble was due to a rotting of the stem of the young plant below ground, which rotting evidently proceeded from the seed potato, which was found in every case to be a putrid mass, while the decay was gradually extending up the young stem. Careful search for the cause of the rotting failed to reveal any particular organism to which it could be ascribed. That it was of bacterial origin seemed quite certain, as the decayed tissue swarmed with organisms of this class, while no fungus which could be considered the cause of the rotting was found. In the cortex and exterior portions of decayed stems several forms of Micrococcus and also other bacteria were found in abundance. In the interior portions a large, motionless bacillus occurred quite abundantly and exclusively, and may have been the primary cause of the rotting. The most probable explanation, however, seems to be that the normal functions of the plant were disturbed and its growth checked by the unusual amount of moisture in the soil. The seed potato, with its supply of reserve food material for the young plant thus left idle in the soil, naturally rotted away, and this rotting communicated itself more or less to the young stem proceeding from the "seed." The plant, not being in a condition of vigorous growth to resist this rotting, gradually succumbed to it, and in most cases died. The few plants, as mentioned above, which continued a feeble growth through the season, accomplished this by throwing out roots above the rotted portion of the stem, and thus prolonged a feeble existence. Such plants produced no tubers, and consequently had no value whatever.

This, then, was the first of the troubles affecting the potato crop in this section. We do not describe or consider it as a specific "disease" of the potato, nor do we deem it necessary to consider any treatment for it. We at first recommended removing affected plants, but doubt now if such a course would have been of any considerable practical value. We are inclined to believe that the trouble was not brought about by any specific or especially destructive organism, but was simply the result of the unusual meteorological conditions of the season, and under such conditions could not be prevented from occurring by any means at our command.

By July 1, most of the plants which had fallen a prey to the above disease were withered away and dead, while those which had escaped had made a fairly good growth and nearly reached maturity in point of size. About July 15 several hot, sunny days came on, following a long very rainy spell. In many potato fields on low ground the plants began to wilt and die down. In a large field at the college, situated on a long slope, the plants at the top were unaffected, but those in a limited area at the bottom of the slope — the wettest part of the field — began to wilt (see plate). Many had already died here from the effects of the first disease. It is a well-known fact that plants often wilt when exposed to strong sunlight after a continued cloudy and wet period, this being due to excessive evaporation or transpiration of water from the leaves. In this case, however, the wilting was too pronounced to be attributed to this simple physiological phenomenon. Investigation showed that the leaves were not "blighted" nor were they affected in any way except the simple wilting, which was evidently caused by some trouble at the root. Plants were then dug in various portions of the affected area, and in all stages of collapse, and their roots examined for the cause of the trouble. It was found that there was no one organism (except possibly bacteria) attacking the plant, but there was a general rotting, resulting from the wet condition of the soil and consequent low vitality of the plant. The features of this rotting varied greatly in different plants, however, and scarcely any two were affected in an exactly similar manner, it being almost impossible to specify a feature of the disease common to all, except the wilting of the tops. In the very wettest part of the affected area the tubers were rotting badly. These rotten tubers were swarming with bacteria, but they were of various kinds, and to no one could be ascribed the beginning of the trouble. Various species of fungi were found in some, but these were moulds and similar forms, and included nothing which by any probability could have caused the rotting. Since fungi were entirely absent in many of the rotten tubers, it is certain that they did not cause the trouble. In many cases the decay seemed to have started where a grub of some kind had eaten into the potato. On somewhat dryer ground, where the plants wilted, the tubers were not rotten. In many cases, however, the stem was found to be decayed just where it joins the root. The young rootlets were also rotting, so that the cortex fell away from the central portion. These symptoms also occurred, and more pronouncedly, in cases where the tubers were rotten. In these decayed stems and roots no one organism could be found as the cause of the rotting. Bacteria (mostly micrococcus) swarmed in all affected parts, and several mould fungi also occurred. Quite noticeable on all affected plants was the occurrence on tubers and even on the base of the stem, of small, white, mealy dots, scattered abundantly over the surface. These were apparently enlarged lenticels, being composed of parenchymal cells breaking out at the surface. It seems probable, or is at least possible, that their production was due to the scarcity of air in the wet soil.

We can only conclude here, as in the other case, that this cannot be called a definite disease, but rather was the result of abnormal and unusual conditions. During the long-continued rain the living functions of the plant were disturbed and its growth checked. Various organisms then came in, and, gaining a foothold, so weakened it that when the sun came out it wilted down and in the worst cases died. Had it been possible to thoroughly cultivate and stir the soil at this time, it is reasonable to suppose that much of the trouble might have been averted; but the extreme wetness made such a course impossible.

This trouble came on after the potatoes had reached a marketable size. We therefore recommended digging them in all affected places, in order to save them from decay. Beyond this there could be no practical treatment suggested.

Early in August, or even sooner, the real potato blight or rot, Phytophthora infestans, began to appear, and developed very extensively during the month, killing the tops of potatoes everywhere, and causing great loss by rotting of the tubers. This disease is too well known to need extended description. Its ravages might probably have been controlled to some extent by thorough spraying throughout the season, but it would have been practically impossible to entirely prevent it in such a summer.

The "Drop" of Lettuce.

The loss represented by this disease frequently amounts to thousands of dollars in a single season in Massachusetts. Almost every lettuce grower has had more or less experience with it, although, as with every other disease, some have been much more affected than others. We have known several instances during the season where extensive growers have lost practically their whole crop, and, as a consequence, have become much discouraged with lettuce growing. Inasmuch as the general characteristics of this disease were given in the ninth annual report, it is not necessary to enter upon any minute description here. Suffice it to say that the disease makes its appearance in the stem, close to the surface of the ground, where the tissue becomes slimy and soft, and ēventually the whole stem at this point disintegrates and collapses. This occurs most frequently just as the plants reach maturity.

The fungus causing this disease is well known to all greenhouse men. The "damping fungus" (Botrytis), which causes the drop, often gives rise to disastrous effects on begonia and other cuttings in the propagating pit. The fungus, however, as it appears upon the lettuce, presents some aspects which are different from its appearance upon cuttings, and reaches a more advanced stage of development. Our present knowledge in this direction possesses more of a technical than practical interest, although an understanding of the complete life history of the fungus will, no doubt, lend much aid to its rational treatment.

The natural conditions governing the development of the organism appear to be similar to those of most organisms, — that is, it requires the presence of oxygen. It is well known that almost any object when driven into the ground will undergo disintegration much more rapidly at the surface of the soil, for here the conditions of moisture, etc., are most favorable for the organisms producing disintegration. And so it is with the "drop" fungus; it finds just the conditions at the surface of the soil, under the moist, shady leaves of the mature lettuce plants, for its destructive work.

Our experiments upon the control of this fungus are by no means complete, but it will not be out of place here to offer some suggestions in regard to its general habits and the methods of treatment which may be tried. Probably every grower has the germs of the disease in his lettuce soil to a greater or less extent, but the conditions giving rise to their excessive development are not always present. Some claim that manure is the principal source of infection; yet, on the other hand, while all use manure, all are not troubled in the same degree. As a remedy for the drop, some have resorted to the practice of sanding the surface of the soil or putting on a layer of yellow loam. This is for the purpose of giving a clean, uninfested surface to the soil surrounding the plants. In regard to the effect of this treatment, it may be stated that opinions differ considerably. Whether the method of applying a superficial layer of sand or subsoil to the surface will be of any assistance in keeping the drop in check appears somewhat doubtful, from an experiment made of burying some infested plants to a depth of three or four inches in a pot of yellow loam subsoil. It was found that the fungus made its way to the top in a very few days, as was evident from the mould-like growth of the mycelium upon the surface of the soil and the death by drop of plants which had been set in the pot. Neither can we expect much from the application of chemicals, as any such treatment would interfere with the growth of the plant, and hence become objectionable. Some experiments are now being made with gases, with the idea of killing the organism by fumigation; but this method does not promise much success.

The application of live steam to the soil, and thus sterilizing it, would undoubtedly destroy the germs of the disease. To do this would necessitate laying two-inch tile at a depth of eight inches or a foot below the surface of the soil, and at a distance of one or two feet apart, and driving in steam under pressure and allowing the same to permeate the soil. This method can be employed on a small scale with good results, but the larger area of a lettuce house would render its practical application uncertain. Another method of treatment by steam, which would be far cheaper, would be to sterilize the surface of the soil to a depth of three or four inches or more. This can be done by constructing a pit in the lettuce house and covering the bottom with tile or one and one-half or two inch steam piping. The tile allows the steam to escape very readily; and, in order to get the best effect, they should be laid close together, say one foot, or less. In case steam pipes are used, — and they are probably more effective than tile, — they should be bored with holes every three or four inches, to allow the steam to escape. With an arrangement of this kind, one would be able to sterilize the soil in a few hours. A pit twenty feet long, ten feet wide and eighteen inches deep would hold sufficient soil to cover twelve hundred square feet of surface three inches deep. The time required to heat this earth up to 200° F. would be only a few hours. Of course the pressure of steam available, the closeness of the pipes and the number of outlets for the steam would largely determine the time necessary to heat the earth.

Various methods of treatment for this disease are being tried, to determine how it may be most effectually dealt with. In connection with the method of steam sterilization, which seems by far the most promising, it is especially desirable to ascertain just how deep the soil must be sterilized in order to keep down the fungus.

The Asparagus Rust.

(*Puccinia asparagi.* D. C.)

In the last annual report of this division attention was called to a new disease which had appeared upon the asparagus, and the apprehension expressed that it might come to be a serious matter. That apprehension has been more than justified. The asparagus rust, unknown to the growers of Massachusetts in 1895, slightly prevalent in 1896, has appeared everywhere during the past season, and bids fair to become a most important factor in the growing of this crop.

The disease first appeared in the fall of 1896, both in this State and in several others, but was not generally prevalent at that time, although in some fields it was very abundant. Cutting and burning infested tops was generally recommended and to some extent practiced; but the majority of asparagus growers had not as yet become acquainted with this new danger menacing their crops.

This rust, like the well-known one of the wheat, has three different stages or forms in its development, though in this case they are all developed upon the asparagus plant, while in the other, one form comes upon the barberry bush and the other two upon the wheat and other grains and grasses. When first noticed in 1896, the asparagus rust was in the fall stage, the black rust or *teleuto* stage, the earlier stages not having attracted attention. In 1897 many asparagus fields were found to be affected as early as July 1, and by August the complaint was general throughout the asparagus-growing sections of the State. It was now the red rust, or *uredo* form, which was present, being followed again in the fall by the black form. Apparently almost every field of asparagus in the State was affected before the end of the season. The rust in most cases appeared first on young beds, — which was natural to expect, since the stalks were not being continually cut off as they appeared. In the older beds, from which the stalks were being cut for market, little or no rust appeared until well into July or August, after cutting had been suspended and the tops allowed to develop. In most cases, however, they were soon affected as badly as any. The effect of the rusting was that the tops lost their green color, and turned brown and died prematurely. Mr. George P. Davis of Bedford says in regard to his beds: "The twenty-sixth of July the tops were all turned brown, and looked as though a fire had swept over the field. There was no green to be seen. . . . In handling the tops a fine dust which looked like smoke was quite noticeable." This dust consisted of countless numbers of the spores of the fungus.

The first attempts at checking the rust were made in the fall of 1896, and consisted of cutting and burning affected tops. When the disease appeared so extensively in 1897, many growers cut the tops in August, when they had become badly rusted. It is impossible to say with much certainty what the result of the first cutting (fall of 1896) may have been, inasmuch as comparatively few beds were thus treated or badly affected at that time. A good-sized bed at the college was considerably rusted, and the tops were cut and burned late in the fall. The bed was well cultivated and fertilized, and no rust appeared upon it in 1897 (that is, not enough to be noticeable) until well into the fall, when the black rust stage was quite as abundant as it had been in 1896. Mr. S. T. Davis of Orleans also mentions having observed a small bed, which was cut in the fall of 1896, upon which no rust appeared in 1897. Whether the cutting of the tops or some other factor kept down the rust in these beds, we are not prepared to say. The cutting which was quite extensively practiced in the summer of 1897 seems to have been entirely without effect, as the rust appeared again just as badly on the second growth.

The experience of another season is necessary to demonstrate the actual effect and seriousness of this disease. Its perennial occurrence to the extent of the past season could not fail to have a disastrous effect upon the asparagus-growing industry. It is not the sort of disease which is effectually suppressed by spraying methods, though something of that sort may be developed if it becomes necessary.* It should be remembered, however, that the past season was an unusually favorable one for all fungous diseases, and consequently it may have developed much more extensively than it ordinarily would. If it could be mostly confined to its teleuto or black rust stage, which appears in the fall when the plants have practically completed their growth, it is not probable that any serious injury would result. At all events, the effect of the great prevalence of the rust in 1897 upon the asparagus crop of 1898 will be awaited with great interest by all interested in its cultivation.

The Fire Blight.

(*Micrococcus amylovirus.*)

This disease of the pear, quince, apple and other pomaceous trees has been the subject of frequent inquiry during the past season. It ordinarily causes the most damage on the pear and quince, and is one of the most destructive of plant

* Recent experiments indicate some amenability of the rust to spraying, although not more than twenty-five per cent. reduction is claimed.

diseases. The trouble appears in the branches, sometimes a whole limb of considerable size, but more often the smaller terminal twigs, being affected. These portions of the tree suddenly wilt and die, the leaves and young fruit turning black and hanging to the branches, producing the characteristic scorched appearance which gives the disease its name. It spreads rapidly about an orchard and increases from year to year, often involving the entire tree and causing its death if left unrestricted.

The cause of this trouble was long a matter of speculation, but it is now known to be a species of bacteria which gains access to the tissues of the tree and by its rapid multiplication therein causes great destruction. This disease cannot be reached by spraying, and the only remedy consists in severely cutting back all affected branches, or whole trees if badly affected. All such prunings should then be destroyed by burning. This cutting should be done whenever the disease is observed, but is especially advisable in the fall or late summer, when the trees should be carefully examined, to make sure that no diseased branches or twigs are left to perpetuate the disease over winter. As the disease affects the hawthorne (Cratægus), shad bush (Amelanchier) and mountain ash (Pirus Americana), as well as the cultivated fruits, it may spread from some of these wild trees to the latter, unless care is taken to prevent such contagion. It is not probable, however, that such infection is ordinarily at all extensive.

The Quince Rust.

(*Gymnosporangium clavipes* C. and P.)

The numerous inquiries which we have received during the past season concerning this not uncommon trouble, as well as our own observations, indicate that it has been unusually prevalent and destructive. The disease affects principally the fruit, but also the young wood, causing distortion and malformation in both cases. It is very conspicuous upon the affected quinces in midsummer, both from their distorted shape, and from the numerous white, tubular excrescences appearing upon their surface. These excrescences contain masses of the bright orange-yellow colored spores of the fungus which causes the disease. The fungus has a peculiar course of development. It not only exists in the form seen upon the quince, but has also another form or stage, living upon a different kind of plant and quite different in appearance. This stage of the fungus lives upon the red and white cedar and the juniper, and is one of the forms which produce upon those plants the abnormal growths popularly known as "cedar apples." These cedar apples are peculiar outgrowths upon the twigs of cedars and junipers, reaching their complete development in early spring. They are oftentimes regarded as the proper product of the tree, or as insect galls, — which ideas are equally incorrect. These growths begin to form in midsummer, developing as small excrescences upon the twigs and gradually increasing in size until winter, when they are nearly full grown. An "apple" consists at this stage of an abnormal mass of the cells of the tree, with the filaments of the fungus growing abundantly between them. Remaining thus over winter, the first warm, moist weather of spring starts it into further growth and development. Upon the surface of the affected wood numerous projections appear, of a conical shape, and composed of a yellow, gelatinous substance. These projections are composed of a mass of the fungous filaments and a gelatinous substance which they secrete. In them are produced the spores of this, the *teleuto* stage. These spores are composed of two cells and borne on long stalks. The sudden appearance of these peculiar growths on cedar trees just after a spring rain is often taken for the blossoming of the tree, but is in reality the fructification of the fungus parasitic upon it. The gelatinous appendages of the cedar "apples" soon dry up and wither away after the rain, but not until the teleuto spores contained in them have germinated and produced secondary reproductive bodies called *sporidia*. These are carried away in the air, and proceed to infect, not cedar trees, but quinces or one or two other related plants. Upon the surface of these they germinate and produce filaments which grow into the substance of the young fruit or stems, and by their presence there cause the distortion in shape seen in affected specimens. Upon this host the fungus forms little pustules just beneath the surface, finally breaking out into the air as tubular projections. In these are formed the yellow spores of this stage, called *æcidia*. These spores are unable to infest quinces again, but upon cedar trees begin the development of a new generation of "apples," which will in turn produce teleuto spores the following spring.

Treatment. — It is not often that the damage caused by this disease is of great extent. Sometimes, however, it becomes sufficiently troublesome to make it worth while to attempt to repress it. It is evident that the most vulnerable point of the fungus causing the trouble lies in its inability to reproduce itself continuously upon the quince. The most direct method of treatment, therefore, is to exterminate all white and red cedars and junipers from the vicinity of the orchard, and cut off all affected parts of the fruit trees, or entirely destroy badly affected ones. This, for various reasons, however, may not always be possible or desirable. As to spraying methods, it has been found quite effective to spray with Bordeaux mixture two or three times during the spring, especially during or just after rainy weather, when the spores are being disseminated. It may also be possible sometimes to remove affected twigs of cedar and juniper trees before the spores have been produced.

This same fungus has also been unusually abundant during the past season upon the fruit of various species of Cratægus (hawthorne), accompanied by an equal abundance of the closely related species, Gymnosporangium globosum, upon the leaves. We have also noticed these or related species upon the fruit of the Japanese quince (Cydonia Japonica) and mountain ash (Pirus Americana).

The Brown Rot of Stone Fruits.

(*Monilia fructigena.* Pers.)

This well-known disease found in the past summer just the conditions suited to its best development, and the peach, plum and cherry crops suffered in consequence. The disease needs no description to those who have ever tried to raise any of the above-mentioned fruits. It appears in the summer, some time after the fruit has set, often just as it comes to maturity, or even earlier in the season, the time of its appearance depending a great deal upon the weather, a warm, rainy period being liable to bring it on at any time. Indeed, it does not always wait for the production of fruit upon which to make its attacks, but often develops upon the blossoms, causing them to abort, and spreading thence into the young twigs upon which they are borne, results in their death. Upon the fruit the rotting is almost always found to some extent at the time of ripening, and, as already mentioned, often occurs earlier in the season when the weather is favorable, i. e., warm and moist. At such times the greater part of the crop is sometimes destroyed. In cherries the chief damage is done upon the ripe fruit. In peaches and plums, which have a longer season of ripening, the young fruit is more frequently affected. Early peaches are considered more susceptible to the disease than the later varieties.

The cause of this disease is a mould-like fungus (a true parasite, nevertheless), which spreads its vegetative filaments through the affected fruit and thus causes its decay. Wet weather brings about the rotting of the fruit by favoring the growth of the fungus, not by its direct effect. Fruit which is affected begins to discolor and soften, and gradually dries up and shrivels into a shrunken mass about the stone. It often remains on the tree for months, especially in the peach. In the early stages of infection the surface becomes covered over with little grayish spots of a powdery, dusty nature. These are clusters of the spores of the fungus, produced in countless numbers on the ends of filaments from the inside of the fruit which have pushed out through the surface. These spores, which serve to reproduce the fungus, are extremely minute in size, so that *en masse* they appear as a fine dust. Being easily carried by the wind, they are spread far and wide, and may thus infect a large district in a few days, under favorable conditions. After becoming dry and hard the affected fruits cease producing spores, but their period of harmfulness is not yet ended. After lying over winter in a dormant state, the fungus in them is again aroused to life by the warm rains of spring, and begins the production of spores which are ready to infect the crop about to be produced.

It has been thought practicable by some to exterminate or at least greatly reduce this disease by the destruction of all affected fruit and thus prevent the fungus from surviving through the winter. The variety of fruits upon which it can exist, however, and the practical hopelessness of accomplishing the destruction of any considerable proportion of it, together with the uncertainty of the fungus being altogether dependent upon the dormant stage found in the dried-up fruit for its existence over winter, make the success of this plan very doubtful. We would not, however, discourage the practice of removing and destroying the affected fruit, especially any remaining upon the trees over winter; for this may result in future decrease of the rotting, especially in isolated orchards or trees.

The usual methods of orchard spraying have been found to keep this disease in check to a considerable extent, though in favorable weather it will often sweep through an orchard, despite all precautions. The spraying should be begun early, and kept up through the season with considerable frequency, especially near the time when the fruit is maturing. For such spraying, Professor Maynard recommends the use of the ammoniacal copper carbonate or a weak solution of copper sulphate. Details in regard to the treatment of this disease may be found in Bulletin 44 of this station.

The Chrysanthemum Rust.

(*Puccinia Tanaceti*, S.)

In the last annual report a rust upon chrysanthemum leaves was described, this being, as far as known, the first published mention of such a disease. The specimens were sent by Mr. G. H. Hastings of Fitchburg, who had experienced heavy loss as the result of the rust. This was the only occurrence of the disease encountered during 1896.

This year it has appeared in many places, both in this and other States, occasioning considerable loss, as it is often very destructive to infected plants. It is not yet generally known, however, among those who cultivate the chrysanthemum, though we fear that it may be by another year. Judging from the history of many similar diseases (asparagus rust, carnation rust, hollyhock rust, etc.), it will not be surprising if a general epidemic of this disease occurs next year. It will be well worth while, therefore, for growers to take precautions for guarding against it as much as possible, especially those whose stock is already infected. Great care should be exercised to get cuttings from vigorous plants, unaffected by the rust; and it will no doubt be profitable in the end to spray them a few times during the summer with the Bordeaux mixture or potassium sulphide, using one ounce of the latter in two gallons of water, or stronger, if the leaves will stand it. Should the rust appear on the young plants, they should certainly be sprayed at once and at frequent intervals thereafter, and the affected plants removed and destroyed. It will be useless to try to save them as they are doomed to destruction, or at best will only attain a weak, sickly, worthless growth. When the plants are placed in the benches for the fall, great care should be taken that no rusty specimen goes in, else it may bring about the ruin of the entire lot. Further than these suggestions little more can be said about the disease until time shall have shown what its seriousness may be and to what extent it can be controlled.

There are several other diseases affecting the leaves of the chrysanthemum, so that some may be in doubt whether their plants are really infested with the rust. It causes discoloration of the leaves, like other less destructive diseases, but may be distinguished from them by its production of small pustules, of a dark-red, powdery substance, on the under side of the leaves, something as in the carnation rust. This red powder consists of the spores of the fungus, which reproduce and disseminate it.

A Disease of the Cultivated Geranium.

During the past summer there appeared upon the leaves of some geranium plants upon the college grounds a disease which appears to be different from anything heretofore described. The plants in question grew in a long border bed, and comprised several different varieties. Along the back edge of the bed, trees and low shrubbery hung over to a considerable extent, so that the plants in that portion were quite shaded, while those in front were exposed more directly to the sun. The disease came on in the latter part of July, during the rainy weather then prevailing. The leaves began to turn yellow in small spots, which gradually increased in size, the leaf tissue dying away at those points; thus the leaves soon became covered with dead spots of considerable size, and finally lost their vitality completely. The plants in the front of the bed were most affected, those in the shaded portion showing little or none of the disease. All varieties, as above mentioned, were equally affected. The plants were sprayed with the Bordeaux mixture, but with no apparent success. The same disease was brought to our notice in Northampton and also in the eastern part of the State.

The trouble appeared to be the result of the attack of some fungus, but investigation of the affected leaves failed to reveal any such organism. Neither was there any evidence of the presence of insects. Numerous bacteria, however, were found in all affected tissue, and appeared to be the cause of the spotting of the leaves. We do not consider this a genuine disease of the geranium, nor do we expect to find it occurring in the future. That the plants were in a condition of low vitality and hindered growth by reason of the excessive moisture, and hence were an easy prey to organisms which ordinarily would be unable to affect them, seems the most probable explanation. The futility of spraying to prevent such a disease becomes apparent when its real nature is revealed.

Some Leaf Blights of Native Trees.

During the past season several different kinds of trees have been so generally affected with certain leaf-attacking fungi as to become almost entirely defoliated before the end of the summer. While of no great economic or practical importance, these attacks have been so marked and their effects so conspicuous that a brief description of the nature of the trouble may be of interest. The following diseases were generally prevalent wherever the host trees occurred, over the considerable portion of New England which we visited during the summer.

A Leaf Blight of the Sycamore or Buttonwood.

(*Glocosporium nervisequum* Fckl. Sacc.)

Numerous inquiries reached us during the spring and early summer concerning the very prevalent and destructive blighting of the leaves of the sycamore tree (*Platanus occidentalis*). It is probable that every good-sized tree of this species in the State was attacked by the disease. The younger trees were apparently, for some unexplained reason, less susceptible. The trouble appeared in May, when the trees, which had just leaved out, appeared as if they had been nipped by a frost or scorched by fire. The leaves withered and turned brown, the new twigs were killed and many of the leaves fell to the ground. In this condition the trees lost all beauty, and became unsightly objects. This disease is not entirely new in this State, although it has never been so generally prevalent before. It was first described in Germany in 1848, and has been common in various parts of Europe since then. In this country it has occurred mostly within the last fifteen years. It first appeared in the District of Columbia, Ohio, Kentucky and other parts of the country south of here, but is now widespread.

The cause of this disease is a parasitic fungus, growing in the leaves and young twigs of the tree, and causing their death. Several other fungi are usually found in connection with the disease, and may have something to do in causing it. This disease is a very serious drain upon the vitality of the tree, and often results in its death. Its occurrence early in the season, however, favors the tree, since it has a chance to, and in fact does, produce a new crop of foliage to carry it through the season. This exhausts the tree, however, and if repeated for several seasons is likely to cause its death.

As to a remedy for this disease, there is little to say. Spraying with fungicides is not to be practically considered, on account of the size and small economic importance of the tree. Gathering and burning diseased branches and leaves might lessen the trouble somewhat; but, if the disease continues to prevail, it will probably be best in the end to dispense with the sycamore as an ornamental tree, and plant something else instead.

A Leaf Blight of the Butternut.

(*Glocosporium Juglandis* (Lib.) Mont.)

No fungous disease has been more noticeable throughout the State during the past season than this. It first became apparent in July, when butternut trees were noticed to be losing their foliage. Examination showed that the rapidly falling leaflets were covered with dead and discolored spots, and had lost their vitality. All trees were not affected in the same degree, as some were almost completely defoliated in August, while others were attacked later or lost their leaves more slowly. By October 1, however, it was almost or quite impossible to find a butternut tree which had not lost the greater part of its leaves.

The cause of the trouble is a fungus, which lives in spots in the leaf, killing the tissue at these points and gradually causing the death of the whole leaflet, so that it falls to the ground. The disease spreads rapidly from leaf to leaf and from tree to tree, and many trees are soon defoliated. It is a well-known fungus, but has been unusually abundant this year.

A Leaf Spot of the Chestnut.

(*Septoria ochroleuca* (B. and C.)

This is another disease, quite similar to those above described, which has been very prevalent this year. It first became noticeable in July, when the ground under chestnut trees was covered with fallen leaves. Upon these leaves the fungus manifested itself very prominently in small, round, dead spots, about one-eighth of an inch in diameter, scattered over the surface more or less abundantly. These spots are the points where the fungus has become established and killed the tissue. The fungus, like all those causing these diseases, reproduces itself by spores, which are produced in minute cavities in the dead area, usually on the under side of the leaf. Almost all the leaves on affected trees become dotted over with the little dead spots, and most of them fall to the ground before their time, thus weakening the tree. The disease is not, however, an especially destructive one, except to the beauty of the tree.

A Leaf Spot of the Wild Black Cherry.

(*Septoria cerasina*, Pk.)

The well-known "shot-hole" fungus, which often causes extensive damage to the plum and cherry, has been exceedingly abundant this year upon the leaves of the wild black cherry (*Prunus serotina*), many trees being almost entirely leafless in August. This fungus attacks the leaves of plums and cherries of several species, producing dead spots upon them, and eventually causing their death. In connection with the wild cherry the disease has little economic importance, except as it may spread from that tree to cultivated species. On this account, the destruction of the wild cherry, so desirable for the repression of the black knot and tent caterpillar, is even more advisable.

BACTERIAL BLIGHT OF GERANIUM

QUINCE.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The lines of work in this division the past season have been largely the same as for 1896.

Raspberry Seedlings.

The collection of raspberry seedlings, now three years old, produced a large crop of fruit the past season, and many most promising varieties were found among them. These seedlings were from the hybrid or purple-cap variety *Shaffer*. They produced a great variety of forms, from the black-cap type (*Rubus occidentalis*), the hybrid type of the parent, to some of the most beautiful forms of the red raspberry (*Rubus strigosus*) and to albino forms of both species. Careful records of the hardiness of cane, vigor of growth, time of ripening, productiveness and quality were made during the season, and at this time the plantation is a very handsome one.

Another collection of seedlings from the same source, but one year younger, also shows many interesting forms of growth.

Seedling Currants.

About three hundred seedling currant bushes two years old have made a good growth and show many interesting varieties.

Grape Seedlings.

The collection of seedling grapes, numbering some six hundred varieties, is very interesting. The growth has been very vigorous and healthy, and most of them are in a condition to yield enough fruit next season to determine something of their value. From the appearance of the foliage and the growth of vine we may look for a great variety of types of fruit.

Strawberry Seedlings.

This collection, numbering about four hundred varieties, is in a very fine condition, and some varieties have shown decided merits.

Named Kinds of Strawberries.

Many new varieties of strawberries of decided merit have been added to the collection. Many of the older varieties of little merit have been discarded, and the plots at this time never looked so well.

Strawberry Field.

The field crop is planted on the knoll south of the old farm buildings, and is in a remarkably good condition. This land is of a gravelly nature, but with a retentive subsoil of hardpan, which in an ordinarily moist season may be depended upon to produce a large crop of fruit, but in a very dry time suffers severely. The land slopes in such a manner that either the trench system or the spraying systems of irrigation or sub-irrigation can be employed in case of drought. Two reservoirs on the grounds are available for this purpose, and the three methods may be comparatively tested. A considerable quantity of two and one-half and two inch pipe on hand is available for this work. This need not be of any great expense, while its importance is very great, as no comparative results have ever been obtained that show whether any of the methods can be profitably employed, or which is the most valuable.

Variety Testing.

The value of the comparative tests of varieties of fruits, vegetables, flowers, etc., is often discussed. That it is a legitimate and important part of the work of the stations is shown in the demand made for the publications recording the results of such tests. When we consider the large number of new varieties of fruits, vegetables, etc., offered to the public every year at high prices, with the claim of merits for them far above those of the standard sorts, and which the average grower cannot afford to buy and test, it is certain that the stations can save the people much loss and expense.

In the work of variety testing at this station in past years, the reports show that the new varieties reported as being the most valuable have been those that later were considered most valuable and were most largely grown by the commercial grower, while the varieties reported as having little or no value have been everywhere soon discarded by the growers who tested them. This work would be of much greater value, without doubt, if one or more sub-stations in different parts of the State could be established, where the same varieties could be tested under different conditions of soil and exposure.

The large number of new varieties of all kinds of fruit, vegetables, etc., being introduced every year, and generally with extravagant claims of merit, renders this work of the Experiment Station imperative, and the people should refuse to purchase such varieties until they have the endorsement of the stations of several States. A single season's trial of a variety is of very little value. It requires several years, at least, to prove the value of vegetables or even the more early maturing small fruits, while tree fruits require a much longer period.

Other Experiments.

Among the other experiments now under way may be mentioned the destruction of greenhouse insects by the use of hydrocyanic acid; the testing of the value and keeping qualities of some fifty-five varieties of celery; sub-irrigation in growing lettuce under glass; the use of different kinds of mulch for strawberries; methods of overcoming the asparagus rust; testing varieties of dwarf Lima beans, etc.

Reports will soon be made of the results of the variety tests of fruits, vegetables, etc.; the use of "Laurel Green" as an insecticide and fungicide; of arsenate of lead as an insecticide; and of other work done during the year.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. Lindsey.
Assistants, E. B. Holland, F. W. Mossman, B. K. Jones, H. H. Roper.

Part I. — Laboratory Work.

Outline of Year's Work.

Part II. — Feeding Experiments and Dairy Studies.

Part I.

Extent of Chemical Work.

The work of the chemical laboratory connected with this department has very materially increased during the past year. There have been tested 150 samples of water, 197 samples of milk, 2 samples of oleomargarine, 1 sample of butter, 123 samples of miscellaneous substances. In addition to the above, which were sent to the station for examination, there have been analyzed 260 samples of milk and 388 samples of feed stuffs, in connection with experiments in progress by this and other divisions of the station, making a total of 1,147 substances which have passed through the laboratory within twelve months. There have also been carried on, for the Association of Official Agricultural Chemists, chemical investigations, relative to the methods best adapted for the estimation of starch in agricultural products. This has involved a great amount of chemical work, the extent of which it is impossible to express in mere figures.

Character of Chemical Work.

Water. — The analyses of water have been made by the same methods as heretofore, and with the same end in view, namely, to aid farmers and others in guarding against the danger arising from the use of waters coming from polluted springs and wells. Illness frequently occurs in the family, the cause of which it is often difficult to explain, until an examination of the water reveals its pollution with sink, privy, stable or other drainage. The waters tested show much the same condition as in former years; in round numbers, 15 per cent. could be pronounced excellent, 40 per cent. fair, 25 per cent. suspicious and 20 per cent. dangerous for drinking. Fully 50 per cent., therefore, were considered of a suspicious character. Three samples were found to contain lead, and had been known to have produced lead poisoning. We can only repeat the advice given in former years, in cautioning all who are obliged to depend upon wells and springs for their water supply to take every precaution to prevent any drainage from entering, and to keep the grounds about the well or spring free from all objectionable matter. Lead pipes should never be used to draw water through, especially if the water is free from mineral matter (soft).

Milk. — The most of the milk received at the station has been sent by farmers who ship their milk to Boston contractors. They had probably been notified by the contractors that their milk was below the Massachusetts standard,* and they wished to ascertain its exact quality, and what, if anything, could be done for its improvement. The larger part of this milk was found to contain 12 to 12.5 per cent. of solids and from 3.25 to 3.50 per cent. of fat, and was in all probability the unadulterated product of the cow. The contractor, however, because of the large amount of milk

* The Massachusetts standard calls for 13 per cent. solids and 3.70 per cent. fat, excepting during April, May, June, July and August, when but 12 per cent. solids and 3 per cent. fat are required.

offered, can afford to be particular, and desires only that up to, or above the legal standard. In such cases there is nothing for the farmer to do but to add some grade Jersey or Guernsey cows to his herd. It certainly would be a long step forward, if milk were sold not simply as milk, but with a guarantee of composition. Milk containing 11.5 per cent. solids and 3 per cent. of fat should surely bring less per quart than milk containing 12, 13 or 14 per cent. solids, and 3.25, 4 or 5 per cent. fat.

Cattle Feeds.—At its session of 1897, the State Legislature passed a law authorizing the inspection of feed stuffs. The work is being carried out by this department, and it is hoped that it will result in keeping out poor and adulterated material, and in keeping the regular articles of as constant a composition as possible. Considerable adulterated cotton-seed meal was found on the market during the early spring months. This material consisted of a mixture of hulls and meal, the former ground very fine in order to conceal its identity. The adulterated product contained from 22 to 30 per cent. of protein, while a prime meal should show from 40 to 45 per cent. Farmers were warned through the agricultural and daily papers of the presence of the adulterated article, and cautioned against its purchase. The result of this has been to produce a feeling of uncertainty and to restrict the use of the genuine article. To overcome this, the American Cotton Oil Company have placed a guarantee of composition upon every bag put out by them. It is hoped other manufacturers will follow this example. *Farmers should by all means give the preference to the guaranteed article.*

Other new feed stuffs are those put out by the H. O. Company, under the name of dairy, horse and poultry feeds. The feeding values of these feeds are being investigated. Varieties of oat feeds, being mixtures of oat hulls with more or less corn meal, are found in the market without name or guarantee. Farmers are cautioned against their purchase, for the reason that the price asked is, as a rule, considerably in excess of their feeding value.

Methods for the Determination of Starch.—The work undertaken for the Association of Official Chemists, already alluded to, has been reported to them. While more work will be done along this line, it has been quite clearly demonstrated that the so-called Maercker and Reinke methods for the estimation of starch in agricultural products are faulty, and will give altogether too high results. The only method from which reasonably accurate results may be expected is the diastase or malt method,* and this method has been adopted by the official chemists in place of all others.

PART II.

EXPERIMENTS WITH PIGS.

Two experiments have been completed with pigs, and a third is now near completion. These experiments were designed to study the value of corn meal as compared with hominy and cerealine feeds for pork production, when fed in combination with skim-milk. Both these feeds are quite similar in composition. They consist of the hull, germ and more or less bran and starch removed from white corn, during the preparation of cracked hominy and cerealine flakes for human consumption. Cerealine is much more bulky than the hominy feed. These experiments will be published in detail later. It can be said, however, that pigs have made nearly, and in some cases fully, as good growth on these feeds as on an equal amount of corn meal.

SALT MARSH HAY.

A thorough investigation has been completed concerning the general character and feeding value of salt marsh hay. The results are being published in bulletin form. The practical conclusions, briefly stated, are as follows: —

The several varieties of salt hay have, ton for ton, from 10 to 17 per cent. less feeding value than average English hay. When 10 to 12 pounds of salt hay were fed daily, together with 7 or 8 pounds of grain and a bushel of ensilage, the ration produced within 2 to 5 per cent. as much milk and

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* Sachsse's method can be used for estimating starch in commercial starch and in potatoes.

butter as an equal amount of English hay similarly combined.

Because of the less market value of salt as compared with English hay, rations containing the salt hay, as given above, produced milk and butter from 10 to 20 per cent. less than did rations containing English hay. No objectionable flavor was noticed when the salt hay was fed directly after milking.

It is undoubtedly wise for farmers living near the salt marshes to feed salt hay and sell English hay. For the results in detail, and a fuller discussion, see the bulletin.

Digestion Experiments.

During the past year we have studied the amount of actual nutriment in salt hays, to which reference has already been made, in a number of new by-products and in green crops for soiling. Many of our results, together with practical conclusions therefrom, will soon be ready for publication.

COTTON-SEED FEED AS A HAY SUBSTITUTE FOR MILCH COWS.

J. B. LINDSEY, E. B. HOLLAND AND B. K. JONES.

The Experiment concisely described.

What Cotton-seed Feed is. — The seeds of the cotton plant are irregular, egg-shaped in form, and almost hidden by a tuft of white fibre which covers their surface. The meat of the seed is covered with a thick, tough hull of a black color. Machines have been invented to remove this hull, and the meat is subjected to warm pressure for the purpose of removing as much as possible of the oil. The pressed meat or cake is ground, and results in the decorticated, bright yellow cotton-seed meal of commerce. The black hull, covered with the white fibre, was formerly almost entirely used as fuel, and the ashes were sold for fertilizing purposes. Of late many southern farmers, at the recommendation of experiment stations in the south, have been mixing these hulls with the cotton-seed meal and feeding them to beef and dairy cattle, with very good success. Within the last few years this material, under the name of *cotton-seed feed*, has been offered in our Massachusetts markets. The manufacturers claim that the feed consists of 1,600 pounds of hull and 400 pounds of meal, thoroughly mixed by machinery. The price charged has been $13 per ton in car lots, delivered in Massachusetts, which would be equivalent to at least $15 in single tons. The feed, shipped in bags, is quite bulky, and, because of the white fibre covering the hull, looks somewhat like wool waste. Its color is light yellow, due to the admixture of the cotton-seed meal.

The Experiments briefly stated.

The experiment station has conducted four experiments with this feed, two with milch cows and two with sheep.

The feed for the first experiment was furnished by the manufacturers. In the second experiment we procured the separate ingredients, and mixed the feed ourselves. Each of the two milk experiments was made with six cows. In the first experiment the feed consisted of a constant grain and ensilage ration, together with a good quality of first-cut hay and cotton-seed feed; in the second experiment there was a constant grain and mangel ration, in addition to the hay and cotton-seed feed. The cotton-seed feed was looked upon as being similar in character to hay, and, in attempting to get at its value, from 12 to 15 pounds were substituted daily for a like quantity of hay. The first experiment lasted twenty-one days and the second twenty-eight days. In case of digestion experiments, in which six single tests were made, some of the sheep received nothing but the cotton-seed feed, and others received half hay and half of the feed. While the cotton-seed feed has not an attractive appearance, the animals in all cases ate their daily rations with no apparent objections.

The Results.

I. The total average gain of the six cows in live weight during the cotton-seed period was 95 pounds, and during the hay period 166 pounds.

II. The production of milk, milk solids and butter fat was so nearly alike in the average of both experiments as to be within the limits of experimental error.

III. The cost of producing milk and butter with the hay and with the cotton-seed ration varied but very little.

IV. A ton of cotton-seed feed contained about 964 pounds of digestible matter, and a ton of the hay about 1,007 pounds of digestible material.

V. A full description of the experiments, together with all data bearing on the results, will be found further on.

Is Cotton-seed Feed economical for Massachusetts Farmers?

There would unquestionably be no advantage for the average farmer to feed this material in place of hay, unless he could sell his hay for a sufficient advance over the cost of the feed to warrant the change. Milkmen in the vicinity of large cities, and others who are obliged to purchase their coarse feed, might find it to their advantage to use some of this material, especially if it could be bought for less than a good quality of hay. It is possible that animals would tire of this feed sooner than of hay. The cows used by the station consumed it continuously for over a month with no seeming objections. The cotton-seed feed must be looked upon from a feeding stand-point in the light of a hay substitute, and not as a grain feed, and only 8 to 10 pounds should be fed each animal daily, in place of a like amount of hay or other coarse fodder. Southern rather than northern farmers can utilize cotton-seed feed to the best advantage.

The Experiments in Detail.

In 1889 Stone * records the fact that increasing quantities of cotton-seed hulls and various mixtures of hulls and cotton-seed meal were being fed by the farmers of the south for beef and milk production. Since 1889 a great variety of digestion and beef-producing experiments have been made by the North Carolina station,† which have been productive of a large amount of information relative to the physiological and economic value of cotton-seed feed. The Texas experiment station ‡ has made experiments with milch cows to study the economic value of this feed in a variety of fodder rations.

In 1894 Armsby § published the results of two experiments with cotton-seed feed. In the first experiment the cows, five in number, were fed as follows: Ration I. consisted daily of 7.95 pounds of wheat bran and 11.69 pounds of cotton-seed feed; while Ration II. contained 3 pounds of cotton-seed meal, 7 pounds of corn meal, 6 pounds of corn fodder and 3.27 pounds of hay. Practically, the corn meal and cotton-seed meal of the second ration were matched against the bran, and cotton-seed meal contained in the cotton-seed feed of the first ration, leaving the corn fodder

* Tennessee Experiment Station, Vol. II., No. 3, 1889.

† Bulletins 80*c*, 81, 87*d*, 93, 97, 106, 109, 118.

‡ Bulletin 33, 1894.

§ Report Pennsylvania Experiment Station, page 44, 1894.

and hay to be compared with about the same quantity of cotton hulls. The results, as would naturally be expected, were in favor of Ration II. This latter ration contained also 4 pounds more of digestible matter. In the second trial, six cows were each given daily 6 pounds of Buffalo gluten feed and 2 pounds of wheat bran. Ration I. contained in addition 10.6 pounds of cotton-seed feed, and Ration II. 4 pounds of corn meal and 9.7 pounds of clover hay. It is not possible to regard this as a fair comparison, for any one can see at a glance that 4 pounds of corn meal and 9.7 pounds of clover hay (13.7 pounds) must give better results than 10.6 pounds of cotton-seed feed. At least a fairer comparison would have been to have matched the cotton-seed feed against a like quantity of clover hay. Simply because cotton-seed feed consists of a mixture of cotton-seed hulls with cotton-seed meal, it is not at all necessary when making a comparison to put the like amount of cotton-seed meal or other grain into the opposite ration. By so doing, one simply compares cotton-seed hulls with some other fodder or fodder combination. The hulls themselves have an inferior nutritive value; experiments have demonstrated that their nutritive effect is increased by the addition of the cotton-seed meal. In order, therefore, to get at the feeding value of this material, it must be regarded as a single feed stuff, and ought to be compared with other coarse fodders of similar composition. It has been the aim of the experimenter, in the two experiments that follow, to make such a comparison.

A. Composition of Cotton-seed Feed.

The first lot of feed, supplied through the kindness of Mr. H. C. Haskell of the Southern Cotton Oil Company of Savannah, Ga., was said to have been mixed in the proportion of 1,600 pounds of hulls to 400 pounds of meal. The lot for the second experiment we prepared ourselves, in the same proportion. The two lots varied very little in moisture, but, for the sake of more exact comparison, the results are presented in dry matter.

	No. 1 (Per Cent.).	No. 2 (Per Cent.).	Theoretical Protein Content of No. 2 (Per Cent.).	Composition of Two Samples of Hay fed in the Two Experiments (Per Cent.).	
				I.	II.
Ash,	3.82	3.51	–	5.94	5.78
Protein,	13.02	11.98	13.85	11.07	8.41
Fibre,	39.67	40.69	–	32.00	33.98
Extract matter,	39.59	40.13	–	47.92	49.15
Fat,	3.90	3.69	–	3.07	2.68

Both Nos. 1 and 2 run rather below the theoretical percentage of protein. This is not surprising, from the fact that it is extremely difficult to get a strictly average sample of this feed. It is impossible to grind the hulls fine, and in spite of all one can do, more or less of the meal will fall through the hulls and not be included in the sample. It will be noted that the cotton-seed feed and the hay resemble each other in chemical composition, excepting that the cotton-seed feed contains somewhat more fibre and less extract matter.

B. Digestibility of Cotton-seed Feed.

Recognizing the valuable information secured by digestion tests, six single trials with sheep were made of the two samples of feed. The sheep were grade Southdown mature wethers. In four cases the cotton-seed feed was fed alone, and in the remaining two the daily ration consisted of one-half hay and one-half cotton-seed feed. In both cases the results agree quite closely, except in case of the fat, which showed a digestibility of 98 per cent. when the cotton-seed feed was fed in connection with hay. This high result it was thought best to exclude from the average. The cotton-seed feed appeared to agree better with the sheep when fed in connection with hay than when fed by itself. In the latter case, at the close of the period the sheep began to show signs of digestion disturbances, which would certainly have become quite pronounced had the feeding been continued much longer. The digestibility of the two different samples of cotton-seed feed was practically the same. The North Carolina station has made a very extended study of the digestibility of hulls and meal fed in different proportions. The Pennsylvania station has also made three single determinations. These results, in addition to our own, are tabulated below: —

Digestion Coefficients.

	Proportions fed.	Number Single Determinations.	Dry Matter (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Extract Matter (Per Cent.).	Fat (Per Cent.).
Massachusetts station,	4-1	6	56	41	56	59	92
North Carolina station,	6-1	2	46	46	40	50	82
North Carolina station,	4-1	2	54	54	45	58	85
North Carolina station,	3-1 1½-1	9	54	64	47	54	85
Pennsylvania station,	5-1	3	43	36	31	54	84
Hay of mixed grasses with ten per cent. protein for comparison.	-	-	58	58	60	59	48

The experiments made by the North Carolina station (4–1) and by the Pennsylvania station were carried out with steers. The only difference between the results obtained by the Massachusetts station and those recorded by the North Carolina station (4–1) consists in the higher percentage of protein and the lower percentage of fibre digested by the steers in the North Carolina experiments. The coefficients for fat digestibility also show some variation, but, the fat percentage being comparatively small, the difference is not of so much account. The coefficients obtained by Armsby are lower than would be expected. The coefficients of digestibility for an extra quality of hay are not very noticeably higher — excepting the protein — than those for the cotton-seed feed.

According to the average coefficients of digestibility, a ton of the hay and a ton of the cotton-seed feed fed in the milk experiments would contain the following amounts of digestible organic nutrients : —

One ton hay, ...	1,007.3
One ton cotton-seed feed, ...	964.4

One would therefore suppose that a ton of cotton-seed feed would have nearly the same feeding value as a like quantity of hay. There might be one exception to the above statement, in that it is possible that rather more energy would be required to digest the cotton-seed feed than the hay.

C. Milk Experiments with Cotton-seed Feed.

Experiment I.

This experiment was conducted during April and May, 1896. The animals, six in number, were evenly divided into two lots. In order to counteract the natural milk shrinkage, three of the animals in the first half of the experiment were fed the cotton-seed feed ration, while the other three were having the hay ration. In the second half this order was reversed. Each half of the experiment lasted twenty-one days, and from seven to ten days were allowed between the halves.

History of the Cows.

NAME.	Breed.	Age (Years).	Last Calf dropped.	Number of Days with Calf.	Milk Yield at Beginning of Experiment (Pounds).
Ada, . .	Grade Ayrshire,	7	Oct. 1	106	19
Red Spot, .	Grade Durham, .	6	Sept. –	90	21
Bessie, .	Grade Ayrshire,	7	Sept. 10	69	25
Beauty, .	Grade Jersey, .	5	Sept. 15	96	20
Red, . .	Grade Durham, .	7	Oct. 8	141	20
Spot, . .	Grade Durham, .	7	Oct. 8	141	20

Five of the above cows had been in two previous experiments since October, 1895.

Dates of the Experiment.

	Cotton-seed Ration.	Hay Ration.
April 8 through April 28, . . .	Cows 3, 4, 5	Cows 1, 2, 6
May 11 through May 31, . . .	Cows 1, 2, 6	Cows 3, 4, 5

Rations consumed Daily (Pounds).

PERIOD.	Name.	Hay.	Cotton-seed Feed.	Wheat Bran.	Peoria Gluten Feed.	Linseed Meal.	Millet and Soy Bean Ensilage.
Cotton-seed feed.	Ada, . .	–	10	2	3	1	15
	Red Spot, .	–	13	3	2	2	20
	Bessie, . .	–	15	3	2	2	20
	Beauty, . .	–	15	3	2	2	20
	Red, . . .	–	15	3	2	2	20
	Spot, . .	–	13	3	2	2	20
Hay.	Ada, . .	10	–	2	3	1	15
	Red Spot, .	13	–	3	2	2	20
	Bessie, . .	15	–	3	2	2	20
	Beauty, . .	15	–	3	2	2	20
	Red, . . .	14.2	–	3	2	2	20
	Spot, . .	13	–	3	2	2	20
Average cotton-seed feed.		–	13.5	2.83	2.17	1.83	19.17
Average hay, . .		13.47	–	2.83	2.17	1.83	19.17

Although but three of the six cows received the same ration at the same time, each animal received during the experiment the two different rations for exactly the same length of time. It will be observed that the only difference between the rations consists in the substitution of the cotton-seed feed for the hay, and *vice versa.* The entire rations were eaten clean, excepting a small amount of hay refused by Red, which was preserved, analyzed and deducted from the total fed. The feeds were weighed out daily and given in two portions. Water was before the animals constantly. The cows were carded daily, and allowed the run of a yard in pleasant weather.

Digestible Nutrients in Daily Rations (Pounds).

Period.	Name.	Total Dry Matter.	Digestible.				Nutritive Ratio.
			Protein.	Carbohydrates.	Fat.	Total.	
Cotton-seed feed	Ada,	17.36	1.77	8.30	.67	10.74	1:5.63
	Red Spot,	21.88	2.23	10.10	.82	13.15	1:5.45
	Bessie,	23.42	2.31	10.82	.86	13.99	1:5.61
	Beauty,	23.42	2.31	10.82	.86	13.99	1:5.61
	Red,	23.42	2.31	10.82	.86	13.99	1:5.61
	Spot,	21.88	2.23	10.10	.82	13.15	1:5.45
Hay	Ada,	17.30	1.92	8.74	.50	11.16	1:5.20
	Red Spot,	21.81	2.42	10.70	.59	13.71	1:5.03
	Bessie,	23.90	2.57	11.05	.64	14.26	1:4.92
	Beauty,	23.90	2.57	11.05	.64	14.26	1:4.92
	Red,	23.19	2.53	10.72	.63	13.88	1:4.86
	Spot,	21.81	2.42	10.70	.59	13.71	1:5.03
Average cotton-seed feed.		21.89	2.19	10.16	.82	13.17	1:5.56
Average hay,		21.99	2.41	10.49	.60	13.50	1:4.99

The coefficients of digestibility for the cotton-seed feed and for the hay used in calculating the above digestible nutrients were those obtained in our experiments with sheep. Average coefficients were used for the grain feeds. The above results show but little variation in the digestible amounts of the several groups contained in the two rations.

Weight of Animals at Beginning and End of Experiment (Pounds).

		Ada.	Red Spot.	Bessie.	Beauty.	Red.	Spot.	Total Herd Gain.
Cotton-seed period,	Beginning,	771	891	795	937	1010	967	10
	End,	771	888	792	928	1025	977	
Hay period,	Beginning,	775	892	861	1000	1070	965	40
	End,	775	902	855	1012	1082	977	

Two weights were taken of each animal at the beginning and two at the end of the experiment. No marked variations were noted due to the influence of either ration.

Yield of Milk and Butter.

PERIOD.	Cows.	Total Yield of Milk (Pounds).	Daily Yield of Milk (Pounds).	Daily Yield of Milk (Quarts).	Total Milk Solids (Pounds).	Total Butter Fat (Pounds).	Total Butter (Pounds).	Daily Yield of Butter (Pounds).
Cotton-seed Feed.	Ada,	395.48	18.83	8.76	54.60	19.53	22.78	1.08
	Red Spot,	439.12	20.91	9.72	62.58	22.89	26.70	1.27
	Bessie,	542.11	25.71	11.96	73.50	26.67	31.11	1.48
	Beauty,	444.00	21.14	9.83	66.99	24.99	29.15	1.39
	Red,	416.62	19.82	9.22	58.38	21.00	24.50	1.17
	Spot,	337.25	16.06	7.47	50.82	18.27	21.31	1.01
Hay.	Ada,	402.71	19.18	8.92	54.60	18.60	21.70	1.03
	Red Spot,	458.75	21.84	10.16	64.05	21.29	24.84	1.11
	Bessie,	526.86	25.09	11.67	70.35	23.81	27.78	1.32
	Beauty,	399.89	19.04	8.86	58.17	20.35	23.74	1.13
	Red,	275.50	13.12	6.43	38.22	12.84	14.98	.71
	Spot,	419.50	19.98	9.29	61.53	22.11	25.80	1.23
Total cotton-seed feed,		2,574.58	122.47	56.96	366.87	133.33	155.55	7.40
Total hay,		2,483.21	118.25	55.33	346.92	119.00	138.84	6.60
Percentage increase cotton-seed feed over hay.		3.6+	-	-	5.44+	10.76+	-	-

The cotton-seed feed ration gave a slightly larger amount of milk than the hay ration. A 5.4 percentage increase in the amount of total solids is also noted, while fully ten per cent. more butter fat was produced by the cotton-seed ration. This latter result could hardly have been expected. Should cotton-seed feed exert a favorable influence in increasing the relative amount of butter fat in the milk, other experiments would show similar results, which we shall presently show has not been the case. A part of the decrease in the amount of milk, solids and fat produced by the hay ration can be accounted for in the sudden shrinkage of Cow V. (Red) in the second (hay) period. This cow was a grade Durham, and at the beginning of her second period was about 105 days from calving time. She began then to dry off rapidly, showing a shrinkage of 34 per cent. in yield of milk from that produced in the previous period, while other animals shrank only from 5, to in one case 20 per cent. Had Red shrank only 20 per cent., the total decrease in milk yield in the hay period would have been but a trifle over 1 per cent. The results of this experiment make rather more of a favorable showing for the cotton-seed feed than one would naturally expect, judging from its composition and digestibility. Before, therefore, drawing positive conclusions, the reader is referred to the results of a second experiment, described further on.

Dry and Digestible Matter required to produce Milk and Butter (Per Cent.).

Dry Matter required to Produce —	Cotton-seed Period.	Hay Period.	Digestible Matter required to produce —	Cotton-seed Period.	Hay Period.
100 pounds milk, . .	107.10	111.56	100 pounds milk, .	64.40	68.49
1 pound milk solids, .	7.52	7.98	1 pound milk solids, .	4.52	4.90
1 pound milk fat, . .	20.69	23.27	1 pound milk fat, .	12.44	14.28
1 pound butter, . .	17.75	19.99	1 pound butter, . .	10.68	12.27

Market Cost of Feed Stuffs.

Wheat bran, ...	$15 00	per ton.
Peoria gluten feed, ...	15 00	"
Linseed meal, ...	20 00	"
Millet and soya bean ensilage, . .	3 50	"
Hay, ...	15 00	"
Cotton-seed feed, ...	15 00	"

With the above figures as a basis, we obtain the following figures for the cost of feed required to produce milk and butter: —

	COWS.	Daily Feed (Cents).	100 Pounds Milk (Cents).	Quart of Milk (Cents).	Pound Butter Fat (Cents).	Pound Butter (Cents).
Cotton-seed period.	Ada,	14.87	79.00	1.69	15.99	13.77
	Red Spot,	19.00	90.90	1.95	17.43	15.00
	Bessie,	20.50	79.70	1.71	16.14	13.85
	Beauty,	20.50	97.00	2.08	17.23	14.03
	Red,	20.50	103.40	2.22	20.50	17.52
	Spot,	19.00	118.20	2.54	21.84	18.81
Hay period.	Ada,	14.87	77.50	1.67	16.71	14.43
	Red Spot,	19.00	87.00	1.87	18.81	16.10
	Bessie,	20.50	81.70	1.76	18.14	15.53
	Beauty,	20.50	107.60	2.31	21.13	18.14
	Red,	19.90	151.70	3.09	32.62	28.03
	Spot,	19.00	95.00	2.05	18.09	15.45
Average cotton-seed feed period.		19.06	94.70	2.03	18.19	15.49
Average hay period,		18.96	100.10	2.12	20.92	17.94

The two rations costing the same, the cost of producing milk and butter was rather favorable to the cotton-seed feed ration.

Experiment II. (1896).

In view of the results obtained in the first experiment, it was thought advisable to conduct a second under practically the same conditions. The six cows were all approximately fresh in milk. The experiment was carried out in exactly the same way as the preceding one.

History of Cows.

NAME.	Breed.	Age (Years).	Last Calf Dropped.
Mary, ...	Grade Jersey, . .	9	July 1.
Jennie, . . .	Grade Guernsey, .	6	September.
Nora, . . .	Grade Jersey, . .	10	August 23.
Beauty, . . .	Grade Jersey, . .	6	September 15.
Red, ...	Grade Durham, . .	8	August 20.
Spot, ...	Grade Durham, . .	8	August 17.

The cows were farrow at the beginning of the experiment, and all were served during the progress of the trial.

Dates of the Experiment.

	Cotton-seed Period.	Hay Period.
October 6 through November 3, . .	Cows 1, 2, 5.	Cows 3, 4, 6.
November 17 through December 15, .	Cows 3, 4, 6.	Cows 1, 2, 5.

Rations eaten Per Day (Pounds).

	NAME.	Hay.	Cotton-seed Feed.	Mangolds.	Wheat Bran.	Chicago Gluten Meal.
Cotton-seed period.	Mary, ...	2	15	15	5	3
	Jennie, . . .	3	12	15	5	3
	Nora, ...	–	15	15	5	3
	Beauty, . . .	5	15	15	5	3
	Red, ...	3	15	15	5	3
	Spot, ...	3	14.46	15	5	3

Rations eaten Per Day (Pounds) — Concluded.

	NAME.	Hay.	Cotton-seed Feed.	Mangolds.	Wheat Bran.	Chicago Gluten Meal.
Hay period.	Mary,	17	–	15	5	3
	Jennie,	15	–	15	5	3
	Nora,	15	–	15	5	3
	Beauty,	20	–	15	5	3
	Red,	18	–	15	5	3
	Spot,	18	–	15	5	3
Average cotton-seed feed period.		2.68	14.41	15	5	3
Average hay period,		17.17	–	15	5	3

It was not considered advisable to feed more than from 12 to 15 pounds of the cotton-seed feed daily, and the additional quantity of coarse fodder was secured by adding from 2 to 5 pounds of hay, to suit the appetites of the various animals. We have, then, 12 to 15 pounds of cotton-seed feed, compared with a like amount of hay. The cotton-seed feed was mixed daily in the proportion of 4 pounds of hulls to 1 pound of meal. The hay was a mixture of grasses, with Timothy predominating. Some clover was scattered through the mixture.

Digestible Matter in Rations (Per Cent.).

	NAME.	Total Dry Matter.	Digestible. Protein.	Digestible. Carbohydrates.	Digestible. Fat.	Digestible. Total.	Nutritive Ratio.
Cotton-seed period	Mary,	23.20	2.45	10.58	.83	13.86	1:5.08
	Jennie,	21.44	2.37	9.78	.76	12.91	1:4.85
	Nora,	21.44	2.37	9.76	.81	12.94	1:4.85
	Beauty,	25.83	2.57	11.82	.87	15.26	1:5.36
	Red,	24.07	2.49	10.99	.85	14.33	1:5.60
	Spot,	23.61	2.47	10.77	.83	14.07	1:5.08

Digestible Matter in Rations (Per Cent.) — Concluded.

	NAME.	Total Dry Matter.	DIGESTIBLE. Protein.	Carbohydrates.	Fat.	Total.	Nutritive Ratio.
Hay period.	Mary, . . .	23.17	2.41	10.67	.56	13.64	1:4.95
	Jennie, . . .	21.42	2.33	9.85	.54	12.72	1:4.77
	Nora, . . .	21.42	2.33	9.85	.54	12.72	1:4.77
	Beauty, . . .	25.78	2.53	11.91	.60	15.04	1:4.30
	Red, . . .	24.08	2.45	11.08	.58	14.11	1:5.00
	Spot, . . .	24.08	2.45	11.08	.58	14.11	1:5.00
Average cotton-seed feed period.		23.26	2.45	10.62	.82	13.64	1:5.14
Average hay period, .		23.32	2.42	10.74	.57	13.72	1:5.00

The amounts and proportions of digestible matter in each of the two rations are identical. In calculating the above rations, average digestion coefficients were taken for the grains, the coefficients obtained at this station for the cotton-seed feed, and in case of the hay, the coefficients obtained by us for hay of similar appearance and composition. It must be remembered that the above digestible material in the two rations is only estimated. It is therefore quite possible that, had actual digestion experiments been made with the cows, these figures may have been somewhat modified.

Weight of Animals at Beginning and End of Experiment (Pounds).

		Mary.	Jennie.	Nora.	Beauty.	Red.	Spot.	Total Gain.
Cotton-seed period, .	Beginning, . .	768	818	745	943	1,006	1,007	-
	End, . . .	767	840	767	954	1,042	1,002	85
Hay period, . . .	Beginning, . .	829	897	757	946	1,096	954	-
	End, . . .	825	888	780	973	1,115	1,024	126

The cows were weighed at the same time for three consecutive days at the beginning and end of the experiment.

Four of the six cows were rather thin in flesh at the beginning of the test, and made gains on both rations. The hay period showed a herd increase of 41 pounds over the cotton-seed period.

Milk and Butter Yields (Pounds).

PERIOD.	Cows.	Total Milk.	Daily Milk.	Daily Quarts.	Total Milk Solids.	Total Fat.	Total Butter.	Daily Butter.
Cotton-seed period.	Mary,	596.88	21.32	9.92	83.38	28.29	33.00	1.18
	Jennie,	609.97	21.78	10.13	88.81	30.50	35.59	1.27
	Nora,	519.12	18.54	8.62	69.81	23.62	27.56	.98
	Beauty,	587.68	20.99	9.76	84.75	30.97	36.13	1.29
	Red,	549.94	19.64	9.13	67.63	21.28	24.82	.88
	Spot,	428.77	15.31	7.12	62.23	22.42	26.16	.93
Hay period.	Mary,	575.64	20.55	9.57	79.83	27.34	31.90	1.14
	Jennie,	527.12	18.82	8.75	80.49	30.46	35.54	1.27
	Nora,	613.34	21.89	10.17	80.77	24.78	28.91	1.03
	Beauty,	685.67	24.47	11.38	97.85	33.60	39.20	1.40
	Red,	557.00	19.89	9.25	69.62	22.72	26.51	.95
	Spot,	491.17	17.56	8.17	70.83	23.23	27.10	.97
Average cotton-seed feed ration.		548.73	19.59	9.10	76.10	26.18	30.54	1.09
Average hay ration,		574.99	20.53	9.55	79.90	27.02	31.53	1.13
Percentage increase hay over cotton-seed period.		4.6+	-	-	4.8+	3.1+	-	-

In this experiment, the results are the reverse of those obtained in the first test, the hay period yielding several per cent. more milk, milk solids and fat. Our observations of the animals from day to day during the trial indicated that the cotton-seed feed ration was falling slightly behind the hay ration. The animals, being in the early part of the lactation period, would naturally be more sensitive to the effect of food than in the latter portion of the period of lactation.

Dry and Digestible Matter required to produce Milk and Butter (Per Cent.).

Dry Matter required to produce —	Cotton-seed Period.	Hay Period.	Digestible Matter required to produce —	Cotton-seed Period.	Hay Period.
100 pounds milk, . .	118.70	113.60	100 pounds milk, .	70.90	66.90
1 pound milk solids, .	8.56	8.18	1 pound milk solids, .	5.11	4.81
1 pound milk fat, . .	24.88	24.17	1 pound milk fat, .	14.86	14.22
1 pound butter, . .	21.38	20.70	1 pound butter, . .	12.77	12.18

Market Cost of Feed Stuffs.

Wheat bran, ...	$14 00	per ton.
Chicago gluten meal, ...	18 00	"
Mangolds, ...	3 00	"
Hay, ...	15 00	"
Cotton-seed feed, ...	15 00	"

Cost of Feed to produce Milk and Butter. Average for Six Cows (Cents).

	Daily Feed.	100 Pounds Milk.	Quart Milk.	Pound Butter Fat.	Pound Butter.
Cotton-seed period, ...	21.32	110.6	2.38	23.40	20.10
Hay period, ...	21.32	104.9	2.26	22.69	19.33
Increased percentage cost of cotton-seed over hay period.	-	5.2+	-	-	3.2+

The cotton-seed rations slightly increased the cost of the milk and butter.

D. Average Results from Two Experiments.

It is thought desirable to bring together the results of both experiments, believing that they will give a fair representation of the relative values of like quantities of cotton-seed feed and a good quality of hay.

1. Total Live Weight gained by the Six Cows in Both Experiments (Pounds).

Cotton-seed feed periods, ...	95
Hay periods, ...	166

2. *Average Dry and Digestible Matter Consumed Daily (Pounds).*

	Total Dry Matter.	Digestible.				Nutritive Ratio.
		Protein.	Fat.	Carbohydrates.	Total.	
Cotton-seed period,	22.57	2.32	.82	10.39	13.40	1: 5.35
Hay period,	22.65	2.41	.59	10.61	13.61	1: 5.00

These figures show very slight variations.

3. *Total Milk and Butter Yields (Pounds).*

	Milk.	Milk Solids.	Milk Fat.	Butter.
Cotton-seed period,	5867	823.5	290.4	338.8
Hay period,	5933	826.3	281.1	328.0
Percentage increase hay over cotton-seed,	1.1+	.34+	3.2—	3.2—

These variations can be regarded as within the limits of experimental error.

4. *Average Feed Cost of Milk and Butter (Cents).*

	Daily Cost of Feed.	100 Pounds Milk.	Quart Milk.	Pound Butter Fat.	Pound Butter.
Cotton seed period,	20.19	102.6	2.20	20.79	17.79
Hay period,	20.14	102.5	2.19	21.80	18.63
Percentage increased cost of hay over cotton-seed.	±	±	±	4.63+	4.5+

The 4.6 percentage increased cost of butter in the hay period is due to the rather unexpected results in the first experiment.

5. *Dry and Digestible Matter required to produce Milk and Butter.*

I. Dry Matter (Pounds).

	100 Pounds Milk.	Pound Milk Solids.	Pound Butter Fat.	Pound Butter.
Cotton-seed period,	112.9	8.04	22.79	19.56
Hay period,	112.6	8.08	23.72	20.37

II. Digestible Matter (Pounds).

	100 Pounds Milk.	Pound Milk Solids.	Pound Butter Fat.	Pound Butter.
Cotton-seed period,	67.65	4.81	13.65	11.72
Hay period,	67.69	4.85	14.25	12.22

General Conclusions.

Cotton-seed feed, from its appearance, is certainly not an attractive looking article for consumption. The cotton-seed hulls, comprising the bulk of the feed, consists of the dark seed coats, together with an entangling mass of fibre. They are difficult to masticate, and quite indigestible. The cotton-seed meal with which the hulls are mixed imparts its flavor to the material, and actually increases the digestibility of the hulls. In our experiments we have had no trouble in inducing animals to eat 12 to 15 pounds daily within three or four days. The two experiments have shown cotton-seed feed to give as large milk and butter yields, at as low a cost, as a good quality of hay. The writer is of the opinion, however, that this feed requires more energy for its digestion than hay, and, when fed for any length of time, would have a tendency to induce digestive disturbances. A mixture of hulls and meal could probably be turned to better account for fattening steers than as a continuous feed for dairy cows. Massachusetts farmers could derive no benefit from feeding this material in place of hay. For those who are obliged to purchase all of their coarse feeds, it might be desirable to use one-half of this material in place of hay, provided it could be purchased for somewhat less money. Cotton-seed feed should be consumed where it is produced. For the farmers of the south it is undoubtedly a cheap source of coarse feed, and, when fed in moderate quantities, will unquestionably return good results.

Analytical Data.

Dry Matter Determinations (Per Cent.).

Experiment I.

	Hay.	Millet and Soy Bean Ensilage.	Cotton seed-Feed.	Wheat Bran.	Linseed Meal.	Peoria Gluten Feed.
April 8 through April 28, .	90.33	18.79	89.00	87.89	90.58	93.04
May 11 through May 31, .	89.84	20.58	88.10	87.86	90.48	93.23

Experiment II.

	Hay.	Mangolds.	Cotton-seed Feed.	Wheat Bran.	Chicago Gluten Meal.
Hay * and cotton-seed periods, . .	87.60	8.00	87.8	87.2	90.6

* The dry matter determinations varied so little in the two halves of this experiment that the average in each case was taken.

Composition of Feeds (Per Cent.).

Experiment I.

	Hay.	Millet and Soy Bean Ensilage.	Cotton-seed Feed.	Wheat Bran.	Linseed Meal.	Peoria Gluten Feed.
Ash, ...	5.94	12.77	3.82	6.42	4.94	1.07
Fibre, ...	32.00	34.02	39.67	11.37	7.26	7.13
Fat, ...	3.07	2.59	3.90	5.73	7.05	7.59
Protein, ...	11.07	9.40	13.02	18.68	41.99	23.83
Extract matter, . . .	47.92	41.22	39.59	57.80	38.76	60.38

Experiment II.

	Hay.	Mangolds.	Cotton-seed Feed.	Wheat Bran.	Chicago Gluten Meal.
Ash, ...	5.78	15.49	3.51	7.11	1.52
Fibre, ...	33.98	10.67	40.69	12.08	3.21
Fat, ...	2.68	.73	3.69	5.69	7.38
Protein, ...	8.41	14.35	11.98	18.12	40.38
Extract matter, ...	49.15	58.76	40.13	57.00	47.51

Coefficients of Digestibility.

Experiment I.

	Hay.	Ensilage.	Cotton-seed Feed.	Wheat Bran.	Linseed Meal.	Peoria Gluten Feed.	Chicago Gluten Meal.	Mangolds.
Fibre,	66	69	59	22	57	78	-	-
Fat,	53	72	89	71	89	79	-	-
Protein,	62	57	39	78	89	83	-	-
Extract Matter,	64	59	58	68	78	90	-	-
Experiment II.								
Fibre,	58	-	55	22	-	-	-	43
Fat,	50	-	93	68	-	-	93	-
Protein,	54	-	42	79	-	-	89	75
Extract Matter,	56	-	59	69	-	-	93	91

Composition of Milk (Per Cent.).

Experiment I.

	Ada.		Red Spot.		Bessie.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period,	13.84	4.93	14.01	4.84	13.63	4.93
	13.82	5.00	14.48	5.59	-	-
Average,	13.83	4.96	14.24	5.21	13.63	4.93
Hay period,	13.57	4.62	13.95	4.64	13.26	4.53
	-	-	-	-	13.47	4.52
Average,	13.57	4.62	13.95	4.64	13.36	4.52

Experiment I. — Concluded.

	Beauty.		Red.		Spot.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period, . .	15.08	5.62	14.03	5.05	14.88	5.33
	-	-	-	-	15.28	5.48
Average, . . .	15.08	5.62	14.03	5.05	15.08	5.40
Hay period, . . .	14.54	5.13	13.91	4.72	14.77	5.27
	14.61	5.05	13.87	4.60	-	-
Average, . . .	14.57	5.09	13.89	4.66	14.77	5.27

Experiment II.

	Mary.		Jennie.		Nora.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period, . .	13.96	4.64	14.36	4.73	13.39	4.48
	13.81	4.80	14.58	5.33	13.44	4.58
	14.20	4.93	14.58	4.92	13.52	4.63
	13.91	4.74	14.73	5.00	13.45	4.50
Average, . . .	13.97	4.74	14.56	5.00	13.45	4.55
Hay period, . . .	13.76	4.73	14.79	5.45	13.00	3.81
	13.86	4.75	15.39	5.88	12.93	4.10
	14.01	4.85	15.55	6.00	13.46	4.17
	13.85	4.68	15.37	5.78	13.28	4.07
Average, . . .	13.87	4.75	15.27	5.78	13.17	4.04

Experiment II. — Concluded.

	Beauty.		Red.		Spot.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period,	14.62	5.35	12.48	3.89	14.57	5.08
	13.95	4.85	11.88	3.93	14.77	5.05
	14.66	5.48	12.60	4.02	14.92	5.15
	14.46	5.40	12.23	3.63	13.90	5.63
Average,	14.42	5.27	12.30	3.87	14.54	5.23
Hay period,	-	-	12.26	4.00	14.01	4.34
	14.12	4.93	12.41	4.05	14.14	4.75
	14.49	4.97	12.74	4.20	14.59	4.94
	14.19	4.80	12.53	4.08	14.94	4.91
Average,	14.27	4.90	12.49	4.08	14.42	4.73

Average Results of Six Cows.

	Experiment I.		Experiment II.	
	Solids.	Fat.	Solids.	Fat.
Cotton-seed period,	14.31	5.18	13.87	4.78
Hay period,	14.02	4.80	13.91	4.71

Each distinct analysis represents a composite sample from 8 different milkings. In Experiment I., samples were taken for four days of the last two weeks only. In Experiment II., each analysis represents the comparison of the milk for each of the four weeks.

REPORT OF THE ENTOMOLOGIST.

CHARLES H. FERNALD.

Two bulletins have been issued from this department during the year, — one on the habits, food and economic value of the American toad (*Bufo lentiginosus americanus*), and one on the brown-tail moth (*Euproctis chrysorrhœa*). I have been able in the intervals of other duties to prepare a monograph of the plume-moths (*Pterophoridæ*) of North America, which is published with illustrations in the thirty-fifth annual report of the college. A large amount of time has also been devoted to the work on the gypsy moth in the eastern part of the State.

San José Scale.

The San José scale (*Aspidiotus perniciosus*) has appeared in many places in Massachusetts, having been received on nursery stock from nurseries both in this and in other States. In the early part of the season my assistants visited, as far as possible, all the nurseries in the State, and carefully examined them for this scale. Most of them appeared to be entirely free from this insect, but a few were more or less infested. The owners of these infested nurseries have taken the most active measures to destroy this pest, under the supervision of one of my assistants. Many of the nurserymen do not raise a sufficient amount of stock to supply all of their orders, and often purchase from outside sources. This stock is often received and sent out without examination, and in this way it is possible for the San José scale to be distributed by those whose nurseries are not infested. A bulletin on the San José scale will be published as soon as other duties will permit, in which will be given a more complete account of the condition of the nurseries visited, together with the measures taken to eradicate the pest.

The scale insects have been and are still being introduced into this country from other parts of the world, and in this way we are liable at any time to find new or unknown species on our fruit or ornamental trees and shrubs and in our greenhouses. It therefore seems wise to learn as much as possible about these insects, in order that we may know what to do with those already here, and any that may hereafter be brought into this country. To this end, more than six hundred circular letters were sent out to all entomologists whose names and addresses could be obtained, asking for specimens of two genera of the scale insects, and already a large amount of material has been received. Prof. R. S. Lull has undertaken to work up and prepare a monograph of the genus *Pulvinaria*, and Mr. R. A. Cooley a monograph of the genus *Chionaspis*. Very commendable progress has already been made by these two gentlemen.

Army Worm.

During the summer of 1896 the army worm (*Leucania unipuncta*) was very abundant in Amherst and in many other parts of the State, often in destructive numbers, and in the correspondence with this department information concerning this insect was asked for more than of all others combined. During the summer of 1897, however, the army worm seems to have been present in so few numbers as to have done no harm, and it was not referred to in a single letter received by me. It is a well-known fact that this insect has never in the past appeared in destructive numbers two years in succession in the same place, and the past season seems to have been no exception. The caterpillars were reported in many cases to have been more or less infested with the eggs of a parasitic fly. These eggs no doubt hatched and the young maggots made their way into the caterpillars and destroyed them, thus reducing the army worm to insignificant numbers, so that the few remaining have been entirely overlooked.

Plant Lice.

While the army worm has been very scarce during the past season, the aphids or plant lice have been very abundant on trees and shrubs, and many letters have been received, asking how to destroy them. The best method, so far as known, is to spray the trees with kerosene emulsion; but in spraying it is very difficult to reach every insect, and, as they multiply very rapidly, they soon become as abundant as ever, and it becomes necessary to spray the trees or shrubs repeatedly after short intervals.

Tobacco Cutworm.

Early in the season cutworms were said to be destroying the young tobacco plants in the tobacco fields of the Connecticut valley, and specimens that were brought in and bred to maturity developed into moths which proved to be *Carneades messoria.* The caterpillars of this species partake of a rather varied diet, consisting not only of tobacco, but also of cabbage, corn, potatoes, spinach, onions, lettuce and fruit trees. The usual method taken by our tobacco growers, so far as I can learn, is to reset tobacco plants where they have been cut off by the worms, and at the same time dig out and destroy the worm that has done the mischief.

Canker Worms.

Four years ago canker worms began to increase so rapidly in this town that public attention was called to them, and a general account of the species occurring in Massachusetts was given with illustrations in Bulletin No. 20, published in January, 1893. In that bulletin the usual remedies were given. These consisted of tacking bands of heavy paper around the trunks of the trees and painting these bands with prepared printers' ink, repainting with the ink as often as it became dry or hardened enough to permit the females to cross the band. The method of protecting the trees with oil troughs of zinc or tin around the trunks was also mentioned. It was finally stated that probably the most effectual method was to spray the trees with Paris green in water as soon as the eggs hatched in the spring. A further account of canker worms was given in Bulletin No. 28, published in April, 1895.

A careful study of the different methods used to destroy these insects, which are so prevalent in many parts of this Commonwealth, has been made on thirteen apple trees on my own premises in Amherst. Three years ago these trees were carefully banded with heavy paper and painted with Morrill's tree ink early in the spring, when the first females began to ascend the trees, and the painting was repeated as often as necessary. It was found that the ink would often harden on the trees even during the night following the application, and remain hard on the shady side long enough in the morning for some of the females to ascend the tree on that side, so that this method did not prove to be a perfect protection. The cost of the materials and of their application averaged about fifty cents to each tree.

The oil troughs are also quite expensive, and often leak so that the rain displaces the oil and then evaporates, allowing the females to ascend the trees; or spiders spin their webs across beneath the overhanging protection, forming a bridge on which the moths may easily pass, so that this device does not form a perfect protection.

Two years ago these trees were sprayed with Paris green in water, in the proportion of one pound to one hundred and fifty gallons, at a cost of five cents a tree, allowing fifteen cents an hour for labor. There was a strong wind blowing, and more time was required to do the work than would otherwise have been the case. Last year the same trees were sprayed with Paris green, in the same proportion as before. At this time it was nearly calm, and the cost of spraying was three cents a tree. The contrast between these trees and those on adjacent lots were very marked, for the sprayed trees retained their foliage and yielded a full crop, while the unsprayed trees were stripped of leaves, and bore no fruit. These trees were sprayed but once, and this method appears to have been more effectual and far cheaper than the others. In case of rain it might be necessary to repeat the spraying, but even then it would be the cheaper method.

REPORT OF THE CHEMIST.

DEPARTMENT OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.
Assistants: HENRI D. HASKINS, CHARLES I. GOESSMANN, GEORGE D. LEAVENS.

I. Report on Official Inspection of Commercial Fertilizers.
II. Report on General Work in the Chemical Laboratory.
III. Observations with Special Fertilizers on Tobacco raised in Massachusetts.

I. REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS IN 1897.

CHARLES A. GOESSMANN.

Sixty-six manufacturers and dealers in commercial fertilizers and agricultural chemicals have secured, during the past year, licenses for the sale of their goods in the State. Thirty-six of these parties have offices for the general distribution of their goods in Massachusetts; the remainder reside in other States, — ten in New York, six in Connecticut, three in Rhode Island, three in Vermont, two in Pennsylvania, one in Maryland, one in Illinois, one in Ohio and three in Canada.

The number of distinct brands licensed, including agricultural chemicals, amounted to two hundred and ninety.

The collecting and sampling of the material for official analyses were in charge of Mr. R. H. Smith, a graduate of the Massachusetts Agricultural College in the class of 1892, who since his graduation has been an efficient assistant in the chemical laboratory of the experiment station for the examination of commercial fertilizers.

Four hundred and fifteen samples of fertilizer have thus far been collected during the present year; of these, three hundred and one samples, representing two hundred and twenty-three distinct brands, were analyzed by the close of the month of November, and the results published in July and November bulletins, Nos. 48 and 49, of the Hatch Experiment Station of the Massachusetts Agricultural College. The remaining samples, in common with others coming under our observation before the expiration of the licenses, will be analyzed in due time, and the results published in conformity with our laws for the regulation of the trade in commercial fertilizers.

The results of the inspection during the past season are, on the whole, quite satisfactory, and if anything are an improvement on the results of the preceding year. The beneficial results of improved machinery and of improved skill in the management of the manufacture of fertilizers show themselves in a marked degree when compared with the general character of commercial fertilizers in earlier periods of the business.

To render the actual conditions of the trade in commercial fertilizers during the past season more prominent, a summary of our results is here inserted. In reading the subsequent statement, it has to be remembered that only the lowest stated guarantee is legally binding in all sales: —

(*a*) Where three essential elements of plant food were guaranteed: —

Number with three elements equal to or above the highest guarantee,	3
Number with two elements above the highest guarantee,	2
Number with one element above the highest guarantee,	60
Number with three elements between the lowest and highest guarantee,	69
Number with two elements between the lowest and highest guarantees,	63
Number with one element between the lowest and highest guarantees,	16

Number with two elements below the lowest guarantee,	6
Number with one element below the lowest guarantee,	29

(*b*) Where two essential elements of plant feed were guaranteed:—

Number with two elements above the highest guarantee,	3
Number with one element above the highest guarantee,	10
Number with two elements between the lowest and highest guarantees,	13
Number with one element between the lowest and highest guarantees,	12
Number with one element below the lowest guarantee,	6
Number with two elements below the lowest guarantee,	3

(*c*) Where one essential element of plant food was guaranteed:—

Number above the highest guarantee,	10
Number between the lowest and highest guarantees,	23
Number below the lowest guarantee,	1

The modes of analyses adopted in this work were in all essential points those recommended by the Association of Official Chemists.

Attention has been called, in previous reports, to the fact that the introduction of a more liberal amount of potash into the make-up of a large class of so-called complete manures has become from year to year more general. This change has been slow but decided, and in a large degree may be ascribed to the daily increasing evidence, resulting from actual observations in field and garden, that the farm lands of Massachusetts are frequently especially deficient in potash compounds, and consequently need in many instances a more liberal supply of available potash from outside sources to give satisfactory returns. Whenever garden vegetables, fruits and forage crops constitute the principal products of the land, this recent change in the mode of manuring deserves a particularly careful trial; for the crops raised consume exceptionally large quantities of potash, as compared with grain crops. In view of these facts, it will be conceded that a system of manuring farm and garden which tends to meet the more satisfactory recognized conditions of large areas of land, as well as the special wants of important growing branches of agricultural industries, is a movement in the right direction.

In repeating these statements, it is not assumed that it will remain economical to continue the practice after a repeated application of a liberal amount of potash, without some special reason.

To restore to the soil those essential manurial constituents which the crops carry off is a safe rule to follow in the effort to secure the maintenance of the fertility of the soil; yet to obtain this result in the most economical way will always remain the ultimate aim of farming as a business enterprise.

A judicious management of the trade in commercial fertilizers implies a due recognition of results well established by experiment, regarding the requirements of a remunerative production of farm and garden crops; yet, as the manufacturer at best can only prepare the composition of his special fertilizers on general lines, not knowing the particular condition and character of the soil which ultimately receives them, it becomes of the utmost importance on the part of the farmer to make himself acquainted with his special wants of manurial substances, and to thus qualify himself for a more judicious selection from the various fertilizers offered for purchase.

The present condition of the trade in commercial fertilizers offers exceptional advantages to provide efficient manures for the raising of farm and garden crops of every description congenial to soil and climate. The various essential articles of plant food, as potash, phosphoric acid and nitrogen compounds, are freely offered for sale in forms suitable to render, by their addition, the different kinds of manurial refuse matter of the farm in a higher degree fit to meet the special wants of the crops to be raised.

As the physical conditions and chemical resources of soils on available plant food frequently differ widely even on the same farm, no definite rule can be given for manuring farm lands, beyond the advice to return to the soil in available form those plant constituents which the crops raised during the preceding years have abstracted in exceptionally large proportion, and which will be especially called for by the crops to be raised.

An intelligent selection of fertilizers from among the various brands offered for sale requires, in the main, two kinds of knowledge; namely, that the brand of fertilizer in question actually contains the guaranteed quantities and qualities of essential articles of plant food at a reasonable cost, and that it contains them in such form and proportions as will best meet under existing circumstances the special wants of soil and crop.

In some cases it may be only phosphoric acid or nitrogen or potash; in others, two of them; and in others again, all three. A remunerative use of commercial fertilizers can only be secured by attending carefully to these considerations.

To assist farmers in selecting their fertilizers with reference to the wants of the crops they wish to cultivate, the writer has for years published in his annual reports a compilation of the analyses of farm and garden crops, to serve as a guide to all interested in a rational mode of manuring plants. Copies of these compilations of analyses may be secured by asking for them at the office of the Hatch Experiment Station at Amherst, Mass.

An economical use of manurial substances from any source is only possible after the local condition of the soil under consideration, as well as the special wants of the crops to be raised, have been duly considered. It becomes the business of every progressive farmer to acquire such information as is called for to select intelligently, from the various manurial resources at his disposal, those materials which will meet best his wants for a complete fertilizer.

In making choice from among the so-called complete fertilizers, two points seem to be in particular worth remembering. First, select them with reference to the amount, the quality and the kind of essential constituents they are guaranteed to contain, and not merely with reference to cost per ton; mere trade names are no guarantee of fitness. High-priced articles, when offered by reputable manufacturers, have proved in many instances cheaper than low-priced goods. Second, buy your supplies of reputable dealers, and insist in all cases on a statement of guaranteed composition.

The majority of manufacturers and dealers in commercial fertilizers in Massachusetts have been for years on record, regarding the character of their goods, in the published reports of the State inspector, which are open to the public; to these records this office invariably refers all parties asking for information in that direction.

Valuation of Commercial Fertilizers.

The market value of the higher grades of agricultural chemicals and compound fertilizers depends in the majority of cases on the amount and the particular form of three essential articles of plant food which they contain, *i.e.*, nitrogen, potash and phosphoric acid. Supply and demand control the temporary market prices not less in the fertilizer trade than in other lines of commercial business.

The approximate market value of a fertilizer, simple or compound, is obtained by multiplying the pounds contained in a ton of two thousand pounds by the trade value per pound of each of the three above-stated essential constituents of plant food present. The same course is adopted with reference to the different forms of each, wherever different prices are recognized in the trade. Adding the different values per ton obtained, we find the total value per ton at the principal place of distribution.

As farmers are quite frequently not in the position to secure the desired information regarding the market cost of fertilizers they wish to secure, the official inspectors of commercial fertilizers have aided them for years in ascertaining the current market prices of the following leading or standard raw materials: —

Sulphate of ammonia.	Ammoniate.
Nitrate of soda.	Castor pomace.
Muriate of potash.	Linseed meal.
Sulphate of potash.	Dried blood.
Cotton-seed meal.	Dried ground meat.
Dry ground fish.	Bone and tankage.
Azotin.	Plain superphosphates, etc.

Which serve largely in the manufacture of good fertilizers for our market; and have published the results of their inquiries in form of tables, stating the average trade values per pound, for the six months preceding, of the different kinds and forms of fertilizing materials at the leading places of distribution.

The market value of fertilizing ingredients, like other merchandise, is liable to changes during the season. The values stated below are based on the condition of the fertilizer market in centres of distribution in New England during the six months preceding March, 1897: —

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1897 (Cents per Pound).

Nitrogen in ammonia salts,	13.5
Nitrogen in nitrates,	14.0
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade mixed fertilizers,	14.0
Organic nitrogen in cotton-seed meal, linseed meal and in castor pomace,	12.0
Organic nitrogen in fine-ground bone and tankage,	13.5
Organic nitrogen in medium-ground bone and tankage,	11.0
Organic nitrogen in coarse bone and tankage,	8.0
Phosphoric acid soluble in water,	5.5
Phosphoric acid soluble in ammonium citrate,	5.0
Phosphoric acid in fine bone and tankage,	5.0
Phosphoric acid in medium bone and tankage,	4.0
Phosphoric acid in coarse bone and tankage,	2.5
Phosphoric acid in fine-ground fish, cotton-seed meal, linseed meal, castor pomace and wood ashes,	5.0
Phosphoric acid insoluble (in am. cit.) in mixed fertilizers,	2.0
Potash as sulphate, free from chlorides,	5.0
Potash as muriate,	4.5

From these figures it is apparent that the best forms of nitrogen and phosphoric acid have suffered a material reduction in cost, as compared with preceding years.

The market value of low-priced materials used for manurial purposes, as salt, wood ashes, various kinds of lime, barn-yard manure, factory refuse and waste materials of various description, quite frequently does not stand in a close relation to the current market value of the amount of essential articles of plant food they contain. Their cost varies in different localities. Local facilities for cheap transportation, and more or less advantageous mechanical conditions for speedy action, exert, as a rule, a decided influence on their selling price.

The mechanical condition of any fertilizing material, simple or compound, deserves the most serious consideration of farmers when articles of a similar chemical character are offered for their choice. The degree of pulverization controls, almost without exception, under similar conditions, the rate of solubility, and the more or less rapid diffusion of the different articles of plant food throughout the soil.

The state of moisture exerts a no less important influence on the pecuniary value in case of one and the same kind of substance. Two samples of fish fertilizers, although equally pure, may differ from fifty to one hundred per cent. in commercial value, on account of mere difference in moisture.

Crude stock for the manufacture of fertilizers, and refuse materials of various descriptions, have to be valued with reference to the market price of their principal constituents, taking into consideration at the same time their general fitness for speedy action.

Consumers of commercial manurial substances will do well to buy, whenever practicable, on a guarantee of composition of their essential constituents, and to see to it that the bill of sale recognizes the point of the bargain. Any mistake or misunderstanding in the transaction may be readily adjusted, in that case, between the contending parties. The responsibility of the dealer ends with furnishing an article corresponding in its composition with the lowest stated quantity of each specified essential constituent.

It is of the first importance, when buying fertilizers for home consumption, to consider their cost with reference to what they promise to furnish.

List of Manufacturers and Dealers who have secured Certificates for the sale of Commercial Fertilizers in the State during the Past Year (May 1, 1897, to May 1, 1898) and the Brands licensed by Each.

The Armour Fertilizer Works, Chicago, Ill.: —
- Bone Meal.
- Bone and Blood.
- Ammoniated Bone and Potash.
- All Soluble.
- Bone, Blood and Potash.
- Grain Grower.

American Fertilizer Co., Boston, Mass.: —
- Alkali Nitrate Phosphate for Hoed Crops.

American Fertilizer Co. — *Con.*
- Alkali Nitrate Phosphate for Grass and Grain.
- General American Fertilizer.
- Potato Fertilizer.

Wm. H. Abbott, Holyoke, Mass.: —
- Eagle Brand for Grass and Grain.
- Complete Tobacco Fertilizer.
- Animal Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.
- Tankage.

H. J. Baker & Bro., New York, N. Y.: —
- Pure Ground Bone.
- Standard Un X Ld Fertilizer.
- Strawberry Manure.
- Potato Manure.
- Tobacco Manure.
- Grass and Grain Manure.
- A. A. Ammoniated Superphosphate.
- Harvest Home Fertilizer.

C. A. Bartlett, Worcester, Mass.: —
- Fine-ground Bone.
- Animal Fertilizer.

Berkshire Mills Co., Bridgeport, Conn.: —
- Complete Fertilizers.
- Ammoniated Bone Phosphate.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Hill and Drill Phosphate.
- Farm and Garden Phosphate.
- Lawn and Garden Dressing.
- Fish and Potash.
- Potato and Vegetable Manure.
- Potato Phosphate.
- Market Garden Manure.
- Sure Crop Phosphate.
- Gloucester Fish and Potash.
- High-grade Fertilizer.
- Essex Fertilizer.
- Bone and Wood Ash Fertilizer.
- Nitrate of Soda.
- Dried Blood.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulphate of Potash.

William E. Brightman, Tiverton, R.I.: —
- Potato and Root Manure.
- Phosphate.
- Fish and Potash.

Bradley Fertilizer Co., Boston, Mass.: —
- X. L. Superphosphate.
- Potato Manure.
- B. D. Sea Fowl Guano.
- Complete Manures.
- Fish and Potash.
- High-grade Tobacco Manure.
- English Lawn Fertilizer.
- Ammoniated Bone Phosphate.
- Breck's Lawn and Garden Dressing.
- Sulphate of Potash.

Bradley Fertilizer Co. — *Con.*
- Muriate of Potash.
- Nitrate of Soda.
- Sulphate of Ammonia.
- Dissolved Bone-black.
- Fine-ground Bone.

Daniel T. Church, Providence, R. I. (E. Wilcox, general agent): —
- Church's B Special.
- Church's C Standard.
- Church's D Fish and Potash.

The Cleveland Linseed Oil Co., Cleveland, O.: —
- Screened Linseed Meal.

Clark's Cove Fertilizer Co., Boston, Mass.: —
- Bay State Fertilizer.
- Bay State Fertilizer G. G. Brand.
- Great Planet Manure.
- Potato and Tobacco Fertilizer.
- King Philip Guano.
- Potato Manure.
- Fish and Potash.
- White Oak Pure Bone Meal.

Cleveland Dryer Co., Boston, Mass.: —
- Superphosphate.
- Potato Phosphate.
- Cleveland Fertilizer.

E. Frank Coe Co., New York, N. Y.: —
- High-grade Potato Fertilizer.
- Bay State Ammoniated Bone Super phosphate.
- Bay State Potato Manure.
- High-grade Ammoniated Bone Superphosphate.
- Gold Brand Excelsior Guano.
- Fish Guano and Potash.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y.: —
- Ammoniated Bone Superphosphate.
- Potato, Hop and Tobacco Phosphate.
- Ammoniated Wheat and Corn Phosphate.
- New Rival Ammoniated Superphosphate.
- Practical Ammoniated Superphosphate.
- Vegetable Bone Superphosphate.
- General Crop Phosphate.
- Universal Grain Grower.
- Special Potato Manure.
- New England Tobacco and Potato Grower.

Crocker Fertilizer and Chemical Co. — *Con.*
- Coolidge Bros. Special Truck Fertilizer.
- A. A. Complete Manure.
- Ground Bone Meal.
- Pure Ground Bone.
- Muriate of Potash.
- Nitrate of Soda.

Cumberland Bone Phosphate Co., Boston, Mass. : —
- Superphosphate.
- Potato Fertilizer.
- Concentrated Phosphate.
- Guano.

City Florist, Brockton, Mass. : —
- Boo Boo Plant Food.

L. B. Darling Fertilizer Co., Pawtucket, R. I. : —
- Animal Fertilizer.
- Potato and Root Crop Manure.
- Lawn Dressing.
- Tobacco Grower.
- Blood, Bone and Potash.
- Special Formula.
- Fine-ground Bone.
- Muriate of Potash.
- Nitrate of Soda.

John C. Dow & Co., Boston, Mass. : —
- Ground Bone Fertilizer.
- Nitrogenous Superphosphate.
- Pure Ground Bone.

W. E. Fife & Co., Clinton, Mass. : —
- Wood Ashes.

Great Eastern Fertilizer Co., Rutland, Vt. : —
- Northern Corn Special.
- General Fertilizer.
- Vegetable Vine and Tobacco Fertilizer.
- Garden Special.
- Soluble Bone and Potash.

Thomas Hersom & Co., New Bedford, Mass. : —
- Bone Meal.
- Meat and Bone.

Alonzo P. Henderson, Hanover, Mass. : —
- Acme Brand Fertilizer.

Edmund Hersey, Hingham, Mass. : —
- Ground Bone.

John G. Jefferds, Worcester, Mass. : —
- Animal Fertilizer.
- Potato Manure.
- Fine-ground Bone.

Thomas Joint, St. Helen, Ontario, Can. : —
- Unleached Hard-wood Ashes.

Thomas Kirley, South Hadley Falls, Mass. : —
- Pride of the Valley.

A. Lee & Co., Lawrence, Mass. : —
- Lawrence Fertilizer.

Lowell Fertilizer Co., Boston, Mass. : —
- Bone Fertilizer for Corn and Grain.
- Complete Manure for Vegetables.
- Animal Fertilizer.
- Potato Phosphate.
- Bone and Potash.
- Lawn Dressing.
- Tobacco Manure.
- Empire Fertilizer.

Lowe Bros. & Co., Fitchburg, Mass. : —
- Tankage.

F. L. Lalor, Dunville, Ontario, Can. : —
- Canada Unleached Hard-wood Ashes.

The Mapes Formula and Peruvian Guano Co., New York, N. Y. : —
- Bone Manures.
- Superphosphates.
- Special Crop Manures.
- Sulphate of Potash.
- Double Manure Salts.
- Nitrate of Soda.

E. McGarvey & Co., London, Ontario, Can. : —
- Unleached Hard-wood Ashes.

McQuade Bros., West Auburn Mass. : —
- Fine-ground Bone.

Geo. L. Monroe, Oswego, N. Y. : —
- Canada Unleached Hard-wood Ashes.

National Fertilizer Co., Bridgeport, Conn. : —
- Complete Fertilizers.
- Ammoniated Bone.

National Fertilizer Co. — *Con.*
- Market-garden Manure.
- Potato Phosphate.
- Fish and Potash.
- Ground Bone.

Niagara Fertilizer Works, Buffalo, N. Y.: —
- Wheat and Corn Producer.
- Grain and Grass Grower.
- Potato, Tobacco and Hop Fertilizer.
- Niagara Triumph.

New England Dressed Meat and Wool Co., Boston, Mass.: —
- Sheep Fertilizer.

Packers Union Fertilizer Co., New York, N. Y.: —
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.
- Animal Corn Fertilizer.
- Potato Manure.
- Gardener's Complete Manure.

Pacific Guano Co., Boston, Mass : —
- Soluble Pacific Guano.
- Special Potato Manure.
- Special for Potatoes and Tobacco.
- Nobsque Guano.
- High-grade General Fertilizer.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Star Brand Fertilizer.
- Butman Brand Fertilizer.
- Special Potato.
- Strawberry.
- Ground Bone.
- Muriate of Potash.
- Sulphate of Potash.
- Nitrate of Soda.

A. W. Perkins & Co., Rutland, Vt.: —
- Plantene.

Prentiss, Brooks & Co., Holyoke, Mass.: —
- Complete Manures.
- Phosphate.
- Nitrate of Soda.
- Muriate of Potash.
- Sulphate of Potash.

Preston Fertilizer Co., Brooklyn, N. Y.: —
- Ammoniated Bone Superphosphate.

Quinnipiac Co., Boston, Mass.: —
- Phosphate.
- Potato Manure.
- Market-garden Manure.
- Fish and Potash.
- Havana Tobacco Grower.
- Grass Fertilizer.
- Corn Manure.
- Potato Phosphate.
- Onion Manure.
- Pure Ground Bone.
- Dry Ground Fish.
- Muriate of Potash.
- Sulphate of Potash.
- Nitrate of Soda.
- Sulphate of Ammonia.
- Dissolved Bone-black.

Read Fertilizer Co., New York, N. Y. (H. D. Foster, general agent): —
- Standard Fertilizer.
- High-grade Farmers' Friend.
- Practical Potato Special.
- Farmer's Friend,
- Vegetable and Vine.

N. Roy & Son, South Attleborough, Mass.: —
- Complete Animal Fertilizer.

The Rogers & Hubbard Co., Middletown, Conn.: —
- Soluble Potato Manure.
- Soluble Tobacco Manure.
- Fairchild's Formula for Corn and General Crops.
- Fruit Fertilizer.
- Grass and Grain Fertilizer.
- Oats and Top-dressing Fertilizer.
- Pure Raw Knuckle Bone Flour.
- Strictly Pure Fine Bone.
- Fertilizer for all Soils and all Crops.

Russia Cement Co., Gloucester, Mass.:—
- X X X Fish and Potash.
- High-grade Superphosphate.
- Corn, Grain and Grass Manure.
- Potato, Root and Vegetable Manure.
- Special Tobacco Fertilizer.
- Odorless Lawn Dressing.

Lucien Sanderson, New Haven, Conn.:—
- Formula A.
- Blood, Bone and Meat.
- Dissolved Bone-black.
- Nitrate of Soda.
- Sulphate of Potash.
- Muriate of Potash.

Edward H. Smith, Northborough, Mass.: —
Ground Bone.

J. Stroup & Son Co., Boston, Mass.: —
Hard-wood Ashes.

Thomas L. Stetson, Randolph, Mass.:—
Ground Bone.

Standard Fertilizer Co., Boston, Mass.:—
Standard Fertilizer.
Potato and Tobacco Fertilizer.
Standard Guano.
Complete Manure.
Fine-ground Bone.

C. F. Sturtevant, Hartford, Conn: —
Tobacco and Sulphur Fertilizer.

Henry F. Tucker, Boston, Mass.: —
Original Bay State Bone Superphosphate.
Imperial Bone Superphosphate.
Special Potato Fertilizer.

I. P. Thomas & Son Co., Philadelphia, Pa.: —
Martin's Bone Mixture.
So. Carolina Phosphate with Potash.
So. Carolina Phosphate.
Pure Ground Animal Bone.
Steamed Bone.
Improved Superphosphate.
Potato and Tomato Manure.
Normal Bone Phosphate.
Farmer's Choice Bone Phosphate.
Tobacco Fertilizer.

Walker, Stratman & Co., Pittsburg, Pa.: —
Potato Special.
Big Bonanza.
Smoky City.
Four Fold.

Andrew H. Ward, Boston, Mass.: —
Ward's Chemical Fertilizer.

I. S. Whittemore, Wayland, Mass.: —
Complete Manure.

D. Whithed, Lowell, Mass.: —
Champion Fertilizer.
Bone Meal.

The Wilcox Fertilizer Works, Mystic Conn.: —
Potato, Onion and Tobacco Manure.
Ammoniated Bone Phosphate.
High-grade Fish and Potash.
Dry Ground Fish Guano.

Williams & Clark Fertilizer Co., Boston, Mass.: —
Ammoniated Bone Superphosphate.
Potato Phosphate
High-grade Special.
Fine Wrapper Tobacco Grower.
Royal Bone Phosphate.
Corn Phosphate.
Potato and Tobacco Manure.
Grass Manure.
Fish and Potash.
Universal Ammoniated Dissolved Bone.
Prolific Crop Producer.
Onion Manure.
Bone Meal.
Dry Ground Fish.
Sulphate of Potash.
Muriate of Potash.
Nitrate of Soda.
Dissolved Bone-black.
Sulphate of Ammonia.

M. E. Wheeler & Co, Rutland, Vt.: —
High-grade Corn Fertilizer.
High-grade Potato Manure.
Superior Truck Fertilizer.
Havana Tobacco Grower.
High-grade Fruit Fertilizer.
High-grade Grass and Oats Fertilizer.
Electrical Dissolved Bone.

II. REPORT ON GENERAL WORK IN THE CHEMICAL LABORATORY.

CHARLES A. GOESSMANN.

1. Analyses of Materials sent on for Examination.
2. Notes on Barn-yard Manure.
3. Notes on Wood Ashes.
4. Notes on Cotton-seed Meal.
5. Notes on Guano from West Coast of Africa.
6. Notes on Ashes from Crematory Furnace for City Garbage.
7. Notes on Wool Washings.

1. Analyses of Materials sent on for Examination.

The work carried on in this connection is growing from year to year in importance. A large proportion of commercial manurial substances consists of by or waste products of various industries. The composition and general character of these materials depend on the current mode of manufacture. The rapid advancement in many branches of industries is at any time liable to affect more or less seriously the commercial as well as the manurial value of their waste products. A frequent examination of that class of materials cannot fail to benefit the vital interests of our farming community. For this reason arrangements were made, as in previous years, to attend to the examination of substances of interest to farmers to the full extent of the resources placed at the disposal of the officer in charge of this work. These investigations are carried on free of charge to farmers of the State. The results are considered public property, and are published from time to time in the bulletins of the station.

The number of substances tested in this connection amount to two hundred and thirty-eight. As the detailed results of their analyses have already been published in three bulletins, Nos. 45, 48 and 49, March, July and November, 1897, a brief statement of the names of the different articles analyzed will, on this occasion, suffice to convey some idea of the extent and the character of the work accomplished. Only a few of these materials of more special importance are reserved for a subsequent short discussion.

The substances tested from Dec. 1, 1897, to Dec. 1, 1898, are as follows: wood ashes, 89; cotton-seed meal, 23; cotton-seed hull ashes, 3; cotton factory waste, 5; tankage, bone and fish, 17; muck, peat and soils, 16; chemicals, 14; acid phosphates and dissolved bone-blacks, 5; natural phosphates, 6; tobacco refuse, 2; complete fertilizers, 31; miscellaneous, 9; Damara land guano, garbage cremation ashes and wool washings, each 1.

Aside from this work are the complete analyses of 36 samples of tobacco leaves, together with numerous tests for the quality of ash and rate of combustion. See Bulletin No. 47, on tobacco experiments, published in April, 1897.

The responsibility of the genuineness of all articles sent on for examination rests with the parties asking for the analysis. Our publications of the results refer merely to the locality they come from, to avoid misunderstandings. Samples of fertilizers collected from original packages by authorized agents of the station in the general markets furnish the material for official analyses, and are considered genuine articles.

2. Notes on Barn-yard Manure.

The importance of barn-yard manure as a home source of plant food cannot be over-estimated in a mixed farm management. In a well-regulated rational system of stock feeding it is one of the cheapest if not the cheapest source of valuable manurial constituents. An exceptional liability to vary in composition is the strongest objection which can be raised against its exclusive use as a manure supply for the farm and garden, yet this objection has lost much of its force since the causes of variation are better understood, and may thus be avoided to a considerable extent. We have learned how to improve its efficiency as a complete manure under varying conditions of soil as well as of varying wants of crops, by adding those manurial constituents which are called for in different relative proportions, and which the barn-yard manure on hand does not contain.

Analyses of Eighty Samples of Barn-yard Manure made at Amherst, Mass.

ANALYSIS.	POUNDS PER HUNDRED.			Pounds per Ton (2,000 Pounds).
	Highest.	Lowest.	Average.	
Moisture,	75.00	60.00	67.24	1344.80
Nitrogen,	1.36	.21	.52	10.40
Potassium oxide,	1.40	.13	.56	11.20
Phosphoric acid,	.75	.10	.39	7.80

The average barn-yard manure contains, as will be noticed from the above statement, a larger percentage of nitrogen as compared with potash and phosphoric acid than is generally considered economical in a complete fertilizer for general farm purposes.

The practice of adding to the manurial refuse materials of the farm, as stable manure, vegetable compost, etc., such single commercial manurial substances as will enrich them in the direction desirable for any particular crop, does not yet receive that degree of general attention which it deserves. An addition of potash in the form of muriate or sulphate of potash, or of phosphoric acid in the form of fine-ground South Carolina or Florida soft phosphate, etc., will in many instances not only improve their general fitness as complete manure, but quite frequently permit a material reduction in the amount of barn-yard manure ordinarily considered necessary to secure satisfactory results. An addition of from thirty to forty pounds of muriate of potash and one hundred pounds of fine-ground soft Florida phosphate per ton of barn-yard manure, at any time before applying the latter to the soil deserves recommendation.

3. Notes on Wood Ashes.

Forty per cent. of all articles sent on for examination consist of wood ashes. They are sold in the majority of cases under the trade name "Unleached Canada hard-wood ashes." Ninety-eight samples tested at the station during the past year gave the following results: —

	No. of Samples.
Moisture from 1 to 3 per cent.,	10
" 4 to 6 "	8
" 6 to 10 "	13
" 10 to 15 "	19
" 15 to 20 "	11
" 20 to 30 "	10
Moisture above 35 per cent.,	1
Potassium oxide above 8 per cent.,	3
" " from 7 to 8 per cent.,	8
" " " 6 to 7 "	21
" " " 5 to 6 "	28
" " " 4 to 5 "	10
" " " 3 to 4 "	3
" " below 3 per cent.,	none
Phosphoric acid above 2 "	4
" " from 1 to 2 per cent.,	45
" " below 1 per cent.,	24
Average per cent. of calcium oxide (lime),	34.29
Per cent. mineral matter insoluble in diluted hydrochloric acid, from — 6 to 10,	10
10 to 15,	30
15 to 20,	15
20 to 30,	3
above 30,	1

The variations noticeable in the composition of wood ashes are not surprising when we consider the crude mode of collecting and handling them for commercial purposes. The particular effects of both varying quantities of foreign insoluble matter, as soil, coal ashes, etc., and of moisture, on the composition of a given sample of genuine wood ashes, as far as its percentage of potash and of phosphoric acid is concerned, depend largely on the particular kind of wood which has served for the production of the ash. The color of the wood ashes in case of dark varieties depends usually on admixture of more or less charcoal, while an exceptionally light color is not unfrequently due to the kind of wood which furnishes it. Some kinds of wood, as elm wood, produce a white ash of excellent quality, judging from samples sent on for examination.

As the dealer is only obliged to guarantee the amount of potash and of phosphoric acid present in a given quantity of wood ashes, no serious objection can be raised on the part of the buyer on account of moisture, etc., as long as the article contains the specified amount of both potash and phosphoric acid.

Wood ashes ought to be bought and sold by weight, and not by measure, for both moisture and foreign matters are apt to affect seriously the weight of a given measure.

Some dealers in wood ashes have adopted of late the practice of stating merely the sum of both, instead of specifying the amount of each of them present. As phosphoric acid and potassium oxide contained in wood ashes are considered in our section of the country, pound for pound of an equal commercial value, from 4.5 to 5 cents, no particular objection can be raised against a joint statement of both as far as the mere money value of the samples is concerned; yet, as this mode of stating the guaranteed composition is apt to lead to misconception and abuse, it ought to be discouraged and discontinued.

The large percentage of lime, from 30 to 40 per cent., found in genuine wood ashes, imparts a special agricultural value to them as a fertilizer, aside from the amount of potash and phosphoric acid they contain. Wherever an application of lime is desired, wood ashes deserve favorable consideration, on account of the superior mechanical condition of the lime they furnish.

4. Notes on Cotton-seed Meal as a Fertilizer.

Recent low prices of some concentrated feed stuffs have favored experiments to test their fitness for supplying directly nitrogen, phosphoric acid and potash for plant food. Whenever the market value of the amount of nitrogen, phosphoric acid and potash they contain compares fairly well with the market cost of these three ingredients, the trials deserve, for various reasons, encouragement.

The richness of cotten-seed meal, linseed meal, etc., as well as their marked disposition to rot in the presence of moisture and of a fair average temperature, caused their selection. Both are quite frequently looked upon with favor as suitable materials to furnish plant food for various farm crops. Cotton-seed meal in particular is to-day used extensively by tobacco growers in the Connecticut River valley as the main source of nitrogen for that crop.

The increasing importance of cotton-seed meal as a fertilizer has been followed by the writer with a frequent examination of the articles sold in our markets to protect the interests of our farmers. Importers of cotton-seed meal, claiming that they sold their articles as a feed stuff and not as a fertilizer, declined as a rule until quite recently to take out a fertilizer license which would oblige them to sell with a stated guarantee of at least the nitrogen.

The results of sixty-five analyses carried on under my direction are as follows: —

	Per Cent.		
	Maximum.	Minimum.	Average.
Moisture,	10.80	3.90	7.00
Nitrogen,	7.95	2.08	6.60
Phosphoric acid,	3.36	.73	1.79
Potassium oxide,	2.38	.48	1.76

Allowing 12 cents for every pound of nitrogen, 5 cents per pound for each of phosphoric acid and potassium oxide, these three ingredients represent per ton a market value of —

$19.39 in case of our average sample of cotton-seed meal.
24.82 in case of our highest sample of cotton-seed meal.
6.20 in case of our lowest sample of cotton-seed meal.

The above-stated difference in the composition of cotton-seed meal is mainly due to the presence of more or less ground skins and husks of the cotton seed. Cotton-seed meal designed for fodder ought to be free from skins and husks, to deserve a recommendation for that purpose; cotton-seed meal to be used for fertilizer may contain more or less of this substance, provided the entire material is finely ground and the price in accordance with the composition.

We advise farmers to buy cotton-seed meal, like all other fertilizing materials, on the basis of a guarantee of (at least) nitrogen as the basis of the bargain. For their information it seems but proper to state in this connection that the American Cotton Oil Company of New York has quite recently secured a license for the sale of their cotton-seed meal as a fertilizer in our State, and intend to sell on the basis of the amount of nitrogen their article contains.

5. Notes on Damara Land Guano.

The material which served for our examination was sent on to this office by Messrs. H. J. Baker & Bro. of New York City. It consisted of a bag containing two hundred pounds of guano, and was accompanied by analyses of two chemists of London, Eng. As every new source of a genuine guano claiming to resemble the Peruvian guano of earlier periods in the trade of commercial fertilizers must be of special importance to all interested in the temporary resources of our supplies of plant food, our results are briefly stated below: —

Analysis of Damara Land Guano (Per Cent.).

Moisture at 100° C.,	17.70
Organic matter,	25.63
Total ash,	56.67
Total nitrogen,	5.79
Nitrogen in form of ammoniates,	1.80
Nitrogen in form of nitrates,	.05
Nitrogen in form of organic matter,	3.94
Carbonic acid,	trace
Total phosphoric acid,	14.78
Soluble phosphoric acid,	4.90
Reverted phosphoric acid,	5.79
Insoluble phosphoric acid,	4.09
Total potassium oxide,	3.53
Potassium oxide soluble in water,	3.46
Sodium oxide,	7.03
Calcium oxide,	14.21
Magnesium oxide,	2.05
Iron and aluminum oxides,	trace
Sulphuric acid,	5.94
Chlorine,	5.77
Insoluble matter,	9.26

The results of our analyses of the sample (two hundred pound bag) kindly sent on for trial by Messrs. H. J. Baker & Bro., New York City, are fairly within the stated composition of English chemists. The guano, it is stated, has been brought from some islands off the west coast of Africa; it is a valuable material, as may be seen from our detailed statement.

6. Notes on Crematory Ashes from City Garbage.

In my annual report for 1895 (pages 160 and 161), special attention was called to two important recent modes of saving city garbage, kitchen refuse in particular, for manurial purposes. Sanitary considerations are the first cause of the introduction of these new modes of disposing of objectionable refuse matter, which promise to become from day to day more important as supplies of valuable fertilizer materials.

Our attention has been in particular called to the products of the crematory furnace ashes from Lowell, Mass. The article is evidently improving, in consequence of the adoption of a proper system of sifting and grinding the ashes, as will be seen from the accompanying analysis, representing, according to statement, one hundred tons. The selling price, from $10 to $11 per ton, invites serious trials, as a fertilizer furnishing potash, phosphoric acid and lime.

Analysis of Ashes from the Cremation of City Garbage (Per Cent.).

Moisture at 100° C.,	.53
Potassium oxide,	6.01
Sodium oxide,	15.65
Total phosphoric acid,	10.21
Available phosphoric acid,	2.34
Insoluble phosphoric acid,	7.87
Sulphuric acid (So_3),	4.57
Chlorine,	4.75
Carbonic acid (CO_2),	10.85
Calcium oxide,	20.22
Magnesium oxide,	1.16
Iron and alumina,	9.32
Insoluble matter,	24.26
Nitrogen (inactive lyan compounds),	.17

7. Notes on Wool Washings as a Source of Fertilizer.

It is a well-known fact that the skins of sheep and raw wool are coated with potash compounds of a soap-like nature. In many localities in Europe it is a common practice to turn to account for manuring grass lands the water used in washing sheep before shearing, as well as the wash water obtained from raw wool in factories. This is used in form of an overflow. Wherever meadows adjoin the place of washing wool, arrangements may be readily provided for turning the wool washings directly to account. Samples of raw wool tested here for potash some years ago gave the following results: —

Potassium oxide soluble in water (per cent.),	3.92
Potassium oxide soluble in diluted hydrochloric acid (per cent.),	4.20

Of interest in this connection are the results of examination of a material sent on from a factory in this State. The article was labelled "concentrated potash liquor," and described as obtained from the washings of wool with water after the grease had been extracted by naphtha. It consisted of a highly colored, thick, syrup-like mass, containing a liberal admixture of fine fibrous vegetable matter. An analysis made with reference to its approximate value as a fertilizer gave the following results: —

	Per Cent.
Moisture at 100° C.,	41.13
Dry matter,	58.87

The dry matter left behind contained: —

	Per Cent.
Potassium oxide,	10.15
Phosphoric acid,	.10
Nitrogen,	1.09

The commercial value of these ingredients per ton of the original substance at the present rates amounts approximately to $12.40. In charring the original material directly, 100 parts left behind 36.49 parts; the charred mass tested for potassium oxide showed 34.91 per cent. present, or 698.2 pounds of potassium oxide per ton of charred residue, which equals 1,012 pounds of carbonate of potash per ton of charred residue practically free from chlorine.

The scarcity of a good quality of carbonate of potash for manurial purposes in case of tobacco and similar industrial crops ought to encourage attempts to turn the concentrated potash liquor to account.

The charred mass might serve directly as material for the manufacture of a high-grade potash fertilizer.

III. NOTES OF FIELD EXPERIMENTS WITH TOBACCO IN MASSACHUSETTS, 1893–96.

CHARLES A. GOESSMANN.

The experiments briefly described in the following pages were carried on with the co-operation of the Valley Tobacco Experiment Association of Massachusetts.

The officers of this organization consisted of President L. A. Crafts of Whately, Vice-President C. L. Fowler of Westfield, Secretary and Treasurer G. D. Fisk of Agawam; Board of Directors, W. A. Porter of Agawam and C. L. Warner of Hatfield.

Hatfield, Westfield and Agawam were chosen for the location of the experiments. The selection of the particular field in each place was left to a special committee of the association. In all cases a deep, sandy loam was selected for the trial.

The same kind and the same amount of fertilizing ingredients were used in all cases, and the observations continued for three successive years. For details see Bulletin No. 47, April, 1897.

The variety of tobacco selected for the trial was Havana seed. For the purpose of securing uniformity of fertilizer during the years of the experiment, it was decided to purchase at once, as far as advisable, enough of each kind to supply the needed materials for three years.

Statement of Fertilizers used upon Different Plots.

The fertilizer mixture used during the entire time of observation contained in all cases, per acre: —

	Pounds.
Potassium oxide (available)	300
Nitrogen (available), ...	100
Phosphoric acid (available), ...	60

One-fourth of the nitrogen was in all cases used in the form of nitrates of soda or potash, to secure a uniform condition of availability of nitrogen during the early stages of growth.

Each experiment plot measured 3,634 square feet, or approximately one-twelfth of one acre.

Chemical Composition of the Different Fertilizing Ingredients used in compounding the Special Fertilizers for Different Plots in the Tobacco Experiment. Ingredients containing Chlorine were carefully excluded from the Mixtures of Fertilizers in All Cases.

NAME OF MATERIAL.	Nitrogen.	Phosphoric Acid.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.
Nitrate of soda, ...	15.59	–	–	35.00	–	–
Nitrate of potash, ...	12.79	–	45.05	–	–	–
Cotton-seed meal, ...	6.50	3.17	2.25	–	–*	–*
Linseed meal, ...	5.91	1.95	1.08	–	–*	–*
Castor pomace, ...	5.60	2.26	3.40	–	–*	–*
Dissolved bone-black, ...	–	13.38	–	–	–*	–
Odorless phosphate, or phosphatic slag,	–	18.42	–	–	48.27	–
High-grade sulphate of potash, . .	–	–	50.20	–	–	–
Potash-magnesia sulphate, . . .	–	–	24.32	–	–	12.58
Cotton-seed hull ashes, ...	–	7.93	23.96	–	9.30	10.47
Carbonate of potash-magnesia, . .	–	–	18.48	–	–	19.52
Barn-yard manure, ...	.52	.39	.56	–*	–*	–*

* Not determined.

Chemical Composition of the Different Special Formulas used in the Tobacco Experiment.

PLOT 1.

NAME OF FERTILIZING MATERIAL USED.	Pounds per Acre.	POUNDS OF FERTILIZING ELEMENTS PER ACRE.		
		Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Nitrate of potash, ...	195	–	88	25
Cotton-seed meal, ...	1,154	37	26	75
Dissolved bone-black, . . .	175	23	–	–
Potash-magnesia sulphate, . .	765	–	186	–
Total, ...	–	60	300	100

PLOT 2.

NAME OF FERTILIZING MATERIAL USED.	Pounds per Acre.	POUNDS OF FERTILIZING ELEMENTS PER ACRE. Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Nitrate of potash,	195	–	88.0	25
Castor pomace,	1,340	31	45.0	75
Dissolved bone-black,	221	29	–	–
Potash-magnesia sulphate,	685	–	166.5	–
Total,	–	60	299.5	100

PLOT 3.

Nitrate of soda,	160.3	–	–	25
Cotton-seed meal,	1,154.0	37.00	26	75
Cotton-seed hull ashes,	1,142.0	90.56	274	–
Total,	–	127.56	300	100

PLOT 4.

Nitrate of soda,	160.3	–	–	25
Castor pomace,	1,340.0	31.0	45.50	75
Cotton-seed hull ashes,	1,060.0	84.1	253.97	–
Total,	–	115.1	299.47	100

[PLOT 5.—No manure at any time during the experiment.]

PLOT 6.

Nitrate of soda,	160.3	–	–	25
Cotton-seed meal,	1,154.0	37	26	75
Dissolved bone-black,	175.0	23	–	–
High-grade sulphate of potash,	545.8	–	274	–
Total,	–	60	300	100

PLOT 7.

NAME OF FERTILIZING MATERIAL USED.	Pounds per Acre.	POUNDS OF FERTILIZING ELEMENTS PER ACRE.		
		Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Nitrate of soda, ...	160.3	–	–	25
Castor pomace, ...	1,340.0	31	45.50	75
Dissolved bone-black, . . .	221.0	29	–	–
High-grade sulphate of potash, .	506.0	–	254.50	–
Total, ...	–	60	300.00	100

PLOT 8.

Nitrate of soda, ...	160.3	–	–	25
Linseed meal, ...	1,271.0	24.78	14	75
Dissolved bone-black, . . .	263.0	35.22	–	–
High-grade sulphate of potash, .	569.7	–	286	–
Total, ...	–	60.00	300	100

PLOT 9.

Nitrate of potash, ...	195	–	88	25
Cotton-seed meal, ...	1,154	37	26	75
Cotton-seed hull ashes, . . .	776	62	186	–
Total, ...	-	99	300	100

PLOT 10.

Nitrate of potash, ...	195.0	–	88.00	25
Castor pomace, ...	1,340.0	31	45.50	75
Phosphatic slag meal, . . .	157.0	29	–	–
Carbonate of potash-magnesia, .	900.9	–	166.50	–
Total, ...	–	60	300.00	100

PLOTS 11 AND 12.*

Barn-yard manure, ...	20,000	78	112	104

* Average analysis of seventy-five samples tested at the station laboratory at Amherst, Mass.

Summary of Three Years of Observation at Hatfield, Agawam and Westfield.

I. Number of Plants harvested and Yield of Tobacco per One Thousand Plants.

Hatfield (Old Tobacco Land).

Year.	Average Number of Plants.		Difference in Yield per Plot on the Basis of 1,000 Plants (Pounds).	
	Per Plot.*	Per Acre.	Highest.	Lowest.
1893,	561	6,734	266	217
1894,	618	7,419	223	191
1895,	626	7,512	222	191

* One-twelfth of one acre.

Westfield (New Tobacco Land).

1894,	670	8,040	192	155
1895,	593	7,122	245	217
1896,	689	8,269	216	191

Agawam (New Tobacco Land).

1893,	696	8,352	225	158
1894,	704	8,432	220	164
1895,	695	8,340	222	148

Year.	Average Yield of Tobacco on the Basis of 1,000 Plants Harvested (Pounds).		
	Hatfield.	Westfield.	Agawam.
1893,	235.2	–	191.3
1894,	206.4	171.6	186.7
1895,	210.5	228.0	176.2
1896,	–	199.4	–

II. Average Yield of Tobacco, with Reference to Wrapper, per One Thousand Plants.

Hatfield.

YEAR.	Average Yield of Tobacco.	Average Yield of Wrappers.	Average Percentage of Wrappers.	Variations in Percentage of Wrappers in Plots.
	Pounds.	Pounds.		
1893, ...	235.2	97.2	41.2	21.0–71.0
1894, ...	206.6	105.0	50.7	38.8–64.4
1895, ...	210.1	109.3	52.1	36.8–63.1

Westfield.

1894, ...	171.3	90.3	52.3	41.6–62.10
1895, ...	228.7	49.6	21.2	6.4–34.40
1896, ...	199.3	138.2	69.6	59.0–78.80

Agawam.

1893, ...	190.8	–*	–*	–*
1894, ...	191.7	52.2	26.7	8.8–44.4
1895, ...	178.8	–*	–*	–*

* Not determined.

Conclusions drawn from the Third Year of Observation.

1. Good mechanical preparation of the soil and early application, and thus good diffusion of the fertilizers, not less than early planting and a suitable number of plants to a given area, exert a decided influence on the quantity and the quality of the crop, under otherwise corresponding conditions. Planting as early as the local climate admits secures the benefit of the winter moisture.

Too close planting interferes with a liberal or rapid development of the leaves, and too large open spaces between the individual plants tends to favor a coarser structure. Rows three feet and four inches apart with plants twenty inches from each other in the row (Westfield), and rows two feet and eight inches apart with plants two feet from each other in the row (Hatfield) gave better returns than rows three feet apart with plants eighteen inches from each other in the row (Agawam).

2. A timely, shallow use of the cultivator or hoe for the removal of weeds favors a uniform progress of growth. A careless use of cultivator or hoe invariably checks more or less the growth of the plants, and modifies more or less their structure and general character.

3. The different fertilizer mixtures used in our experiments have affected in a less marked degree the weight of the crop raised by their aid than the quality. New lands reduced by previous cropping to a state approaching general exhaustion of available plant food, if otherwise well fitted for raising tobacco, have given excellent results when supplied with a suitable mixture of fertilizing ingredients in quantities similar to those applied during our experiments (Westfield). Such lands are at times preferable to old tobacco lands overcharged with remnants of all kinds of saline ingredients, usually associated with the common run of commercial fertilizers.

4. Cotton-seed meal, linseed meal and castor pomace have proved equally good sources of nitrogen for the successful raising of tobacco when used in connection with nitrate of soda or potash, sufficient to furnish one-fourth of the nitrogen called for by the crop.

5. Nitrate of soda as a part of the nitrogen supply in the fertilizer (25 per cent.), when used in presence of acid phosphate, dissolved bone-black, etc., has been accompanied with better results regarding quality of crop than nitrate of potash under otherwise similar conditions.

6. Cotton-seed hull ashes and high-grade sulphate of potash have proved in our observation most valuable sources of potash for tobacco, the former in the majority of cases leading. Nitrate of potash has produced excellent results when used in connection with an alkaline phosphate, as phosphatic slag meal or with carbonate of potash-magnesia. Our

results with potash-magnesia sulphate as the main potash sources of a tobacco fertilizer are not encouraging.

7. The difference noticed in the color of ash, etc., in case of the crop being raised upon different plots, is in several instances so slight that an attempt to classify the various fertilizers used with reference to their superior fitness on the basis of color and compactness of ash cannot be otherwise than arbitrary. With this qualification in mind, the following classification is offered for the consideration of parties engaged in the cultivation of tobacco in our section of the country: —

First Class.

Plot 4. — Nitrate of soda, cotton-seed hull ashes and castor pomace.

Plot 3. — Nitrate of soda, cotton-seed hull ashes and cotton-seed meal.

Plot 9. — Nitrate of potash, cotton-seed hull ashes and cotton-seed meal.

Plot 10. — Nitrate of potash, carbonate of potash-magnesia and phosphatic slag.

Second Class.

Plot 6. — Nitrate of soda, high-grade sulphate of potash, cotton-seed meal and dissolved bone-black.

Plot 8. — Nitrate of soda, high-grade sulphate of potash, linseed meal and dissolved bone-black.

Plot 7. — Nitrate of soda, high-grade sulphate of potash, castor pomace and dissolved bone-black.

Third Class.

Plot 1. — Nitrate of potash, potash-magnesia sulphate, cotton-seed meal and dissolved bone-black.

Plot 2. — Nitrate of potash, potash-magnesia sulphate, castor pomace and dissolved bone-black.

The observations with barn-yard manure have not been considered in the above classification; they are very encouraging, but not sufficient in number to permit detailed discussion in this connection; besides, the amount of barn-yard manure used in our experiment, ten tons per acre, contained nearly two hundred pounds of potassium oxide and from thirty to forty pounds of available phosphoric acid less than our formula of commercial fertilizing ingredients called for.

An early application of barn-yard manure, properly supplemented with a suitable potash compound and available phosphoric acid, has produced excellent results in other localities.

INDEX.

PUBLIC DOCUMENT . . . . No. 31.

THIRTY-SIXTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1899.

BOSTON:
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MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Jan. 2, 1899.

To His Excellency ROGER WOLCOTT.

SIR: — I have the honor to transmit herewith, to Your Excellency and the Honorable Council, the thirty-sixth annual report of the trustees of the Massachusetts Agricultural College.

I am, very respectfully,
Your obedient servant,

HENRY H. GOODELL,
President.

CONTENTS.

CALENDAR FOR 1899–1900.

1899.

January 4, Wednesday, winter term begins, at 8 A.M.

March 23, Thursday, winter term closes, at 10.15 A.M.

April 5, Wednesday, spring term begins, at 8 A.M.

June 17, Saturday, Grinnell prize examination of the senior class in agriculture.

June 18, Sunday,
- Baccalaureate sermon.
- Address before the College Young Men's Christian Association.

June 19, Monday,
- Burnham prize speaking.
- Flint prize oratorical contest.

June 20, Tuesday,
- Class-day exercises.
- Meeting of the alumni.
- Reception by the president and trustees.

June 21, Wednesday, commencement exercises.

June 22–23, Thursday and Friday, examinations for admission, at 9 A.M., Botanic Museum, Amherst; at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; and at Sedgwick Institute, Great Barrington. Two full days are required for examination, and candidates must come prepared to stay that length of time.

September 5–6, Tuesday and Wednesday, examinations for admission, at 9 A.M., Botanic Museum.

September 7, Thursday, fall term begins, at 8 A.M.

December 21, Thursday, fall term closes, at 10.15 A.M.

1900.

January 3, Wednesday, winter term begins, at 8 A.M.

March 22, Thursday, winter term closes, at 10.15 A.M.

ANNUAL REPORT OF THE TRUSTEES

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

His Excellency the Governor and the Honorable Council.

There has passed away within the last few days one who for forty years has been a leader in the council chamber of the nation. Patriotic and wise in his statesmanship, conservative, yet firm as the rocky hills of his native State, in his convictions he impressed his own force and strength of character upon his associates. Courteous and gentle in manner, he so won their love and affection that his wishes became law and personal solicitation secured what argument failed to effect. Keenly alive to the lack of an education which had been bounded by the narrow limits of his village school, he resolved to place within the grasp of the industrial classes an education which should best fit them for the duties and professions of life. After years of effort he succeeded, at a time when the country was distracted and rent by civil dissension and war, in passing an act establishing, in each State and Territory accepting its provisions, a college to teach such branches of learning as are related to agriculture and the mechanic arts, in order to promote the liberal and practical education of the industrial classes. Twenty-eight years later, recognizing that the growth of a college must depend upon an increased income to keep pace with its increased demands, he succeeded in materially adding to their endowment. The last days of his life were spent in devising means for placing that endowment upon a secure and permanent foundation. In the death of Senator Justin S. Morrill the whole country has sustained a great loss. What he was in shaping the policy of the nation, he was in the cause of education. It would seem fitting, then, that in this public document of the Commonwealth the trustees of the Massachusetts Agricultural College, its faculty and students, unite in this expression of love and esteem for his character and reverence for the wisdom and foresight that inaugurated a system of education so complete and far-reaching in its results.

Dr. Harris in one of his addresses made the remark that the experiment station, as a laboratory, is the pivot on which the agricultural college is wheeling. What the experiment station is to the college, the laboratory is in all matters of education. It is the nut on the other side of the beam which holds the bolt and prevents it from drawing through. It drives home and clinches the theories advanced in the recitation room. For what a man has himself performed he can never forget, and the educated hand and trained eye never lose their cunning till sense and motion cease in the absolute repose of death. Taking advantage, then, of this strong right arm in education, we have planted our laboratories in every department: in the botanical, to study plant diseases and their remedies; in the horticultural, to test the different varieties of fruit, flowers and vegetables and the effects of crossing and pollination; in the entomological, to breed the crawling, creeping, flying scourges that assail our crops, and find out the most effective poisons that will exterminate them without injury to the plant; in the chemical, to resolve compounds into their component parts, and reassemble them into other useful or destructive combinations; in the physical, to study the principles of draft and mechanics, or the wondrous powers of electricity; in the agricultural, to study the properties of soil and the fertilizers to be added or withheld; in the drill hall, to give the student a graceful, easy carriage, and build up a strong and manly body as the fit accompaniment and framework for a strong and manly soul. In pursuance of this plan, at the last session of the General Court, an appropriation was asked in order to erect and maintain a veterinary laboratory and hospital-stable, for the study of animal diseases and the hygienic principles affecting the health of domestic stock. The veterinary department, though the last to be recognized, is perhaps the most important in the whole college curriculum. It touches the life and health of the farm animals to the amount of $20,000,000, and through them it affects most intimately the life and health of the 2,500,000 citizens of this Commonwealth, dependent upon them and their products. It is one of the earliest attempts, in this State, to encourage the intelligent study of animal disease, and is only in line with the very first principle of education, that instruction and study must go hand in hand.

The committee of trustees having in charge the erection of the necessary buildings advertised for bids. Sixteen, from different parts of the State, were offered, as shown in the following table: —

James Bowdry, Jr., Holyoke,	$21,985
H. P. Cummins & Co., Ware,	20,944
S. S. & H. N. Lawrence, Fitchburg,	27,475
Joseph Hebert, Northampton,	22,865
N. L. Cain, Holyoke,	23,150
H. C. Wood, Westfield,	19,157
A. A. Jones, Holyoke,	20,070
Thorpe Bros., Holyoke,	21,647
La Liberte, Holyoke,	22,971
La France & La Rivier, Holyoke,	20,789
Lynch Brick Company, Holyoke,	22,963
J. W. Bishop & Co., Worcester,	19,868
Cutting, Bardwell & Co., Worcester,	24,750
E. L. Witherell, Westfield (stable),	6,874
Allen Bros., Amherst,	20,300
Henry Mellen & Son, Worcester,	17,985

The lowest, that of Henry Mellen & Son of Worcester, was accepted. The laboratory and stable, built of brick with brown-stone trimmings, are now well advanced towards completion, the walls being up and roofed over and the slate already in place. In like manner the building intended for the dairy plant was let to the lowest bidder, and will soon be ready for work.

The wave of patriotism that swept over our land left its impress upon the college, as it did upon all similar institutions. It found there willing minds and loyal hearts, and stirred them as none have been stirred since the days of

'61–'65. The men who framed and passed the act of 1862, establishing in each State and Territory an agricultural and mechanical college, builded far better than they knew when they imposed instruction in the art and theory of war as a condition to the acceptance of the grant. Never was there a larger return for capital invested. Hardly had the call to arms been sounded, when, all over the country, scholars, teachers, graduates, who had enjoyed the advantages of military instruction in these colleges, leaped to the front, and, offering their services, took the field. No one observing either the number or the quality of these men could for an instant doubt the wisdom of a policy which had in time of peace so carefully prepared for war and furnished material for just such an emergency. The presidents of twenty-four of these colleges reported that 29 of the undergraduates and 50 alumni had been commissioned in the regular army, and 157 undergraduates and 296 alumni in the volunteer service, — a total of 541 officers, or enough for about 12 regiments. Further, 1,084 students and ex-students joined the army as non-commissioned officers or privates. From these figures, reported by only one-half of the colleges, we may safely assume that when full returns are received the number of officers will foot up to at least 600, and the non-commissioned officers and privates to 1,500 or 1,600. One college alone, that of the State University of Ohio, and from which incomplete returns have as yet been received, was represented in the army by 3 field officers, 28 line and 209 non-commissioned officers and privates. Our own college furnished for its quota 28. Of these, 4 were in the regular army and navy, and the rest in the volunteer service. Seven dropped their college work and endured the discipline of camp and garrison life. Of these, 5 have been discharged by reason of expiration of term of service, and 2 are still in camp, pending the result of their applications for discharge to return and resume their studies. One private, Harvey R. Atkins, pined away and died of a broken heart on the shores of Santiago, consumed with longing for his native land; and one, alas, now sleeps beneath a spreading oak in the national cemetery at Arlington. Wounded in the arm, then shot through a vital part of the body, a third time wounded in the leg and twice more grazed by hostile balls, he lay all day amid the heat and conflict of the battle at El Caney, and as the night was lengthening into the dawn he passed away. On the afternoon of November 9 memorial services were held in the college chapel, and on its walls was placed a bronze tablet, set in Sienna marble, in loving remembrance of Captain Walter Mason Dickinson, by his college friends.

The entering class this year was fully up to the mark of the last two or three years, 34 having entered the freshman class, and the sophomore receiving 5 additions. The plan proposed by the college committee of the Board of Overseers, to place one-half of the free scholarships offered by the State within the gift of the members of the Board of Agriculture, would be a move in the right direction. It would have the effect of enlisting the co-operation and aid of a wider circle of men, fully in sympathy with the college and its aims, and strengthening the bond which now unites the two. Legislation would be necessary to bring about this change, but the direct benefits appear so obvious that it is worthy of careful consideration.

The studies of the senior year, sixteen in number, have thus far been elective, with the exception of English and military, which were required. An experience of six years has shown that there has been much misdirected effort on the part of the students, resulting partly from inclination, but mostly from a failure to grasp the proper correlation of subjects. Certain studies naturally fall into the same group, — as entomology, botany and German, or geology, agriculture and chemistry. But these groupings are not always clearly seen nor appreciated. To aid the students in selecting a proper sequence of studies, a dozen or more courses have been arranged, which will be offered for selection. It is believed that in this way better results will be secured and more thorough work done in the time allowed. The courses in geology and astronomy, established last year, have been appreciated, and supply a want long felt.

During March a true meridian was established by a number of observations on Polaris at western elongation. In September the work was checked by observations at eastern elongation. The line has been transferred to a suitable place and permanently marked. The location of the south end is the centre of the upper end of a piece of one and one-half inch gas pipe on the west side of the road near the drill hall. The north end is a cross, cut in the stone on the south end of the east step at the eastern entrance to the chapel-library building. This point is believed to be free from local attraction, and compasses should be set up there when magnetic declination is to be determined. This line may be used by any who so desire for testing their compasses and determining the angle between the true and magnetic north, as given by any particular instrument at any desired time. The change in the direction of magnetic north from year to year may also be determined.

The finances of the college demand special consideration. The income from the maintenance fund has steadily decreased, while the expenses have correspondingly increased. New methods and appliances and new courses opened to meet the growing demands have required corresponding outlays. The number of buildings has increased from six to twenty-eight, each building requiring care and attention and more or less repairing each year. The teaching force has been augmented from four to eighteen, and is still inadequate to give the instruction required by the charter of the college and the law of the United States under which it was founded. It is the logical outcome of a growing institution. There can be no middle ground; it must either advance or retrograde,—it cannot stand still. This year the income from our maintenance fund has diminished $1,500, and we are assured that it will probably be less the ensuing twelve months. Predicating our resources on last year's receipts, we find ourselves in debt, through no fault of our own, but through the falling off of the rate per cent. of our investments. To maintain the college, not only in its present standing, but to enable it to do the work for which it was founded, we ask that an annual increase to our resources be made of $10,000. Our teachers are underpaid and overworked. The dairy school requires additional equipment and teaching force. The short winter courses, for those unable to spend four years in securing an education, need extra help; and the library, which places tools in the hands of teacher and pupil, has received the barest additions, except through gift and exchange, the past two years. Massachusetts offers her sons and daughters the best, and they have a right to demand the best. But the best can only be had at the market price for the best.

In addition to the customary reports, I have the honor to submit a special paper on "Butter Cultures."

Respectfully submitted, by order of the trustees,

HENRY H. GOODELL,
President.

Amherst, Jan. 2, 1899.

THE CORPORATION.

	TERM EXPIRES
J. HOWE DEMOND of Northampton,	1900
ELMER D. HOWE of Marlborough,	1900
NATHANIEL I. BOWDITCH of Framingham,	1901
WILLIAM WHEELER of Concord,	1901
ELIJAH W. WOOD of West Newton,	1902
CHARLES A. GLEASON, of New Braintree,	1902
JAMES DRAPER of Worcester,	1903
SAMUEL C. DAMON of Lancaster,	1903
HENRY S. HYDE of Springfield,	1904
MERRITT I. WHEELER of Great Barrington,	1904
JAMES S. GRINNELL of Greenfield,	1905
CHARLES L. FLINT of Brookline,	1905
WILLIAM H. BOWKER of Boston,	1906
J. D. W. FRENCH of Boston,	1907

Members Ex Officio.

His Excellency Governor ROGER WOLCOTT,
President of the Corporation.

HENRY H. GOODELL, *President of the College.*
FRANK A. HILL, *Secretary of the Board of Education.*
WILLIAM R. SESSIONS, *Secretary of the Board of Agriculture.*

JAMES S. GRINNELL of Greenfield,
Vice-President of the Corporation.

GEORGE F. MILLS of Amherst, *Treasurer.*

CHARLES A. GLEASON of New Braintree, *Auditor.*

Committee on Finance and Buildings.*

JAMES S. GRINNELL. HENRY S. HYDE.
J. HOWE DEMOND. SAMUEL C. DAMON.
CHARLES A. GLEASON, *Chairman.*

Committee on Course of Study and Faculty.*

WILLIAM H. BOWKER. ELMER D. HOWE.
CHARLES L. FLINT. J. D. W. FRENCH.
WILLIAM WHEELER, *Chairman.*

Committee on Farm and Horticultural Department.*

WILLIAM R. SESSIONS. JAMES DRAPER.
NATHANIEL I. BOWDITCH. MERRITT I. WHEELER.
ELIJAH W. WOOD, *Chairman.*

Committee on Experiment Department.*

CHARLES A. GLEASON. ELIJAH W. WOOD.
WILLIAM WHEELER. WILLIAM R. SESSIONS.
JAMES DRAPER, *Chairman.*

Committee on New Buildings and Arrangement of Grounds.*

WILLIAM WHEELER. SAMUEL C. DAMON.
CHARLES L. FLINT. J. D. W. FRENCH.
JAMES DRAPER, *Chairman.*

Board of Overseers.

STATE BOARD OF AGRICULTURE.

Examining Committee of Overseers.

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E. A. HARWOOD, . . . of North Brookfield.
JOHN BURSLEY, ... of West Barnstable.
C. K. BREWSTER, . . . of Worthington.
WESLEY B. BARTON, . . of Dalton.

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* The president of the college is ex officio a member of each of these committees.

The Faculty.

HENRY H. GOODELL, LL.D., *President.*
Professor of Modern Languages.

LEVI STOCKBRIDGE,
Professor of Agriculture, Honorary.

CHARLES A. GOESSMANN, Ph.D., LL.D.,
Professor of Chemistry.

SAMUEL T. MAYNARD, B.Sc.,
Professor of Horticulture.

CHARLES WELLINGTON, Ph.D.,
Associate Professor of Chemistry.

CHARLES H. FERNALD, Ph.D.,
Professor of Zoölogy.

Rev. CHARLES S. WALKER, Ph.D.,
Professor of Mental and Political Science.

WILLIAM P. BROOKS, Ph.D.,
Professor of Agriculture.

GEORGE F. MILLS, M.A.,
Professor of English and Latin.

JAMES B. PAIGE, D.V.S.,
Professor of Veterinary Science.

GEORGE E. STONE, Ph.D.,
Professor of Botany.

JOHN E. OSTRANDER, M.A., C.E.,
Professor of Mathematics and Civil Engineering.

HERMAN BABSON, M.A.,
Assistant Professor of English.

EDWARD R. FLINT, Ph.D.,
Assistant Professor of Chemistry.

FRED S. COOLEY, B.Sc.,
Assistant Professor of Agriculture.
(Animal Husbandry and Dairying.)

RICHARD S. LULL, M.S.,
Assistant Professor of Zoölogy.

RALPH E. SMITH, B.Sc.,
Instructor in German and Botany.

PHILIP B. HASBROUCK, B.S.,
Assistant Professor of Mathematics.

WILLIAM M. WRIGHT, Captain, 2d Infantry, U.S.A.,
Professor of Military Science and Tactics.

ROBERT W. LYMAN, LL.B.,
Lecturer on Farm Law.

HENRY H. GOODELL, LL.D.,
Librarian.

ELISHA A. JONES, B.Sc.,
Farm Superintendent.

Graduates of 1898.*

Master of Science.

Holland, Edward Bertram, ...	Amherst.

Bachelor of Science.

Adjemian, Avedis Garrabet (Boston Univ.),	Kharpoot, Turkey.
Baxter, Charles Newcomb (Boston Univ.), .	Quincy.
Clark, Clifford Gay (Boston Univ.), . .	Sunderland.
Eaton, Julian Stiles (Boston Univ.), . .	Nyack, N. Y.
Fisher, Willis Sikes (Boston Univ.), . .	Ludlow.
Montgomery, Jr., Alexander (Boston Univ.),	Natick.

* The annual report, being made in January, necessarily includes parts of two academic years, and the catalogue bears the names of such students as have been connected with the college during any portion of the year 1898.

Nickerson, John Peter (Boston Univ.),	West Harwich.
Warden, Randall Duncan (Boston Univ.),	Roxbury.
Wiley, Samuel William (Boston Univ.),	Amherst.
Wright, George Henry (Boston Univ.),	Deerfield.
Young, Charles Elisha ('81),	White Plains, N. Y.
Total,	12

Senior Class.

Armstrong, William Henry,	Cambridge.
Beaman, Dan Ashley,	Leverett.
Boutelle, Albert Arthur,	Leominster.
Chapin, William Edward,	Chicopee.
Dana, Herbert Warner,	South Amherst.
Hinds, Warren Elmer,	Townsend.
Hooker, William Anson,	Amherst.
Hubbard, George Caleb,	Sunderland.
Maynard, Howard Eddy,	Amherst.
Pingree, Melvin Herbert,	Denmark, Me.
Sharpe, Edward Hewett,	Northfield.
Smith, Bernard Howard,	Middlefield.
Smith, Samuel Eldredge,	Middlefield.
Stacy, Clifford Eli,	Gloucester.
Turner, Frederick Harvey,	Housatonic.
Walker, Charles Morehouse,	Amherst.
Wright, Edwin Monroe,	Manteno, Ill.
Total,	17

Junior Class.

Atkins, Edwin Kellogg,	North Amherst.
Baker, Howard,	Dudley.
Brown, Frank Howard,	Newton Centre.
Campbell, Morton Alfred,	Townsend.
Canto, Ysidro Herrera,	Cansahcat, Mexico.
Crane, Henry Lewis,	Ellis.
Crowell, Jr., Charles Augustus,	Everett.
Crowell, Warner Rogers,	Everett.
Felch, Percy Fletcher,	Worcester.
Frost, Arthur Forrester,	South Monmouth, Me.
Gile, Alfred Dewing,	Worcester.
Halligan, James Edward,	Roslindale.

Harmon, Arthur Atwell, . . .	Chelmsford.
Hull, Edward Taylor, . . .	Greenfield Hill, Conn.
Kellogg, James William, . . .	Amherst.
Landers, Morris Bernard, . . .	Bondsville.
Lewis, James, ...	Fairhaven.
March, Allen Lucas, ...	Ashfield.
Merrill, Frederic Augustus, . .	Boston.
Monahan, Arthur Coleman, . .	South Framingham.
Morrill, Austin Winfield, . . .	Tewksbury.
Munson, Mark Hayes, . . .	Huntington.
Otis, Wilbur Corthell, . . .	Beachmont.
Ovalle Barros, Julio Moises, . .	Santiago, Chili.
Parmenter, George Freeman, . .	Dover.
Saunders, Edward Boyle, . . .	Southwick.
Stanley, Francis Guy, . . .	Springfield.
Walker, Henry Earl, ...	Vineyard Haven.
West, Albert Merril, ...	Brookville.
Total, ...	29

Sophomore Class.

Ahearn, Michael Francis, . . .	Framingham.
Barry, John Cornelius, . . .	Amherst.
Boutelle, Clarence Alfred, . . .	Leominster.
Bridgeforth, George Ruffin, . .	Westmoreland, Ala.
Brooks, Percival Cushing, . . .	Brockton.
Casey, Thomas, ...	Amherst.
Chapman, John Chauncey, . . .	Amherst.
Chickering, James Henry, . . .	Dover.
Clarke, George Crowell, . . .	Malden.
Cooke, Theodore Frederic, . . .	Austerlitz, N. Y.
Curtis, Ernest Waldo, . . .	Canton.
Dana, George Henry, . . .	South Amherst.
Dawson, William Alucius, . . .	Worcester.
Dickerman, William Carlton, . .	Taunton.
Dorman, Allison Rice, . . .	Springfield.
Gamwell, Edward Stephen, . .	Pittsfield.
Gordon, Clarence Everett, . . .	Clinton.
Graves, Jr., Thaddeus, . . .	Hatfield.
Greeley, Dana Sanford Bernard, .	East Foxborough.
Gurney, Victor Henry, . . .	Forge Village.
Hemenway, Francis Ellis, . . .	Williamsville.
Henry, James Buel, ...	Scitico, Conn.
Howard, John Herbert, . . .	Littleton Common.

Hunting, Nathan Justus, . . .	Shutesbury.
Jones, Clark Winthrop, . . .	Huntington.
Jones, Cyrus Walter, . . .	Amherst.
Judd, Warren Harold, . . .	South Hadley Falls.
Leslie, Charles Thomas, . . .	Pittsfield.
Macomber, Ernest Leslie, . . .	Taunton.
Moulton, Harry Jackson, . . .	Milford.
Paul, Herbert Amasa, . . .	Lynn.
Pierson, Wallace Rogers, . . .	Cromwell, Conn.
Rice, Charles Leslie, ...	Pittsfield.
Rogers, William Berry, . . .	Cambridge.
Root, Luther Augustus, . . .	Deerfield.
Smith, Ralph Ingram, . . .	Leverett.
Tashjian, Dickran Bedross, . .	Kharpoot, Turkey.
Todd, John Harris, ...	Rowley.
Whitman, Nathan Davis, . . .	South Boston.
Wilson, Alexander Cavassa, . .	Boston.
Total, ...	40

Freshman Class.

Adams, Edward Ellis, . . .	Millis.
Ball, George Treadwell, . . .	Holyoke.
Belden, Joshua Herbert, . . .	Newington, Conn.
Blake, Maurice Adin, . . .	Millis.
Bodfish, Henry Look, . . .	Tisbury.
Chapin, Warren Luther, . . .	Amherst.
Chase, William Zachariah, . . .	Lynn.
Church, Frederick Richard, . .	Ashfield.
Claflin, Leander Chapin, . . .	Philadelphia, Pa.
Cole, William Richardson, . . .	West Boxford.
Cook, Lyman Adams, . . .	Millis.
Cooley, Orrin Fulton, . . .	South Deerfield.
Dacy, Arthur Lincoln, . . .	Boston.
Dellea, John Martin, ...	North Egremont.
Dwyer, Chester Edwards, . . .	Lynn.
Fulton, Erwin Stanley, . . .	Lynn.
Gates, Victor Adolph, . . .	Memphis, Tenn.
Greenman, Fred Howard, . . .	Haverhill.
Hall, John Clifford, ...	Rock Bottom.
Hanlon, Harold Clinton, . . .	North Easton.
Hodgkiss, Harold Edward, . . .	Wilkinsonville.
Holder, Walter Safford, . . .	Lynn.
James, Harold Francis, . . .	Boston.

James, Hubert Carey,	Boston.
Kinney, Charles Milton,	Northampton.
Knight, Howard Lawton,	Gardner.
Lewis, Claude Isaac,	Unionville.
McCobb, Edmund Franklin,	Milford.
Morse, Ransom Wesley,	Belchertown.
Peabody, Harry Eldridge,	Stoneham.
Smith, Samuel Leroy,	South Hadley.
Walker, Alpheus Hazard,	Millbrook.
Warden, James Kent,	Rocky Point, N. Y.
West, David Nelson,	Northampton.
Total,	34

Short Winter Courses.

Dickinson, Raymond Daniel,	North Amherst.
Gifford, John Edwin,	Sutton.
Holt, Jonathan Edward,	Andover.
Killam, Myron E.,	West Boxford.
Leach, Oliver Herbert,	Moultonborough, N. H.
Packard, Walter T.,	Campello.
Risley, Clayton Erastus,	Plainfield, N. J.
Ward, Hezekiah Erwin,	Buckland.
Total,	8

Graduate Course.

For Degree of M.S.

Adjemian (B.Sc., M. A. C., '98), Avedis Garrabet,	Kharpoot, Turkey.
Armstrong (B.Sc., M. A. C., '97), Herbert Julius,	Sunderland.
Caudell (B.S., Oklahoma, '96), Andrew Nelson,	Kansas City, Mo.
Goessmann (B.Sc., M. A. C., '97), Charles Ignatius,	Amherst.
Goodale (A.B., Amherst College, '98), Alfred Shepard,	South Amherst.
Hemenway, (B.Sc., M. A. C., '95), Herbert Daniel,	Williamsville.
Kochi (B.S., Sapporo, '91), Chujiro,	Bingo, Japan.
Leavens (B.Sc., M. A. C., '97), George Davison,	Brooklyn Heights, N. Y.

Peters, (B.Sc., M. A. C., '97), Charles Adams,	Worcester.	
Stevens (B.A., Harvard Univ., '95), Waldo Warland,	Groton.	
Total,		10

Resident Graduates at the College and Experiment Station.

Cooley, B.Sc., Robert Allen,	South Deerfield.	
Drew, B.Sc., George Albert,	Westford.	
Haskins, B.Sc., Henri Darwin,	North Amherst.	
Holland, B.Sc., Edward Bertram,	Amherst.	
Jones, B.Sc., Benjamin Kent,	Middlefield.	
Kinney, B.Sc., Asa Stephen,	Worcester.	
Mossman, B.Sc., Fred Way,	Westminster.	
Roper, B.Sc., Harry Howard,	East Hubbardston.	
Smith, B.Sc., Frederic Jason,	North Hadley.	
Smith, Jr., B.Sc., Philip Henry,	South Hadley Falls.	
Thomson, B.Sc., Henry Martin,	Monterey.	
Wiley, B.Sc., Samuel William,	Amherst.	
Total,		12

Special Students.

Howard (Amh. Coll.), Arthur Day,	Glencoe, Ill.	
Kendall (Amh. Coll.), Henry Plimpton,	Walpole.	
Total,		2

Summary.

Graduate course: —		
For degree of M.S.,	10	
Four-years course: —		
Graduates of 1898,	12	
Senior class,	17	
Junior class,	29	
Sophomore class,	40	
Freshman class,	34	
Winter course,	8	
Resident graduates,	12	
Special students,	2	
Total,		164
Entered twice,		3
Total,		161

FOUR-YEARS COURSE OF STUDY.

Freshman Year.

	Agriculture.	Botany and Horticulture.	Chemistry.	Natural History.	Mathematics.	Latin and English.	French and Social Science.	Drawing and Military.
Fall, . .	- -	Botany, structural, — 5.	- -	- -	Advanced algebra, — 5. Book-keeping, —2.	English, — 3.	French, — 4.	Study of tactics, — 1.
Winter, .	History of agriculture. Breeds of horses and sheep, — 4.	- -	- -	- -	Advanced algebra and geometry (plane), — 4.	English, — 3.	French, — 4.	Mechanical drawing, — 6.
Summer, .	Breeds of cattle and swine, — 4.	Botany, analytical, — 4.	Lectures in elementary chemistry, —3.	- -	Geometry (solid), — 3.	English, — 3.	French, — 3.	- -

Sophomore Year.

	Agriculture.	Botany and Horticulture.	Chemistry.	Natural History.	Mathematics.	Latin and English.	French and Social Science.	Drawing and Military.
Fall, . .	Breeding of live stock, poultry farming, dairy farming, — 4.	Botany, economic and laboratory work, — 4.	Lectures in elementary chemistry, —4.	- -	Trigonometry and surveying, — 5.	English, — 2	- -	- -
Winter, .	- -	Laboratory work, — 4.	Lectures and practice, — 4.	Anatomy and physiology, —4.	Mechanics, — 3.	English, — 3.	- -	Mechanical drawing, — 4.
Summer, .	Soils: characteristics, improvement of, drainage, grasses, etc., — 5.	Horticulture, — 5.	Dry and humid qualitative analysis, — 6.	- -	Surveying, — 4.	English, — 2.	- -	- -

JUNIOR YEAR.

	Agriculture.	Botany and Horticulture.	Chemistry, Geology and Astronomy.	Zoölogy.	Mathematics.	Latin and English.	French and Social Science.	Drawing and Military.
Fall, . .	Manures and fertilizers, green manuring, rotation of crops, — 4.	Market gardening, — 3.	Qualitative analysis, — 5.	Zoölogy, laboratory work, — 8.	Physics, — 2.	English literature, — 4.	- -	- -
Winter, .	Relation of the atmosphere to plant growth, drainage, — 2.	- -	Lectures and practice in organic chemistry, — 6.	Zoölogy, — 3.	Physics, — 3. Laboratory physics, — 2.	English literature, — 4.	- -	- -
Summer, .	- -	Landscape gardening, — 5.	The same continued, — 5.	Entomology, — 6.	Physics, — 4. Laboratory physics, — 2.	English, — 2.	- -	- -

SENIOR YEAR (ELECTIVE).*

	Agriculture.	Botany and Horticulture.	Chemistry, Geology and Astronomy.	Zoölogy.	Mathematics.	Latin and English.	French and Social Science.	Drawing and Military.
Fall, . .	Ensilage, cattle feeding, — 5,	Botany, cryptogamic, — 8.	Chemical physics and quantitative analysis, — 8. Astronomy, — 5.	Entomology, — 8. Veterinary science, — 5.	Engineering, — 5. Analytical geometry, — 5.	English, — 2. Advanced English, — 5. Latin, — 5.	Political economy, — 5. German, — 5. History, — 5.	Military science, — 1.
Winter, .	Field crops, seed raising, production and improvement of varieties, machines and implements, — 5.	Botany, cryptogamic, — 8.	Advanced work with lectures, — 8. Astronomy, Geology, } 5.	Entomology, — 8. Veterinary science, — 5.	Engineering, — 5. Differential calculus, — 5.	English, — 2. Advanced English, — 5. Latin, — 5.	Political economy, — 5. German, — 5. History, — 5.	Military science, — 1. Law lectures, — 1.
Summer, .	Rural economy, experimental work in agriculture, — 5.	Botany, physiological, — 8.	The same continued, — 8. Geology, — 5.	Entomology, — 8. Veterinary science, — 5.	Engineering, — 5. Integral calculus, — 5.	English, — 2. Advanced English, — 5. Latin, — 5.	Constitutional history, — 5. German, — 5. History, — 5.	Military science, — 1.

* English and military science are required; of the other studies three at least must be chosen.

SHORT WINTER COURSES.

[All courses optional.]

Agriculture.

I, General Agriculture.		*II. Animal Husbandry.*	
1. Soils and operations upon them, drainage, irrigation, etc.,	10	1. Introduction,	1
2. Farm implements and machinery,	5	2. Location and soil,	2
3. Manures and fertilizers,	10	3. Building,	4
4. Crops of the farm, characteristics, management, etc.,	10	4. Breeds of cattle,*	10
5. Crop rotation,	2	5. Breeds of horses,	6
6. Farm book-keeping,	5	6. Grain and fodder crops,*	11
7. Agricultural economics,	11	7. Foods and feeding,*	11
8. Farm, dairy and poultry management,	11	8. Extra,	19
Total hours,	64	Total hours,	64

* With dairy course.

Dairying.

III. Lectures and Class-room Work.		*III. Lectures, etc.* — Concluded.	
1. The soil and crops,	22	8. Composition and physical peculiarities of milk; conditions which effect creaming, churning, methods of testing and preservation,	22
2. The dairy breeds and cattle breeding,	22	9. Milk testing,	6
3. Stable construction and sanitation, care of cattle,	11	10. Butter making,	12
4. Common diseases of stock, their prevention and treatment,	11	11. Practice in aeration, pasteurization,	6
5. Foods and feeding,	11	Total hours,	156
6. Book-keeping for the dairy farm and butter factory,	22		
7. Pasteurization and preparation of milk on physicians' prescriptions,	11		

Horticulture.

IV. Fruit Culture.		*V. Floriculture* — Concluded.	
1. Introduction,	1	5. Insects and fungi which attack greenhouse plants,	2
2. Propagation of fruit trees by seed, budding, grafting, forming the head, digging, planting, pruning, training, cultivation, etc.,	28	Total hours,	33
3. Insects and fungous diseases,	3	*VI. Market Gardening.*	
Total hours,	32	1. Introduction, equipment, tools, manures, fertilizers, etc.,	3
V. Floriculture.		2. Greenhouse construction and heating,	6
1. Greenhouse construction and heating,	6	3. Forcing vegetables under glass,	3
2. Propagation of greenhouse and other plants by seed, cuttings, grafting, etc.,	3	4. Seed growing by the market gardener,	3
3. Cultivation of rose, carnation, chrysanthemum and orchids,	12	5. Special treatment required by each crop,	10
4. Propagation and care of greenhouse and bedding plants,	10	6. Insects and fungi, with remedies,	2
		Total hours,	27

Botany.

VII. Lectures on Injurious Fungi of the Farm, Garden, Greenhouse, Orchard and Vineyard.

1.	Introduction,	2
2.	Nature and structure of rusts,	4
3.	Nature and structure of smuts,	4
4.	Nature and structure of mildews,	4
5.	Nature and structure of rots,	4
6.	Beneficial fungi of roots,	2
7.	Edible mushrooms,	2
	Total hours,	22

VIII. Lectures and Demonstrations on "How Plants Grow."

1.	Introduction,	1
2.	The parts of a plant,	1
3.	Structure of the cell and plant in general,	3
4.	Functions of root, stem and leaves,	3
5.	Food of plant obtained from air,	3
6.	Food of plant obtained from soil,	3
7.	Transference and elaboration of food,	2
8.	Growth of plants,	2
9.	Effects of light, moisture, heat and cold,	2
10.	Root tubercles on pea and clover,	1
11.	Cross fertilization of flowers,	1
	Total hours,	22

Chemistry.

IX. General Agricultural Chemistry.

1.	Introduction,	2
2.	The fourteen elements of agricultural chemistry,	1
3.	Rocks and soils,	8
4.	The atmosphere,	7
5.	The chemistry of crop-growing,	8
6.	Fertilizers,	8
7.	Animal chemistry,	8
	Total hours,	55

X. Chemistry of the Dairy.

1.	Introduction,	2
2.	The fourteen elements of agricultural chemistry,	14
3.	The physical properties of milk,	13
4.	Analysis of milk, butter, cheese and other dairy products,	13
5.	Chemistry of the manufacture of dairy products,	13
	Total hours,	55

Zoölogy.

XI. Animal Life on the Farm.

Total hours, ... 22

XII. Insect Friends and Foes of the Farmers.

Total hours, ... 33

AGRICULTURE.

(*a*) The origin and formation of soils, their physical properties and how to improve them; (*b*) tillage, subsoiling, drainage and irrigation; (*c*) use of fertilizers and manures; (*d*) farm implements and plans of farm buildings; (*e*) animal husbandry, breeds, stock breeding and feeding. As aids to practical instruction, there are models of the domestic animals; a farm of four hundred acres; a barn with one hundred head of stock, types of the leading breeds, and a complete dairy outfit, where the operations of pasteurizing milk and cream, butter making, milk testing and separation of cream are carried on.

BOTANY.

The course in botany commences with the study of the simpler features connected with the plant, and it is pursued in the following order: (*a*) structural botany (morphology and anatomy); (*b*) systematic botany and flower analysis (taxonomy and classification); (*c*) study of useful plants (economic botany), including grasses, trees, shrubs, etc.; (*d*) study of the function (physiology) and minute structure (histology) of a few typical plants. The following course is elective: (*e*) cryptogamic botany, with special reference to plant diseases (plant pathology); (*f*) physiological botany, or study of the more complicated plant functions.

Besides the above course, there is one outlined for post-graduate students, which, besides containing more or less general botany, is devoted to vegetable physiology and vegetable pathology.

Throughout all of the courses "laboratory methods" prevail, which are supplemented by lectures and text-books. For practical work there is a laboratory abundantly supplied with dissecting and compound microscopes, microtomes, histological reagents, and numerous appliances for illustration and investigation of the phenomena of plant life.

CHEMISTRY.

The chemical department teaches the composition, the value and the uses of all products of nature and of art. This study is an essential part of the training of the farmer, the manufacturer, the business man, the physician and the advanced student of any subject, for it deals with the ultimate character of all kinds of matter.

The special fields of study are mineral and organic, the latter including vegetable and animal matter. Each of these is studied by analysis and synthesis both qualitative and quantitative. There are three laboratories to suit the varying wants of the students.

Chemical Instruction.

Domains.			*Methods.*	
Mineral.		Each studied by	Analysis,	qualitative.
				quantitative.
Organic,	vegetable.		Synthesis,	qualitative.
	animal.			quantitative.

ENGLISH.

The aim of this department is to secure: (*a*) ability to give oral and written expression of thought in correct, effective English; (*b*) ability to present in logical form oral and written arguments on questions assigned for debate; (*c*) acquaintance with the masterpieces of English literature. These are secured by constant practice in writing and speaking, by the study of rhetoric and American literature in freshman and sophomore years, and by the study of English literature and the principles of argumentation in junior and senior years. Instruction is given partly by text-book and partly by lecture. The course in rhetoric consists of a study of the choice of words, the theory of phraseology, special objects in style, the sentence, the paragraph, the whole composition as regards plan, arrangement and parts. This is followed by a series of lectures on invention, in which the different elements and underlying principles of literature are discussed. The work in American literature is carried on partly by text-book and partly by lecture.

During the junior year the history of English literature is studied, and the class is introduced to the writings of a few of the principal authors. A distinction is made between the history of literature and literature itself, and an attempt is made to become acquainted with an author through his writings. This work is continued through the senior year, with a more particular study of the principles of literary criticism as illustrated in literature. During the senior year the principles of argumentation also are studied, and their practical illustration is secured by oral debate and written briefs and forensics.

HORTICULTURE.

Instruction is given in: (*a*) fruit culture; (*b*) market gardening; (*c*) floriculture; (*d*) forestry. For practical work there are extensive, well-stocked orchards, nurseries and greenhouses, where the production of fruit, market-garden and greenhouse crops is constantly carried on.

MATHEMATICS AND ENGINEERING.

(*a*) Pure mathematics; (*b*) physics; (*c*) drawing; (*d*) engineering. The department is well supplied with the necessary instruments for surveying and engineering, and practical work in the field is required. A laboratory for physics has recently been opened, where the student can solve for himself problems in mechanics, electricity, light and sound. The senior engineering option is designed to give to the student the necessary engineering training to enable him to take up and apply, on the lines of landscape engineering and the development of property, his knowledge of landscape gardening, agriculture, forestry, botany and horticulture. It embraces a course of lectures, recitations and field work on the following subjects: topography, railroad curves, earth work, construction and maintenance of roads, water works and sewerage systems, elementary structures, elementary mechanism, etc.

MILITARY.

This was established by act of Congress, and all students, unless physically disabled, are required to attend its exercises. Its object is threefold: first, the dissemination of military knowledge throughout the country; second, physical exercise and muscular training; and third, to inculcate respect and obedience to those in authority. There are three hours' drill per week for the whole college, one hour recitation for the senior class and a weekly inspection of the rooms in the dormitory.

POLITICAL SCIENCE.

To make a good citizen and a successful man of business is the aim of this department. To realize this aim the course of instruction covers: (*a*) principles of political economy; (*b*) industrial history of England and America; (*c*) discussion of economic problems; (*d*) study of the science of government.

VETERINARY.

To give a general idea of the principles of veterinary science in such simple and comprehensive manner as to enable any person to give animals under his supervision the treatment that will tend to prevent the occurrence of disease among them, is the aim of the course of study in this department. (*a*) The hygiene of the stable; (*b*) the anatomy and physiology of the circulatory, respiratory and digestive systems; (*c*) a study of the common diseased processes and the causes, symptoms and effects of disease; (*d*) the nature, action and uses of different drugs. This study is elective.

ZOÖLOGY.

Physiology. — This course is offered to the sophomore class during the winter term, and extends throughout the entire eleven weeks, four hours a week. It is taught by means of a text-book, Martin's "The Human Body" (advanced course), supplemented by lectures and demonstrations on the skeleton and models. The aim is to give, as thoroughly as may be, a knowledge of the anatomy of the human system, the physiology of its various parts, a general idea of hygiene, and to urge upon the student the practice of its teachings. The course presupposes an elementary knowledge of the subject, so that the result, aside from its own worth, forms a valuable aid to the study of zoölogy which follows.

Zoölogy. — Zoölogy is a required subject, junior year, and may be divided into three parts; a laboratory course in comparative anatomy, a lecture course in general zoölogy and a course in elementary entomology. During the fall term, eight hours a week for sixteen weeks are spent, mainly in the laboratory, where a series of typical forms, ranging from the amœba, and other microscopic animals, through the earthworm, clam, squid, lobster, starfish, sea-urchin, shark, frog and pigeon to the cat, are dissected, studied and drawn. Previous to the dissection of any form a short lecture is given, which, supplemented by a full list of laboratory guides and other text-books, gives the student a sufficient knowledge to enable him intelligently to study the creature before him. Each man provides himself with a set of dissecting instruments and note books, but all other apparatus and books are owned by the laboratory. During the winter term a series of thirty lectures is given, covering the entire subject of zoölogy, except that portion having reference to the insects, which, because of their importance, are treated in a separate science. The aim here is to supplement and render orderly the knowledge already gained through the medium of the microscope and scalpel, and the lectures are abundantly illustrated by the very complete museum belonging to the department and containing over twelve thousand specimens. Collateral reading is encouraged, and occasional quizzes are given, as a test of a student's knowledge from all sources.

Entomology. — A course of six hours a week is offered in entomology, during the summer term, its aim being to give a general knowledge of insect anatomy and physiology and a systematic review of the entire group, taking as types, as far as possible, those forms of economic interest to man, and at the same time giving an idea of the life history of each species so taken and the means of combating it. A knowledge of insecticides and insecticide machinery and their use is given. An interesting feature of the course is the collection which each student makes and arranges of the more common species which may be found on the college grounds and the nearby region. A very full museum collection serves as an aid to identification and arrangement.

GRADUATE COURSE.

1. Honorary degrees will not be conferred.

2. Applicants will not be eligible to the degree of M.S. until they have received the degree of B.Sc. or its equivalent.

3. The faculty shall offer a course of study in each of the following subjects: mathematics and physics; chemistry; agriculture; botany; horticulture; entomology; veterinary. Upon the satisfactory completion of any two of these the applicant shall receive the degree of M.S. This prescribed work may be done at the Massachusetts Agricultural College or at any institution which the applicant may choose; but in either case the degree shall be conferred only after the applicant has passed an examination at the college under such rules and regulations as may be prescribed.

4. The degree of Doctor of Philosophy may be conferred upon graduates of this college or other colleges of good standing who shall spend three years at this institution, taking chemistry, botany and entomology as their major and minor studies, if in this time the amount and quality of work done be satisfactory to the professors in charge of the above-named departments.

5. Every student in the graduate course shall pay twenty-five dollars to the treasurer of the college before receiving the degree of M.S. or Ph.D.

TEXT-BOOKS.

GRAY — "Manual." American Book Company, New York.

DARWIN and ACTON — "Practical Physiology of Plants." University Press, Cambridge.

STRASBURGER — "Practical Botany." Swan, Sonnenschein & Co., London.

SORAUER — "Physiology of Plants." Longmans, Green & Co., New York and London.

CAMPBELL — "Structural and Systematic Botany." Ginn & Co., Boston.

KNOBEL — "Trees and Shrubs of New England." Bradlee Whidden, Boston.

GREINER — "How to make the Garden Pay." Wm. Maule, Philadelphia.

LONG — "Ornamental Gardening for Americans." Orange Judd Company, New York.

TAFT — "Greenhouse Construction." Orange Judd Company, New York.

TAFT — "Greenhouse Management." Orange Judd Company, New York.

WEED — "Insects and Insecticides." Orange Judd Company, New York.

WEED — "Fungi and Fungicides." Orange Judd Company, New York.

FULLER — "Practical Forestry." Orange Judd Company, New York.

MAYNARD — "Practical Fruit Grower." Orange Judd Company, New York.

MCALPINE — "How to know Grasses by their Leaves." David Douglas, Edinburgh.

LODEMAN — "The Spraying of Crops." Macmillan & Co., New York.

SAUNDERS — "Insects injurious to Fruits." Lippincott & Co., Philadelphia.

MORROW and HUNT — "Soils and Crops." Howard & Wilson Publishing Company.

AIKMAN — "Manures and the Principles of Manuring." Wm. Blackwood & Son, Edinburgh.

MILES — "Stock Breeding." D. Appleton & Co., New York.

CURTIS — "Horses, Cattle, Sheep and Swine." Orange Judd Company, New York.

FARRINGTON and WOLL — "Testing Milk and its Products." Mendota Book Company, Madison, Wis.

HENRY — "Feeds and Feeding." W. A. Henry, Madison, Wis.

WING — "Milk and its Products." Macmillan & Co., New York.

VON RICHTER — "A Text-book of Inorganic Chemistry." P. Blakiston, Son & Co., Philadelphia.

MÜTER — "Analytical Chemistry." P. Blakiston, Son & Co., Philadelphia.

ROSCOE — "Lessons in Elementary Chemistry." Macmillan & Co., New York.

BERNTHSEN and McGOWAN — "Text-book of Organic Chemistry." Blackie & Son, London.

REYNOLDS — "Experimental Chemistry." Longmans, Green & Co., New York and London.

SUTTON — "Volumetric Analysis." J. & A. Churchill, London.

DANA — "Manual of Determinative Mineralogy." John Wiley & Sons, New York.

DANA — "A Text-book of Elementary Mechanics for the Use of Colleges and Schools." John Wiley & Sons, New York.

GAGE — "The Principles of Physics." Ginn & Co., Boston.

FAUNCE — "Mechanical Drawing." Linus Faunce, Boston.

WELLS — "College Algebra." Leach, Shewell & Sanborn, Boston.

MESERVEY — "Meservey's Book-keeping, Single and Double Entry." Thompson, Brown & Co., Boston.

WELLS — "Essentials of Trigonometry." Leach, Shewell & Sanborn, Boston.

GILLESPIE — "A Manual of the Principles and Practice of Road Making." A. S. Barnes & Co., New York.

MERRIMAN — "A Treatise on Hydraulics." John Wiley & Sons, New York.

MILLER — "A Treatise on Plane and Spherical Trigonometry." Leach, Shewell & Sanborn, Boston.

RAYMOND — "A Text-book on Plane Surveying." American Book Company, New York.

WENTWORTH — "Elements of Analytic Geometry." Ginn & Co., Boston.

OSBORNE — "An Elementary Treatise on the Differential and Integral Calculus." Leach, Shewell & Sanborn, Boston.

MERRIMAN — "A Text-book on Roofs and Bridges." John Wiley & Sons, New York.

YOUNG — "A Text-book of General Astronomy." Ginn & Co., Boston.

PHILIPS and FISHER — "Elements of Geometry." Harper & Brothers, New York.

MERRIMAN — "Elements of Sanitary Engineering." John Wiley & Sons, New York.

MARTIN — "The Human Body" (advanced course). Henry Holt & Co., New York.

WALKER — "Political Economy" (briefer course). Henry Holt & Co., New York.

GIBBINS — "The Industrial History of England." Methuen & Co., London.

WILSON — "The State." D. C. Heath & Co., Boston.

FIELDEN — "A Short Constitutional History of England." Ginn & Co., Boston.

GENUNG — "Outlines of Rhetoric." Ginn & Co., Boston.

WENTWORTH — "Irving's Sketch Book." Allyn & Bacon, Boston.

LONGFELLOW — "Poems." Houghton, Mifflin & Co., Boston.

Pattee — "A History of American Literature." Silver, Burdett & Co., Boston.

Pancoast — "Representative English Literature." Henry Holt & Co., New York.

Corson — "Selections from Chaucer's Canterbury Tales." The Macmillan Company, New York.

Rolfe — "English Classics." Harper & Brothers, New York.

"Standard English Classics." Ginn & Co., Boston.

MacEwan — "Essentials of Argumentation." D. C. Heath & Co., Boston.

Whitney — "French Grammar." Henry Holt & Co., New York.

Hodges — "Course in Scientific German." D. C. Heath & Co., Boston.

Joynes-Meissner — "German Grammar." D. C. Heath & Co., Boston.

Pettit — "Elements of Military Science." The Tuttle, Morehouse & Taylor Press, New Haven, Conn.

"Infantry Drill Regulations." Army and Navy Journal, New York.

To give not only a practical but a liberal education is the aim in each department, and the several courses have been so arranged as to best subserve that end. Exercises in composition and declamation are held throughout the course. The instruction in agriculture and horticulture is both theoretical and practical, the lessons of the recitation room being practically enforced in the garden and field. Students are allowed to work for wages during such leisure hours as are at their disposal. Under the act by which the college was founded, instruction in military tactics is imperative, and each student, unless physically debarred,* is required to attend such exercises as are prescribed, under the direction of a regular army officer stationed at the college.

FOUR-YEARS COURSE.

Admission.

Candidates for admission to the freshman class will be examined orally and in writing upon the following subjects: English grammar, geography, United States history, physiology (Martin's "The Human Body," briefer course), physical geography (Guyot's "Physical Geography" or its equivalent), arithmetic, the metric system, algebra (through quadratics), geometry (two books) and civil government (Mowry's "Studies in Civil Government"). The standard required is 65 per cent. on each paper. Examinations in the following subjects may be taken a year before the

* Certificates of disability must be procured of Dr. Herbert B. Perry of Amherst.

candidate expects to enter college: English grammar, geography, United States history, physical geography and physiology. Satisfactory examination in a substantial part of the subjects offered will be required, that the applicant may have credit for this preliminary examination.

Candidates for higher standing are examined as above, and also in the studies gone over by the class to which they desire admission.

No one can be admitted to the college until he is sixteen years of age. The regular examinations for admission are held at the Botanic Museum, at 9 o'clock A.M., on Thursday and Friday, June 22 and 23, and on Tuesday and Wednesday, September 5 and 6; but candidates may be examined and admitted at any other time in the year. For the accommodation of those living in the eastern part of the State, examinations will also be held at 9 o'clock A.M., on Thursday and Friday, June 22 and 23, at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; and for the accommodation of those in the western part of the State, at the same date and time, at the Sedgwick Institute, Great Barrington, by James Bird. Two full days are required for examination, and candidates must come prepared to stay that length of time.

WINTER COURSES.

For these short winter courses examinations are not required. They commence the first Wednesday in January and end the third Wednesday in March. Candidates must be at least sixteen years of age. The doors of the college are opened to applicants from both sexes. The same privileges in regard to room and board will obtain as with other students. Attendance upon general exercises is required. The usual fees for apparatus and material used in laboratory work will be required. Attendance upon military drill is not expected.

ENTRANCE EXAMINATION PAPERS USED IN 1898.

The standard required is 65 per cent. on each paper.

Arithmetic and Metric System.

1. Find the greatest common divisor of 72, 126, 216.
2. Find the least common multiple of 21, 30, 44, 126.
3. From $\frac{6\frac{3}{5}}{2\frac{16}{25}}$ take $\frac{4\frac{2}{7}}{7\frac{1}{2}}$.
4. Divide .09936 by .276.

5. What is the interest on \$1,560 for 45 days, at 7 per cent.? (Use 365 days to the year.)

6. What was the cost of wheat, sold at \$1.50 per bushel, if the gain was 25 per cent. of the cost?

7. In a board 6m. long and .3m. wide, how many square decimeters?

8. A platform sustains a weight of 50 lbs. per square foot. What is the weight in grams per square centimeter?

Algebra.

1. Find the greatest common divisor and the least common multiple of $12x^2+29x+14$ and $18x^2-3x-10$.

2. Reduce to lowest terms $\frac{x^6+y^6}{x^4-y^4}$.

3. Prove that $a^\circ=1$; and also express with positive exponents $\left(\frac{x^{-\frac{2}{3}}}{y^{\frac{1}{2}}}\right)^{-\frac{1}{2}}$.

4. $\sqrt[4]{2x+11}=\sqrt{5}$. Solve for x.

5. $\frac{\sqrt{2}+1}{\sqrt{2}-1}-\frac{\sqrt{2}-1}{\sqrt{2}+1}=?$ Express result with rational denominator.

6. $\left\{\begin{matrix} x^3+y^3=407 \\ x+y=11 \end{matrix}\right\}$. Solve for x and y.

Geometry.

1. Define a plane, a proposition, a corollary, a circle, a segment.

2. Prove that two triangles are equal when three sides of one equal three sides of the other.

3. Prove that in any triangle the greater angle lies opposite the greater side.

4. Prove that the angle between a tangent and a chord is measured by one-half the intercepted arc.

5. Construct a tangent to a circle from a given point without the circle. Explain construction *fully*.

United States History.

1. In the early settlement of North America, what parts were played by the following nations: (*a*) Spain, (*b*) France, (*c*) England?

2. Contrast the colony of Virginia with that of Massachusetts, according to the following outline: —

(*a*) Purpose of settlement of each.

(*b*) Class of people in each.

(*c*) Education and religion in each.

3. Name the wars that have been fought by the United States, and describe any *one* of them.

4. Name four great orators in our history, and write briefly upon any *one* of them.

5. The chief events of the following administrations: (*a*) Washington's, (*b*) Madison's, (*c*) Jackson's, (*d*) Polk's, (*e*) Lincoln's, (*f*) Johnson's, (*g*) Cleveland's second.

6. What part has compromise played in our history?

Geography.

1. Name and describe briefly the continents.

Note — Do not include Australia in answering.

2. Name and describe two rivers in each continent.

3. (*a*) Describe the British Isles.

(*b*) Name the principal British possessions in the world.

4. Describe *any* journey round the world, not entirely by water.

5. Locate ten large cities of the United States.

6. Contrast North America with South America with respect to the classes of people living in each.

7. Locate: (*a*) Budapest, (*b*) Bagdad, (*c*) Bermudas, (*d*) Jamaica, (*e*) Berlin, (*f*) Munich, (*g*) Geneva, (*h*) Montevideo, (*i*) Manila, (*j*) Rotterdam.

Physical Geography.

1. What is the earth? What is its general shape? By what is it surrounded?

2. Define an earthquake. Tell of the distribution of earthquakes.

3. Give the relative areas and positions of the great land masses of the globe.

4. What is a plateau? What is a mountain by folding? Give example. What is a mountain by fracture? Give example.

5. How may islands be classified? Describe each sort.

6. Define climate, astronomical climate and physical climate.

7. What is a tornado? What is a water-spout?

8. What are glaciers? How are they formed? Tell of their geographical distribution.

9. State what you know of the vegetation of different latitudes.

10. Tell of the geographical distribution of the different races of man.

Civil Government.

1. Write the name of the town or city in which you live. If you live in a town, answer the following: —

(*a*) Who make the laws for your town?

(*b*) What is the title of the principal executive officer or officers of your town?

(*c*) What are the principal items of your town's expenses? How is Mr. Brown's share of these expenses determined?

If you live in a city, write a full description of its government, naming especially the title of its chief executive officer and of other prominent officials.

2. Name the county in which you live, and give the title of your principal county officials.

3. Who make the laws for the government of the State in which you live? By whom are these law-makers chosen? How long do they hold office?

4. In what year was the Constitution of the United States framed? In what year did it go into effect? Who was the first President, and where was he inaugurated?

5. What is the Congress of the United States? Of how many bodies does it consist? How many men represent Massachusetts in these bodies?

6. Of how many members does the United States Senate now consist? Who is its presiding officer? Name the United States senators from Massachusetts.

7. For how long a time is the President of the United States chosen? What is the President's Cabinet? Give title and name of the members of President McKinley's Cabinet.

8. Do you regard our form of government as superior to that of Great Britain? If you do, give reasons.

Physiology.

1. How many elements are found in the body? Name the four or five most important.

2. Name and describe the four different sorts of joints connecting the bones.

3. Give a full anatomical description of a muscle, such as the biceps muscle of the arm. Describe its physiological action and the effect it produces.

4. Why is the human body warm? What keeps it so?

5. Define the terms digestion, absorption, assimilation, respiration, circulation and excretion.

6. There are several uses of saliva which may be classed as physical and chemical. Describe them, telling under which head each one falls.

7. What are the kidneys? Locate them, and give their function.

8. What is meant by reflex action?

9. How is voice produced? Describe the vocal apparatus.

10. Name the more harmful stimulants and narcotics, giving your reasons for condemning each of them.

English Grammar and Composition.

NOTE. — Spelling, capitalization, and punctuation will be considered in determining the excellence of your paper.

1. Write three compositions, of at least two hundred words each, upon any three of the following subjects: —

(*a*) The War with Spain.
(*b*) The Battle in the Philippines.
(*c*) Henry W. Longfellow.
(*d*) "Robinson Crusoe."
(*e*) A Day's Outing.
(*f*) Value of Good Reading.
(*g*) "Evangeline."
(*h*) Why I come to College.
(*i*) A Sunset Scene.
(*j*) An Act of Heroism.

2. Name, define, and give examples of the various kinds of sentences from the grammatical point of view.

3. Correct the following, *stating reasons*: —

(*a*) John or his brothers are living on the outskirts of the town.

(*b*) The colonel with his staff officers ride up to headquarters.

(*c*) Any one looking for swell suits can get in this store just what he wants to.

(*d*) When the emperor entered the room, he was much surprised; and many new pieces of furniture were seen.

(*e*) They said he ought to go; and I also said he had.

DEGREES.

Those who complete the four-years course receive the degree of Bachelor of Science, the diploma being signed by the governor of Massachusetts, who is the president of the corporation.

Regular students of the college may also, on application, become members of Boston University, and upon graduation receive its diploma in addition to that of the college, thereby becoming entitled to all the privileges of its alumni.

Those completing the prescribed graduate course receive the degree of Master of Science or Doctor of Philosophy.

EXPENSES.

Tuition in advance: —			
Fall term,	$30 00		
Winter term,	25 00		
Summer term,	25 00		
		$80 00	$80 00
Room rent, in advance, $8 to $16 per term,		24 00	48 00
Board, $2.50 to $5 per week,		95 00	190 00
Fuel, $5 to $15,		5 00	15 00
Washing, 30 to 60 cents per week,		11 40	22 80
Military suit,		15 75	15 75
Expenses per year,		$231 15	$371 55

Board in clubs has been about $2.45 per week; in private families, $4 to $5. The military suit must be obtained immediately upon entrance at college, and used in the drill exercises prescribed. The following fees will be charged for the maintenance of the several laboratories: chemical, $10 per term used; zoölogical, $4 per term used; botanical, $1 per term used by sophomore class, $2 per term used by senior class; entomological, $2 per term used. Some expense will also be incurred for lights and text-books. Students whose homes are within the State of Massachusetts can in most cases obtain a scholarship by applying to the senator of the district in which they live.

THE LABOR FUND.

The object of this fund is to assist those students who are dependent either wholly or in part on their own exertions, by furnishing them work in the several departments of the college. The greatest opportunity for such work is found in the agricultural and horticultural departments. Application should be made to Profs. William P. Brooks and Samuel T. Maynard, respectively in charge of said departments. Students desiring to avail themselves of its benefits must bring a certificate signed by one of the selectmen of the town in which they are resident, certifying to the fact that they require aid.

ROOMS.

All students, except those living with parents or guardians, will be required to occupy rooms in the college dormitories.

For the information of those desiring to carpet their rooms, the following measurements are given: in the new south dormitory the study rooms are about fifteen by fourteen feet, with a recess seven feet four inches by three feet; and the bedrooms are eleven feet two inches by eight feet five inches. This building is heated by steam. In the north dormitory the corner rooms are fourteen by fifteen feet, and the annexed bedrooms eight by ten feet. The inside rooms are thirteen and one-half by fourteen and one-half feet, and the bedrooms eight by eight feet. A coal stove is furnished with each room. Aside from this, all rooms are unfurnished. Mr. Thomas Canavan has the general superintendence of the dormitories, and all correspondence relative to the engaging of rooms should be with him.

SCHOLARSHIPS.

Established by Private Individuals.

Mary Robinson Fund of one thousand dollars, the bequest of Miss Mary Robinson of Medfield.

Whiting Street Fund of one thousand dollars, the bequest of Whiting Street, Esq., of Northampton.

Henry Gassett Fund of one thousand dollars, the bequest of Henry Gassett, Esq., of North Weymouth.

The income of the above funds is assigned by the faculty to worthy students requiring aid.

Congressional Scholarships.

The trustees voted in January, 1878, to establish one free scholarship for each of the congressional districts of the State. Application for such scholarships should be made to the representative from the district to which the applicant belongs. The selection for these scholarships will be determined as each member of Congress may prefer; but, where several applications are sent in from the same district, a competitive examination would seem to be desirable. Applicants should be good scholars, of vigorous constitution, and should enter college with the intention of remaining through the course.

State Scholarships.

The Legislature of 1883 passed the following resolve in favor of the Massachusetts Agricultural College: —

Resolved, That there shall be paid annually, for the term of four years, from the treasury of the Commonwealth to the treasurer of the Massachusetts Agricultural College, the sum of ten thousand dollars, to enable the trustees of said college to provide for the students of said institution the theoretical and practical education required by its charter and the law of the United States relating thereto.

Resolved, That annually, for the term of four years eighty free scholarships be and hereby are established at the Massachusetts Agricultural College, the same to be given by appointment to persons in this Commonwealth, after a competitive examination, under rules prescribed by the president of the college, at such time and place as the senator then in office from each district shall designate; and the said scholarships shall be assigned equally to each senatorial district. But, if there shall be less than two successful applicants for scholarships from any senatorial district, such scholarships may be distributed by the president of the college equally among the other districts, as nearly as possible; but no applicant shall be entitled to a scholarship unless he shall pass an examination in accordance with the rules to be established as hereinbefore provided.

The Legislature of 1886 passed the following resolve, making perpetual the scholarships established: —

Resolved, That annually the scholarships established by chapter forty-six of the resolves of the year eighteen hundred and eighty-three be given and continued in accordance with the provisions of said chapter.

In accordance with these resolves, any one desiring admission to the college can apply to the senator of his district for a scholarship. Blank forms of application will be furnished by the president.

EQUIPMENT.

Agricultural Department.

The Farm. — Among the various means through which instruction in agriculture is given, none exceeds in importance the farm. The part which is directly under the charge of the professor of agriculture comprises about one hundred and sixty acres of improved land, forty acres of pasture and sixteen acres of woodland. Of the improved land, about thirty acres are kept permanently in grass.

The rest of the farm is managed under a system of rotation, all parts being alternately in grass and hoed crops. All the ordinary crops of this section are grown, and many not usually seen upon Massachusetts farms find a place here. Our large stock of milch cows is fed largely in the barn, and hence fodder crops occupy a prominent place. Experiments of various kinds are continually under trial; and every plat is staked, and bears a label stating variety under cultivation, date of planting, and manures and fertilizers used.

Methods of land improvement are constantly illustrated here, tile drainage especially receiving a large share of attention. There are now some nine miles of tile drains in successful and very satisfactory operation upon the farm. Methods of clearing land of stumps are also illustrated, a large amount of such work having been carried on during the last few years.

In all the work of the farm the students are freely employed, and classes are frequently taken into the fields; and to the lessons to be derived from these fields the students are constantly referred.

The Barn and Stock. — Our commodious barns contain a large stock of milch cows, many of which are grades; but the following pure breeds are represented by good animals, viz., Holstein-Friesian, Ayrshire, Jersey, Guernsey and Shorthorn. Experiments in feeding for milk and butter are continually in progress. We have a fine flock of Southdown sheep. Swine are represented by the Chester White, Poland China, Berkshire and Tamworth breeds. Besides work horses, we have a number of pure-bred Percherons, used for breeding as well as for work; and a fine pair of French coach horses.

The barn is a model of convenience and labor-saving arrangements. It illustrates different methods of fastening animals, various styles of mangers, watering devices, etc. Connected with it are commodious storage rooms for vehicles and machines. It contains silos and a granary. A very large share of the work is performed by students, and whenever points require illustration, classes are taken to it for that purpose.

Dairy School. — Connecting with the barn is a wing providing accommodation for practical and educational work in dairying. The wing contains one room for heavy dairy machinery, another for lighter machinery, both large enough to accommodate various styles of all prominent machines; a large ice-house, a cold-storage room and a room for raising cream by gravity methods, a class room and a laboratory. The power used is an electric motor. This department is steam heated and piped for hot and cold water and steam. In this department has been placed a full line of modern dairy machinery, so that we are able to illustrate all the various processes connected with the creaming of milk, its preparation for market and the manufacture of butter. Special instruction in such work is offered in the dairy course.

Equipment of Farm. — Aside from machines and implements generally found upon farms, the more important of those used upon our farm and in our barn which it seems desirable to mention are the following: reversible sulky plough, broadcast fertilizer distributer, manure spreader, grain drill, horse corn planter, potato planter, wheelbarrow grass seeder, hay loader, potato digger and fodder cutter and crusher. It is our aim to try all novelties as they come out, and to illustrate everywhere the latest and best methods of doing farm work.

Lecture Room. — The agricultural lecture room in south college is well adapted to its uses. It is provided with numerous charts and lantern slides, illustrating the subjects taught. Connected with it is a small room at present used for the storage of illustrative material, which comprises soils in great variety, all important fertilizers and fertilizer materials, implements used in the agriculture of our own and other countries, and a collection of grasses and forage plants, grains, etc.

A valuable addition to our resources consists of a full series of Landsberg's models of animals. These are accurate models of selected animals of all the leading breeds of cattle, horses, sheep and swine, from one-sixth to full size, according to subject. We are provided with a complete collection of seeds of all our common grasses and the weeds which grow in mowings, and have also a large collection of the concentrated food stuffs. All these are continually used in illustration of subjects studied.

Museum. — A beginning has been made towards accumulating materials for an agricultural museum. This is to contain the rocks from which soils have been derived, soils, fertilizer materials and manufactured fertilizers, seeds, plants and their products, stuffed animals, machines and implements. It is expected to make this collection of historical importance by including in it old types of machines and implements, earlier forms of breeds, etc. For lack of room the material thus far accumulated is stored in a number of scattered localities, and much of it where it cannot be satisfactorily exhibited.

Botanical Department.

Course of Study. — This department is well equipped to give a comprehensive course in most of the subjects of botany. The course aims to treat of all the more important features connected with the study of plants which have a close bearing upon agriculture, without at the same time deviating from a systematic and logical plan. Throughout the entire course the objective methods of teaching are followed, and the student is constantly furnished with an abundance of plant material for practical study, together with an elaborate series of preserved specimens for illustration and comparison. In the freshman year the study of structural and systematic botany is pursued, with some observation on insect fertilization. This is followed in the first term of the sophomore year by the systematic study of grasses, trees and shrubs, and this during the winter term by an investigation into the microscopic structure of the plant. The senior year is given up entirely to cryptogamic and physiological botany. This includes a study of our common plant diseases, and the simple functions of the plant which it is essential for the agriculturist to become familiar with.

The Botanical Museum contains the Knowlton herbarium, of over ten thousand species of phanerogamous and the higher cryptogamous plants; about five thousand species of fungi, and several collections of lichens and mosses, including those of Tuckerman, Frost, Denslow, Cummings, Müller and Schaerer. It also contains a large collection of native woods, cut so as to show their individual structure; numerous models of native fruits; specimens of abnormal and peculiar forms of stems, fruits, vegetables, etc.; many interesting specimens of unnatural growths of trees and plants, natural grafts, etc.; together with models for illustrating the growth and structure of plants, and including a model of the squash which raised by the expansive force of its growing cells the enormous weight of five thousand pounds.

The Botanical Lecture Room, in the same building, is provided with diagrams and charts of over three thousand figures, illustrating structural, systematic and physiological botany.

The Botanical Laboratory has provision for thirty-four students to work at one time. Each student is provided with a locker, wherein he can dispose of his equipment necessary for study. The laboratory is equipped with Leitz', Reichert's, Bausch and Lomb's, Beck's, Queen's and Tolles' compound microscopes, with objectives varying from four inch to one-fifteenth inch focal length, and also with twenty dissecting microscopes to assist in the study of structural and systematic botany. It also contains four induction coils, including a Du Bois-Reymond induction apparatus and rheocord, a Lippmann capillary electrometer, a galvanometer, and various other forms of electrical appliances especially devised for studying the influence of electricity upon the growth of plants. There are also Thoma, Minot and Beck microtomes, a self-registering thermometer and hygrometer, a Wortmann improved clinostat and also one of special construction, an Arthur centrifugal apparatus with electric motor, various forms of self-registering appliances for registering the growth of plants, including a Pfeffer-Baranetsky electrical self-registering auxanometer, a Sach's arc-auxanometer, a horizontal reading microscope (Pfeffer model), various kinds of dynamometers of special construction, respiration appliances, mercurial sap and vacuum gauges, manometers, gas and exhaust chambers, besides various other appliances for work and demonstration in plant physiology. The laboratory is also provided with an Eastman landscape camera, a Bausch and Lomb micro-photographic camera, and a dark closet equipped for photographic and other kinds of work.

Horticultural Department.

Greenhouses. — To aid in the instruction in botany, as well as in floriculture and market gardening, the glass structures contain a large collection of plants of a botanic and economic value, as well as those grown for commercial purposes. They consist of two large octagons, forty by forty feet, with sides twelve feet high and a central portion over twenty feet high, for the growth of large specimens, like palms, tree ferns, the bamboo, banana, guava, olive, etc.; a moist stove twenty-five feet square; a dry stove of the same dimensions; a rose room, twenty-five by twenty feet; a room for aquatic plants, twenty by twenty-five feet; a room for ferns, mosses and orchids, eighteen by thirty feet: a large propogating house, fifty by twenty-four feet, fitted up with benches sufficient in number to accommodate fifty students at work at one time; a vegetable house, forty-two by thirty-two feet; a large propagating house, thirty-six by seventy-five feet, for the growing of carnations, violets and bedding plants; a cold grapery, eighteen by twenty-five feet. To these glass structures are attached three work rooms, equipped with all kinds of tools for greenhouse work. In building these houses as many as possible of the principles of construction, heating, ventilation, etc., have been incorporated for the purposes of instruction.

Orchards. — These are extensive, and contain nearly all the valuable leading varieties, both old and new, of the large fruits, growing under various conditions of soil and exposure.

Small Fruits. — The small-fruit plantations contain a large number of varieties of each kind, especially the new and promising ones, which are compared with older sorts, in plots and in field culture. Methods of planting, pruning, training, cultivation, study of varieties, gathering, packing and shipping fruit, etc., are taught by field exercises, the students doing a large part of the work of the department.

Nursery. — This contains more than five thousand trees, shrubs and vines in various stages of growth, where the different methods of propagation by cuttings, layers, budding, grafting, pruning and training are practically taught to the students.

Garden. — All kinds of garden and farm-garden crops are grown in this department, furnishing ample illustration of the treatment of market-garden crops. The income from the sales of trees, plants, flowers, fruit and vegetables aids materially in the support of the department, and furnishes illustrations of the methods of business, with which all students are expected to become familiar.

Forestry. — Many kinds of trees suitable for forest planting are grown in the nursery, and plantations have been made upon the college grounds and upon private estates in the vicinity, affording good examples of this most important subject. A large forest grove is connected with this department, where the methods of pruning trees and the management and preservation of forests can be illustrated. In the museum and lecture room are collections of native woods, showing their natural condition and peculiarities; and there have been lately added the prepared wood sections of R. B. Hough, mounted on cards for class-room illustration.

Ornamental trees, shrubs and flowering plants are grouped about the grounds in such a way as to afford as much instruction as possible in the art of landscape gardening. All these, as well as the varieties of large and small fruits, are marked with conspicuous labels, giving their common and Latin names, for the benefit of the students and the public.

Tool House. — A tool house, thirty by eighty feet, has been constructed, containing a general store-room for keeping small tools; a repair shop with forge, anvil and work-bench; and a carpenter shop equipped with a large Sloyd bench and full set of tools. Under one-half of this building is a cellar for storing fruit and vegetables. In the loft is a chamber, thirty by eighty feet, for keeping hot-bed sashes, shutters, mats, berry crates, baskets and other materials when not in use.

Connected with the stable is a cold-storage room, with an ice-chamber over it, for preserving fruit, while the main cellar underneath the stable is devoted to the keeping of vegetables.

All the low land south of the greenhouses has been thoroughly underdrained and put into condition for the production of any garden or small fruit crop.

Department of Zoölogy.

The work in this department begins in the winter term of the sophomore year with human anatomy and physiology, the study of which not only serves as an introduction to zoölogy and the veterinary science, but also gives the student a knowledge of the structure and uses of the different organs of the human body and of the laws of health. In the fall and winter terms the members of the junior class take zoölogy, which is taught by means of lectures and laboratory work. In the laboratory each student is required to dissect and study a series of typical animals, making drawings of the various organs. During the spring term of this year a course of lectures is given on insects in general, their classification and habits and the various methods of destroying those that are injurious, and more or less time in this connection is devoted to laboratory and field work.

There is a most excellent and carefully arranged museum connected with this department, in which are exhibited, as far as possible, all the native animals of this Commonwealth, together with such species from other parts of the world as are necessary to give completeness or for the instruction of the students. This museum furnishes specimens for illustration in the lectures before the classes, and also for general information to visitors as well as members of the college.

During the senior year such members of this class as elect advanced entomology take a course of more technical lectures, in which the following subjects relating to insects are considered quite at length: external and internal anatomy, embryology, transformations, duration of life, luminosity of insects, the color of insects, parasitic insects, diseases of insects, number of insects in existence, geographical and geological distribution of insects, insect architecture, fertilization of plants by insects, economic entomology, bee-keeping and the literature of insects. The laboratory work of this year consists in part of dissections of the caterpillar, pupa and imago stages of insects, and a critical study of the external anatomy of species of each of the orders of insects, followed by the exercise of determining a group of insects in each order; and, finally, each student is required to prepare a thesis on some insect or group of insects pertaining to the business in which he intends to engage. He is asked at the beginning of the year what business he intends to follow after graduation, and is then advised to prepare his thesis on those insects with which he will most have to deal in the business he has selected. In the preparation of this thesis the work is carried on in the most approved methods, so that he may obtain the most scientific and at the same time practical knowledge of the subject; in fact, he is taught such methods of investigation that, if new insect pests appear on his crops, he will know how to properly investigate them and discover the best and cheapest methods for their destruction. If this thesis when completed contains information of public interest, whether of an economic character or otherwise, it is published, with whatever illustrations are necessary.

This course is primarily for the student of agriculture or horticulture, but, when taken in connection with botany and chemistry, is especially adapted to one wishing to fit himself as a teacher of science in our public schools, or to one intending to study medicine, but in this case his laboratory work would be devoted mainly to histology.

This department is now prepared for and is receiving graduates from this and other colleges, who wish to continue the study of entomology beyond what they were able in their undergraduate course. These advanced studies will fit them for positions in the experiment stations or as State entomologists, and also give them most excellent training as teachers in our high schools and colleges.

Veterinary Department.

This department is well equipped with the apparatus necessary to illustrate the subject in the class room.

It consists of an improved Auzoux model of the horse, imported from Paris, constructed so as to separate and show in detail the shape, size, structure and relations of the different parts of the body; two *papier-maché* models of the hind legs of the horse, showing diseases of the soft tissues, — wind-galls, bog spavins, etc., also the diseases of the bone tissues, — splints, spavins and ringbones; two models of the foot, one according to Bracy Clark's description, the other showing the Charlier method of shoeing and the general anatomy of the foot; a full-sized model of the bones of the hind leg, giving shape, size and position of each individual bone; thirty-one full-sized models of the jaws and teeth of the horse and fourteen of the ox, showing the changes which take place in these organs as the animals advance in age.

There is an articulated skeleton of the famous stallion Blackhawk, a disarticulated one of a thoroughbred mare, besides one each of the cow, sheep, pig and dog; two prepared dissections of the fore and hind legs of the horse, showing position and relation of the soft tissues to the bones; a *papier-maché* model of the uterus of the mare and of the pig; a gravid uterus of the cow; a wax model of the uterus, placenta and fœtus of the sheep; showing the position of the fœtus and the attachment of the placenta to the walls of the uterus.

In addition to the above there is a growing collection of pathological specimens of both the soft and osseous tissues, and many parasites common to the domestic animals. A collection of charts and diagrams especially prepared for the college is used in connection with lectures upon the subject of anatomy, parturition and conformation of animals.

Through the kindness of Mr. Henry Adams of Amherst the department has received a large sample collection of the various drugs used in the treatment of the diseases of the domestic animals.

For the benefit of the students, sick or diseased animals are frequently shown them, and operations performed in connection with the class-room work. For the use of the instructor of this department a laboratory has been provided in the old chapel building. It has been equipped with the apparatus necessary for the study of histology, pathology and bacteriology, consisting in part of four improved Zeiss microscopes with one-eighteenth and one-twelfth inch oil immersion objectives, together with the lower powers; a Lautenschlager's incubator and hot-air sterilizer; an Arnold's steam sterilizer and a Bausch and Lomb improved laboratory microtome. This apparatus is used for the preparation of material for the class room and for general investigation.

Mathematical Department.

At first glance it might appear that mathematics would play a very small part in the curriculum of an agricultural college, and, while it is true that its chief object is of a supplementary nature, it is equally true that, entirely aside from its value as a means of mental discipline, mathematics has a well-defined and practical object to accomplish. In this day of scientific experiment, observation and research on the farm, the advantages of a thorough knowledge of the more elementary branches of mathematics, general physics and engineering must be more than ever apparent; and it is to meet the needs of the agricultural college student in these lines that the work in the mathematical department has been planned.

The mathematics of the freshman, sophomore and junior years are required, those of the senior year elective.

A glance at the schedule of studies will show the sequence of subjects: book-keeping, algebra and geometry in the freshman year; trigonometry, mechanical drawing, mechanics and plane surveying, — the latter embracing lectures and field work in elementary engineering, the use of instruments, computation of areas, levelling, etc., — in the sophomore year; general physics with work in laboratory, — including electricity, sound, light and heat, — in the junior year; and, finally, two electives in the senior year, — mathematics and engineering, respectively.*

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* While these two electives are entirely distinct, the student electing engineering is strongly advised to elect mathematics also.

The mathematical option includes the following subjects: fall term, plane analytic geometry, embracing a study of the equations and properties of the point, line and circle, and of the parabola, ellipse and hyperbola; winter term, differential calculus; and summer term, integral calculus.

The senior engineering option is designed to give to the student the necessary engineering training to enable him to take up and apply, on the lines of landscape engineering and the development of property, his knowledge of landscape gardening, agriculture, forestry, botany and horticulture. It embraces a course of lectures, recitations and field work on the following subjects: topography, railroad curves, earth work, construction and maintenance of roads, water works and sewerage systems, elementary structures, elementary mechanism, etc.

It is believed that the engineering elective will equip the student to enter a comparatively new field, that of landscape engineering, which is coming more and more prominently before the public attention; for, with the increasing consideration which is being paid to the public health and the development and beautifying of our towns and cities, come fresh needs and opportunities.

Chemical Department.

Instruction in general agricultural and analytical chemistry and mineralogy is given in the laboratory building. Thirteen commodious rooms, well lighted, ventilated and properly fitted, are occupied by the chemical department.

The lecture room, on the second floor, has ample seating capacity for seventy students. Immediately adjoining it are four smaller rooms, which serve for storing apparatus and preparing material for the lecture table.

The laboratory for beginners is a capacious room on the first floor. It is furnished with forty working tables. Each table is provided with sets of wet and dry re-agents, a fume chamber, water, gas, drawer and locker, and apparatus sufficient to render the student independent of carelessness or accident on the part of others working near by; thus equipped, each worker has the opportunity, under the direction of an instructor, of repeating the processes which he has previously studied in the lecture room, and of carrying out at will any tests which his own observation may suggest.

A systematic study of the properties of elementary matter is here taken up, then the study of the simpler combinations of the elements and their artificial preparation; then follows qualitative analysis of salts, minerals, soils, fertilizers, animal and vegetable products.

The laboratory for advanced students has tables for thirty workers, with adequate apparatus. This is for instruction in the chemistry of various manufacturing industries, especially those of agricultural interest, as the production of sugar, starch, fibres and dairy products; the preparation of plant and animal foods, their digestion, assimilation and economic use; the official analysis of fertilizers, fodders and foods; the analysis of soils and waters, of milk, urine and other animal and vegetable products.

The balance room has four balances and improved apparatus for determining densities of solids, liquids and gases.

Apparatus and Collections. — Large purchases of apparatus require to be made. Deficiencies caused by the wear and breakage of several years need to be supplied and the original outfit increased. The apparatus includes balances, a microscope, spectroscope, polariscope, photometer, barometer and numerous models and sets of apparatus. The various rooms are furnished with an extensive collection of industrial charts. A valuable and growing collection of specimens and samples, fitted to illustrate different subjects taught, is also provided. This includes rocks, minerals, soils, raw and manufactured fertilizers, foods, including milling products, fibres and other vegetable and animal products and artificial preparations of mineral and organic compounds. Series of preparations are used for illustrating the various stages of different manufactures from raw materials to finished products.

Library.

This now numbers 19,180 volumes, having been increased during the year, by gift and purchase, 683 volumes. It is placed in the lower hall of the chapel-library building, and is made available to the general student for reference or investigation. It is especially valuable as a library of reference, and no pains will be spared to make it complete in the departments of agriculture, horticulture, botany and the natural sciences. It is open a portion of each day for consultation, and an hour every evening for the drawing of books.

PRIZES.

Burnham Rhetorical Prizes.

These prizes are awarded for excellence in declamation, and are open to competition, under certain restrictions, to members of the sophomore and freshmen classes.

Flint Prizes.

Mr. Charles L. Flint of the class of 1881 has established two prizes, one of thirty dollars and another of twenty dollars, to be awarded, at an appointed time during commencement week, to the two members of the junior class who may produce the best orations. Excellence in both composition and delivery is considered in making the award.

Grinnell Agricultural Prizes.

Hon. William Claflin of Boston has given the sum of one thousand dollars for the endowment of a first and second prize, to be called the Grinnell agricultural prizes, in honor of George B. Grinnell, Esq., of New York. These two prizes are to be paid in cash to those two members of the graduating class who may pass the best written and oral examination in theoretical and practical agriculture.

Hills Botanical Prizes.

For the best herbarium collected by a member of the class of 1899 a prize of twenty dollars is offered, and for the second best a prize of ten dollars; also a prize of five dollars for the best collection of native woods.

The prizes in 1898 were awarded as follows: —

Burnham Rhetorical Prizes: Francis G. Stanley (1900), first; Howard Baker (1900), second; Alexander C. Wilson (1901), first; George R. Bridgeforth (1901), second.

Flint Oratorical Prizes: Warren E. Hinds (1899), first; Bernard H. Smith (1899), second.

Grinnell Agricultural Prizes: Clifford G. Clark (1898), first; George H. Wright (1898), second; Avedis G. Adjemian (1898), honorable mention.

Hills Botanical Prizes: Willis S. Fisher (1898), first.

Prizes in Drawing, given by William H. Armstrong, '99: Dickran B. Tashjian (1901), first; James B. Henry (1901), second.

Dairy Prizes, given by the Massachusetts Society for Promoting Agriculture: greatest improvement, Walter T. Packard, first (fifty dollars in gold); Oliver H. Leach, second (thirty dollars in gold); Jonathan E. Holt, third (twenty dollars in gold).

RELIGIOUS SERVICES.

Students are required to attend prayers every week-day at 8 A.M. and public worship in the chapel every Sunday at 10.30 A.M. Further opportunities for moral and religious culture are afforded by a Bible class taught by one of the professors during the hour preceding the Sunday morning service and by religious meetings held on Sunday afternoon and during the week, under the auspices of the College Young Men's Christian Association.

LOCATION.

Amherst is on the New London Northern Railroad, connecting at Palmer with the Boston & Albany Railroad, and at Miller's Falls with the Fitchburg Railroad. It is also on the Central Massachusetts Railroad, connecting at Northampton with the Connecticut River Railroad and with the New Haven & Northampton Railroad.

The college buildings are on a healthful site, commanding one of the finest views in New England. The large farm of three hundred and eighty-three acres, with its varied surface and native forests, gives the student the freedom and quiet of a country home.

REPORTS.

TREASURER'S REPORT.

Report of George F. Mills, *Treasurer of Massachusetts Agricultural College, from Jan. 1, 1898, to Jan. 1, 1899.*

	Received.	Paid.
Cash on hand Jan. 1, 1898,	$4,054 10	–
State treasurer,	16,000 00	–
Term bill,	2,888 65	$609 03
Salary,	–	27,020 76
Horticultural department,	3,560 48	6,563 92
Farm,	5,965 40	10,775 11
Expense,	1,293 01	8,197 09
Endowment fund,	10,262 72	–
State scholarship funds,	15,000 00	–
Labor fund,	5,000 00	4,676 02
Botanical laboratory,	99 50	77 15
Chemical laboratory,	576 08	399 36
Entomological laboratory,	27 00	22 97
Zoölogical laboratory,	68 00	134 43
Grinnell prize fund,	40 00	35 00
Gassett scholarship fund,	42 50	55 00
Whiting Street fund,	51 05	50 00
Mary Robinson fund,	35 84	25 00
Burnham emergency fund,	133 12	93 12
Hills fund,	356 16	621 31
Library fund,	426 95	627 87
Extra instruction,	–	372 00
Advertising,	–	281 12
Agricultural department,	513 53	1,381 05
Electric equipment,	639 18	2,837 28
Insurance,	14 15	773 45
Investment N. Y. C. & H. R. R.R.,	4 00	–
Cash on hand Jan. 1, 1899,	–	1,423 38
	$67,051 42	$67,051 42

Cash on Hand, as shown by Treasurer's Statement, belongs to the Following Accounts:

Labor fund,	$316 75
Grinnell prize fund,	30 00
Gassett scholarship fund,	11 02
Whiting Street fund,	11 51
Mary Robinson fund,	15 60
Burnham emergency fund,	89 04
General fund of the college,	949 46
	$1,423 38

BILLS RECEIVABLE JAN. 1, 1899.

Term bill,	$638 98
Horticultural department,	418 73
Farm,	1,175 63
Expense,	83 41
Botanical laboratory,	28 50
Chemical laboratory,	300 00
Entomological laboratory,	6 00
Zoölogical laboratory,	72 00
Electric equipment,	194 81
	$2,918 06

BILLS PAYABLE JAN. 1, 1899.

Horticultural department,	$150 52
Farm,	4,012 24
Expense,	1,485 25
Electric equipment,	309 00
Botanical laboratory,	14 56
Chemical laboratory,	60 00
Insurance,	18 00
	$6,049 57

This is to certify that I have this day examined the accounts from Jan. 1, 1898, to Jan. 1, 1899, of George F. Mills, treasurer of Massachusetts Agricultural College, and find the same correct and properly kept. All disbursements are vouched for, the balance in the treasury being one thousand four hundred and twenty-three dollars and thirty-eight cents ($1,423.38), which sum is shown to be in the hands of the treasurer.

CHARLES A. GLEASON, *Auditor.*

AMHERST, Dec. 28, 1898.

INVENTORY — REAL ESTATE.

Land (Estimated Value).

College farm,	$37,000 00	
Pelham quarry,	500 00	
Bangs place,	1,750 00	
Clark place,	4,500 00	
		$43,750 00

Buildings (Estimated Value).

Drill hall,	$5,000 00	
Powder house,	75 00	
Gun shed,	1,500 00	
Stone chapel,	30,000 00	
South dormitory,	35,000 00	
North dormitory,	25,000 00	
		96,575 00
Amount carried forward,		$140,325 00

Amount brought forward,		$140,325 00
Chemical laboratory,	8,000 00	
Entomological laboratory,	3,000 00	
Farm-house,	2,000 00	
Horse barn,	5,000 00	
Farm barn and dairy school,	33,000 00	
Graves house and barn,	2,500 00	
Boarding-house,	2,000 00	
Botanic museum,	5,500 00	
Botanic barn,	2,500 00	
Tool house,	2,000 00	
Durfee plant house and fixtures,	13,000 00	
Small plant house, with vegetable cellar and cold grapery,	4,700 00	
President's house,	6,500 00	
Dwelling-houses, purchased with farm,	5,000 00	
		94,700 00
		$235,025 00

EQUIPMENT.

Botanical department,	$3,610 00
Horticultural department,	10,779 59
Farm,	15,948 76
Chemical laboratory,	1,986 00
Botanical laboratory,	2,156 53
Zoölogical laboratory,	1,910 38
Natural history collection,	5,440 85
Veterinary department,	1,615 66
Physics and mathematics,	4,813 00
Agricultural department,	3,250 00
Library,	19,200 00
Fire apparatus,	665 00
Furniture,	500 00
Text-books,	207 11
Tools and lumber,	215 40
Electric equipment and supplies,	5,791 27
	$78,089 55

SUMMARY.

Assets.

Total value of real estate, per inventory,	$235,025 00
Total value of equipment, per inventory,	78,089 55
Bills receivable,	2,918 06
Cash on hand,	1,423 38
	$317,455 99

Liabilities.

Bills payable,	6,049 57
	$311,406 42

Maintenance Funds.

	Fund.	Income in '98.
Technical educational fund, United States grant,	$219,000 00	$7,300 00
Technical educational fund, State grant,	141,575 35	2,962 72
Morrill fund, in accordance with act of Congress, approved Aug. 30, 1890,		16,000 00
Hills fund,	8,542 00	356 16
State appropriation made by Legislature of 1896 for four years,		5,000 00
Labor fund, appropriation made by Legislature of 1896 for four years,		5,000 00

Scholarship Funds.

State fund, appropriated by the Legislature of 1886,		10,000 00
Whiting Street fund,	$1,260 00	51 05
Gassett fund,	1,000 00	42 50
Mary Robinson fund,	858 00	35 84

Prize Fund.

Grinnell prize fund,	$1,000 00	40 00

Miscellaneous Funds.

Library fund,	$10,046 12	426 95
Investment, N. Y. C. & H. R. R.R. stock,	100 00	4 00
Burnham emergency fund,	3,431 45	128 62
		$47,347 84

FARM REPORT.

The operations of the farm for the past season call for little comment, as they have been of a strictly routine nature, and for the most part attended with no marked results either in the direction of unusual success or failure, the consideration of which would demand attention. The manurial treatment of the several crops is shown in the table which follows : —

Manure and Fertilizer per Acre, Crops of College Farm, 1898.

	Old Mowings.	Field Corn.	Oats and Peas.	Japanese Millet.	Mangels.	Soy Beans.	Celery.	Carrots.	Rye.	Potatoes.
Manure (cords), ...	–	4	–	2	8	6	10	8	–	–
Nitrate of soda (pounds), . .	150	100	100	125	100	–	150	100	100	150
Plain superphosphate (pounds),	–	150	200	200	200	250	200	200	200	400
South Carolina rock phosphate (pounds), ...	–	–	–	–	–	–	–	–	–	–
Dried blood (pounds), . .	–	–	–	–	–	–	–	–	–	200
Tankage (pounds), . . .	150	–	–	–	–	150	–	–	–	–
Bone meal (pounds), . . .	–	–	–	–	–	–	–	–	–	–
Muriate of potash (pounds), .	75	140	–	–	200	–	–	–	–	–
High-grade sulphate of potash (pounds), ...	–	100	200	125	–	200	200	150	150	300
Dry ground fish (pounds), .	–	–	–	–	–	–	–	–	–	200
Lime (pounds), ...	–	1,000	–	1,000	–	–	–	–	–	–

The average of yield of the several farm crops, together with a statement of cost, as nearly as we are able to calculate it, with the value and amount of profit or loss, will be found in the table below. Concerning the figures in this table, it should be stated that the crop is charged with one-half the manure and three-fourths of the fertilizer employed. This course appears to me to be right, for the reason that all our fields are managed in rotation, including grass, and in the first two years in grass neither manure nor fertilizer is used. No attempt is made to estimate the financial result in the case of the hay crop, for the reason that the proper charge to be made for the after-effects of the manure and fertilizer applied to previous crops is not clear, and for the further reason that a separate account is not kept of the labor expended in securing the hay crop. That crop is charged the full cost of the fertilizer applied this year. In explanation of the comparatively small rowen crop, it should be stated that a considerable proportion of our mowing land was pastured after the first crop had been removed.

College Farm Crops, 1898.

CROP.	Acres.	Total Products.			Cost.		Value.	Net Profit.	Loss.
		Pounds.	Bushels.	Tons.	Manure.	Labor.			
Hay,	85	–	–	200	$264 60	–	$1,600 00	–	–
Rowen,	–	–	–	50	–	–	400 00	–	–
Corn,	18	–	–	240.5	223 83	$506 22	841 75	$335 53	–
Potatoes,	6	–	777 large, 148 small,	–	80 33	160 96	410 70	169 41	–
Celery,	$2\frac{1}{4}$	375*	–	–	60 10	310 97	468 75	97 68	–
Japanese millet,	4.4	–	350, seed,†	14, straw,†	44 66	312 32†	637 00†	280 02†	–
Soy beans,	$7\frac{2}{3}$	–	240	–	105 87	294 10	420 00	20 03	–
Turnips,	2	–	356	–	–	19 85	35 60	15 75	–
Carrots,	$\frac{1}{2}$	6,413	–	–	10 53	25 70	9 54	–	$26 69
Mangels,	$\frac{1}{2}$	–	–	14.5	10 74	26 50	28 50	–	7 74
Oats and peas,	$1\frac{1}{4}$	–	–	10	7 41	18 37	–	–	–

* Dozen bunches.

† In part estimated, as threshing is not yet entirely completed.

The live stock of the farm has maintained a good average of general health; but we have suffered a few losses, viz., one team horse from black water (*hœmaglobinuria*), one Percheron mare in parturition and one Ayrshire heifer from an unknown cause. The live stock now includes the following animals: —

Horses. — Percherons, 1 stallion, 1 two-year-old stallion colt and 1 ridgling; three-quarter blood Percheron, 2 mares; French coach, 1 stallion and 1 mare; one-half blood French coach, 3 colts; farm horses, 4 mares; total, 14 head.

Neat Cattle. — Ayrshire, 1 bull, 1 cow and 1 bull calf; Jerseys, 1 bull, 2 cows and one heifer calf; Shorthorns, 1 bull, 1 cow and 1 heifer calf; Guernsey, 1 bull and 1 cow; Holstein-Friesian, 1 bull, 1 cow and 2 heifers; western Shorthorn grades, 46 cows; and Ayrshire, Holstein-Friesian, Shorthorn, Jersey and Guernsey grades, 17 young cows and 20 heifers and calves; total, 99 head.

Sheep. — Southdowns, 1 ram and 38 ewes.

Swine. — Berkshires, 1 boar, 1 sow and 6 shoats; Poland-Chinas, 1 boar, 1 sow; Chester Whites, 1 boar, 1 sow; Tamworths, 1 sow and 9 shoats; Berkshire-Poland-China, cross-bred, 4 shoats; total, 25 head.

The sales of the year Dec. 10, 1897, to Dec. 15, 1898, have amounted to $7,220.77. The largest items are: milk and cream, $4,019.80; beef, $589.86; potatoes, $531.80; celery, $174.62; hay, $658.10; sheep, wool and lambs, $214.23; and labor, $350.10.

Such degree of success as has attended the operations of the farm is due almost entirely to the faithful attention of the superintendent, Mr. E. A. Jones, to whom, as my responsibilities for experimental work increase, have been left all details of farm management in largely increased measure.

WM. P. BROOKS,
Professor of Agriculture.

AMHERST, Dec. 23, 1898.

GIFTS.

From Massachusetts Society for Promoting Agriculture, one hundred dollars, prizes, winter Dairy School.

O. Douglas Butter Culture Company, Boston, two packages butter culture.

Vermont Farm Machine Company, Bellows Falls, Vt., one dog power.

German Potash Syndicate, sulphate of potash, five tons; muriate of potash, three tons; silicate of potash, two hundred pounds.

Cornell Experiment Station, Ithaca, N. Y., three varieties of seed potatoes.

Central Experiment Station, Ontario, one variety of seed potatoes.

H. C. Marsh, Muncie, Ind., three varieties of seed potatoes.

L. L. Olds, Clinton, Wis., one variety of seed potatoes.

Ford & Son, Ravenna, O., one variety of seed potatoes.

W. H. Maule, Philadelphia, Pa., one variety of seed potatoes.

W. A. Burpee & Sons, Philadelphia, Pa., two varieties of seed potatoes.

A. B. Howard, Belchertown, two varieties of seed potatoes.

A. J. Silberstein, Framingham, plan of and permission to use patent nest.

Florida Experiment Station, Lake City, Fla., one bushel Velvet bean.

Hon. Levi Stockbridge, Amherst, one peck Velvet bean.

Baker & Bros., New York, two hundred pounds Damaraland guano.

From United States Department of Agriculture, Washington, D. C., seeds, — winter vetch, Russian sunflowers, wax bean, kidney vetch, Bromus inermis and several other grasses.

Skabcura Dip Company, St. Louis, Mo., package sheep dip and one of Nikoteen.

B. H. Smith (M. A. C., '99), Middlefield, two flickers.

D. A. Beaman (M. A. C., '99), Leverett, two chipmunks.

W. H. Armstrong (M. A. C., '99), Cambridge, two young red-tailed hawks.

Loans, for Use during Winter Course Dairy School.

From De Laval Separator Company, New York, three separators.

Vermont Farm Machine Company, Bellows Falls, Vt., four separators and one regulator.

Creamery Package Manufacturing Company, Chicago, Ill., Disbrow combined churn and butter worker.

Elgin Manufacturing Company, Elgin, Ill., Babcock testers, power and hand sizes.

Sharpless Manufacturing Company, West Chester, Pa., one separator.

BUTTER CULTURES *v.* NATURAL RIPENING.

F. S. COOLEY.

EFFECT ON THE FLAVOR OF BUTTER.

Butter Cultures *v.* Natural Ripening.

F. S. COOLEY.

EFFECT ON THE FLAVOR OF BUTTER.

Introduction.

A wide-spread interest has been manifested during the past two or three years in the matter of substituting ferments whose action is known for the miscellaneous micro-organisms previously concerned in ripening cream for the manufacture of butter. The movement towards such a substitution is so active and the amount of money at stake so great that it has seemed important to test carefully the claims of manufacturers of pure butter cultures, with a view to determining whether the advantage of using them in the manufacture of butter warrants the outlay.

Recently as the science of bacteriology has come into prominence, it is now recognized as of great importance, and its explanations of every-day phenomena are sought more and more for practical ends.

In the living animal world the encroachments of disease germs are guarded against with a vigilance undreamed of a generation ago, and with a striking result on the health of our crowded cities. The study of the action of bacteria in the world of dead organic matter is still more recent; nevertheless, it is now engrossing the attention of the foremost scientists of the age.

The "happy hunting ground" of a vast and varied horde of micro-organisms is milk. In it as in very few other fluids do they find congenial conditions and proper food for their rapid development and multiplication. It is startling to consider the enormous numbers of the little plants that ordinary milk contains. It is stated that each cubic centimeter, about one twenty-eighth of an ounce, contains numbers varying from ten thousand to several million individuals.

The milkman's problem is seriously complicated by their presence. If we overlook the disease germs which milk harbors so frequently, but which are now carefully guarded against by the best dairymen and many civil authorities, the number of bacteria contained normally in milk is appalling. They gain entrance largely in the stable, — from the stable atmosphere; the dust in suspension; the forage; the sides, belly and udder of the cow where even the orifices of the teats are invaded; and the excreta, which is teeming with life, and which often is not so carefully removed from the sides and udder of the cow as it should be. If the utmost care is not observed in cleaning and sterilizing pails, cans and other dairy apparatus, these, too, form breeding ground for the multiplication of germs, and for seeding subsequent milkings with them.

The effect of bacteria on milk is varied, inasmuch as numerous different forms are present, the principal effect being the fermentation or souring of the product. Sometimes, however, putrefaction, red or blue patches or a ropy condition is the result. The value of milk is dependent in a great measure on its power to keep sweet and resist these undesirable changes. In other words, the value of milk is in inverse ratio to the number of bacteria it contains. Samples of milk from a close city stable, — where the air was foul, the cows fed largely on distillery slops, and the fœtid excrements stuck to the flanks and quarters of the cows so as to nearly conceal the hair, — although removed within half an hour after being drawn, contained from five hundred thousand to over seven hundred thousand bacteria per cubic centimeter, and, placed in a cool room, turned off flavor and began to curdle in ten hours. On the other hand, milk produced under conditions of health, cleanliness and care will keep at low temperature for several days. Cows milked in open air give a better milk than those milked in close stables. Care in cleaning the sides and udder of the cows, and dampening these parts before milking; immediate removal of milk from the stable, and quick cooling; careful cleansing and sterilizing of milk vessels, exposing them to sunlight daily, etc., — all tell in the direction of a more valuable and better-keeping milk product.

The growing favor of milking machines has a scientific foundation, in the fact that they prevent the exposure of milk to contamination by germs.

While nearly every evil we seek to guard against in milk is the result of bacterial action, we are greatly indebted to many of these same bacteria for valuable qualities in butter. Undesirable as is the fermentation and souring produced by them in milk, it is one of the essentials in the manufacture of choice butter. The ripening of cream is the work of these organic ferments, and if they are destroyed, or their development checked, cream does not ripen.

It is not necessary to discuss the use of ripening of cream or securing more complete recovery of butter fat in churning, nor is it necessary to state that butter from ripened cream has a better sale than sweet cream butter. A little acid in the product "covers a multitude of sins" in flavor and other qualities.

All butter makers concede that successful butter making depends largely on producing just the right degree of ripeness. Ripening is no more nor less than a partial fermentation, brought about by bacterial development.

It is only recently that the flavor and aroma of butter were properly ascribed to fermentation. It was the prevalent notion previously that the flavor of butter was entirely due to the feed of cows, and it is only within the past decade that that idea has been proved erroneous. In the last few years much valuable knowledge has been gained on the subject of milk fermentation.

History of Investigation.

The noted Danish scientist, Storch, was perhaps the first investigator along these lines. In 1890 he found that the production of a high-class flavor in butter was dependent on the kind of bacterial life that was present in the cream. If sweet cream was made into butter, it lacked the delicate aroma that was so much desired. He studied carefully the different species of bacteria that were present in ripening cream, and finally succeeded in separating a form that invariably produced a fine flavor when introduced into pasteurized cream. These discoveries opened a new field for investigation. That field has since been assiduously cultivated by several other Danish investigators, by Weigmann in Germany, and by Conn, Russell and Keith in the United States.

Prior to this time the manufacturers of beer had availed themselves of the discoveries of science, and since 1883 a uniform desirable flavor has been produced by the famous Carlsberg brewers, by using bacterial cultures separated by Dr. Emil Christian Hansen of Copenhagen. Up to that time the manufacturers of beer had encountered serious troubles in fermentation, which entirely disappeared on the introduction of pure cultures, and the result was an exceptionally uniform and agreeable flavor. It appears, then, that the use of pure cultures in butter making is an outgrowth, as it were, of their use in the manufacture of beer, and that the latter product earlier enlisted the investigations of science in this direction.

Practice and Improvement in Cream Ripening.

For centuries down to almost the present time cream ripening was a most hap-hazard process, and butter makers little thought of attributing their failures to improper fermentation. During the past few decades the tendency has been strongly in the direction of greater care and method in preparing cream for the churn; and practical men now insist on cleanliness and prevention of entrance of all dirt, dust and other foreign bodies into milk and cream, thus almost unconsciously observing the precautions that the teachings of science would indicate.

Many butter makers have gone further than this, and secured a uniformity of ripening, by adding to each batch of cream as it comes to the factory a little of the cream ripened that day, or of the buttermilk from the last churning. In this way those bacteria which have habitually produced an agreeable flavor are seeded day by day into the fresh cream, and gain ascendency over the less desirable forms that might otherwise predominate, resulting in a uniformly fine butter.

A difficulty in the way of absolute success with this method arises from the fact that after a time the form producing agreeable flavors is liable to run out and be overpowered by one producing injurious effects; as, for instance, a bitter taste or a ropy consistency, or perhaps more often a lack of flavor. This quality is transmitted just as persistently as the other, and is often hard to get rid of. The difficulty has been overcome by introducing a fresh ripener from a neighboring creamery, or, better, from a private dairy whose products are known to possess only good flavors. This last method is almost the final step towards the adoption of a carefully isolated and purely developed culture; and, such cultures being on the market, the tests herein described were made to determine, if possible, whether any real advantage accrued from their use over ripening cream in the ordinary way with the utmost possible care.

Butter Culture described.

In our test four different ripeners were employed, — the old natural Lactic Ferment, Conn's Bacillus No. 41, Boston Butter Culture, and Hansen's Lactic Ferment.

Of the first, it is not necessary to state more than that all possible care was observed to have fermentation take place in a purely normal manner. Our aim was to produce a first-class butter, with natural ripening, for comparison. The conditions for ripening the cream were at least as good as the average in creameries where large amounts are handled, and the product compares fairly, as will be seen by the scores.

The second kind of fermentation was started with the Lactic Ferment, received from Chr. Hansen's laboratory, Little Falls, N. Y. This culture is too well known to require comment, having been for some time in use, and thoroughly tried in other places.

The third series of ripenings were produced by the use of Conn's Bacillus No. 41, prepared by Dr. H. W. Conn, Wesleyan University, Middletown, Conn. This bacillus has been described by Dr. Conn in the Connecticut Storrs Station Bulletin No. 12, February, 1894, as one selected by him from a large number, as producing a uniformly fine, high flavor in butter, when introduced into the cream before ripening. The bacillus was obtained at the World's Columbian Exposition in 1893, from a sample of "preserved milk" from Uruguay, which had become quite bitter.

The other culture used in the test was the Boston Butter Culture, received from Mr. O. Douglas, Boston, Mass., separated in 1896 by Mr. S. C. Keith for Massachusetts Institute of Technology. This last named is newer to the trade, having been first placed on the market less than a year ago, and not having, therefore, as yet been given a thoroughly comparative test. The following statement from Mr. Keith is descriptive of this culture: —

This culture was isolated from a mixture of bacteria growing in an agar tube in April, 1896. At that time I was making a study of the effects various bacteria had on cream, and in the course of my experiments found that this bacterium (which I have since named *Micrococcus-butyri-aroma faciems*) produced a decided flavor and aroma when grown in milk or cream.

This bacterium is similar in respect to its action on milk to the one described by Prof. H. W. Conn in Storrs Agricultural Experiment Station Report as "Bacillus No. 41" but it is radically different from the latter in its morphology and biology, being a micrococcus growing at 37° C. and 20°, slowly liquefying gelatine, and not growing well on potato.

Our bacteriologist, Dr. Jas. B. Paige, found the culture as placed on the market for ripening cream entirely free from foreign forms, and pure.

Claims for Pure Culture.

The claims made by the manufacturers of cultures for ripening cream are these: —

1. *Uniformity of Butter.* — As the same organisms are propagated from day to day and renewed from week to week, the flavor of butter must remain uniform and constant throughout the year.

2. *Increase in Flavor.* — Not only is the flavor uniform during the entire twelve months, but a quick, high flavor, so much prized, is secured. The flavor of "June butter" may be thus enjoyed during the entire year.

3. *Improving the Keeping Quality.* — Contrary to the results of tests made by scientists, indicating that a high flavor is short-lived, and accompanies poor keeping qualities, the producers of these cultures claim a better keeping quality for butter made by their use.

Although no tests have yet been previously reported for all the cream ripeners herein described, some very valuable tests have been made for some of them, and especially for Bacillus No. 41.

Previous Experiments.

Dr. H. W. Conn, in Storrs Experiment Station Report for 1894, has, in addition to an instructive discussion of the theory of cream ripening, the results of numerous practical tests of Bacillus No. 41 in Connecticut butter factories, in which the majority of results were favorable to that bacterium.

The Wisconsin Experiment Station Report for 1895 contains the details of a very thorough and extended experiment, conducted by Professors Farrington and Russell, to determine whether the claims of producers of butter cultures are sustained, or not, resulting in these conclusions: —

1. Cultures of Conn's Bacillus No. 41 did not improve the flavor of butter either from separator cream or gathered cream. On the contrary, there was a perceptible difference in favor of natural ripening.

2. With separator cream, butter in cold storage that was made with Bacillus No. 41 deteriorated less than did normal butter; and, although the latter scored somewhat higher when fresh, it scored slightly lower when taken from cold storage.

3. From gathered cream, the use of Bacillus No. 41 produced no advantage in keeping quality of its butter.

4. There was little difference in the uniformity of Bacillus No. 41 or the natural ripening, what there was being in favor of the latter.

Massachusetts Dairy School Experiment.

At the Massachusetts Dairy School in the winter of 1896, in a single careful test of natural ripening, Bacillus No. 41 and Lactic Ferment, under almost identical conditions of management and churning, the Bacillus No. 41 was judged to have produced the best flavor, although some doubt was expressed as to the results. The following tests were carried out by Mr. H. C. Burrington of

Charlemont, Mass., and Mr. F. W. Carpenter of Waupun, Wis., and the Massachusetts Dairy School, under my supervision, during the winter of 1897. The cream was all produced by use of the separators, and contained a uniform percentage of fat, — about 30 per cent. It was set at about 65° F., and allowed to ripen for twenty-four hours to a uniform acidity, — about .4 per cent. It was then churned in a barrel churn at 58°–60° F., worked to a uniform dryness, salted seven-eighths of an ounce to the pound, put away to stand twenty-four hours, reworked and printed.

Identical conditions were observed in the different lots, as far as possible, and the comparisons were remarkably good, as far as uniformity of circumstances was concerned.

All the tests were made in pairs, and continued for five days. Fresh starters were made and put into the first batch of cream; from this the next was seeded, and so on for five days. A churning of each successive day was made, worked and printed. The prints were carefully put away under number, and at the end of five days one pound of each of the five churnings from both lots was sent away to be scored under cipher numbers by two experts. Mr. Orrin Douglas of Boston had charge of the scoring, being assisted by Mr. Harris in most cases. Their scores were each made independently, without consulting the other's judgment.

The different cultures were paired as follows: —

First week, five churnings, Conn's Bacillus No. 41 *v.* natural ripening.
Second week, five churnings, Conn's Bacillus No. 41 *v.* Boston Butter Culture.
Third week, five churnings, Boston Butter Culture *v.* natural ripening.
Fourth week, five churnings, Boston Butter Culture *v.* Lactic Ferment.
Fifth week, five churnings, Hansen's Lactic Ferment *v.* natural ripening.
Sixth week, five churnings, Hansen's Lactic Ferment *v.* Conn's Bacillus No. 41.

In no instance did the scorers know the method of ripening, or have a key to the numbers of the samples to be scored; and in each case the samples of compared methods of ripening extended over five days and through five successive churnings, so that the averages of conditions were practically identical. The following scores were made on the different lots. Flavor only was considered in scoring, 45 points for perfect: —

First Week.

Average score on flavor of five churnings by two different judges (separate scores not returned the first time): —

Conn's Bacillus No. 41, ...	39.00
Natural ripening, ...	37.00

Second Week.

	With Conn's Bacillus No. 41.		With Boston Butter Culture.	
	Douglas.	Harris.	Douglas.	Harris.
First day, ...	41.00	39.50	38.00	36.00
Second day, . . .	40.00	39.00	38.00	38.00
Third day, . . .	42.00	40.00	38.00	39.00
Fourth day, . . .	40.00	39.50	42.00	39.00
Fifth day, . . .	40.00	39.00	38.00	38.00
Averages, . . .	40.60	39.40	38.80	38.00
General averages, .	40.00		38.40	

Third Week.

	With Boston Butter Culture.		With Natural Ripening.	
	Harris.	Fales.	Harris.	Fales.
First day, ...	42.00	40.00	40.00	39.00
Second day, . . .	40.00	40.50	40.00	40.00
Third day, . . .	40.00	41.00	41.00	41.00
Fourth day, . . .	41.00	39.50	39.50	41.00
Fifth day, . . .	40.50	41.00	40.00	39.00
Averages, . . .	40.70	40.40	40.10	40.00
General averages, .	40.55		40.05	

Fourth Week.

	With Boston Butter Culture.	With Hansen's Lactic Ferment.
	Douglas.	Douglas.
First day, ...	41.00	37.00
Second day, ...	39.00	39.00
Third day, ...	40.50	38.00
Fourth day, ...	39.50	40.00
Fifth day, ...	40.50	37.50
Averages, ...	40.10	38.30

Fifth Week.

	With Hansen's Lactic Ferment.		With Natural Ripening.	
	Harris.	Bent.	Harris.	Bent.
First day, ...	40.00	40.00	39.00	39.00
Second day, ...	39.00	40.00	39.00	40.00
Third day, ...	40.00	40.00	38.00	39.50
Fourth day, ...	40.00	38.00	39.00	40.00
Fifth day, ...	39.50	40.50	39.50	39.00
Averages, . . .	39.70	39.70	38.90	39.50
General averages, .	39.70		39.20	

Sixth Week.

	With Lactic Ferment.		With Bacillus No. 41.	
	Douglas.	Bent.	Douglas.	Bent.
First day, ...	38.50	37.50	39.00	39.00
Second day, ...	39.00	38.75	37.00	38.00
Third day, ...	38.00	38.00	38.50	38.50
Fourth day, ...	41.00	41.00	37.00	37.50
Fifth day, ...	38.00	38.00	38.00	38.00
Averages, . . .	38.90	38.65	37.90	38.20
General averages, .	38.77		38.05	

The averages of all these scores under the ripening cultures (they represent twenty-five scores for each culture) are as follows: —

Boston Butter Culture, ...	39.68
Conn's Bacillus No. 41, ...	39.02
Hansen's Lactic Ferment, ...	38.93
Natural ripening, ...	38.75

The extreme scores for each culture make it evident that the claims on the part of the producers of the cultures *that they produce greater uniformity in butter* are not sustained. Natural ripening gives no greater variation than the most uniform of the cultures, as seen below: —

	Maximum.	Minimum.
Boston Butter Culture, ...	42	36
Conn's Bacillus No. 41, ...	42	37
Hansen's Lactic Ferment, ...	41	37
Natural ripening, ...	41	37

The conclusions we would draw from the tests are: —

1. That Boston Butter Culture, Conn's Bacillus No. 41 and Hansen's Lactic Ferment appear to be slightly superior to natural ripening in their effect on the flavor of butter.

2. That this improvement is most marked with the Boston Butter Culture, Conn's Bacillus No. 41 ranking second.

3. That the advantage of using pure cultures is small, if any.

4. That in uniformity of product none of the pure cultures showed any advantage over natural ripening. The lack of uniformity with each of the methods was probably aggravated by the inexperienced butter makers who performed the work. Dairy students did nearly all of the work of the test.

5. It was thought by those in charge of the test that a more decided superiority over normal butter of butter from Conn's Bacillus No. 41 and Boston Butter Culture was more apparent a few days after the butter was made than when it was fresh. This is an important fact, and wants the confirmation of expert judgment.

ELEVENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1899.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are: —

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, Ph.D.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LL.D.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Samuel T. Maynard, B.Sc.,	*Horticulturist.*
J. E. Ostrander, C.E.,	*Meteorologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Charles I. Goessmann, B.Sc.,	*Assistant Chemist* (fertilizers).
Samuel W. Wiley, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, M.Sc.,	*First Chemist* (foods and feeding).
Fred W. Mossman, B.Sc.,	*Assistant Chemist* (foods and feeding).
Benjamin K. Jones, B.Sc.,	*Assistant Chemist* (foods and feeding).
Philip H. Smith, B.Sc.,	*Assistant in Foods and Feeding.*
Robert A. Cooley, B.Sc.,	*Assistant Entomologist.*
George A. Drew, B.Sc.,	*Assistant Horticulturist.*
Herbert D. Hemenway, B.Sc.,	*Assistant Horticulturist.*
Arthur C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins are still in stock and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 37. Report on fruits, insecticides and fungicides.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 42. Fertilizer analyses; fertilizer laws.
No. 43. Effects of electricity on germination of seeds.
No. 45. Commercial fertilizers; fertilizer analyses; fertilizer laws.
No. 46. Habits, food and economic value of the American toad.
No. 47. Field experiments with tobacco.
No. 48. Fertilizer analyses.
No. 49. Fertilizer analyses.
No 50. The feeding value of salt-marsh hay.
No. 51. Fertilizer analyses.
No. 52. Variety tests of fruits; spraying calendar.
No. 53. Concentrated feed stuffs.
No. 54. Fertilizer analyses.
No. 55. Nematode worms.
No. 56. Concentrated feed stuffs.
No. 57. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Index, 1888–95.

Of the other bulletins, a few copies remain, which can only be supplied to complete sets for libraries.

New methods and new appliances in the feeding and care of animals and plants have opened up new problems, and the demands made upon the station have taxed it to its uttermost. Briefly summarizing the work of the year, we find it distributed as follows: in the division of foods and feeding a new feature has been added, viz., regulating the sale of concentrated feed stuffs. There have been 663 analyses of these materials made, 292 of fodder and 420 of dairy products. In an investigation of Cleveland flax meal *v.* old-process linseed meal for feeding early lambs, it was found that no injurious results followed from the use of flax meal, and that there was the same average daily growth of the lambs on either ration; in an experiment of corn meal *v.* hominy meal and corn meal *v.* cerealine feed for growing pigs, it was found that the corn meal was five to ten per cent. more valuable than cerealine feed used in connection with skim-milk, while hominy meal was quite as valuable as corn meal in connection with skim-milk.

In the entomological division, besides the special work in connection with the gypsy moth, attention has been paid to combining the arsenate of lead and the Bordeaux mixture, with favorable results. The life histories and habits of two pernicious insects have been worked out, — the grass thrips, particularly destructive in this State, and the small clover-leaf beetle (*Phytonomus nigrirostris*). The pernicious scale insects (*Chionaspis*) have also been carefully studied, and the results will soon be published.

The horticultural division has continued its work of testing varieties of fruits, domestic and foreign, suitable for this State, and its investigation of hydrocyanic acid as an insecticide.

The division of fertilizers has made five hundred and fifty-two analyses; has conducted experiments on the use of concentrated chemical manures to supply plant food in greenhouses, combinations of high-grade fertilizers for garden, greenhouse and pot cultivation; and has made observations with dried blood and two kinds of leather refuse as a source of nitrogen for growing rye in presence of acid and alkaline phosphates.

The agricultural division, in addition to its soil tests with corn, onions, oats, etc., has undertaken the testing of seeds of the same variety of potatoes raised in different localities, finding a variation of fifty per cent. in Early Rose and Beauty of Hebron. In experiments with poultry the following results were obtained with reference to egg production: (*a*) that condition powders had no effect; (*b*) that animal meal was of more value than cut bone; (*c*) that the influence of the cock was *nil;* (*d*) that a wide ration was preferable to a narrow ration.

The botanical division has issued an illustrated bulletin (No. 55) on the nematode worm, in which its life history is traced, and a simple remedy, steaming the soil, given for its repression. Work has been done in the drop and top burn of lettuce, asparagus and chrysanthemum rust, and in sub-irrigation and the mechanical condition of soil as affecting the growth of lettuce.

Reports from the different divisions, giving in detail the work of the year, accompany this brief summary.

ANNUAL REPORT

OF GEORGE F. MILLS, *Treasurer* OF THE HATCH EXPERIMENT STATION OF MASSACHUSETTS AGRICULTURAL COLLEGE,

For the Year ending June 30, 1898.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$4,443 00	
for labor,	3,605 36	
for publications,	2,885 54	
for postage and stationery,	235 56	
for freight and express,	355 49	
for heat, light and water,	130 17	
for seeds, plants and sundry supplies,	448 72	
for fertilizers,	285 86	
for feeding stuffs,	141 17	
for library,	244 78	
for tools, implements and machinery,	250 00	
for furniture and fixtures,	105 19	
for scientific apparatus,	228 36	
for live stock,	901 00	
for traveling expenses,	220 00	
for contingent expenses,	80 65	
for building and repairs,	439 15	
		$15,000 00

Cash on hand July 1, 1897,	$19 73	
Received from State treasurer,	11,200 00	
from fertilizer fees,	3,278 75	
from farm products,	1,763 86	
from miscellaneous sources,	1,663 45	
		$17,925 79
Cash paid for salaries,	$8,901 77	
for labor,	3,167 18	
for publications,	708 27	
for postage and stationery,	236 16	
for freight and express,	154 97	
Amount carried forward,	$13,168 35	

Amount brought forward,	$13,168 35	
Cash paid for heat, light and water,	549 44	
for chemical supplies,	958 54	
for seeds, plants and sundry supplies,	368 02	
for feeding stuffs,	592 46	
for library,	191 10	
for tools, implements and machinery,	34 49	
for furniture and fixtures,	40 23	
for scientific apparatus,	187 11	
for live stock,	313 50	
for traveling expenses,	356 73	
for contingent expenses,	163 96	
for building and repairs,	1,001 86	
		$17,925 79

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1898; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $32,925.79, and the corresponding disbursements $32,925.79. All the proper vouchers are on file, and have been by me examined and found to be correct, there being no balance on accounts of the fiscal year ending June 30, 1898.

CHARLES A. GLEASON,
Auditor.

AMHERST, Aug. 31, 1898.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

During the year, as in previous years, the meteorological division has been principally engaged in the observations of the various weather elements and phenomena, and the compilation of the records in permanent form. The more important results, together with summaries of most of the others, have been published, as heretofore, in bulletin form each month. The usual summary of the weather for the year will be issued when the records are completed.

The records of the division were begun with the year 1889; accordingly, this year completes the first decennial period. A tabulation of the results for the whole period is under way, for use in determining the means of the several weather elements at this station. These results should give normal conditions differing but little from those that may afterward be deduced from observations covering a much longer time, and will be found valuable for the purpose of determining departures from mean conditions in the future. The tables are being arranged in a suitable form for publication, so that they may be issued in bulletin form, if it is thought desirable.

While the self-recording instruments in the tower give generally good results, the records of the sun thermometer are lacking in precision. Cold-air currents and variable wind velocities give at times records which cannot be distinguished from those due to cloudiness. The desirability of having a photographic or an electrical sunshine recorder, for use in conjunction with the Draper instrument, is suggested.

The local forecasts of the weather have been received daily, except Sunday, from the Boston office of the United

States Weather Bureau, and the signals displayed on the top of the tower. At the request of Mr. J. W. Smith, director of the New England section of the United States Weather Bureau, this division has arranged to furnish his office the weekly snow reports, as has been done the past few years. The record of the number of days of sleighing, begun by Professor Metcalf, is being continued.

During the year attempts were made to secure some records of atmospheric electricity by using the quadrant electrometer in the tower, but without success. The extreme sensitiveness of the instrument seems to preclude its working at any such height from the ground, where it is necessarily subjected to the vibrations of the building. Unless a suitable location and mounting can be provided elsewhere, the records it was intended to secure cannot be obtained with any degree of success.

During the year the division purchased one of the resistance boxes made after the design of Prof. Milton Whitney, of the Division of Soils, United States Department of Agriculture, for the purpose of continuing the examination of soil moisture by the electrical method. The electrodes could not be obtained from the manufacturer until early in June, and then a number proved defective. Others were loaned us later by the Department at Washington for continuing the work. The results obtained have been even less satisfactory than those of last year. An examination of the electrodes in the soil showed in some cases short circuits to have been produced by the growth of roots across the face; in other cases no cause could be found for unusual changes in the resistance. A continuation of the experiment another year may perhaps furnish more satisfactory results, or reveal the causes of some abnormal fluctuations.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The work of this division during the past year has been carried on in about the same lines as for the year of 1897.

Of the experiments conducted, variety testing of fruits, vegetables, flowers, etc., has occupied considerable attention. This work has been undertaken largely in response to the constant calls from the people to know the value of widely advertised new varieties put upon the market with extravagant claims of merit and at exorbitant prices, nine-tenths or perhaps ninety-nine-hundredths of which prove of less value than the old established sorts.

Fruit Investigations.

The Apple.

With each succeeding year the fact is more and more clear that old varieties, from the many conditions of cultivation, from increased injury by insects and fungous pests, grow more feeble and are more and more subject to the continued action of the above agencies; and that new varieties must be found, that can be more easily and cheaply grown, or that will meet the demand for fruit of better quality. The Baldwin apple, for so long a time the most profitable and satisfactory variety for market, has in many places in the last two or three years shown so great a tendency to the dry-rot spots under the skin, long before its normal time for the breaking down of its tissues in the process of ripening, that much of its fruit put on the market has had the effect of decreasing the demand and lowering the price; while the Ben Davis, not nearly as good in quality, but firm, fresh and solid from skin to core, has been sold in our local markets to the exclusion of the home product.

The varieties of apples tested here and in many other sections, that stand out prominently as possessing those qualities that will enable them to successfully compete with the winter varieties shipped to our markets from other States, are the Sutton Beauty, Palmer, MacIntosh Red, Wealthy and Gano.

Sutton Beauty. — Much superior in quality to the Baldwin; is of similar color, perhaps not quite as large unless thinned, and has not shown the dry-rot spots so common in the latter variety. The tree is vigorous and compact in growth, generally with strong, healthy foliage, and so prolific as to require thinning. For local trade it is one of the best.

Palmer. — An apple of medium to large size, of a golden-yellow color when grown on trees in the full exposure of sunlight, but of a green color if grown on closely planted trees. It is of the best quality, tender, crisp and rich. Being an apple of light color and tender flesh, it should be handled very carefully when gathered, and sold in bushel boxes, in which it will not be subjected to much pressure or jolting.

MacIntosh Red. — This is one of the most beautiful of late fall and early winter apples, and, as far as it has been tested in Massachusetts, has done well, and promises to secure much of the trade for fancy apples that demands such varieties as the Fameuse, or Snow apple, which is not successfully grown in this State.

Wealthy. — Generally this variety has proved very satisfactory, but has only been grown on young trees. Its season of ripening is when there is an abundance of fall apples, but it often keeps into early winter. It colors up early, and its beauty, together with its fine quality and somewhat elastic texture, not easily bruised, makes it a good market variety, and should make it valuable as an early shipping apple with which to open the fall trade in European markets, which in the past has been greatly injured by shipping half-ripe and poorly colored Baldwins, and other varieties not as well colored or matured as the latter variety. It has thus far proved prolific, an early bearer and free from disease, but will be greatly improved by thinning.

Ben Davis. — It has been stated on good authority that more of this variety were sold in the Boston markets and on fruit stands during the winter of 1897 than of any other kind, almost the entire amount of which were imported from the western States. In quality and beauty this apple is far below any of the varieties above mentioned; yet its perfect form, uniform size, good keeping qualities, and its very firm, but somewhat elastic flesh, render it less affected by handling and shipping than almost any variety in cultivation. It is very productive, but, as grown in New England, unless thinned, will be of medium or small size. From its behavior thus far it would seem that, if a variety of so poor quality is to be demanded by our markets, it may be grown quite as successfully in many sections of the State as in any other section of the country. This, however, is not necessary; for, if the previously named varieties are well grown, there will be no difficulty in securing the local markets for them, if they are properly sorted and delivered.

Gano. — This variety was introduced as an improved Ben Davis, and, as far as tested, has proved superior to that variety in color, and perhaps to a very slight degree in quality. As yet it has only been produced on young trees, so that its real value cannot be determined without many years' further trial.

Pears.

With the large number of kinds of choice fruit that is now competing with the fruit grown in New England, the pear seems to be less in demand than formerly. Fewer varieties also are found profitable than a few years ago. Of those that stand at the head of the list, the Bartlett, Bosc, Sheldon, Seckle and Hovey are the most generally grown and bring the highest prices.

Peaches.

The interest in peach growing in this State seems on the increase, and the growers are coming to see that it is useless to plant the peach for profit except on high land, where a moderately vigorous growth can be maintained, and where the temperature is such that the fruit buds mature more fully and are not so liable to be destroyed by extreme cold. The varieties that are popular in the market and that are most profitably and successfully grown are Crawford's Early, Crawford's Late, Old Mixon, Elberta and Crosby. All of these varieties except the Elberta have long been grown in Massachusetts. The latter is an oval peach of large size and of a light-yellow color, with more or less color on the exposed side. It is generally hardy and productive, but the past season, in a great many sections of this and other States, was so seriously injured by the "leaf curl" as to endanger its vitality. Should it continue to be attacked by this disease, it will not long remain a profitable variety.

Plums.

Many growers of this fruit in the State have become discouraged from the lack of profit in the domestic plum, on account of the black knot, plum curculio, leaf blight and brown rot. The results obtained in the station orchards give no reason for such discouragement. Trees of all ages, from thirty years old to those of one or two years' growth, may be found, and almost every variety of any value is represented. Upon these trees will be found hardly a knot to the tree. No leaf blight appeared on the majority of the trees, and many varieties matured their fruit with little or no injury from the brown rot, while a few others were seriously injured. In the average season the use of the Bordeaux mixture, as recommended in the spraying calendar in Bulletin 52, has been found to prevent even the serious injury of the fruit by the brown rot; and the past season, had one or two applications of the copper sulphate solution (one-fourth pound to fifty gallons of water) been made the last of July or in early August, this loss might have been greatly reduced. The black knot has almost wholly succumbed to the treatment outlined in the bulletin mentioned, and the most healthy and vigorous foliage is to be found upon all the trees. The varieties that show the greatest tendency to rot are Lombard, Washington, Gueii, Smith's Orleans and Victoria. Those that show the least are Bradshaw, Prince Englebert, Kingston, Grand Duke, Reine Claude and Fellemberg. The amount of rotting of many varieties, however, is largely dependent upon the weather at the time of their approaching maturity, and only prompt and frequent spraying at this time will save the crop.

Of the newer varieties, those that show the most promise are the Kingston, Lincoln and Fellemberg.

Kingston. — Fruit very large, oval in form, slightly pointed at both ends, of the brightest blue color, firm in texture and very acid in quality; ripens late in the season and hangs a considerable time on the tree; very productive and valuable for canning, though it is rather large for this purpose.

Lincoln. — Early, dark purple, of large size and very fine quality; fruited but two years in the station orchards, but it seems very promising.

Fellemberg. — This seems identical with a variety that we have had growing for nearly thirty years under the name of the German prune. It is a regular biennial bearer, but never produces large crops. The fruit is of medium to large size, tapering at both ends. It is of deep purple color, a perfect freestone and of very good quality. Its great value lies in its long keeping and its fine canning qualities.

The Japanese plums, from their rapid growth, great productiveness, early bearing and attractiveness, are being quite largely planted in nearly all sections of the country, and promise to be of considerable value to our fruit growers who do not succeed in growing the domestic varieties. The trees seem to be a little less subject to the black knot and the brown rot, but more subject to the shot-hole fungus, and are often seriously injured by the use of the copper solution and the arsenites. The fruit is attractive, and meets a ready sale; but whether the demand will be large enough to keep up with the increased planting that is going on, time only can determine. All of the varieties of reported value have been planted in the station orchard, forty-eight in all, many of which will fruit next summer for the first time, unless the fruit buds are destroyed by the cold winter weather. In some cases these varieties are attacked by some disease similar to the peach yellows. Of the varieties that have been tested for several years in various sections of the country, the Abundance, Burbank, Red June and Satsuma have proved satisfactory. Of the newer varieties that are of very fine quality the Wickson, Hale and October Purple may be mentioned.

The Satsuma has not ripened here so as to be of much value for table use, but from the deep-red color of its flesh it is especially valuable for canning. It seems to be weak in self-fertilizing qualities, and needs to be planted among other varieties for the best results in pollination.

Cherries.

The crop of cherries in the station orchard would have been unusually large but for the extremely hot and moist weather at the time of ripening, which caused the fruit to rot badly. The trees had been regularly sprayed with Bordeaux up to the time when it would disfigure the fruit, but there was not a sufficient quantity of the copper from this to spread over the rapidly growing leaves and fruit. From results obtained here and from reports received from other stations, it is probable that spraying thoroughly *immediately* after each rain, as the fruit begins to color, with the copper solution (four ounces of copper sulphate to fifty gallons of water), would largely prevent this loss. It is urged that the coming season those engaged in growing cherries should try this treatment. It must be borne in mind that the application should be made very soon after the rain ceases, as the spores of the brown rot germinate very quickly when placed in moisture, and it is to prevent this germination that the application is made. Heavy rains, especially if soon followed by dry weather, need be little feared, as they tend to wash the spores off the plants, though some may gain a lodgement in the axils of the leaves or in the calyx of the fruit or other places. The varieties most satisfactory were Governor Wood, Napoleon, Black Tartarian and Early Richmond.

Grapes.

Perhaps upon no fruit crop grown in New England is the certainty of protection by spraying so great as with the grape crop, when properly done, and upon which insecticides and fungicides are so easily and cheaply applied. Campbell's Early, the only new variety fruiting that stands out as decidedly promising, produced fruit on several young vines. The growth of vine was satisfactory, the foliage free from disease, the fruit beautiful in appearance and of good quality. The compactness of bunch and firmness of berry will make it a good shipping grape, and, if it does not develop a tendency to disease, it will be a valuable addition to the few varieties that can be profitably grown in New England. It ripens as early or perhaps a little before Moore's Early, and is much superior in quality. The varieties recommended for this section are Winchell or Green Mountain, Worden and Delaware.

Currants.

There is scarcely another fruit the merits of whose new varieties it is so difficult to decide as the currant, because of its great variation in size and productiveness under different conditions. All the new varieties of any prominence have been planted in the station plots, and those that stand out prominently as possessing merit are the Pomona, Wilder and the Red Cross; and, after three years fruiting, their value seems to be in the order given. The Pomona may be mentioned as of especial value, because of its superior quality. We have no records, however, to show that any of the above varieties will be more valuable for general cultivation than Fay's Prolific or the Cherry.

Blackberries.

All of the prominent new varieties have been added to the list under trial, but none have thus far shown themselves to be more valuable than the best older sorts, — the Agawam, Snyder and Taylor's Prolific. On heavy soils, where the growth is large and furnishes an abundant soil cover, thus keeping the ground cool, the first-named variety proves very satisfactory; but when grown on light land it is of much less value.

The Eldorado continues to do well, and compares favorably with the above-mentioned varieties; but whether it will prove more valuable than any other, can only be determined in large plantation.

Raspberries.

With the red raspberry there has been little or no progress made in improved varieties. The Loudon, which, from its stocky growth, hardiness and fruit of good size, color and quality, seemed very promising, has the past season shown a tendency to mildew of the leaves and young growing canes. If this becomes general, it will greatly reduce its value. The seedlings produced from the seeds of the Shaffer, and referred to in a previous bulletin, have again fruited, and many of them show decided merit, some producing fruit of a bright scarlet color upon plants that propagate only from the tip of the cane, as does the Shaffer; while others produce fruit of the Shaffer type that propagate from suckers, like the common red raspberry.

Strawberries.

The past season was favorable for a large crop of fruit, but the extremely wet weather at the time of ripening caused much loss by rotting. The named varieties were planted in plots of twenty-five plants each, while the most promising of these are planted each season in rows under field culture. Of the varieties in plots (soil medium heavy loam), the Brandywine, Gandy Bell, Glen Mary, Sample and Howard's No. 14 gave the best results. Of those grown under field culture, on light land, the Clyde, Cumberland, Glen Mary, Howard's Nos. 36 and 41 gave the best results.

New Fruits.

Several new species of raspberries, the strawberry-raspberry, Logan-berry, Salmon-berry, May-berry, etc., have been planted, some of which have fruited, but only two seem to possess any merit for this climate. The strawberry-raspberry is an herbaceous perennial, the top of which dies to the ground in the winter, but is followed by numerous shoots in the spring from underground stems, that bear most beautiful wine-colored fruit in abundance. This fruit is of a peculiar, insipid, though not unpleasant flavor, and may be the origin of new varieties with a more decidedly pleasant taste. Should such varieties be produced, and a system of cultivation be worked out by which a reasonably certain crop can be secured, it may prove a valuable addition to our list of hardy fruits.

The Logan berry resembles the common dewberry or running blackberry in habit of growth and form of fruit; but the latter is rather larger, and of a dark-red or mahogany color. It possesses a pleasant flavor, but the same obstacle to its general cultivation is met as with the dewberry, — that it is difficult to devise a method of cultivation and training that will give a large crop of fruit every year.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. Lindsey.
Assistants, E. B. Holland, F. W. Mossman, B. K. Jones, P. H. Smith, Jr.

Part I. — Laboratory Work.

Outline of Year's Work.

Part II. — Feeding Experiments and Dairy Studies.

Part I.

Extent of Chemical Work.

The laboratory work connected with this department has been much increased during the past year. We have received for examination 159 samples of water, 228 samples of milk, 17 samples of butter, 4 samples of oleomargarine and 81 samples of feed stuffs. The work in connection with this and other divisions of the Station has consisted of the analysis of 394 samples of milk, 26 samples of butter, 292 samples of fodders and 11 miscellaneous samples. In addition to the above, we have collected 754 samples of feed stuffs under the provisions of the feed law, of which 663 samples have been examined. This makes a total of 1,875 substances analyzed, as against 1,147 in 1897. There have also been carried on for the Association of Official Agricultural Chemists, investigations relative to the best methods for the determination of potash, and of the different ingredients in cattle foods, as well as a study of the most desirable methods to be employed in the estimation of sugar. It is hardly possible to express numerically the extent of this work.

Character of Chemical Work.

Water. — We have followed the same general line of investigation as in former years, in the examination of waters sent by farmers and others.

Whenever possible printed instructions are sent for sampling and sending the water. In making a report to the party, a printed form is used. Upon the form there is explained the meaning of the terms used, so that every one will have at least a general idea of what the analytical results are meant to convey.

Those sending the samples have been advised promptly whether in our judgment the water was suitable for drinking and general domestic purposes. Whenever necessary, suggestions have been offered with the hope of improving the family supply. We again caution everyone who depends upon wells and springs for their drinking water to have all sink drains, etc., remote from the well, and to keep the ground in the vicinity free from objectionable matter. Lead pipes should never be used in drawing water from wells.

Milk. — Some of the milk sent to the station has been from farmers who ship their milk to the Boston market, and having been notified by the contractors that their article was below the legal standard, wished to ascertain if such was the fact, and if so, what could be done for its improvement. To such we have given the same advice as appeared in our last annual report, to which interested parties are referred.

Many farmers are now sending occasional samples of milk, cream and skim-milk to the station, to ascertain the amount of butter fat contained in them. These producers sell their milk to creameries, and they are desirous of knowing its quality for butter production. This is a very encouraging sign, for it shows that the farmer really wishes to know the butter-producing capacity of his cows, and the efficiency of his separator, or Cooley creamer, in removing the fat from his milk. To all who desire, printed information is given, stating how to ascertain the yearly butter capacity of dairy cows.

Much of the milk and butter analyzed in connection with our own experiments has been studied with a great deal of care. We have estimated the water, solids, fat, casein, milk sugar, and ash in a large number of samples. We have also made a very thorough examination of 26 samples of butter fat produced by cows employed in connection with our feeding experiments. There have been determined in duplicates or triplicates, volatile acids, specific gravity, melting point, and the iodine number.

Cattle Feeds. — Our feed law has now been in operation about one and one-half years. We have made frequent inspections covering the entire State, and have published two especially prepared bulletins giving the results of our investigations. We have endeavored to make these bulletins as practical as possible, and judging from the way in which the bulletins are received, it is believed that we have in a measure succeeded. During the spring of 1898 a considerable quantity of adulterated cotton-seed meal was found in various sections of the State. Printed slips of warning were immediately sent to 100 newspapers in the State, and a concise circular was also mailed to every grain dealer, cautioning against its purchase. While meal of this character generally has a darker appearance than the prime article, samples of inferior meal have recently been found having quite a bright yellow color. A number of reputable manufacturers now print a guaranty upon every package, and purchasers are strongly advised to buy only the guaranteed article. The effect of the feed law has been to call the attention of all manufacturers to the necessity of branding their products, and having them run as even as possible in composition. Many of the more reputable manufacturers are now placing a guaranty upon their feeds, and it is hoped others will soon follow.

Many new feeds are constantly being offered for sale in our markets. A number have appeared during the year 1898. Our object is to secure samples of these materials promptly, and ascertain their feeding and comparative commercial values. For detailed information the reader is referred to Bulletins 53 and 56.

Other Chemical Work. — The analyses of feed stuffs and manures in connection with the numerous digestion experiments carried on by this division, involves a considerable amount of time and effort, but because of this work we are enabled to state with a reasonable degree of accuracy the feeding and commercial values of the concentrated feeds sold upon the market, and of the coarse feeds produced upon our farms.

It is the object of this division to assist the Association of Official Agricultural Chemists as much as possible in perfecting methods of chemical analyses, and in finding out methods for the estimation of the quantity and nutritive value of several of the newer carbohydrates. We spend whatever time can be had during each year in working along these lines, believing it will be productive of much good in the future. During the past year we have given attention to the estimation of pentosans, starch and sugar in agricultural plants.

The chemical work received from the agricultural division has very much increased during the past year. This work consists of the determination of dry matter in a large number of plants, the estimation of starch in potatoes, the analyses of feed stuffs used in poultry experiments, and in general fodder analyses. This increased work is now severely taxing the resources of our chemical force.

Part II.

A. Cleveland Flax Meal *v.* Old-process Linseed Meal for Early Lambs.

Object of the Experiment.

It has recently been claimed, by parties who grow early lambs for market, that the so-called new-process linseed meal (Cleveland flax meal) exerted an injurious effect upon the young lamb. Some claim that this meal did not favor growth, and others that it was the cause of frequent sudden deaths. On the other hand, it was stated that the old-process meal did not have these injurious effects, but favored rapid growth and fattening. The station was asked to throw some light on the subject, and conducted the following experiment in the winter and early spring of 1898.

The Experiment.

Six grade Southdown ewes were brought to the station barn the first week in February, and each placed in a separate pen six feet wide by fifteen feet long. The pens were separated by stout wire netting, thus enabling the animals to see each other. The ewes were all in fair condition, and in about two weeks' time began to drop their lambs. Each lamb was weighed five days after being dropped.

Daily Feed for the Ewes after Lambing. — Two pounds corn ensilage, rowen *ad libitum*, 1 pound grain mixture. The grain mixture* was gradually increased until each ewe received 2½ pounds daily. This grain feed was kept up as long as the ewes would take it, and was then gradually reduced. The grain mixture, as will be noticed, contained about one-third of one of the two kinds of linseed meal.

Daily Feed for the Lambs. — The pens were so arranged that the lambs gained access to a separate compartment, containing a mixture of grains. They soon learned to go in as soon as the feed was placed in the troughs. It was our aim

* The grain mixture consisted of 7.5 pounds of old-process linseed or flax meal, 7.5 pounds of bran, 5 pounds corn meal and 5 pounds gluten feed.

to feed them what they would eat daily: grain mixture No. 1, 7.5 pounds flax meal or old-process linseed meal, 7.5 pounds bran, 10 pounds corn meal.

After feeding this mixture for about two weeks, a second was fed, as follows: 10 pounds flax meal or old-process linseed meal, 5 pounds bran, 5 pounds corn meal.

When the lambs each reached 40 pounds in weight, the mixture was again changed to: one-third flax meal or old-process linseed meal, one-third bran, one-third corn meal.

It was our object to give the lambs as much of each of the two linseed meals as they would stand, and keep in a healthy, growing condition.

Care of the Lambs. — The lambs were kept in the pens with the ewes. As the season advanced, they were allowed the run of a large yard in the warmer part of sunny days.

Record of Growth.

Flax Meal Lambs.

Number of Lamb.	Date Five Days after dropping.	Date when slaughtered.	No. of Days in Experiment.	Weight Five Days after dropping (Pounds).	Weight when slaughtered (Pounds).	Total Gain (Pounds).	Daily Gain (Pounds).
Lamb No. 8, . .	March 3,	May 5,	62	15.25	67.00	51.75	.83
Lamb No. 6, . .	March 1,	May 18,	78	10.25	57.50	47.25	.62
Lamb No. 7, . .	March 1,	May 25,	85	10.50	53.00	42.50	.50
Lamb No. 1, . .	February 25,	May 18,	82	9.50	47.50	38.00	.46
Lamb No. 2, . .	February 25,	May 25,	89	9.25	41.00	31.75	.36
Average, . .	-	-	79	10.95	53.20	42.25	.54

Old-process Linseed Meal Lambs.

Number of Lamb.	Date Five Days after dropping.	Date when slaughtered.	No. of Days in Experiment.	Weight Five Days after dropping (Pounds).	Weight when slaughtered (Pounds).	Total Gain (Pounds).	Daily Gain (Pounds).
Lamb No. 5, . .	February 25,	April 29,	63	11.75	52.25	40.50	.64
Lamb No. 3, . .	February 25,	May 18,	82	11.00	50.00	39.00	.48
Lamb No. 4, . .	February 25,	May 25,	89	8.75	44.50	35.75	.40
Lamb No. 9, . .	March 19,	June 1,	74	10.25	52.25	42.00	.57
Lamb No. 10, . .	March 19,	June 1,	74	9.00	51.00	42.00	.57
Average, . .	-	-	76	10.15	50.00	39.85	.53

Note. — Lambs 6 and 7, 1 and 2, 3 and 4, 9 and 10, were twins.

The lambs were shipped to Ira C. Lowe of Greenfield, Mass., who slaughtered them, and reported on their condition. He had no knowledge as to which lambs were fed the flax meal and which lambs were fed the old-process linseed meal ration. Lamb No. 8 was reported to be of extra quaility, Lamb No. 5 next in quality to No. 8, and the others of fair quality only. Looking at the average figures in the above tables, it will be seen that each lot of five lambs showed the *same daily gain*. Mr. Lowe noticed no particular advantage in favor of either lot.

Results of the Experiment.

As a result of our observations, we conclude: —

That the flax meal had no injurious effect either upon the growth or dressed appearance of the lambs, and that both sets of lambs produced the same average daily growth, and were both in the same average condition when slaughtered.

Remarks and Suggestions.

It is well known to all growers of early lambs, that in order to secure a rapid growth of the lamb, the ewe should be thrifty, and a good milker. A liberal feeding will aid in keeping up a continuous flow of milk. The early growth of the lamb will depend very much on the constitution it inherits, and upon its success in obtaining a large supply of milk. Easily digested nitrogenous feed stuffs will unquestionably assist in producing quick growth, but they are secondary to the milk supply. This is quite forcibly illustrated in case of our experiments as described above. Lamb No. 8 was single, and its mother was an excellent milker. The lamb was above the average in size and vigor when dropped. He grew rapidly, showing .83 of a pound gain per day. It was noticed that this lamb did not consume very large amounts of grain, although he had a constant opportunity. He derived the larger part of the food necessary for his growth from his mother. Lamb No. 5 was also a single lamb. He made a very good growth, but the ewe was not as good a milker as the previous one. This lamb took more grain than did No. 8, but was not able to make as rapid growth. The other lambs were twins. They did not grow as rapidly as did the single lambs, because of the lack of milk, although they ate quite freely of the grain mixtures. Lambs Nos. 6 and 7 came from a good milker, and they were also quite vigorous and hearty eaters.

In addition to inherited constitution and plenty of milk, it is very essential, in order to secure rapidity of growth, that early lambs should be housed in a warm, dry barn, and have a maximum amount of sunlight from a southern exposure.

B. Corn Meal *v.* Hominy Meal, and Corn Meal *v.* Cerealine Feed for Growing Pigs.

Experiment I. — Corn meal *v.* hominy meal.
Experiment II. — Corn meal *v.* cerealine feed.
Experiment III. — Corn meal *v.* cerealine feed.

Objects of the Experiments.

Skim-milk is a very valuable feed for growing pigs. It is a digestible, nitrogenous feed stuff. Of itself it is not a complete food, being deficient in solid matter as well as in carbohydrates (starchy material). In order to make a complete food, carbohydrate feeds are necessary to properly balance the daily ration. A combination of skim-milk and corn meal (1 quart milk and from 3 to 6 ounces of meal) has been found to make a most excellent feed for rapid growth. The object of the above-mentioned experiments was to get at the feeding values of hominy meal and cerealine feed, when compared with corn meal, for this purpose.

What Hominy Meal is. — Hominy meal consists of the hulls, germ and some of the starch and gluten of the corn, ground together. This separation is said to be brought about solely by the aid of machinery. The hard, flinty part of the corn is the hominy, which is used as a human food.

What Cerealine Feed is. — This feed consists also of the hull and a portion of the starch of the corn. It contains rather less of the starch than does the hominy meal. It is the by-product resulting from the preparation of the breakfast preparation known as cerealine flakes. It is very coarse looking, and appears much like unground corn hulls.

Results of Experiments.

1. Hominy meal produced 5 to 7 per cent. more growth, when fed to pigs in connection with skim-milk, than did corn meal. This difference was probably due to the dryer condition of the hominy meal, and nearly disappears when the meals are compared on a basis of dry matter they contained.

2. In view of the fact that Pig IV. was thrown out of the experiment, we should hesitate to say that the hominy meal had proved itself in any degree superior to the corn meal. This experiment would seem to indicate, however, that pound for pound, as found in the market, the hominy meal is at least fully as valuable as the corn meal.

3. In the two experiments with cerealine feed and corn meal, the corn meal produced 5 per cent. more growth than did the cerealine feed. Corn meal constituted but 62 per cent. of the dry matter of the ration; and, if 62 per cent. of dry matter of the ration in the form of corn meal produced a gain of 5 per cent., 100 per cent. of corn meal — *e. g.*, its full effect — would show an 8 per cent. gain.

4. We think we are justified in saying that corn meal is from 5 to possibly 10 per cent. more valuable than cerealine feed for use in connection with skim-milk for growing pigs.

5. Cerealine feed might prove equal to corn meal as a feed for milch cows, as digestion experiments with sheep have shown it to contain as much digestible matter as corn meal. It is very probable that pigs are not able to digest the hulls of the corn as well as other animals.

6. Because of the important part played by the individuality of the animal, we are frank to confess that a larger number of pigs would be desirable in conducting experiments of this kind. We feel confident, however, that these experiments give a fairly accurate representation of the comparative values of the several feed stuffs.

Experiment I. — *Corn Meal v. Hominy Meal.*

Nov. 23, 1896, to March 1, 1897 (98 Days). — Eight grade Chester White pigs, all of the same litter, were purchased in October. They were first fed skim-milk alone, and finally divided into two lots, and corn or hominy meal added to the skim-milk diet. Pigs Nos. I. and II. were together in one pen, and so were pigs Nos. VII. and VIII.; the others were in separate pens. Pig IV. was taken sick during the experiment, and his record is not considered. Each pig was allowed from 7 to 10 quarts of skim-milk daily, and from 3 to 6 ounces of grain for each quart of milk, the quantity depending on the appetite and stage of growth of the animals. As the pigs advanced in age and growth, the quantity of grain was increased, thus furnishing an increased food supply and an increasing amount of carbohydrates.

TOTAL FEEDS CONSUMED.

Corn Meal Lot.

Number of Pig.	Skim-milk Consumed.			Grain Consumed.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).
Pig No. V.,	884.00	1,927.12	183.08	255.44	223.25
Pig No. VI.,	883.00	1,924.94	182.87	255.44	223.25
Pigs Nos. VII. and VIII.,	1,766.00	3,849.88	365.74	510.88	446.50
Totals,	3,533.00	7,701.94	731.69	1,021.76	893.00
Averages,	883.25	1,925.49	182.92	255.44	223.25

Hominy Meal Lot.

Number of Pig.	Skim-milk Consumed.			Grain Consumed.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Hominy Meal (Pounds).	Dry Matter (Pounds).
Pigs Nos. I. and II.,	1,768.00	3,854.24	366.15	255.06	470.23
Pig No. III.,	883.00	1,924.94	182.87	255.44	235.46
Totals,	2,651.00	5,779.18	549.02	765.56	705.69
Averages,	883.67	1,926.39	183.01	255.19	235.23

The above tables show that each lot of pigs consumed identical amounts of skim-milk, and very nearly equal amounts of grain. The hominy meal lot ate about 12 pounds more of dry grain per pig, than did the corn meal lot.

TOTAL GAIN IN LIVE WEIGHT.

Corn Meal Lot.

NUMBER OF PIG.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. V.,	54.50	184.25	129.75	1.32
Pig No. VI.,	58.25	167.00	130.25	1.33
Pigs Nos. VII. and VIII.,	109.25	188.50 185.25	243.00	2.48
Totals,	222.00	725.00	503.00	5.13
Averages,	55.50	181.25	125.75	1.28

Hominy Meal Lot.

NUMBER OF PIG.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pigs Nos. I. and II.,	115.50	387.25	271.75	2.77
Pig No. III.,	57.75	196.00	138.25	1.41
Totals,	173.25	583.25	410.00	4.18
Averages,	57.75	194.42	136.66	1.39

One notes a very slight difference in favor of the hominy fed lot, this being caused perhaps by the slightly increased amount of actual dry matter found in the hominy meal.

By referring to the table, it will be noticed that each pig received 223.25 pounds of perfectly dry corn meal and 235.23 pounds of perfectly dry hominy meal.

Total Gain in Dressed Weight.

Corn Meal Lot.

Number of Pig.	Dressed Weight at End of Experiment (Pounds).	Computed Dressed Weight at Beginning of Experiment (Pounds).	Total Gain in Dressed Weight (Pounds).	Loss in Weight in Dressing (Pounds).
Pig No. V.,	150.50	44.52	105.98	18.31
Pig No. VI.,	154.25	47.67	106.58	18.17
Pigs Nos. VII. and VIII.,	287.25	89.09	198.16	18.45
Totals,	592.00	181.28	410.72	54.83
Averages,	148.00	45.32	102.68	18.28

Hominy Meal Lot.

Pigs Nos. I. and II.,	306.00	91.25	214.75	20.89
Pig No. III.,	152.00	44.79	107.21	22.45
Totals,	458.00	136.04	321.96	43.34
Averages,	152.66	45.35	107.32	21.67

Dry Matter required to produce One Pound of Live and Dressed Weight.

Corn Meal Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. V.,	3.13	3.84
Pig No. VI.,	3.12	3.81
Pigs Nos. VII. and VIII.,	3.34	4.09
Averages,	3.20	3.91

Hominy Meal Lot.

Pigs Nos. I. and II.,	3.08	3.89
Pig No. III.,	3.03	3.90
Averages,	3.06	3.89

The very slight difference between the gains in the two lots is within the limit of error.

Experiment II. — Corn Meal v. Cerealine Feed.

April 12 to July 26, 1897 (106 Days). — The six pigs used in this experiment were grade Chester Whites, about five weeks old when purchased, March 2. They were brought into separate pens April 1, and the experiment began April 12. Each pig was fed 6 to 9 quarts of skim-milk daily, together with 3 ounces of grain for each quart of milk. The amount of grain was gradually increased as the animal demanded it, until some 4 pounds daily were fed. The milk never exceeded 9 quarts per day.

At the beginning of the experiment the animals were receiving 1 part protein to 3 parts carbohydrates. The ration was gradually widened, until towards the close of the experiment the nutritive ratio was as 1 to 7. The corn meal heated during the latter part of the experiment, and became somewhat musty.

TOTAL FEEDS CONSUMED.

Corn Meal Lot.

Number of Pig.	Skim-milk Consumed.			Grain Consumed.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).
Pig No. I.,	738.00	1,608.84	152.84	243.63	204.98
Pig No. II.,	738.00	1,608.84	152.84	243.63	204.98
Pig No. III.,	738.00	1,608.84	152.84	243.63	204.98
Totals,	2,214.00	4,826.52	458.52	730.89	614.94
Averages,	738.00	1,608.84	152.84	243.63	204.98

Cerealine Feed Lot.

Number of Pig.	Skim-milk Consumed.			Grain Consumed.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Cerealine Feed (Pounds).	Dry Matter (Pounds).
Pig No. IV.,	738.00	1,608.84	152.84	243.63	214.39
Pig No. V.,	738.00	1,608.84	152.84	243.63	214.39
Pig No. VI.,	738.00	1,608.84	152.84	243.63	214.39
Totals,	2,214.00	4,826.52	458.52	730.89	643.17
Averages,	738.00	1,608.84	152.84	243.63	214.39

Some 10 pounds more dry cerealine feed were consumed per pig than corn meal during the experiment, due to the dryer condition of the cerealine feed when fed.

Total Gain in Live Weight.

Corn Meal Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. I.,	51.25	188.00	136.74	1.29
Pig No. II.,	48.50	184.00	135.50	1.28
Pig No. III.,	43.25	184.25	141.00	1.33
Totals,	143.00	556.25	413.25	3.90
Averages,	47.67	185.42	137.75	1.30

Cerealine Feed Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. IV.,	44.00	175.50	131.50	1.24
Pig No. V.,	41.00	170.50	129.50	1.22
Pig No. VI.,	49.25	186.00	136.75	1.29
Totals,	134.25	532.00	397.75	3.75
Averages,	44.75	177.33	132.58	1.25

A slight gain in favor of the corn meal lot is noted.

Dry Matter required to produce One Pound of Live and Dressed Weight.

Corn Meal Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. I.,	2.62	3.28
Pig No. II.,	2.64	3.30
Pig No. III.,	2.54	3.17
Averages,	2.60	3.25

Cerealine Feed Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. IV.,	2.79	3.49
Pig No. V.,	2.84	3.54
Pig No. VI.,	2.69	3.37
Averages,	2.77	3.46

The above figures show a slight difference in favor of the corn meal, rather less dry matter in corn meal being required to make a pound of growth than in cerealine feed.

Experiment III. — Corn Meal v. Cerealine Feed.

Oct. 25 to Jan. 10, 1898 (78 Days). — The six pigs employed in this experiment were a cross between the Poland-China and the Chester White. They were received early in September, when five weeks old, and allowed the run of a large pen out of doors until October 20, when they were placed in separate pens in the feeding barn, and divided as equally as possible into two lots. They were in a very vigorous condition. In this experiment the cerealine feed heated towards the close of the experiment. It was shovelled over and dried at once when this condition was observed, and the experiment continued. The pigs ate it with seeming relish at all times.

TOTAL FEEDS CONSUMED.

Corn Meal Lot.

Number of Pig.	Skim-milk Consumed.			Grain Consumed.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).
Pig No. IV., ...	468.00	1,020.24	96.92	226.50	197.06
Pig No. V., ...	468.00	1,020.24	96.92	226.50	197.06
Pig No. VI., ...	468.00	1,020.24	96.92	226.50	197.06
Totals, ...	1,404.00	3,060.72	290.76	679.50	591.18
Averages, . . .	468.00	1,020.24	96.92	226.50	197.06

Cerealine Feed Lot.

Number of Pig.	Skim-milk Consumed.			Grain Consumed.	
	Quarts.	Pounds.	Dry Matter (Pounds).	Cerealine Feed (Pounds).	Dry Matter (Pounds).
Pig No. I., . . .	468.00	1,020.24	96.92	226.50	201.59
Pig No. II., . . .	468.00	1,020.24	96.92	222.50	198.03
Pig No. III., . . .	468.00	1,020.24	96.92	226.50	201.59
Averages, . . .	468.00	1,020.24	96.92	225.20	200.40

The amount of feed consumed by the two lots is practically identical.

Total Gain in Live Weight.

Corn Meal Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. IV.,	68.50	172.50	104.00	1.33
Pig No. V.,	67.75	172.00	104.25	1.34
Pig No. VI.,	66.75	173.00	106.25	1.36
Totals,	203.00	517.50	314.50	4.03
Averages,	67.67	172.50	104.83	1.34

Cerealine Feed Lot.

Number of Pig.	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).
Pig No. I.,	73.75	169.00	95.25	1.22
Pig No. II.,	57.25	150.00	92.75	1.19
Pig No. III.,	68.75	174.00	105.25	1.35
Totals,	199.75	593.00	293.25	3.76
Averages,	66.58	164.33	97.75	1.25

Each pig in the corn meal lot shows an average gain of 7 pounds over the cerealine feed pigs. This might partly be accounted for by reason of the poor condition of the cerealine feed, already mentioned.

Dry Matter required to produce One Pound Live and Dressed Weight.

Corn Meal Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. IV.,	2.83	3.53
Pig No. V.,	2.82	3.52
Pig No. VI.,	2.77	3.42
Averages,	2.81	3.49

Cerealine Feed Lot.

Number of Pig.	Live Weight (Pounds).	Dressed Weight (Pounds).
Pig No. I.,	3.13	3.91
Pig No. II.,	3.18	3.98
Pig No. III.,	2.84	3.55
Averages,	3.05	3.81

The dry matter required to produce a pound of gain confirms the results given in the tables under gain in live weight, and shows that in this experiment a pound of live weight was produced by ¼ of a pound less of absolutely dry corn meal than of dry cerealine feed. The conclusions from these three experiments have already been given on page 108.

Composition of Feeds (used in Three Feeding Experiments).

Separate Ingredients of Feeds.	Average Skim-milk, All Experiments (per Cent.).	Experiment I.		Experiment II.			Experiment III.	
		Corn Meal (per Cent.).	Hominy Meal (per Cent.).	Corn Meal, I. (per Cent.).	Corn Meal, II. (per Cent.).	Cerealine Feed (per Cent.).	Corn Meal (per Cent.).	Cerealine Feed (per Cent.).
Water,	90.50	12.63	7.82	20.00	14.00	12.00	13.00	11.00
Protein,	–	8.78	10.59	8.86	9.03	9.55	9.64	10.96
Fat,	–	4.08	8.50	2.18	2.15	6.60	3.59	6.30
Extract matter,	–	71.73	65.46	65.80	71.68	65.23	70.80	64.55
Fibre,	–	1.42	4.11	1.82	1.81	4.40	1.70	4.36
Ash,	–	1.36	3.52	1.34	1.33	2.22	1.27	2.83
Totals,	–	100.00	100.00	100.00	100.00	100.00	100.00	100.00

C. The Cost of Pork Production.

In a section of our State the cream from the milk produced upon the farm is sold to the creamery, and the skim-milk is either fed to pigs or calves. A large number of experiments have been made at this station with growing pigs. The pigs averaged from 37 pounds in weight at the beginning of the experiments to 183 pounds when slaughtered. The daily rations have been essentially as follows: —

I. From 5 to 7 quarts of milk per day; and, beginning with 3 ounces of corn meal to each quart of milk, the grain has been gradually increased to satisfy the appetite of the animal.

II. About the same quantity of milk, and, instead of the corn meal, other carbohydrate foods, such as ground rye, wheat, hominy meal, cerealine feed and oat feed, to satisfy appetites.

III. About the same quantity of milk, together with 3 to 6 ounces of corn meal to each quart of milk, and a mixture of one-third wheat bran, one-third gluten meal and one-third corn meal, to satisfy appetites.

More exact statements of rations will be found farther on. We rarely had more than from 5 to 7 quarts of milk daily for each pig. The animals did well with this amount of milk; if they did not secure this quantity, their growth was noticeably slower.

Explanation of Tables.

As a result of these various experiments, we have endeavored to ascertain: —

1. The price that skim-milk has returned per quart.
2. The cost of feed required to produce *a pound* of *live* or *dressed weight*, taking the various grains at a reasonable range of market prices, and allowing either $\frac{1}{4}$ or $\frac{1}{2}$ cent per quart for the milk.

In tables I., II. and III. will be found the results where milk and corn meal have been fed.

Tables IV., V. and VI. will show the results where milk and other starchy (carbohydrate) feeds have been substituted for the corn meal, such as hominy or cerealine feeds, rye and wheat meals ("grain").

Tables VII., VIII. and IX. show the results where milk and corn meal were fed, and, in addition, wheat bran, gluten meal, etc. ("other grains").

Tables X. and XI. show the average of all the preceding, being the results with 140 pigs, weighing 37 pounds at the beginning, and 183 pounds at the close of the experiments.

TABLE I. — *Milk and Corn Meal.*

FEEDS CONSUMED, ETC.	Quarts.	Pounds.
Total milk consumed by 21 pigs,	16,421	35,797.78
Total corn meal consumed by 21 pigs,	-	5,531.10
Live weight, actually gained,	-	3,012.25
Dressed weight, calculated,	-	2,409.80

TABLE II. — *Price obtained for Skim-milk.*

PRICE RETURNED FOR SKIM-MILK.	WITH CORN MEAL AT $15 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AT $17.50 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AT $20 PER TON, AND DRESSED PORK AT —		
	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).
Per quart (cents), .	.48	.63	.77	.44	.58	.73	.39	.54	.69
Per 100 pounds (cents),	22.02	28.90	35.37	20.19	26.61	33.48	17.89	24.77	31.19

TABLE III. — *Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With corn meal at $15 per ton, and milk at ¼ cent per quart,	2.74	3.44
With corn meal at $15 per ton, and milk at ½ cent per quart,	4.11	5.13
With corn meal at $17.50 per ton, and milk at ¼ cent per quart,	2.98	3.72
With corn meal at $17.50 per ton, and milk at ½ cent per quart,	4.33	5.41
With corn meal at $20 per ton, and milk at ¼ cent per quart,	3.21	4.02
With corn meal at $20 per ton, and milk at ½ cent per quart,	4.59	5.71

TABLE IV. — *Milk and Different Starchy Feeds.*

FEEDS CONSUMED, ETC.	Quarts.	Pounds.
Total milk consumed by 22 pigs, ...	13,153	28,630
Total " grain " consumed by 22 pigs, ...	-	5,135
Live weight, actually gained, ...	-	2,597
Dressed weight, calculated, ...	-	2,078

TABLE V. — *Price obtained for Skim-milk.*

PRICE RETURNED FOR SKIM-MILK.	WITH "GRAIN" AT $15 PER TON, AND DRESSED PORK AT —			WITH "GRAIN" AT $17.50 PER TON, AND DRESSED PORK AT —			WITH "GRAIN" AT $20 PER TON, AND DRESSED PORK AT —		
	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).
Per quart (cents),	.50	.65	.81	.45	.60	.76	.40	.56	.87
Per 100 pounds (cents),	22.90	30.10	37.10	20.60	27.80	35.10	18.35	25.69	39.91

TABLE VI. — *Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With "grain" at $15 per ton, and skim-milk at ¼ cent per quart,	2.75	3.43
With "grain" at $15 per ton, and skim-milk at ½ cent per quart,	4.01	5.01
With "grain" at $17.50 per ton, and skim-milk at ¼ cent per quart,	3.00	3.75
With "grain" at $17.50 per ton, and skim-milk at ½ cent per quart,	4.26	5.32
With "grain" at $20 per ton, and skim-milk at ¼ cent per quart,	3.24	4.05
With "grain" at $20 per ton, and skim-milk at ½ cent per quart,	4.51	5.63

TABLE VII. — *Milk, Corn Meal, Bran, Gluten Meal, etc.*

FEEDS CONSUMED, ETC.	Quarts.	Pounds.
Total milk consumed by 97 pigs,	62,319	135,855
Total corn meal consumed by 97 pigs,	-	21,602
Total "other grains" consumed by 97 pigs,	-	12,663
Live weight actually gained,	-	15,080
Dressed weight calculated,	-	12,064

TABLE VIII. — *Price obtained for Skim-milk.*

PRICE OBTAINED FOR SKIM-MILK.	WITH CORN MEAL AT $15 PER TON, "OTHER GRAINS" AT $17.50 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AT $17.50 PER TON, "OTHER GRAINS" AT $20 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AT $20 PER TON, "OTHER GRAINS" AT $22.50 PER TON, AND DRESSED PORK AT —		
	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).
Per quart (cents), .	.53	.72	.92	.45	.65	.85	.39	.59	.78
Per 100 pounds (cents),	24.30	33.20	42.10	21.20	30.00	39.00	18.00	27.00	36.00

TABLE IX. — *Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With corn meal at $15 " other grains" at $17.50 and milk at ¼ cent per quart, ...	2.84	3.55
With corn meal at $15 " other grains" at $17.50 and milk at ½ cent per quart, ...	3.87	4.84
With corn meal at $17.50 " other grains" at $20 and milk at ¼ cent per quart, ...	3.13	3.90
With corn meal at $17.50 " other grains" at $20 and milk at ½ cent per quart, ...	4.16	5.20
With corn meal at $20 " other grains" at $22.50 and milk at ¼ cent per quart, ...	3.41	4.26
With corn meal at $20 " other grains" at $22.50 and milk at ½ cent per quart, ...	4.44	5.55

TABLE X. — *Price obtained for Skim-milk (All Experiments).*

AVERAGE PRICE OBTAINED FOR SKIM-MILK.	WITH CORN MEAL AND OTHER STARCHY FOODS AT $15 PER TON, "OTHER GRAINS" AT $17.50 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AND OTHER STARCHY FOODS AT $17.50 PER TON, "OTHER GRAINS" AT $20 PER TON, AND DRESSED PORK AT —			WITH CORN MEAL AND OTHER STARCHY FOODS AT $20 PER TON, "OTHER GRAINS" AT $22.50 PER TON, AND DRESSED PORK AT —		
	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).	Five Cents (per Pound).	Six Cents (per Pound).	Seven Cents (per Pound).
Per quart (cents), .	.50	.67	.83	.45	.61	.78	.39	.56	.78
Per 100 pounds (cents),	23.07	30.73	38.19	20.66	28.14	35.86	18.08	25.82	35.70

TABLE XI. — *Average Cost of Feed per Pound of Growth produced.*

	Live Weight (Cents).	Dressed Weight (Cents).
With corn meal at $15 "other grains" at $17.50, milk at ¼ cent per quart,	2.78	3.47
With corn meal at $15 "other grains" at $17.50, milk at ½ cent per quart,	4.00	4.99
With corn meal at $17 50 "other grains" at $20, milk at ¼ cent per quart,	3.04	3.79
With corn meal at $17.50 "other grains" at $20, milk at ½ cent per quart,	4.25	5.31
With corn meal at $20 "other grains" at $22 50, milk at ¼ cent per quart,	3.63	4.53
With corn meal at $20 "other grains" at $22.50, milk at ½ cent per quart,	4.51	5.63

D. RATIONS FOR GROWING PIGS.

RATION NO. I. — *With Unlimited Supply of Milk.*

WEIGHT OF PIGS.	RATIONS.
20 to 60 pounds,	3 ounces of corn meal * to each quart of milk.
60 to 100 pounds,	6 ounces of corn meal to each quart of milk.
100 to 180 pounds,	8 ounces of corn meal to each quart of milk.

RATION NO. II. — *With Limited Supply of Milk (5 to 6 quarts per Pig daily).*

WEIGHT OF PIGS.	RATIONS.
20 to 60 pounds,	3 ounces of corn meal * to each quart of milk, and then gradually increase corn meal to satisfy appetites.
60 to 100 pounds,	
100 to 180 pounds,	

* Wheat, rye or hominy meals can be substituted for corn meal.

RATION NO. III.

WEIGHT OF PIGS.	RATIONS.
20 to 60 pounds,	Milk at disposal, plus mixture of one-third corn meal, one-third wheat bran and one-third gluten meal, to satisfy appetites.
60 to 100 pounds,	Milk at disposal, plus mixture of one-half corn meal, one-quarter wheat bran and one-quarter gluten meal, to satisfy appetites.
100 to 180 pounds,	Milk at disposal, plus mixture of two-thirds corn meal, one-sixth wheat bran and one-sixth gluten meal, to satisfy appetites.

Ration No. IV.*

Weight of Pigs.	Rations.
20 to 60 pounds, .	3 ounces of corn meal to each quart of milk, and 4 ounces of gluten feed as a substitute for quart of milk.
60 to 100 pounds, .	Milk at disposal, and mixture of one-half corn meal and one-half gluten feed, to satisfy appetites.
100 to 180 pounds, .	Milk at disposal, and mixture of two-thirds corn meal and one-third gluten feed, to satisfy appetites.

* This ration is preferable to Ration No. II.

E. Experiments with Salt Hay.

The extensive series of experiments carried on to ascertain the nutritive value of different kinds of salt hay were completed and the experiments and results published in Bulletin No. 50, in January, 1898, to which the reader is referred for all details.

F. Experiments to ascertain the Effect of Different Amounts of Protein upon the Cost and Quality of Milk.

During the winter of 1897–98 two experiments, with twelve cows, were carried out, to investigate the effect of 1.50, 2 and 2.50 pounds of protein upon the cost and quality of milk. The total amount of digestible nutrients fed daily was the same in each case. Experiment I. extended over nine weeks and Experiment II. over four weeks. This work has not been published. About 5 per cent. more milk was produced on 2 pounds, and 10 per cent. more on $2\frac{1}{2}$ pounds, of protein daily, than when the animals received 1^{1} pounds each. The quality of the milk was scarcely changed. The cost of the different rations will depend upon the cost of the several concentrated feeds. As the market has been for the past two years, milk produced by aid of the rations containing $2\frac{1}{2}$ pounds of protein daily would cost rather less than that produced by $1\frac{1}{2}$ or 2 pounds. The manure derived from the highest protein ration would be 10 per cent. more valuable, and the animals generally have a better appearance than when receiving but $1\frac{1}{2}$ pounds per day. It is believed that a continuous feeding of 2 or $2\frac{1}{2}$ pounds of protein daily tends, to some extent, to develop the milk-producing capacity of the cow. Animals that will not stand a reasonably generous feeding had better be consigned to the butcher. The writer is of the opinion that animals weighing from 800 to 1,000 pounds, producing from 10 to 15 quarts of milk per day, should receive about 2.5 pounds of digestible protein and 15 to 16 pounds of total nutrients daily. This is in accordance with Wolff's rations. When protein is costly, it might be advisable to reduce the amount to 2 pounds daily. The detailed records of these and other experiments along this line will be published later.

G. Digestion Experiments.

During the past three years there have been made about forty successful digestion experiments, mostly with the various concentrated feeds, to ascertain their value for feeding purposes. The details of the experiments have not been published. Some of the results (digestion coefficients) have been published in Bulletin No. 50, and in the annual reports for 1896 (page 135) and 1897 (page 84); others follow below. The results have been utilized in showing the nutritive value of a number of coarse fodders, and in preparing a key to the comparative values of concentrated feeds, as given in Bulletin No. 56 (page 23). It is hoped to publish the details of the experiments before long.

Digestion Coefficients resulting from Digestion Experiments.

Kind of Feed Stuff.	Number of Different Samples.	Number of Single Trials.	Dry Matter (per Cent.).	Protein (per Cent.).	Fat (per Cent.).	Extract (per Cent.).	Fibre (per Cent.).	Ash (per Cent.).
Hay (largely *Poa pratensis*), . .	1	6	62	61	50	63	65	46
Hay (largely *Poa pratensis*), . .	1	4	60	58	53	61	60	50
Average, both samples, . . .	2	10	61	60	51	62	63	48
Hay of mixed grasses (late cut), .	1	2	53	54	39	54	56	26
Hay of mixed grasses (late cut), .	1	2	57	55	44	57	59	42
Barn-yard millet hay (late blossom),	1	3	57	64	46	52	62	63
Barn-yard millet (green, blossom), .	1	2	74	68	64	76	74	66
Barn-yard millet (green, week later than above), ...	1	1	67	72	61	65	71	61
Peas and oats (green, in blossom), .	1	3	70	70	57	76	68	49
Vetch and oats (green, in blossom), .	1	3	67	75	47	68	68	53
Corn ensilage (Pride of the North), .	1	2	74	45	77	82	80	26
Hominy meal, ...	1	1	89	53	94	94	-	-
Cerealine feed, ...	1	3	90	80	81	95	82	-
Peoria gluten feed, ...	1	3	91	85	88	95	-	-
Quaker oat feed, ...	1	3	62	81	89	67	43	-
Victor corn and oat feed, . . .	1	3	75	71	87	83	48	-
H. O. dairy feed, ...	1	2	65	78	85	70	41	-
H. O. horse feed, ...	1	1	70	74	84	79	35	-

REPORT OF THE AGRICULTURIST.

WM. P. BROOKS; ASSISTANT, H. M. THOMSON.

Soil Tests.

During the past season four soil tests upon the co-operative plan agreed upon in Washington in 1889 have been carried out. Two of these were upon our own grounds, — one with corn and the other with onions as the crop; one in Norwell, Plymouth County, with oats; and one in Montague, Franklin County, also with oats.

1. Soil Test with Corn. Amherst.

The past is the tenth season that the experiment on this field has been in progress. The crops in order of rotation have been corn, corn, oats, grass and clover, grass and clover, corn followed by mustard as a catch crop, rye, soy beans, white mustard, and this year corn once more. During all this time four of the fourteen plots into which the field is divided have received neither manure nor fertilizer; three have received but a single important manurial element, — every year the same; three have received each year two important elements; one has received all three yearly; and one each has received yearly lime, plaster and farm-yard manure. It will be seen that the greater part of the field has remained either entirely unmanured or has had but a partial manuring, and it will be readily understood that the degree of exhaustion of most of the plots is considerable. The nothing plots produce this year an average of about twelve bushels of shelled corn per acre; and even this figure is somewhat too high, owing to the fact that after this long period one of the nothing plots which adjoins the plot which has been yearly manured at the rate of five cords per acre begins to feel the effect of the high fertility of its neighbor, although separated from it by a strip three and one-half feet wide.

The single-element plots, one receiving nitrate of soda only yearly, another phosphoric acid and the third potash, give this year practically equal crops of grain, respectively at the rate of 20.6, 18.5 and 19.8 bushels per acre. The nitrate of soda and dissolved bone-black give a crop at the rate of 32 bushels per acre, while nitrate of soda and potash give at the rate of but 10.9 bushels. The dissolved bone-black and muriate of potash do much better, yielding at the rate of 41.2 bushels. The fertilizer supplying nitrogen, phosphoric acid and potash gives a crop of 55.9 bushels, while manure gives 67.7 bushels.

It may be remembered that in each of the three previous years in which this field has produced corn the muriate of potash has, whether singly or in any combination, proved much more useful than either of the other fertilizers used. There is much evidence in the behavior of the crops this year, during the growing season and in the results, that this salt is proving injurious in its chemical effect upon the soil. I believe this effect to be a loss of lime in the form of chloride by leaching, but cannot regard this as yet proven. I will present the facts apparently bearing upon the case, and leave full discussion to a later report.

1. During the early part of the growing season the corn upon all the plots which had received muriate of potash was distinctly behind that upon other plots.

2. As the season advanced, the corn upon these plots gradually lost its sickly appearance, gained upon that in the other plots, eventually excelling, in the case of the plot receiving nitrogen, phosphoric acid and potash, that in all other plots except the manure plot.

3. This unhealthy appearance of the corn early in the season, followed by great improvement later, is analogous to effects noticed in other experiments,* where chlorides have been used, and where liming the land has remedied the faulty condition.

* For example, Plot 6, Field A. See report State Experiment Station for 1896.

4. On that plot receiving dissolved bone-black as well as muriate of potash, the crop was in the end a good one. As is well known, the dissolved bone-black contains a large amount of sulphate of lime. It is believed that this may take the place of the lime leached from the soil as a consequence of the use of the muriate of potash, or at least that it corrects in some way the faulty condition consequent upon the use of this salt. It may here be pointed out that a similar corrective influence is evident in the results obtained both in 1897 and 1898 upon our other home-test acre, which will immediately be discussed.

It is of interest, further, to point out that the crop this year upon the lime plot was not quite equal to the average of the nothing plots, while that of the plaster plot (sulphate of lime) was about double that of the lime plot. In the earlier years of this soil test the yield of neither the lime nor the plaster plot ever exceeded that of the nothings, but for the past three years the plaster plot has been relatively gaining. The explanation of this difference between the effect of plaster and lime is not apparent. It will be made the subject of future study.

Conclusions.

1. The yield of the plot which for ten years has received only phosphoric acid and potash (41.2 bushels per acre) illustrates in a striking way the comparative independence of the corn crop of supplied nitrogen upon this soil.

2. The crop raised where nitrogen, phosphoric acid and potash have been yearly applied (nitrate of soda, dissolved bone-black and muriate of potash) for ten years shows that profitable results may be obtained by the use of fertilizers alone. The yearly cost of the application to this plot has been from $10 to $12. The crops have not been much inferior to those on the plot to which manure at the rate of 5 cords per acre has been yearly applied. The two crops this year are, respectively: for the fertilizer, 55.9 bushels; for the manure, 67.7 bushels. The extra 11 bushels of corn will not cover the added cost of the manure, as compared with the fertilizer; and in earlier years the differences in yield have been relatively much smaller than this year.

3. The problems suggested by the results of the year must be regarded as the most valuable product of this experiment. These problems are not solved. Their solution will throw important light upon methods to be employed in compounding and selecting fertilizers.

2. Soil Test with Onions. Amherst.

This experiment occupied a field which has been employed in work of this kind for nine years, the several plots having been every year manured alike, as described under the "Soil test with corn." The crops in the order of rotation have been: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and rutabaga turnips, and potatoes. The land was ploughed in the fall of 1897, and sown with winter rye as a cover crop. The rye was turned in before it had made much of a spring growth, April 21. Fertilizers were employed this year in double the usual quantities; viz., nitrate of soda at the rate of 320 pounds; dissolved bone-black, 640 pounds; and muriate of potash, 320 pounds, per acre. These fertilizers are each used upon one plot singly, in pairs, and upon one plot all three together.

The seed was sown in the customary manner, but more thickly, on May 9. Germination was prompt and perfect. The development of the crop throughout the season was most suggestive in problems for future solution. At the start plants upon the four plots, potash alone, potash and bone-black, potash and nitrate, and potash with both bone-black and nitrate, were much ahead of those on the plots not manured with potash. There was every indication that this element would almost entirely control the crop, for there was good growth wherever potash was applied, and but feeble growth elsewhere. The potash plots, however, after about four weeks, began to lose their superiority; and it was not long ere many of the plants upon these plots became manifestly very unthrifty, and before the end of the season many of them had died. Meanwhile, the phosphoric acid plots began to gain; and the results show that this, more than either the nitrogen or the potash supply, controlled the product. The crop was very light, however, even upon the best plot, which was at the rate of 116.9 bushels per acre, upon the plot receiving nitrate of soda and dissolved bone-black. Upon the plots receiving these two fertilizers and muriate of potash the crop amounted to only 16.3 bushels per acre. Here is strong evidence that the muriate of potash has produced in the soil of this field conditions absolutely prejudicial to the growth of the onion.

Last year this field was in potatoes under the same system of manuring, but with half the quantities employed this year. The crop of potatoes on the nitrate and bone-black was much heavier than on these two and potash, and in commenting upon this fact in my annual report I wrote: "The apparent superiority of the phosphoric acid and nitrogen is chiefly due to the fact that the plot to which these two elements alone were applied was for some reason (not believed to be the effect of the fertilizer alone) nearly twice as great as that upon any other plot. Had the crop where the potash was added to the nitrogen and phosphoric acid been better or even as good as that where the phosphoric acid and nitrogen alone were used, we should be justified in the conclusion that nitrogen and phosphoric acid are the elements chiefly required. The crop where all three elements were combined was, however, much inferior to that where the nitrogen and phosphoric acid were used without potash. We must, therefore, conclude that some disturbing factor, at present unknown, influenced the results."

In view of the similar relative results upon the two plots under discussion this year, I am now forced to conclude that I was mistaken last year in supposing that the superiority of the plot receiving nitrogen and phosphoric acid only was not "the effect of the fertilizer alone."

I now believe that the muriate of potash has proved actually injurious to the last two crops, and that the explanation (the loss of lime which it causes) already suggested accounts for this effect.

The Proper Course as regards Potash Supply.

What, then, in view of such results, are we to recommend? Clearly not to cease using potash, — we have been unable to raise good crops without it. It is believed the remedy will be found in one of three directions; viz., (1) the occasional liberal use of lime where muriate of potash is employed; (2) the use of other potash salts, such as carbonate or sulphate; or (3) the employment of wood ashes as a source of potash. Should potash be supplied in the form of either carbonate or sulphate, lime leaches from the soil much less rapidly; the same is true of ashes, and these, moreover, supply much lime. This entire question, however, demands further experimental study, and I am not at present prepared to give definite advice upon this point.

Again, in conclusion it may be said the most profitable results of the year's work are the suggestions for future lines of work, which, being completed, must throw much needed light upon the problems connected with the use of fertilizers.

3. Soil Test with Oats. Norwell.

The past was the third season of soil test work upon this acre, the two preceding crops having both been corn. The results with both of the tests with corn have indicated a strong demand for potash by corn on this soil. These results were thus in entire agreement with those obtained in almost all of the large number of soil tests with this crop that during the past ten years have been carried out under my direction in all the counties of the State.

The results the past season with oats seem also to be in general accord with results previously obtained in other sections with this crop. This is not shown clearly by the figures giving the yields, for the reason that excessive rains flooded parts of the field which is nearly flat soon after the seed was sown, rendering germination poor and uneven.

From examination during the growing season I feel certain that in this experiment it was the nitrate of soda which most largely benefited the crop. The crop on dissolved boneblack was at the rate of 9.7 bushels per acre; on dissolved bone-black and nitrate of soda it was 13 bushels. On muriate of potash the crop was 10 bushels; on the muriate and nitrate of soda it was 13.6 bushels. On the bone-black and muriate of potash the crop was at the rate of 9.8 bushels per acre; on these two fertilizers and nitrate of soda it was 17.8 bushels. The soil is clearly in need also of both phosphoric acid and potash for good crops, although the figures of this year afford no certain index to its condition, owing to the damage by water above mentioned.

4. Soil Test with Oats. Montague.

The present is also the third season of soil test work upon this soil, the preceding crops having been corn, which, owing to accidental conditions, did not give decisive results. The experiment of the past season is eminently satisfactory. The five nothing plots have given fairly even crops, varying from 18.8 to 24.4 bushels per acre of grain, averaging 21.5 bushels; while the straw yield has varied on these plots from 1,470 to 1,830 pounds, averaging 1,554 pounds, per acre. The crop on nitrate of soda alone was 30.3 bushels of grain and 2,210 pounds of straw; on dissolved bone-black, 24.4 bushels and 1,550 pounds; on muriate of potash, 21.3 bushels and 1,470 pounds. This marked increase on the nitrate of soda, as compared with the almost complete absence of effect of the other fertilizers used alone, is striking.

The dissolved bone-black and muriate of potash together gave 23.8 bushels of grain and 1,810 pounds of straw. Again we see practically no effect; but when we use nitrate of soda with these two fertilizers, we have a crop of 31.3 bushels of grain and 2,710 pounds of straw. Nitrate of soda with muriate of potash gives 30.3 bushels and 2,350 pounds, and with dissolved bone-black it gives 31.3 bushels and 2,330 pounds.

It will be seen, then, that in this experiment it was the nitrate of soda alone which proved effective. Alone and in all its combinations it gave a large increase in crop, and in all cases practically the same. The average increase apparently due to the use of this fertilizer amounted to 8 bushels of grain and 804 pounds of straw. The average increases apparently due to the use of dissolved bone-black were 2.1 bushels of grain and 193.4 pounds of straw; those apparently due to the muriate of potash were 1 bushel of grain and 175 pounds of straw.

Manure at the rate of 5 cords per acre gave about 806 pounds more straw, but only .7 bushels more grain than the complete fertilizer, costing some $13 per acre less; and the manure crop did not indeed surpass the crop on nitrate of soda alone in much greater degree. The latter application cost $3.20 per acre, while the manure can scarcely be estimated at less than $25.

This Montague experiment is one of the most perfectly satisfactory in a long series of such experiments; and it is a pleasure to see that its teaching as to the value of nitrate of soda for the oat crop is so entirely in agreement with that of other experiments with this crop.

For convenience is appended a statement giving the arrangement of plots and the system of manuring in nearly all our soil test work, which now extends over ten seasons: —

Plot 1, nothing.
Plot 2, nitrate of soda, 160 pounds per acre.
Plot 3, dissolved bone-black, 320 pounds per acre.
Plot 4, nothing.
Plot 5, muriate of potash, 160 pounds per acre.
Plot 6, { nitrate of soda, 160 pounds per acre. dissolved bone-black, 320 pounds per acre.
Plot 7, { nitrate of soda, 160 pounds per acre. muriate of potash, 160 pounds per acre.
Plot 8, nothing.
Plot 9, { dissolved bone-black, 320 pounds per acre. muriate of potash, 160 pounds per acre.
Plot 10, { nitrate of soda, 160 pounds per acre. dissolved bone-black, 320 pounds per acre. muriate of potash, 160 pounds per acre.
Plot 11, plaster, 160 pounds per acre.
Plot 12, nothing.
Plot 13, manure, 5 cords per acre.
Plot 14, lime, 160 pounds per acre.
Plot 15, nothing.

Manure Alone v. Manure and Potash.

An experiment in continued corn culture for the comparison of an average application of manure with a smaller application of manure used in connection with muriate of potash was begun in 1890. A full account will be found in the annual reports of 1890–95, and in the latter year a general summary of the results is given.

The land used in this experiment was seeded with a mixture of timothy, red-top and clover in the standing corn of 1896. A good stand of grass and clover was secured, although the latter was rather unevenly developed in different parts of the field, suggesting a possible lack of thoroughness in mixing the seeds.

No manure or potash was used in 1897. The field includes four plots, of one-fourth an acre each. The average results for 1897 are shown below: —

Plots 1 and 3 (manure alone, 6 cords per acre, 1890–96): hay, 1,403½ pounds; rowen, 784 pounds.

Plots 2 and 4 (manure, 3 cords per acre, 1890–92; 4 cords, 1893–96; and potash, 160 pounds per acre): hay, 961¼ pounds; rowen, 536½ pounds.

This field was continued in grass and clover during the present season, but manure and potash were applied as shown below: —

Plot 1, manure, 1 cord; weight, 5,087.5 pounds.

Plot 2, { manure, .5 cord; weight, 2,712.5 pounds.
muriate of potash; weight, 40 pounds.

Plot 3, manure, 1 cord; weight, 5,372.5 pounds.

Plot 4, { manure, .5 cord; weight, 2,855 pounds.
muriate of potash; weight, 40 pounds.

The manure applied to each plot was sampled and analyzed, and from the analyses the amounts of the three most essential elements of plant food applied per acre were calculated, with results shown below: —

Manurial Ingredients per Plot.

Plots.	Nitrogen (Pounds).	Phosphoric Acid (Pounds).	Potash (Pounds).
Plot 1, in manure,	20.9	14.2	25.9
Plot 2, in manure,	11.4	6.2	15.2 } 35.1
Plot 2, in muriate of potash,	-	-	19.9 } 35.1
Plot 3, in manure,	22.0	15.0	26.9
Plot 4, in manure,	15.1	9.7	18.0 } 37.9
Plot 4, in muriate of potash,	-	-	19.9 } 37.9

The manure was applied on April 1, the muriate of potash to plots 2 and 4 on April 9.

During the later growth of the mixed grasses and clovers upon these plots it was plainly evident that the clover was relatively more prominent upon plots 2 and 4. The first crop was cut on June 20; the second, on August 26, and both were secured in excellent condition.

Yield per Plot.

Plots.	Hay (Pounds).	Rowen (Pounds).
Plot 1,	1,395	840
Plot 2,	1,120	730
Plot 3,	1,460	810
Plot 4,	1,497	830

Average Yield per Acre.

Plots 1 and 3 (manure alone),	5,710	3,300
Plots 2 and 4 (manure and potash),	5,235	3,120

Combining the figures showing the yields in hay and rowen, we find that the average of plots 1 and 3 is at the rate of 9,010 pounds per acre; and of plots 2 and 4, 8,355 pounds. There is, then, a difference of 655 pounds only in total yields per acre, in favor of the large application of manure alone. This amount is quite insufficient to cover the larger cost of the acre application ($6.80 in the case of the manure alone). This field has now been broken up, and will next year be put once more into corn, when it is believed the beneficial effect of the large growth of clover upon plots 2 and 4 will become apparent.

"Special" Corn Fertilizer *v.* Fertilizer Richer in Potash.

This experiment was begun with a view to comparing the results obtained with a fertilizer proportioned like the average "*special*" *corn fertilizers* found upon the markets in 1891 with those obtained with a fertilizer richer in potash, but furnishing less nitrogen and phosphoric acid.

Corn was grown during each of the years from 1891 to 1896 inclusive. From 1891 to 1895 it was found that the fertilizer richer in potash gave the more profitable results. In 1896 there was no practical difference. It was decided during the season of 1896 that it might be possible to derive a greater benefit from the larger quantity of potash applied to two of the four plots if grass and clover should be grown in rotation with the corn. Accordingly the land was seeded with a mixture of timothy, red-top and clover in the standing corn in July, 1896. The field is divided into four plots of one-fourth of an acre each. The materials supplied to the several plots are shown in the following table: —

Fertilizers.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	20.0	18.0
Dried blood,	30.0	30.0
Dry ground fish,	30.0	20.0
Plain superphosphate,	226.0	120.0
Muriate of potash,	22.5	60.0
Cost of materials per plot,	$3 23	$3 10

In 1897 the average (both hay and rowen) produced by plots 1 and 3 was 873.5 pounds, or 3,494 pounds per acre; on plots 2 and 4, 860.5 pounds, or 3,442 pounds per acre. This difference is too small to be of practical significance. The rowen crop was heavier on plots 2 and 4 than on plots

1 and 3, showing an apparent influence of the greater amount of potash used on these plots in a larger proportion of clover.

For the present season the fertilizers were applied as last year, being evenly broadcasted on April 11. The first crop was cut June 21. It consisted largely of red-top, which was then not fully in bloom. The second crop was cut August 26. Both crops were well secured, and the yields are shown below: —

Yield of Hay and Rowen, 1898.

Plots.	Hay (Pounds).	Rowen (Pounds).
Plot 1 (lesser potash),	670	530
Plot 2 (richer in potash),	585	440
Plot 3 (lesser potash),	540	365
Plot 4 (richer in potash),	550	415

Average Rates per Acre.

Plots 1 and 3,	2,420	1,790
Plots 2 and 4,	2,270	1,710

We have then, as will be seen, an average product, from the application richer in nitrogen and phosphoric acid, at the rate of 150 pounds of hay and 80 pounds of rowen per acre more than from the application poorer in these elements and richer in potash. It is believed that the failure of plots 2 and 4 to show greatly superior development of clover is in part due to variations in physical characteristics of the soil of the different plots, leading to unfavorable moisture conditions, which prevented an even catch of clover on plots 2, 3 and 4, but did not injuriously affect Plot 1. Further, it should be pointed out that results which will be published later in this report in the case of clover experiments on a series of plots manured alternately with muriate of potash and with sulphate of potash indicate that the long-continued use of muriate of potash in liberal amounts without liming is unfavorable to the healthy development of clover. This field has now been broken up, and will be again put into corn next season.

Leguminous Crops (Clover, Pea and Bean or "Pod" Family) as Nitrogen Gatherers. (Field A.)

This experiment is a continuation of a series begun in 1889. The objects in view have been: —

1. To determine the extent to which plants of the clover family are capable of enriching the soil in nitrogen taken by them from the air through the agency of the nodular bacteria found upon their roots.

2. To compare nitrate of soda, sulphate of ammonia, dried blood and farm-yard manure as sources of nitrogen.*

The plots, eleven in number, are one-tenth acre each, and are numbered 0 to 10. Three plots (4, 7 and 9) have received no nitrogen-containing manure or fertilizers since 1884; one (0) has received farm-yard manure; two (1 and 2), nitrate of soda; three (5, 6, and 8), sulphate of ammonia; and two (3 and 10), dried blood every year since 1889. These materials have been used in amounts to furnish nitrogen at the rate of 45 pounds per acre each year.

All the plots have received yearly equal quantities of phosphoric acid and potash; viz., 80 pounds per acre of the former and 125 pounds of the latter from 1889 to 1894 and the past two seasons; but in 1894 and 1895, double these quantities. To some of the plots the potash is applied in the form of potash-magnesia sulphate; to others, in the form of muriate. The results with the former salt have been superior to those with the latter, as a rule, particularly when used in connection with sulphate of ammonia.

Up to this year we may briefly characterize the results, in so far as these have a bearing upon the two main questions proposed, as follows: —

1. The leguminous crops grown (soy beans in 1892, 1894 and 1896) have not appeared to enrich the soil in nitrogen, if we accept the results with the next following crop as affording a basis of judgment.

2. The different sources of nitrogen have ranked on the

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* Only such details are given here as are necessary to an understanding of the nature of the experiment. Full particulars will be found in our ninth and tenth annual reports.

average in the following order: nitrate of soda, farm-yard manure, dried blood and sulphate of ammonia.

After the oat crop of 1897 was harvested the land was ploughed, and late in July sown to Mammoth red clover. Germination was quick and good; but the young plants on all plots failed to flourish, and soon took on a most unhealthy appearance on all except the manure plot, and even on this their development was not what could be desired. In April of this year the plots were most carefully examined, and the clover ranked as follows: plot 0, good; 1, fair; 2, poorer than 1; 3, like 2; 4, mostly dead; 5, all dead; 6, all dead; 7, like 2; 8, best in field (limed in 1896); 9, like 2; 10, somewhat better than 2.*

The general average of condition was so poor that it was decided to plough the field, which was done on April 18. From previous observations upon this series of plots it was decided that liming was called for, and accordingly 200 pounds per plot of partially air-slaked lime was spread on and harrowed in on April 20. Eight hundred pounds of manure was applied to plot 0 on April 23, and on April 26 the fertilizers were applied.

The plots were all sown to Clydesdale oats on April 27, $8\frac{1}{2}$ pounds per plot. The analysis of the manure and a table showing fertilizer treatment and yields follow: —

Analysis of Manure Used.

	Per Cent.
Moisture,	72.53
Nitrogen,	.43
Phosphoric acid,	.16
Potash,	.26

* For manuring of these plots, see page 138.

Nitrogen Experiment.—Fertilizer Treatment and Yields of Oats, 1898.

Plots	Fertilizers.	Pounds.	Weight of Oats (Pounds).	Weight of Straw (Pounds).	Bushels Oats per Acre.	Weight of Straw per Acre (Pounds).
Plot 0,	Barn-yarn manure, Potash-magnesia sulphate, Dissolved bone-black,	800.0 32.0 18.0	83.0	125	25.90	1,250.0
Plot 1,	Nitrate of soda, Potash-magnesia sulphate, Dissolved bone-black,	29.0 48.5 50.0	103.0	150	32.20	1,500.0
Plot 2,	Nitrate of soda, Potash-magnesia sulphate, Dissolved bone-black,	29.0 48.5 50.0	115.0	175	35.90	1,750.0
Plot 3,	Dried blood, Muriate of potash, Dissolved bone-black,	43.0 25.0 50.0	96.0	155	30.00	1,550.0
Plot 4,	Muriate of potash, Dissolved bone-black,	25.0 50.0	56.0	80	17.50	800.0
Plot 5,	Ammonium sulphate, Potash-magnesia sulphate, Dissolved bone-black,	22.5 48.5 50.0	103.0	135	32.20	1,350.0
Plot 6,	Ammonium sulphate, Muriate of potash, Dissolved bone-black,	22.5 25.0 50.0	109.0	160	34.10	1,600.0
Plot 7,	Muriate of potash, Dissolved bone-black,	25.0 50.0	72.5	95	22.70	950.0
Plot 8,	Ammonium sulphate, Muriate of potash, Dissolved bone-black,	22.5 25.0 50.0	123.0	155	38.40	1,550.0
Plot 9,	Muriate of potash, Dissolved bone-black,	25.0 50.0	76.5	95	23.90	950.0
Plot10,	Dried blood, Potash-magnesia sulphate, Dissolved bone-black,	43.0 48.5 40.0	112.0	135	35.00	1,350.0
Average of no-nitrogen plots,					21.40	900.0
Average of muriate of potash plot (as far as comparable),					32.05	1,595.0
Average of sulphate plots (as far as comparable),					35.20	1,416.7

It is important to point out that the oats on the several plots ripened at different times. An effort was made to harvest the crop upon all at the same stage of maturity. With this end in view, plots 1, 2 and 5 were cut on July 29; plots 6, 8, 9 and 10, on July 30; and the balance on August 2. Meanwhile, there had occurred the phenomenally heavy rain and wind of July 30, P.M., and numerous other heavy showers; moreover, the weather continued persistently bad much of the time until the middle of August, and there was much loss through shelling of the grain. The straw, therefore, perhaps better than the grain, affords an index to the relative value of the several manurings. The rank of the different sources of nitrogen, taking straw production as the basis of estimation, is nitrate of soda, sulphate of ammonia, dried blood and farm-yard manure.

After the oats were harvested the land was ploughed, and without further manuring sown to Mammoth red clover, which at the time winter set in was in excellent condition.

The reader will naturally, perhaps, conclude that the better condition of the clover this year as compared with last is a consequence of the liming, and I am of opinion that this may be the case; but nevertheless I cannot regard this as certain, for the reason that upon Field B (reported upon below), where clover sown in the summer of 1897 failed, we have now an excellent stand of this crop obtained by sowing seed where it had failed this spring, without liming or reploughing.

Muriate *v.* Sulphate of Potash for Clover. (Field B.)

Field B is laid off in eleven equal plots, of two-fifteenths of an acre each. The manuring has been uniform since 1884. These plots are numbered from 11 to 21. *Every year each plot has received an application of ground bone at the rate of 600 pounds per acre. The odd-number plots have yearly received muriate of potash and the even-number plots the high-grade sulphate, in each case at the uniform rate of 400 pounds per acre.* This series of plots has produced a great variety of crops, including potatoes, corn, grasses, oats and barley each, with vetches, rye and clovers. The crops have been generally excellent. Full details will be found in the tenth and twelfth annual reports of the State Experiment Station, and the reports of the Hatch Experiment Station for the last three years. In the summer of 1895 two plots (one muriate the other sulphate) of each of the following clovers were sown: sweet clover (*Melilotus alba*), mammoth red clover, medium red clover and alsike clover. Between the crops produced respectively on the muriate and sulphate of potash no marked difference in yield was observed in either 1896 or 1897. It was, however, noticed in 1896 that the clover raised on the sulphate of potash was richer in starch and similar extractive substances, in the case of the mammoth, medium and alsike clovers, than that raised on the muriate, thus making the sulphate clover the more valuable.

Bad Effect of the Muriate.

In August of 1897 the plots were ploughed and all again seeded to the same varieties of clover. Germination was excellent, but within a very few weeks after the young plants appeared it was observed that in the case of the mammoth, medium and alsike varieties the plants were doing very poorly upon the muriate plots. As the autumn advanced, these plants for the most part grew more and more feeble, and many died. The winter was favorable to newly seeded land; but in the spring it was found that a large proportion of the plants upon the muriate plots were dead, in the case of the varieties above named. The sweet clover showed no difference between the two fertilizers. The condition of the clovers upon the sulphate plots was not entirely satisfactory, although far superior to that upon the muriate.

It was decided to sow additional seed upon all the plots without reploughing. Accordingly, on April 2, 4 pounds of seed of the appropriate variety were sown upon each of the plots. The conditions were favorable to germination, and a good stand of young clover was obtained upon all the plots. The sulphate plots gave much the larger yields of clover this season, because they contained a far larger proportion of the older plants from last summer's sowing. At the present time, however, the condition of the clover upon the muriate and sulphate plots is fairly even, for the spring-sown clover has done equally well upon both the potash salts.

This record of facts is made without comment, as without further investigation it appears to be impossible to explain why the summer-sown clover failed on the muriate, while the spring-sown has flourished upon the same plots without reploughing or any change in treatment.

Muriate *v.* Sulphate of Potash for Corn. (Field B.)

Two plots in Field B, one muriate and one sulphate, were planted to Sibley's Pride of the North corn, with a view to testing the relative value of these two potash salts for this crop. It will be remembered that these plots have been under the same manurial treatment since 1884. The fertilizers were broadcasted after ploughing, and harrowed in, and the corn was planted on May 30, in drills 3½ feet apart. It was later thinned to 1 foot in the drills. The crop was cut September 9 and husked the middle of October.

Corn on Muriate and on Sulphate of Potash.

Manuring per Acre.	Corn (Pounds).	Stover (Pounds).	Yield per Acre.	
			Corn (Bushels).	Stover (Pounds).
Plot 19, { Muriate of potash, 400 pounds, Ground bone, 600 pounds, }	488.5	866	45.8	6,495
Plot 20, { Sulphate of potash, 400 pounds, Ground bone, 600 pounds, }	428.5	652	40.1	4,890

The apparent superiority of the crop raised on the muriate of potash is considerable. During the growth of the crop, as the result of frequent examinations, no such difference was evident; and it is regretted that the moisture test has not been completed in season for this report, as it is felt that there may have been a difference in condition of the two crops when weighed, owing to the very rainy weather of the autumn.

Sweet Clover (*Melilotus alba*).

As has been stated under "Muriate *v.* Sulphate of Potash for Clovers," sweet clover occupied two of the plots in Field B. The present is the third successive year that this clover has been grown upon these plots, and the soil appears now to have become thoroughly stocked with the nodular bacteria peculiar to the plant. As reported in 1896, but few of the plants on these plots in that year possessed bacteria, and only those which did made vigorous growth. The next year, as already reported, about one-half of the plants apparently possessed nodules and made vigorous growth early in the season. Later all seemed to acquire the ability to make use of the atmospheric nitrogen which these nodular bacteria give. The crop of this season has been extremely vigorous from the very first. The rapid growth of this legume in early spring seemed to indicate its possible value as a cover crop for green manuring; and to test this point one square yard (believed to be average) was harvested at each of three different dates, and a determination of dry matter and of nitrogen contained therein was made. The results calculated per acre were: —

Date.	Height (Feet).	Dry Matter (Pounds).	Nitrogen (Pounds).
June 6,	2½	3,661.6	136.8
June 15,	3½	3,961.7	130.2
July 10,	5½	7,573.0	192.5

The crop was in full bloom at the time the last cutting was made, but it goes on blooming freely for almost the entire summer.

Corn for the silo may here be planted up to the middle of June, with a good prospect of success; and, as will be seen, previous to that date the sweet clover makes a large growth and contains a heavy amount of nitrogen. The amount of this element at the date of the second cutting is equivalent to that contained in about 6 cords of rich manure. To what extent, however, this nitrogen has been taken from the soil, and to what extent from the air, our experiments afford us no means for determining. Kühn has pointed out that the acquisition of atmospheric nitrogen by plants of the clover family takes place most abundantly in the later stages of their growth; and that, if they be ploughed under immature, we can hope for but little gain in that element. Our experiment, then, is not conclusive, as yet, as to the value of this clover as a green manuring crop. Since, however, being sown in the latter part of July or early in August, it will afford winter protection to the soil and furnish a large growth before late corn planting time, it seems worthy of further trial.

Value for Bees.

As is known to many, this clover furnishes an abundant and long-continued supply of honey. For many weeks the plants in our plots were daily visited by countless myriad bees, and the rate of honey production of those kept near by was very rapid, The honey is of good quality.

High-priced Seed an Obstacle to the Use of Sweet Clover.

The high price at which the seed of this clover is at present offered in our markets constitutes a great obstacle to its use as a green manuring crop. Recognizing this fact, and wishing to determine whether the seed might not be more cheaply offered, our crop of this year was allowed to mature. The sulphate of potash plot (two-fifteenths acre) gave a product of 43.5 pounds and the muriate plot 46.5 pounds of rather poorly cleaned seed. It is true that the season was unfavorable to the ripening of the seed; but the indication of this single experiment is that the species can not be counted upon for a liberal seed product, and that, therefore, the seed must remain high in price.

Nitragin, A Germ Fertilizer.

In connection with my report upon sweet clover, it has been shown that in the early attempts to cultivate this crop but partial success was obtained, because the germs of the appropriate nodular bacteria (microscopic plants, which, growing in nodules upon the roots, give the power of assimilating the free nitrogen of the air) were not present in sufficient numbers. It is there pointed out that, after three years' culture of the sweet clover upon the same plots, these bacteria so multiplied in the soil that complete success with the clover followed. Similar results in the first attempts to cultivate plants of the "pod" family (*Leguminosæ*) in localities where they had not been before grown have many times been observed; and many times, also, has ultimate success crowned the effort to produce the new plant, and for the reason above alluded to. The attainment of success in this manner, however, requires some few years; and time is precious. Recognizing this fact, an attempt to propagate the bacteria connected with nitrogen assimilation artificially and to put them upon the market was some few years ago made by Professor Nobbe of Tharandt, Germany. The effort was successful, and the product, under the name *Nitragin*, has been offered for the past few years by a German firm with which Professor Nobbe completed arrangements for its production and sale. Full particulars concerning *Nitragin*, and directions for its use, will be found in our eleventh annual report. The unsuccessful results of its trial upon clover in 1897 are published in our last annual report.

The scientific standing of Professor Nobbe is such and the general importance of the subject so great that further trials and with other plants seemed desirable. Accordingly, nitragin for the following species was ordered direct from the makers: crimson clover, red clover, alfalfa, sweet clover, soy bean, vetch and pea.

The experiments are not yet complete, but are being carried out upon poor plain land hired for the purpose, where most of these crops have never been cultivated, as well as upon our own grounds. The plan of the experiment upon the plain land is shown below.

Plan of Nitragin Experiments.

The plots are one-twentieth of an acre each, duly separated by dividing strips. The treatment of the several plots for each crop will be clear from the table: —

Plot 1, no fertilizers. No nitragin.
Plot 2, no fertilizers. Nitragin.
Plot 3, { acid phosphate, 400 pounds per acre. muriate of potash, 250 pounds per acre. lime, 1,000 pounds per acre, } No nitragin.
Plot 4, manurial treatment, like Plot 3. Nitragin.
Plot 5, same manures as 3, and, in addition, 180 pounds per acre of nitrate of soda. No nitragin.

The plan upon the home grounds is similar, with two exceptions: (1) The plots are smaller, and (2) there are no plots left unfertilized.

The crops started in the spring upon the "plain" include field peas, alfalfa, alsike clover and common red clover. The peas were harvested early in August. The yields of the several plots were very small, and showed no favorable influence from the nitragin. Of all the other crops, it can be reported to-day that the general condition is poor; that the best condition is to be found in every case upon Plot 5 (supplied with available fertilizer nitrogen), and that the crop upon mineral fertilizers with nitragin (4) appears somewhat better than the corresponding plot (3) without nitragin. Between plots 1 and 2 there appears to be no appreciable difference.

Upon our home grounds the field pea with nitragin gave a slightly better crop on mineral fertilizers alone than on mineral fertilizers without nitragin. Alfalfa upon mineral fertilizers and nitragin now looks better than on the same fertilizers without nitragin. It will be seen, then, that thus far the experiments of this season afford indications that some slight benefit has followed the use of this germ fertilizer.* Of the crops sown in late summer it is as yet too early to report.

Fertilizers for Garden Crops.

This series of experiments, begun in 1891, was originally intended to test the value for the different garden crops of nitrate of soda, sulphate of ammonia and dried blood as sources of nitrogen; but in the second year it was made to include also a comparison of muriate with sulphate of potash, each used with each of the three nitrogen fertilizers, for the same class of crops. Dissolved bone-black has been applied equally to all the plots from the first. The number of plots and the fertilizers annually applied to each up to the present year are shown in the following table: —

* It may be useful, though this fact has already many times been pointed out, to remark here that a third, and often very satisfactory, method of securing a stock of nodular bacteria consists in taking earth from soil where the crop under trial flourishes, and incorporating a little, as one might fertilizer, with the soil where the new crop is to be grown. This method is now under trial here with alfalfa with soil from Kansas.

Annual Supply of Manurial Substances (Pounds).

Plot 1,	Sulphate of ammonia,	38
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 2,	Nitrate of soda,	47
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 3,	Dried blood,	75
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 4,	Sulphate of ammonia,	38
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plot 5,	Nitrate of soda,	47
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plot 6,	Dried blood,	75
	Sulphate of potash,	30
	Dissolved bone-black,	40

The area of the plots is about one-eighth of an acre each. The fertilizers used supply, at the rates per acre: phosphoric acid, 50.4 pounds; nitrogen, 60 pounds; potash, 120 pounds.

The management of the experiment and results and conclusions are presented in great detail in our eighth, ninth and tenth annual reports, and to these the student of these experiments is referred. It suffices for our present purpose to call attention to the general results up to the end of the year 1897, which are shown below: —

Averages of Garden Crops, 1892 to 1897, inclusive.

PLOTS.	Spinach, grown Three Years (Pounds).	Lettuce, grown Three Years (Pounds).	Tomatoes, grown Four Years (Pounds).	Beans, grown Three Years (Pounds).	Onions, grown Two Years (Pounds).	Sweet Corn, grown Two Years (Pounds).	Green Peas, grown One Year (Pounds).	Table Beets, grown Two Years (Pounds).
Plot 1,	153	37	482	43	111	144	177	255
Plot 2,	210	43	707	49	326	179	203	479
Plot 3,	182	42	577	50	259	160	281	372
Plot 4,	196	63	717	44	221	151	348	425
Plot 5,	232	66	790	59	298	143	343	591
Plot 6,	149	41	503	51	235	154	307	483

It is important to point out that none of the crops included above has in any year occupied the whole of the area under experiment. Each year we have had some four or five crops, and the areas in each have varied. The above figures are valuable, then, solely as a basis of comparison between the several plots.

Conclusions based on Results up to 1897.

The chief conclusions which seemed justified by the results above given are the following: —

1. Sulphate of potash in connection with nitrate of soda (Plot 5) has generally given the best crop. In those cases where this has not been true, the inferiority of this combination has usually been small. In one case only has it fallen much behind, viz., with sweet corn, a crop which makes much of its growth in the latter part of the season.

2. Nitrate of soda (plots 2 and 5) has in almost every instance proved the most valuable source of nitrogen, whether used with muriate or the sulphate of potash.

3. The combination of sulphate of ammonia and muriate of potash (Plot 1) has in every instance given the poorest crop. This fact is apparently due, as Dr. Goessmann has pointed out, to an interchange of acids and bases leading to the formation of chloride of ammonia, which injuriously affects growth.

The Experiment in 1898.

In the fall of 1897 the plots were ploughed, and rye sown on all (without further manuring) as a cover crop, chiefly to prevent soil washing. The growth on Plot 1 (sulphate of ammonia and muriate of potash) was sickly and feeble, but no particular difference was noticed between the other plots.

Change in Plan.

In view of the fact that market gardeners, in whose interests chiefly these experiments are being carried out, almost invariably use large quantities of stable manure, and employ fertilizers, if at all, simply to supplement the manure, it was decided to make a change in the plan of the experiment, in order that the conditions under which we are working may more nearly conform to those of the average market gardener.

Accordingly, it was decided to apply equal amounts of thoroughly mixed stable manure to each plot, and to use on each, in addition, the same fertilizers as heretofore. Further, in order to have a basis for determining whether the fertilizers should prove in any degree useful, another plot was added, to which manure alone is applied. It was impossible to secure for this purpose a plot of exactly the same shape as the others, and of course it has not had the same history. It is, however, contiguous, and it has the same elevation and similar soil. This plot, which will be called plot 0, has for the past fifteen years received an annual application at the rate of ground bone 400 pounds and muriate of potash 200 pounds per acre. It has been planted yearly with a variety of the newer forage crops. Manure was applied at the rate per acre of twelve cords to all of the seven plots. The manure was applied by measure, but it was also weighed. The table shows the weight applied to each plot and the quantities of plant food which it carried: —

PLOTS.	Manure (Pounds).	Nitrogen (per Cent.).	Potassium Oxide (per Cent.).	Phosphoric Acid (per Cent.).
Plot 0,	6,720	28.8960	10.7520	17.4720
Plot 1,	6,977	30.0011	11.1632	18.1402
Plot 2,	6,775	29.1325	10.8400	17.6150
Plot 3,	7,065	30.3795	11.3040	18.3690
Plot 4,	6,617	28.4531	10.5872	17.2042
Plot 5,	7,210	31.0030	11.5360	18.7460
Plot 6,	6,945	29.8635	11.1120	18.0570
Manure contained,	–	.0043	.0016	.0026

Details.

The manure was evenly spread upon the surface April 18–23. The land was ploughed April 27, a thin crop of rye, previously alluded to, being turned under. The fertilizers were applied evenly, broadcast as in previous years, on May 2, and harrowed in. The land was once more harrowed on May 5. Throughout the season all plots received clean culture.

The crops the past season have been: strawberries (Clyde), spinach, lettuce, table beets, tomatoes, cabbage, celery and potatoes; and, as a second crop, turnips.

Clyde Strawberries. — Three rows were set in each plot. The growth was vigorous and healthy on all plots. Plots 4, 5 and 2 now show a slight superiority over the others, while Plot 0 is the poorest. All are well stocked, in matted rows.

Long Standing Spinach. — Three rows of this crop were planted in each plot May 7. All germinated well, but by June 9 many plants were dying on plots 1 and 4 (sulphate of ammonia and muriate of potash, and sulphate of ammonia and sulphate of potash), while nearly all the plants in these plots appeared yellow and sickly. All the spinach was harvested in two cuttings. The yields in pounds were as follows: Plot 0, 69; Plot 1, 1¼; Plot 2, 156½; Plot 3, 77¾; Plot 4, 13½; Plot 5, 159½; Plot 6, 73¾.

The average yields in pounds produced by the different fertilizers* were: —

Manure alone (Plot 0),	88.7
Average of manure and muriate of potash (plots 1, 2 and 3),	78.5
Average of manure and sulphate of potash (plots 4, 5 and 6),	82.3
Average of manure and sulphate of ammonia (plots 1 and 4),	7.4
Average of manure and nitrate of soda (plots 2 and 5),	158.0
Average of manure and dried blood (plots 3 and 6),	75.8

It will be noticed that the muriate of potash plots are inferior to those receiving sulphate of potash, though the difference is small. The sulphate of ammonia plots proved almost an absolute failure, while the dried blood gave a much smaller crop than the nitrate of soda. The most important fact brought out is the marked superiority of the latter as a source of nitrogen for spinach.

Hanson Lettuce. — Two rows of this crop, planted May 7, were grown in each plot, the plants being brought by

* To enable the reader the better to make comparisons, the plots are characterized as "manure and muriate of potash," "manure and sulphate of potash," etc. It should be remembered that dissolved bone-black was applied to all except Plot 0, and that every plot received material supplying both nitrogen and potash as well as phosphoric acid in addition to the manure. For the full list of fertilizers applied to each plot, see page 146.

thinning and resetting to a uniform distance of 1 foot in the rows, except on plots 1 and 4, where a large number of the plants died soon after coming up. In harvesting, the heads of market size were cut from day to day. The total crop in pounds on the several plots was: Plot 0, 179¼; Plot 1, 40; Plot 2, 194¼; Plot 3, 220¾; Plot 4, 135; Plot 5, 219; and Plot 6, 231¼.

The average yields, in pounds, produced by the different fertilizers were: —

Manure alone (Plot 0, *corrected for area*), . . .	230.5
Manure and muriate of potash (plots 1, 2 and 3), . .	151.7
Manure and sulphate of potash (plots 4, 5 and 6), . .	195.1
Manure and sulphate of ammonia (plots 1 and 4), . .	87.5
Manure and nitrate of soda (plots 2 and 5), . . .	206.6
Manure and dried blood (plots 3 and 6), . . .	226.0

The manure alone gave, as will be seen, a larger yield than any of the plots to which fertilizers as well as manure were applied. The only point clearly indicated is the apparent highly injurious effect of the sulphate of ammonia, particularly where used with the muriate of potash.

Dewing's Blood Turnip Beet. — Six rows of this crop, planted May 7, were grown in each plot. In plots 1 and 4 most of the plants soon became weak and sickly and many died, and there were not enough to restock to the uniform distance of 4 inches in the row, to which all the other plots were brought by thinning and resetting where needed. The few plants in plots 1 and 4 which survived until about July 1 then appeared to recover their vigor, and grew very rapidly. The yields of roots and tops were as shown below: —

Plots.	Beets (Pounds).	Tops (Pounds).
Plot 0, ...	340	440
Plot 1, ...	80	160
Plot 2, ...	440	570
Plot 3, ...	365	515
Plot 4, ...	260	470
Plot 5, ...	460	490
Plot 6, ...	325	335

The average yields in pounds per plot were as follows: —

	Roots.	Tops.
Manure alone (Plot 0, corrected),	374.7	484.9
Manure and muriate of potash (plots 1, 2 and 3),	295.0	415.0
Manure and sulphate of potash (plots 4, 5 and 6),	348.3	431.7
Manure and sulphate of ammonia (plots 1 and 4),	170.0	315.0
Manure and nitrate of soda (plots 2 and 5),	450.0	530.0
Manure and dried blood (plots 3 and 6),	345.0	425.0

The general result here is similar to that with spinach; *i.e.*, muriate is inferior to the sulphate of potash; nitrate of soda is the best source of nitrogen; and sulphate of ammonia shows itself to have been actually injurious, particularly so with muriate of potash.

Dwarf Champion Tomato. — Two rows were set in each of the original six plots and three in Plot 0, the plants, purchased of the Horticultural Department, being rather small and uneven. The crop was picked as it ripened until September 23, when the balance of the fruit was picked green. The weights of ripe and of green fruit in pounds per plot are shown below:* —

Plots.	Ripe Fruit.	Green Fruit.
	Lbs. oz.	Lbs. oz.
Plot 0,	422 3	179 8
Plot 1,	387 7	223 0
Plot 2,	501 4	160 0
Plot 3,	328 2	178 0
Plot 4,	430 6	181 0
Plot 5,	413 1	84 8
Plot 6,	405 4	181 8

The averages of ripe fruit and total yield in pounds per plot were as shown in the table: —

* The record of one day's picking of ripe fruit was lost, but this does not change the relative standing of the plots.

	Ripe Fruit.	Total.
Manure alone (Plot 0, corrected for area),	361.9	515.7
Manure and muriate of potash (plots 1, 2 and 3),	405.6	592.6
Manure and sulphate of potash (plots 4, 5 and 6),	416.2	565.2
Manure and sulphate of ammonia (plots 1 and 4),	408.9	610.9
Manure and nitrate of soda (plots 2 and 5),	457.2	579.4
Manure and dried blood (plots 3 and 6),	366.7	546.4

The differences brought out by these averages are much smaller than in the case of the spinach and beets, but are in the same direction for ripe fruit; *i.e.*, sulphate of potash gives somewhat better returns than muriate, and nitrate of soda gives the largest yield of any of the sources of nitrogen. It is noteworthy that the sulphate of ammonia does not appear to have injuriously affected this crop. This is perhaps due to the fact that the tomato is not set until about the first of June, and makes most of its growth when the season is well advanced. The crops shown to have been injured by the sulphate of ammonia, spinach and beets, are sown early, and make most of their growth before the season is far advanced.

Fotler's Drumhead Cabbage. — Two rows in each of the original six plots and three in Plot 0 were grown. The seed was planted May 23, in hills, and later thinned to one in each hill, those destroyed by maggots being replaced. Owing to the unusually hot season, the crop was well grown by September 1, and numerous heads were beginning to crack. They were harvested as they matured, September 8 to November 5. The yield in pounds of heads, practically all well filled and hard, was as follows: Plot 0, 729; Plot 1, 720; Plot 2, 780; Plot 3, 710; Plot 4, 755; Plot 5, 744; and Plot 6, 651.

The average yields in pounds per plot were as follows: —

Manure alone (Plot 0, corrected),	624.9
Manure and muriate of potash (plots 1, 2 and 3),	736.7
Manure and sulphate of potash (plots 4, 5 and 6),	716.7
Manure and sulphate of ammonia (plots 1 and 4),	737.5
Manure and nitrate of soda (plots 2 and 5),	762.0
Manure and dried blood (plots 3 and 6),	680.5

Here we find the fertilizers have apparently produced a moderate increase in crop. The differences between them are far less marked than in the case of most of the other crops grown this year. The nitrate of soda appears to have been the best source of nitrogen for the cabbage.

Early Maine Potatoes. — The seed planted was grown in the State of Maine. It was treated with corrosive sublimate solution, for prevention of scab, and sun-sprouted. Before planting, the tubers were cut to pieces with two eyes each. Three rows per plot (4 on Plot 0) were grown. The seed was planted on May 9 in rows 3 feet apart, the pieces being dropped 1 foot apart in the rows. Ordinary thorough culture was given until the vines covered the ground. The vines were sprayed with Bordeaux mixture (first on June 7) to repel the flea beetle. They were sprayed with sufficient frequency to keep the vines well covered with the mixture until the middle of August, the last application being made August 8. The Bordeaux mixture was applied nine times in all, frequent re-application being necessary, on account of the numerous heavy rains. The vines were slightly attacked by blight about the middle of July; but later in August new shoots were thrown out from the axils of the lower leaves, making a healthy growth, which remained green until very late in September. The tubers averaged large and smooth, and showed very little rot when dug. A few weeks after storing there were a few more decayed tubers. The yield in pounds was as follows: —

Plots.	Merchantable Tubers.	Small Tubers.
Plot 0,	441.5	41.0
Plot 1,	449.0	40.0
Plot 2,	426.0	40.0
Plot 3,	409.0	62.5
Plot 4,	550.0	35.0
Plot 5,	482.0	31.5
Plot 6,	482.0	51.5

Yield per Acre (Bushels).

Plots.	Merchantable Tubers.	Small Tubers.
Plot 0,	381.5	35.4
Plot 1,	447.2	35.8
Plot 2,	381.7	35.8
Plot 3,	366.5	56.0
Plot 4,	492.8	31.4
Plot 5,	431.9	28.3
Plot 6,	431.9	46.1

The averages calculated to show the relative effect of the different fertilizers are given below in pounds per plot: —

Plots.	Merchantable Tubers.	Small Tubers.
Manure alone (Plot 0, corrected),	425.7	39.5
Manure and muriate of potash (plots 1, 2 and 3),	444.7	47.5
Manure and sulphate of potash (plots 4, 5 and 6),	504.7	39.3
Manure and sulphate of ammonia (plots 1 and 4),	524.5	37.5
Manure and nitrate of soda (plots 2 and 5),	454.0	35.8
Manure and dried blood (plots 3 and 6),	445.5	57.0

It becomes evident from a study of these figures that the fertilizers proved moderately beneficial to this crop, and that the sulphate of potash is superior to the muriate. The various sources of nitrogen rank in the order, sulphate of ammonia, nitrate of soda and dried blood, the first giving a much larger average crop than either of the others. It seems further important to point out that the combination sulphate of ammonia with muriate of potash, which has proved both in previous years and in this year so fatal to most crops, has given a fine crop of potatoes, at the rate of 447 bushels to the acre, the second in rank among the seven plots. No explanation can be offered, beyond that already suggested in the case of tomatoes, viz., that the potato has a much longer growing season than the crops doing so very poorly on this combination of fertilizers. It seems reasonable to suppose that, as the season advances, the injurious ammonium chloride formed at first is either washed out of the soil or destroyed by further chemical changes. This question will be made a matter of further study.

The spraying with Bordeaux mixture, although necessarily nine times repeated on account of the unusual number of heavy rains, must be considered to have been profitable, as the yield was very heavy, while in general the crop this year was light where spraying was not practised.

Giant Pascal Celery. — Two rows were grown in each plot; the plants, large and well grown, were set 1 foot apart in rows 5 feet apart on July 19. Banking began September 29, and the crop was put into the cellar in good condition on November 4. The growth on plots 0, 1 and 4 was fair; on the other plots, excellent. There was considerable rust on Plot 0, while there was little or none on the other plots. The weights in pounds of the plants (including roots and a little earth) were as follows: Plot 0, 443; Plot 1, 328; Plot 2, 478; Plot 3, 478; Plot 4, 348; Plot 5, 568; Plot 6, 488.

The calculated averages will not be given until the crop is blanched, since the earth, of necessity left adhering to the roots of the plants as put into the cellar, is an element of uncertainty. It may be of interest to state that these averages indicate little if any increase which can be attributed to the fertilizers.

White Egg Turnips. — This crop followed spinach, lettuce and table beets, without further manuring. The land was reploughed and fitted and the seed sown on July 28, in rows 14 inches apart. Soon after sowing a heavy shower caused some washing across the plots, which was particularly injurious on Plot 0. The crop was harvested November 8 and 9, and was of excellent quality. The yields in pounds are shown in the following table: —

Plots.	Roots.	Tops.
Plot 0,	580.0	185
Plot 1,	702.0	348
Plot 2,	753.5	315
Plot 3,	735.0	315
Plot 4,	938.0	335
Plot 5,	655.0	260
Plot 6,	690.0	215

The calculated averages in pounds are given in the following table: —

	Roots.	Tops.
Manure alone (Plot 0, corrected),	688.3	219.7
Manure and muriate of potash (plots 1, 2 and 3),	730.3	326.0
Manure and sulphate of potash (plots 4, 5 and 6),	761.0	270.0
Manure and sulphate of ammonia (plots 1 and 4),	820.0	341.5
Manure and nitrate of soda (plots 2 and 5),	704.3	287.5
Manure and dried blood (plots 3 and 6),	712.5	265.0

The fertilizers are shown to have been moderately beneficial, there is not much difference between the two potash salts, and the sulphate of ammonia gives a much better crop than either of the nitrogen fertilizers. This is not strange, in view of these facts: (1) the plots to which this had been applied had produced but very small first crops, while the others had yielded heavily; and (2) that the turnips made their growth so late in the season that the injurious compounds often formed by this salt had become dissipated, or destroyed by further chemical changes.

Experiments in Manuring Grass Lands.

The system of using wood ashes, ground bone and muriate of potash, and manure in rotation upon grass land has been continued. We have three large plots (between two and three acres each) under this treatment. Under this system each plot receives wood ashes at the rate of 1 ton per acre one year; the next year, ground bone 600 pounds and muriate of potash 200 pounds per acre; and the third year, manure at the rate of 8 tons. The system is so planned that each year we have one plot under each manuring. The manure is always applied in the fall, the other materials early in the spring; this year April 8 and 9.

Plot 1, which this year received bone and potash, gave a yield at the rate of 5,137 pounds of hay and 2,370 pounds of rowen per acre. Plot 2, which received ashes, yielded 4,602 pounds of hay and 2,142 pounds of rowen. Plot 3, which was dressed with manure in the fall of 1897, yielded 5,233 pounds of hay and 2,823 pounds of rowen per acre. This field has now been ten years in grass, and during the continuance of the present system of manuring (since 1893) has produced an average product (hay and rowen both included) at the rate of 6,808 pounds per acre. The plots when dressed with manure have averaged 7,211 pounds per acre; when receiving bone and potash, 6,671 pounds per acre; and when receiving wood ashes, 6,541 pounds per acre.

Variety Tests.

Our work in testing varieties this year has been confined to testing the potato. With this it has been extensive. The tests have been of two sorts; (1) a preliminary test with varieties grown for the first time; and (2) a test of the best twenty-five varieties, as indicated by the trial of last year.

1. *Preliminary Test.* — As has been stated in my previous reports upon variety work with the potato, I consider several years' trial necessary to the formation of a judgment. The seed of new varieties as they are brought out must of necessity come from many widely separated localities. Such seed is unfit to serve as a basis for comparison, with the object of determining the relative merits of varieties, as it is well known to many and quite generally admitted that the place where any given variety of seed potatoes is produced may greatly influence its product. Newly obtained varieties must also of necessity have been subjected to widely variant conditions of handling, preservation and

transportation, and all these factors influence product. For all these reasons our practice is to obtain but a small quantity of seed of new varieties as they come to our attention, and to plant this for the purpose of raising seed for the next year's trial, which shall have been produced under similar conditions and similarly handled. This constitutes our "*preliminary test.*"

This test the past season included seventy-five varieties, obtained from almost as many seedsmen, scattered all over New England, the middle and central States and Canada. The seed of all was treated with corrosive sublimate solution and sun-sprouted. It was then cut to pieces of two good eyes each, and planted one piece to a foot, in rows 3 feet apart. The soil was a good medium loam, naturally well drained. The fertilizers used in pounds per acre were: —

Nitrate of soda,	240
Acid phosphate,	400
Sulphate of potash (high grade),	250
Tankage,	240
Dried blood,	100

These materials were mixed just before using, and scattered broadly in the drills before dropping the seed. The planting took place May 11 and 12. All varieties were injured by hot, dry weather, which came just as the tubers were forming, and by blight, although sprayed with Bordeaux mixture six times between June 13 and August 2. The varieties on which blight was first noticed were Salzer's Earliest, Bliss Triumph, King of the Earliest and Lincoln, — July 24 and 25. All other varieties showed blight between July 28 and August 1, and to about an equal degree. It is thought that no varieties blighted long before they were mature; but, nevertheless, the blight undoubtedly greatly reduced the yields. Owing to the blight, the period of apparent ripening of all varieties was nearly the same, viz., August 27 to September 8. The potatoes were dug late in September. The average number of sets for each variety was about forty, and to this number the yield of all has been corrected. Such correction, in our experience, always proves unduly favorable to the varieties of which we have the least seed. Our effort has always been to obtain just three pounds of each variety; but sometimes we are unable to obtain so much, or it may be that some tubers obtained prove unfit to plant, owing to bruising or decay.

The yield this year has varied from 8.5 to 46.7 pounds of merchantable tubers for 40 sets.* Six varieties have given a yield of 40 pounds or above of merchantable tubers from 40 sets, viz., Ford's No. 31, 46.7; Early Minnesota, 44.7; Champion of the World, 41.8; Burr's No. 1, 40.8; and American Wonder and Early Dawn, 40 each. Eight varieties gave under 20 pounds from 40 sets, viz., Lady Finger, 8.5; Mayflower, 13.9; Salzer's Earliest, 14.2; Potentate, 15.3; Mills's Long Keeper, 16; Livingston's Pinkeye, 16.8; and King of the Earliest and White Beauty, 18.5 each.

2. *Test with Twenty-five Varieties (the Best of Last Season).* — The seed of these varieties, it will be understood, was all of our own growing, and was of most excellent quality. It was prepared for planting as above described, and was planted upon similar soil and similarly manured. One hundred sets of each variety were planted on May 13. These varieties were sprayed six times, as were those in the preliminary test. They, however, showed considerable blight, and doubtless gave diminished yields because of this affection. The yields have been calculated to 40 sets, to make them comparable with the varieties in the other test. These are shown in the table following: —

* Forty pounds for 40 sets corresponds to a yield of 242.4 bushels per acre. Thirty pounds for 40 sets corresponds to a yield of 181.8 bushels per acre. Twenty pounds for 40 sets corresponds to a yield of 121.2 bushels per acre.

Variety Test of Potatoes. Yield in Pounds from 40 Sets.

Variety.	Merchantable Tubers.	Small Tubers.
Beauty of Hebron,	33.40	7.00
Bliss's Triumph,	20.40	9.60
Carmen No. 1,	23.40	12.80
Dakota Red,	19.20	10.80
Dutton's Seedling,	32.20	15.20
Early Maine,	21.20	2.80
Early Rose,	28.00	9.00
Early Sunrise,	26.40	10.80
Empire State,	12.40	7.60
Enormous,	36.80	4.20
Fillbasket,	37.60	5.60
Late Puritan,	26.80	9.60
Money Maker,	26.60	7.40
New Satisfaction,	26.60	6.00
Prolific Rose,	28.20	8.00
Restaurant,	34.80	7.60
Rochester Rose,	29.60	8.80
Rose No. 9,	34.00	5.20
Sir William,	26.80	6.20
State of Maine,	34.00	4.80
Thorburn,	35.80	6.40
Uncle Sam,	28.40	3.80
Vanguard,	31.80	9.00
White Elephant,	40.20	8.00
Woodbury's White,	35.90	5.00

Last year the eleven best varieties ranked in yield of merchantable tubers in the following order: Rose No. 9, Restaurant, Woodbury's White, Bliss's Triumph, Prolific Rose, Empire State, Early Maine, Dakota Red, Sir William, Early Rose and Beauty of Hebron. All of these then gave a product at the rate of more than 220 bushels of merchantable tubers per acre.

This year the relative rank, as will be seen, is quite different. The yields are in general much lower. The results of this year, however, owing to the blight, cannot be regarded as affording a reliable index to the relative merits of the varieties. Their publication, however, serves to illustrate how almost impossible it is, in the making of such tests, to establish the relative merits of varieties. As I have remarked in previous reports, it is significant that the old standard, Beauty of Hebron, is once more one of the first ten varieties.

Identical Varieties under Different Names.

As far as we are able to judge, there is no difference between King of the Earliest and Early Ohio; Salzer's Earliest and Bliss's Triumph; Mills's Banner and Livingston's Banner; while White Beauty and Cambridge Russet differ but very slightly, the latter having a slightly more russetted skin than the former.

Test of Seed of the Same Variety from Different Localities.

In order to test the soundness of the *a priori* conclusion that, to make the results of a variety test comparable for the purpose of determining relative merits, the seed of all should have been produced in the same locality and handled in all respects alike, an experiment was carried out with two of the old standard sorts, — Beauty of Hebron and Early Rose, — with seed of each from a considerable number of sources. The seed of the former came from eight different producers; that of the latter, from six. The methods pursued in seed preparation, soil, manuring, spraying, etc., were in all respects as in the variety test.

Comparison of Seed Potatoes from Different Localities. Yield in Pounds of 40 Sets.

Source of the Seed.	Varieties.			
	Beauty of Hebron.		Early Rose.	
	Merchantable.	Small.	Merchantable.	Small.
Home grown,	30.0	2.5	25.0	2.9
Guelph, Ontario, D. of C.,	32.3	1.8	–	–
Pennsylvania grown, Dreer,	24.5	3.3	27.5	3.5
James J. H. Gregory, Marblehead, Mass.,	35.5	2.5	–	–
Cornell Experiment Station, Ithaca, N.Y.,	29.3	2.5	31.0	2.0
Wisconsin, Olds Seed Company,	26.0	4.5	–	–
Maine, A. H. Weeks Company,	33.3	2.8	–	–
Dibble Seed Company, N. Y.,	26.5	3.8	32.5	2.0
Minnesota, Farmer Seed Company,	–	–	21.0	3.8
Kansas, F. Barteldes & Co.,	–	–	20.0	7.8

The range of variation in yield, as will be seen, is large, amounting to almost 50 per cent. in the yield of merchantable tubers for the Beauty of Hebron and to rather over 50 per cent. for the Early Rose. In view of this wide difference in the yield of the same variety, it must be admitted that variety tests in which the seed is brought together from many sources can have but a doubtful value.

The extent of the variation in the type of the potatoes grown in this test was considerable, so great, indeed, as to make it doubtful whether in all cases the seed was true to name, although obtained from the most reliable parties in every instance. The extent of the variation is in part shown in the table below, in which each lot is compared with the crop from our home-grown seed of the same variety: —

Potatoes. — Comparison of Crops, Seed from Different Sources.

ORIGIN OF THE SEED.	Shape.	Color.	Size.	Eyes.
Beauty of Hebron.				
Home grown,	Long, elliptical, slightly flattened, tapering strongly towards tip.	Light flesh, mottled with darker shades.	Medium,	Medium, rather deep.
J. J. H. Gregory,	Same,	Same,	Same,	Smaller, less deep.
Dreer, Pennsylvania,	Shorter,	Same,	Larger,	Same.
Olds Company, Wisconsin.	Oval, slightly flat, same at both ends.	Lighter,	Smaller,	Small.
Weeks Company, Maine.	Same,	Same,	Larger,	Less deep.
Cornell Experiment Station.	Same,	Light, bright pink,	Larger,	Smaller.
Guelph, Ontario, Experiment Station.	Same,	Same,	Same,	Same.
Dibble Company, N. Y.,	Same,	Lighter,	Same,	Same.
Early Rose.				
Home grown,	Long, flattened, tapering towards seed end, curved.	Light pink, bright pink at seed end.	Medium,	Medium large.
Dreer, Pennsylvania,	Broader, more compact.	Lighter,	Same,	Same.
Farmer Company, Minnesota.	Much broader, less curved.	Same,	Smaller,	Same.
Cornell Experiment Station.	Longer, more curved.	Same,	Larger,	Same.
Kansas, Barteldes & Co.,	Broader, more like Hebron.	Same,	Same,	Smaller, more shallow.
Dibble Company, N. Y.,	Same,	Same,	Larger,	Large, shallow.

Individual Variation, Tubers of the Same Variety.

In view of the frequently reported tests of varieties in which some two or three tubers only of each are used, it was thought best to carry out an experiment to determine if possible the extent to which the product of single tubers will vary when grown under conditions as favorable as possible to uniformity of yield. As a preparation for this test, tiles two feet in diameter and four feet long were set into the ground in a single row, the distance between them being about two and one-half feet. To insure equal drainage conditions, a drain tile was laid at about the level of the lower edge of the tile, being given just enough pitch to carry off water. The plot of land in which the tiles were set was surrounded with drain tile, to prevent the ingress of soil water from outside. This plot had been uniformly manured for many years, so that the subsoil conditions below the tiles must have been practically uniform. The plots were set so that the surface water from outside was excluded, but the earth outside was brought to within about one inch of the upper edge.

These tiles so set were filled to within one foot of the top with carefully mixed subsoil, consisting of a very fine sand, this subsoil being settled by the liberal use of water. After this subsoil had thoroughly settled and somewhat dried, equal weights of carefully mixed medium loam were put into each tile, the quantities being sufficient to fill them. The amount used was two hundred and twenty-five pounds for each tile. Conclusive evidence that the work was well and uniformly done is afforded by the fact that the earth in the several tiles remained at practically uniform height throughout the season.

With the upper four inches in depth of soil in these tiles were most carefully mixed the fertilizers applied, precisely the same weights as determined by chemical balances to each tile. The materials used supplied per tile and at the rate per acre as follows: —

Materials Used.	Per Tile (Grams).	Rate per Acre (Pounds).
Nitrate of soda,	8.07	250
Dried blood,	3.23	100
Tankage,	8.07	250
Acid phosphate,	12.92	400
Sulphate of potash (high grade),	9.69	300

This fertilizer was applied May 9, and the seed was planted the same day. The variety was Carmen No. 1. The tubers selected were uniform in form, weight and all external characteristics, as far as it was possible to obtain such. The weights of the tubers were as follows: No. 1, 160 grams; No. 2, 135 grams; No. 3, 160 grams; No. 4, 140 grams; No. 5, 135 grams; No. 6, 140 grams; No. 7, 140 grams; No. 8, 140 grams. The first seven tubers were treated with corrosive sublimate solution, and sun-sprouted; No. 8 was not treated. Each tuber was cut to exact halves by weight, and the number of eyes on each half reduced to five in the same part of the tuber. The tubers were all typical of the variety, and all were entirely free from scab, but there had been a few scabbed potatoes in the crop from which they came. They were all planted face downward at the same depth, the halves of tuber No. 1 in tiles 1 and 2, the halves of tuber No. 2 in tiles 3 and 4, and so on, — and finally one-half of tuber No. 8 in tile 15. They all came up in good season, but somewhat irregularly, May 26 to May 28. They were most carefully cultivated by hand, kept entirely free from weeds and from bugs by hand pulling and picking. Bordeaux mixture was applied six times, June 6 to July 25. There was practically no injury from either flea beetle or blight. The vines in different tiles showed quite different minor characteristics, and ripened unevenly, September 20 to October 1, when the crop was harvested. At that time there was a very little yellowish-green color on part of one stalk in tile 9 and on one entire stalk in tile 8. All leaves had for some time been dead. The yields and remarks are given in the table: —

Yield of Different Tubers, Carmen Potato.

No. of Tuber.	Tile.	Number of Tubers.	Weight (Kilograms).*	Remarks.
Tuber No. 1, . . .	1	10	1.470	
	2	14	1.520	
Tuber No. 2, . . .	3	14	1.300	One scabby.
	4	11	1.340	
Tuber No. 3, . . .	5	15	1.440	Several slightly scabby.
	6	10	1.440	
Tuber No. 4, . . .	7	12	1.180	Small amount of scab.
	8	8	1.330	
Tuber No. 5, . . .	9	17	1.440	A very little scab.
	10	15	1.620	
Tuber No. 6, . . .	11	19	1.460	A little scab.
	12	9	1.340	
Tuber No. 7, . . .	13	13	1.240	A little scab.
	14	14	1.450	
One-half of Tuber No. 8, .	15	16	1.320	Considerable scab.

* The kilogram equals almost exactly 2.2 English pounds.

The above weights were taken after the tubers had been carefully washed and dried. They showed a range of variation amounting between halves to a little over 37 per cent., and between tubers of about 22 per cent. The differences in number and size of tubers are equally striking. In view of these facts, I submit that variety tests of potatoes upon a small scale can have but a small value for determining the probable relative yield of varieties.

Poultry Experiments.

The experiments with poultry completed since our last annual report were begun in the late fall of 1897, and extended through the winter of 1897 and 1898, and a part of them through the past summer and into the fall. The points upon which these experiments were designed to afford information are the following: —

1. Effect upon egg-production of the use of condition powders.

2. Comparative value for egg-production of flesh or animal meal and cut fresh bone.

3. Comparison for egg-production of a wide nutritive ration with a narrow; or, in other words, of a ration in

which corn meal and corn were prominent with one in which these feeds were replaced wholly or in large part with more nitrogenous foods, such as wheat middlings, gluten feed, wheat and oats.

4. The influence of the presence of a cock with the hens upon egg-production.

General Conditions.

In all these experiments pullets purchased in Plymouth County and reaching us about the middle of October were used. These pullets were well-bred Barred Plymouth Rocks, not fancy stock (*i. e.*, as to feather), but bright, healthy stock, hatched in April. These pullets were evenly divided into lots of twenty each, being matched in sets of two lots as closely as possible. Each lot occupied a detached house, including laying and roosting room ten by twelve feet and scratching shed eight by twelve feet, with the run of large yards of equal size whenever weather permitted. The winter tests began December 12 and ended April 30. The latter part of March a few hens were removed from each house for sitters, the same number from each. Egg records of the separate lots were kept from the time laying began to the time of beginning experiments, for the purpose of affording an index as to the equality or otherwise of the matched pairs of lots. The hens were all marked with leg bands, as a precautionary measure for the purpose of identification in the case of accidental mixture of fowls.

All the meals and the cut clover were given in the form of a mash, fed early in the morning. This was mixed the night before with boiling water until January 8, and fed at the temperature of about 70° F. After January 8, the mashes were mixed with boiling water in the morning, and fed hot. At noon a few oats were scattered in the straw with which the scratching sheds were littered. At night the balance of the whole grain was fed (also by scattering in the straw) one hour before dark. The fowls were given what whole grain they would eat up clean. Water, shells and artificial grit were kept before the fowls at all times. About twice a week a small cabbage was given to each lot of fowls, this, like all other food, being weighed. The eggs from each lot were weighed weekly. The fowls were all weighed once each month.

No male birds were kept in any of the pens in the winter experiments, nor, indeed, in any except where the influence of the cock was the subject of experiment. Sitters, except those taken out, above alluded to, were confined in a coop until broken up, being meanwhile fed like their mates.

The prices per hundred weight for foods, upon which financial calculations are based, are shown below: —

Wheat,	$1 75
Oats,	1 00
Wheat bran,	60
Wheat middlings,	75
Gluten feed,	2 00
Animal meal,	2 00
Cut clover rowen,	1 50
Cabbage,	25
Cut bone,	2 00
Gluten meal,	80
Corn meal,	85
Corn,	85

Composition of Foods (Per Cent.).

Kind.	Moisture.	Air Dry Food contains —				
		Ash.	Protein.	Fibre.	Extract.	Fat.
Whole wheat,	10.51	1.85	12.64	2.55	71.01	1.44
Whole oats,	8.06	3.21	11.96	11.64	61.48	3.65
Cut clover rowen,	9.80	7.36	17.88	22.18	39.70	3.08
Wheat middlings,	9.25	4.63	17.52	9.91	53.11	5.58
Animal meal,	5.06	39.26	37.66	1.01	5.56	11.45
Whole corn,	12.11	1.31	9.55	1.90	71.26	3.87

Kind.	Moisture.	Dry Matter contains —				
		Ash.	Protein.	Fibre.	Extract.	Fat.
Bran,	12.72	6.96	18.01	11.65	57.92	5.46
Gluten feed,	9.10	0.92	24.59	7.17	63.43	3.89
Corn meal,	13.43	1.46	11.01	1.96	81.44	4.13
Cabbage,	89.45	7.94	25.69	9.31	54.76	2.30
Cut bone,	26.29	21.50	20.62	–	–	31.38
Gluten meal,	8.77	1.50	37.64	3.87	54.59	2.40

1. Effect of Condition Powder upon Egg-production.

Each coop contained twenty pullets at the beginning of the experiment; the fowls in the no condition-powder coop weighing 103 pounds, and having laid, November 18 to December 12, 46 eggs; the fowls in the condition-powder coop weighing 97 pounds, and having laid 14 eggs. The rations of the two lots of fowls were the same, except to the morning mash of one lot was added condition powder to the full amount recommended by makers; viz., 3 scoops (provided for measuring) heaping full. This amount of condition powder was enough to make the mash several shades darker than the one without it, and to impart a strong odor. Being mixed sometimes in the room where milk was standing, it imparted a flavor to butter made therefrom which was recognized by our expert butter maker, who knew nothing concerning its use, and who worked in rooms a quarter of a mile distant, to which the milk was taken. The pen receiving the powder consumed during the winter four two-pound cans of it, costing at retail $4.

Both lots of fowls were healthy throughout the entire test. Two fowls were stolen from the lot receiving no condition powders on the night of March 27. One soft-shelled egg was laid by a fowl receiving condition powder. The tables give all details necessary to a comparison of the results: —

Foods consumed, Condition-powder Experiment.

Kinds of Food.	Amount.			
	Condition Powder.		No Condition Powder.	
	Lbs.	oz.	Lbs.	oz.
Wheat,	269	0	250	0
Oats,	155	0	152	0
Bran,	44	0	44	8
Middlings	44	0	44	8
Gluten feed,	44	0	44	8
Animal meal,	52	0	52	8
Clover,	43	0	44	8
Cabbage,	15	15	15	3

Average Weights of the Fowls (Pounds).

Dates.	Condition Powder.	No Condition Powder.
December 12,	4.85	5.15
January 31,	5.21	5.41
February 25,	5.44	5.53
March 30,	5.25	5.48
April 30,	5.11	4.88

Eggs per Month (Number).

Months.	Condition Powder.	No Condition Powder.
December,	28	59
January,	90	66
February,	86	101
March,	217	288
April,	298	291
Totals,	719	745

Condition Powder for Egg-production (December 12 to April 30).

	Condition Powder.	No Condition Powder.
Hen days,	2,751	2,656
Gross cost of food,	$8 91	$8 59
Cost per hen day,	$0 0032	$0 0032
Total number of eggs,	719	745
Cost per egg, not including powder,	$0 0124	$0 0115
Cost per egg, including powder,	$0 0180	$0 0115
Eggs per hen day,	.26+	.28+
Total weight of eggs (pounds),	88.08	90.80
Average weight of eggs (ounces),	1.96	1.95
Dry matter to produce 1 egg (pounds),	.82	.77
Dry matter consumed per hen day (pounds),	.22—	.22—
Nutritive ratio,	1:4.6+	1:4.6—
Sitters,	8	14

Eggs from both lots of fowls were tested under numbers by two families. One family reports no difference; the other found the eggs from the hens not getting the powder "much preferable" to the others.

Conclusion.

A study of the figures showing results shows that the hens not getting the condition powder laid more eggs, of practically the same average weight. The food required to produce a single egg was less, and the cost was very materially less. The average weight of the fowls not getting the powder at the close of the experiment was about one-quarter of a pound less than that of the other.

We have now carried through three experiments to test the value of condition powder for egg-production. The differences have in every case been small. In favor of the condition powder we have one experiment, against it we have two experiments. It is not, however, my disposition to claim that the powder is injurious, but simply *that it is not beneficial.* This the four experiments, carried out with the utmost fairness and with every care, certainly prove. *In the light of these results, it is believed that poultry keepers throw away money expended for condition powder.*

2. Animal Meal v. Cut Bone for Egg-production (December 12 to April 30).

In this experiment there were nineteen pullets in each house when the experiment began. Those in the animal-meal house weighed 101.5 pounds, and had laid, November 8 to December 12, 82 eggs. The pullets in the cut-bone coop weighed 101.25 pounds, and had laid 41 eggs.

In the morning mash of one lot one part animal meal to five parts total dry materials was used; in the mash of the other lot, the same proportion of fresh-cut bone was mixed. The large, flat bones, comparatively free from meat or fat, were used.

In the animal-meal coop the health of the birds was good, but one fowl being out of condition in any way. She became sick about April 1, and was killed, as she seemed to be growing gradually worse, on April 10. The nature of the trouble was unknown. Almost from the first, bowel troubles were not uncommon in the cut-bone coop. Two fowls died (December 23 and January 11) after short illness. On April 11 one hen was found with a disjointed leg, and she was killed. The animal-meal coop laid three soft-shelled eggs; the other, two.

The bone fed amounted to only .27 ounce per hen daily. One-half ounce and over is the usual recommendation by writers upon the subject. We find it impossible to feed so largely without serious bowel trouble.

Foods consumed, Animal Meal v. Cut Bone.

Kinds of Food.	Animal Meal.		Cut Bone.	
	lbs.	oz.	lbs.	oz.
Wheat,	256	0	262	0
Oats,	143	0	145	0
Bran,	44	8	39	0
Wheat middlings,	44	8	39	0
Gluten feed,	44	8	-	
Gluten meal,	-		39	0
Animal meal,	44	8	-	
Cut bone,	-		40	0
Clover rowen,	44	8	39	0
Cabbage,	19	3	18	8

Average Weights of the Fowls (Pounds).

Dates.	Animal Meal.	Cut Bone.
December 12,	5.34	5.38
January 31,	5.64	5.66
February 25,	5.66	5.88
March 30,	5.09	5.27
April 30,	5.06	5.53

Eggs per Month (Number).

Months.	Animal Meal.	Cut Bone.
December,	63	57
January,	92	83
February,	184	120
March,	263	259
April,	210	209
Totals,	812	728

Animal Meal v. Cut Bone for Egg-production.

	Animal Meal.	Cut Bone.
Total number of eggs,	812	728
Hen days,	2,561	2,331
Gross cost of foods,	$8 45	$8 29
Cost per egg,	$0 0104	$0 0114
Cost per hen day,	$0 0033	$0 0035
Total weight of eggs (pounds),	100.5	88.7
Average weight per egg (ounces),	1.98	1.95
Eggs per hen day,	.32	.31
Dry matter consumed per hen day (pounds),	.22	.23
Dry matter to produce 1 egg (pounds),	.695	.739
Nutritive ratio,	1:4.6	1:4.7
Sitters,	22	13

A test of the eggs both raw and boiled was made by an expert, who found the animal-meal eggs inferior, in color and flavor, to the others.

Conclusion.

In conclusion, then, I may quote the closing summary of results made in my report upon a similar experiment last year. "The advantage in this trial lies, then, clearly with the animal meal as a food for egg-production. It has given more eggs of greater average weight and at considerably less cost than the bone; and it is, moreover, a more convenient food to use, as well as safer." In one respect only is the animal meal apparently inferior to the bone this year, viz., the fowls getting it weigh less at the close of the experiment than the others. This loss in weight is, however, far more than covered by the greater value of eggs produced.

We have now carried through five experiments, comparing these two feeds. Two have given results slightly favorable to the bone in number of eggs; one a similar result in favor of the animal meal; and two — the two last, which have been the most perfectly carried out — have been most decisively favorable to the animal meal. The latter has also been found the safer food. *The greatly preponderating weight of the evidence afforded by these experiments, which have been most carefully conducted, is, therefore, in favor of the animal meal.*

3. Narrow v. Wide Ration for Egg-production.

The experiments coming under this head have been two, one extending from December 12 to April 30, the other from May 1 to October 4. The object in view was to test the correctness of the generally held opinion that the food of the laying hen must be very rich in nitrogenous constituents. As we have carried out the experiment, it amounts to a substitution of corn meal for wheat middlings and gluten feed in the morning mash, and the replacement of about one-half of the oats and the wheat fed at night with the corn. The proportions of cut clover and of animal meal have remained the same in the two rations.

The health of the fowls on both rations has been uniformly good throughout both the winter and summer test, with a single exception, — the loss of one fowl from the effects of indigestion, — on the wide ration. It was found to require the exercise of more judgment in feeding to keep the fowls on the heavier corn ration in perfect condition. They were more easily overfed, and on two or three occasions lost appetite for their feed for short periods.

The Winter Experiment.

On December 12 the pullets, 19 in each lot, weighed as follows: narrow ration, 101.75 pounds; wide ration, 102.5

pounds. The first lot had laid, November 12 to December 12, 127 eggs; the other lot, 85 eggs, and one in this lot was broody. The foods consumed during the winter experiment and other details are shown in the following table: —

Foods consumed, Narrow v. Wide Ration (December 12 to April 30).

KINDS OF FOOD.	Narrow Ration.	Wide Ration.
	lbs. oz.	lbs. oz.
Wheat,	257 0	126 0
Oats,	147 0	63 0
Bran,	43 0	39 0
Middlings,	43 0	-
Gluten feed,	43 0	-
Animal meal,	43 0	39 0
Clover,	44 0	39 0
Corn meal,	-	108 0
Corn,	-	136 0
Cabbage,	18 5	16 5

Average Weight of the Fowls (Pounds).

DATES.	Narrow Ration.	Wide Ration.
December 12,	5.36	5.39
January 31,	5.41	5.84
February 25,	5.45	5.80
March 30,	5.16	5.57
April 30,	5.17	5.31

Number of Eggs per Month, Narrow v. Wide Ration, Winter Test.

MONTHS.	Narrow Ration.	Wide Ration.
December 12 to 31,	94	89
January,	99	148
February,	147	258
March,	310	317
April,	210	259
Totals,	860	1,071

Narrow v. Wide Ration for Egg-production, Winter Test.

	Narrow Ration.	Wide Ration.
Hen days,	2,529	2,538
Gross cost of foods,	$8 54	$6 56
Cost per hen day,	$0 0033	$0 0026
Total number of eggs,	860	1,071
Cost per egg,	$0 0099	$0 0061
Eggs per hen day,	.34—	.42+
Total weight of eggs (pounds),	102.425	130.53—
Average weight of eggs (ounces),	1.98	1.95
Dry matter to produce one egg (pounds),	.655	.46
Dry matter consumed per hen day (pounds),	.22	.19
Nutritive ratio,	1:4.7—	1:5.6—
Number of sitters,	30	24

Summer Experiment.

The summer experiment was continued with the same fowls that had been used in the winter. The method of feeding remained the same, save in two particulars: (1) in place of cut clover rowen in the mash every morning, lawn clippings in such quantity as the fowls would eat before wilting were fed three times per week, to each lot the same; and (2) the feeding of cabbages was discontinued. The yards (fifty by twenty-four feet) were kept fresh by frequent use of the cultivator. The health of one fowl only suffered during the experiment. One of the corn-fed fowls appeared dumpy for a few days, but was fully recovered in two weeks. As in the winter test, the fowls fed largely on corn showed less relish for their whole grain than the others. Food consumed and other details are shown below: —

Foods consumed, Narrow v. Wide Ration (May 1 to October 4).

Kinds of Food.	Narrow Ration.	Wide Ration.
	Lbs.	Lbs.
Wheat,	276	131½
Oats,	97	43
Bran,	43	40
Middlings,	43	–
Animal meal,	43	40
Corn meal,	–	106½
Corn,	–	217½
Gluten feed,	43	16

Average Weight of the Fowls (Pounds).

Dates.	Narrow Ration.	Wide Ration.
April 30,	5.17	5.31
June 11,	5.00	5.25
July 16,	5.47	5.22
August 11,	5.05	5.50
Before killing,	5.07	5.44
Dressed,	4.37*	4.81†

* Or 86 per cent. † Or 88 per cent.

Eggs per Month (Number).

Months.	Narrow Ration.	Wide Ration.
May,	216	292
June,	182	204
July,	157	210
August,	151	197
September,	139	174
October 1-14,	14	18
Totals,	859	1,095

Narrow v. Wide Ration for Egg-production, Summer Test.

	Narrow Ration.	Wide Ration.
Hen days,	2,355	2,512
Gross cost,	$7 56	$6 64
Cost per hen day,	$0 0032	$0 0026
Total number of eggs,	859	1,095
Cost per egg,	$0 0088	$0 0061
Eggs per hen day,	.36	.44
Total weight of eggs (pounds),	106.3	130
Average weight of eggs (ounces),	1.98	1.90
Dry matter to produce one egg (pounds),	.57+	.48+
Dry matter consumed per hen day (pounds),	.21—	.21+
Sitters,	67	60

The fowls on the wide (corn) ration laid three soft-shelled eggs during the winter test and one during the summer. These are not included in the tabular reports.

Study of the results reveals the following facts: —

1. *The hens on the wide (rich in corn) ration laid a great many more eggs in both the winter and in the summer experiments than those on the narrower ration.*

2. *The difference in favor of the wide ration amounts to 25 per cent. in the winter trial and to 33⅓ per cent. in the summer trial, upon the basis of equal number of hen days.*

3. *The total cost of feeds was less for the wide ration, and of course the cost per egg was much less. In the production of one hundred dozen eggs the saving on the basis of our winter test would amount to $4.56; on the basis of the summer test, to $3.24.*

4. *In average weight of the eggs produced there is a small difference in favor of the narrow ration; but in quality the weight of family evidence shows the eggs produced by the corn-fed hens to have been somewhat superior. They were deeper yellow and of a milder flavor than the eggs from the narrower ration.*

5. *The fowls on the wide ration gained somewhat in weight and were heavier at the close of the experiment than the others, notwithstanding the much larger number of eggs laid.*

At the close of the experiment the fowls were closely judged as to the condition of the plumage while still living, and it was decided that the corn-fed hens were farther advanced in moulting than the others. The fowls were slaughtered, and the judgment of the men removing the feathers coincided with the judgment on the living fowls.

The averages before and after dressing were as follows: narrow-ration fowls, 5.07 pounds; dressed weight, 4.37 pounds; wide-ration fowls, 5.44 pounds; dressed weight, 4.81 pounds. The narrow-ration fowls gave 86 per cent. dressed weight; the others, 88 per cent. The dressed fowls were judged by a market expert, who pronounced the corn-fed fowls slightly superior to the others.

The results are thus greatly in favor of the ration richer in *corn meal and corn; and so important will a knowledge of this fact prove (if confirmed by further trials), because of the cheapness of these foods as compared with wheat, that the experiment is being repeated this year with three different breeds of fowls, using corn yet more largely than last year.*

4. *Influence of the Cock on Egg-production.*

At the close of the winter tests the hens that had been used in the condition-powder and cut-bone experiments were matched in such a manner as to equalize previous feed conditions in four coops of sixteen fowls each. The fowls were all put upon the same feed, and egg records were kept for two weeks, to determine whether the fowls seemed evenly matched. At the end of the time a vigorous White Leghorn cock was placed in two of the coops. We had thus two experiments co-incidently running. These will be designated respectively test No. 1 and test No. 2.

Test No. 1. Influence of the Cock on Egg-production. — In the preliminary trial the hens in pen 1 laid 129 eggs; those in pen 2, 107 eggs. In the first pen five hens were brooding; in the second, seven. The fowls in both pens were fed alike, each receiving, in addition to the feed recorded, lawn clippings three times per week. The experiment began May 13 and extended to September 2. In calculating the food cost per hen day the cock is included in the hen days, but in calculating the number of eggs per hen day the cock is not included. No ill health or accidents of any kind occurred. The cock in the trial was in pen 1.

Foods consumed (May 14 to September 2).

Kinds of Food.	Pen 1.	Pen 2.
	Lbs.	Lbs.
Wheat,	194	194
Oats,	82	78
Bran,	32	32
Middlings,	32	32
Gluten feed,	32	32
Animal meal,	32	32

Average Weight of Fowls (Pounds).

Dates.		Pen 1.	Pen 2.
May	14, beginning,	5.12	5.09
June	11,	4.69	4.91
July	16,	4.91	4.94
August	11,	4.87	5.09
September	1, end,	4.82	4.95

Influence of Cock on Egg-production.

	Cock with Hens.	No Cock with Hens.
Hen days, including cock,	1,904	-
Hen days, without cock,	1,792	1,792
Gross cost of food,	$5 53	$5 49
Cost per hen day,	$0 0029	$0 0031
Total number of eggs,	631	630
Cost per egg,	$0 0088	$0 0087
Eggs per hen day,	.35+	.36—
Total weight of eggs (pounds),	77.3	76.79
Average weight of eggs (ounces),	1.96	1.95
Dry matter consumed per hen day (pounds),	.19	.20
Dry matter consumed per egg (pounds),	.58—	.57+
Nutritive ratio,	1:4.7—	1:4.7
Sitters,	41	45

Test No. 2. Influence of the Cock on Egg-production. — During the preliminary period the fowls in pen 5 laid 90 eggs, three offering to sit; those in pen 6 laid 107 eggs, five offering to sit. The cock was placed in pen 6. One hen in pen 6 was lame from July 6 to the end of the test; one in pen 5 was injured in the back on July 22, and died August 4. This test closed August 25.

Foods consumed (May 14 to August 25).

KINDS OF FOOD.	Pen 6.	Pen 5.
	Lbs.	Lbs.
Wheat,	179	161½
Oats,	80¾	81¾
Bran,	31½	30¼
Middlings,	31½	30¼
Gluten feed,	31½	30¼
Animal meal,	31½	30¼

Average Weight of Hens (Pounds).

DATES.	Pen 6.	Pen 5.
May 14,	4.91	5.06
June 11,	4.79	4.94
July 16,	4.91	5.09
August 11,	4.94	5.17
August 23,	4.72	5.02

Influence of the Cock on Egg-production.

	Cock with Hens.	No Cock with Hens.
Hen days,	1,664	1,643
Hen days with cock,	1,768	–
Gross cost of foods,	$5 24	$4 89
Cost per hen day,	$0 0030	$0 0030
Total number of eggs,	629	526
Cost per egg,	$0 0083	$0 0093
Eggs per hen day,	.38+	.33–
Total weight of eggs (pounds),	77.84	64.76
Average weight of eggs (ounces),	1.98	1.97
Dry matter to produce 1 egg (pounds),	.55	.63–
Dry matter consumed per hen day (pounds),	.20	.20
Nutritive ratio,	1:4.8	1:4.7
Sitters,	35	33

Study of these results shows that the cock was without apparent influence upon the egg product of these fowls. The differences are very small, too insignificant to have much weight, even if in both trials of the same nature. When we note, however, that in one trial the balance was very slightly in favor of the set of fowls with which the cock was kept, and that in the other trial it was with the fowls kept without the cock, we must conclude that the results prove neither benefit nor injury due to the presence of the male. In one respect only is there agreement in the results of the two trials; the average weight of the eggs from the hens with which a male was kept was slightly the greater in both trials. It seems not impossible that this effect may be due to the fact that the eggs had been fertilized. The difference is, however, exceedingly small, and would be wholly without significance to the producer of eggs for market or for table use.

REPORT OF THE ENTOMOLOGIST.

CHARLES H. FERNALD.

The work of the past season has been along the lines indicated in a previous report, so far as time and circumstances would permit. It has seemed desirable to give especial attention to the immediate needs of the citizens of this Commonwealth, as indicated by the extensive correspondence, from which one is enabled to gain a pretty clear idea of the insects especially troublesome, and upon which help is needed, from year to year. The work on the gypsy and brown-tail moths has demanded a large amount of time, not only in frequent inspections of the field work in the infested territory, but also in planning and directing the scientific part of the work.

A monograph of the plume-moths (*Pterophoridæ*) of North America was prepared and published in the last college report, and a revised edition was issued in July as a special bulletin from this station. Such monographs are absolutely essential as foundation work in economic entomology. I am now at work, when other duties permit, on a similar monograph of the two remaining families of the *Pyralidæ*. Mr. Cooley's monograph on the genus *Chionaspis*, a group of very pernicious scale insects, is now quite far advanced, and will soon be ready for publication.

The San José Scale.

This insect has now unfortunately become established in various parts of the State, and has been sent here for determination during the past season more frequently than any other. This pest, as well as several other injurious scale insects, has been brought into the State and distributed among our fruit growers on nursery stock; and, unless present in large numbers, they are liable to be entirely overlooked, both by the nurseryman and the purchaser, but when they are discovered, not only does the purchaser suffer from the loss of his trees, but the nurseryman is sure to lose his trade. As a result, some of our more progressive dealers in nursery stock, by my advice, have built fumigating houses, and treat all stock received and sent out, with hydro-cyanic acid gas.

Many of the other States have enacted laws for the regular examination of their nurseries, and also prohibiting the introduction of nursery stock that has not been examined by an expert entomologist, appointed for that purpose by the State from which the stock was shipped, and accompanied by his certificate of examination. This has shut out the trade of our nurserymen more or less from all those States where such laws exist, and, at the same time, leaves Massachusetts as a dumping ground for the infested nursery stock of other States. It is evident, therefore, that we need some law to protect us against the introduction of the San José scale and other injurious insects.

The Grass Thrips.

The amount of damage to grass done by this insect has been estimated at more than that of all others combined. This may be an overestimate, but there is no doubt that it is one of the most destructive grass insects in this Commonwealth. Very little has been known of it, beyond the fact that it is very injurious; but no method of dealing with it has been suggested that promised any great degree of success. One of my assistants has worked out its life history and bred it through all of its stages, and will prepare a bulletin on it soon.

The Small Clover-leaf Beetle.

This insect (*Phytonomus nigrirostris*) is very common on the college farm, and is quite destructive to the clover on which it feeds. Its habits and life history will be published when the investigations now being made on it are completed. An allied species, the clover-leaf beetle (*Phytonomus punctatus*), is reported in various parts of this country, and is said to have done a great deal of damage.

The Buffalo Carpet Beetle.

The Buffalo carpet beetle has caused housekeepers more or less trouble for a long time, and the correspondence about this insect has been more extensive during the last ten years than on almost any other. My attention has recently been called to an invasion of this insect in the storehouse of the Geo. Gilbert Manufacturing Company, in Ware, where it was destroying woolen goods. After considering the matter very fully, the owners were advised to close the house as tightly as possible, and fumigate it with hydro-cyanic acid gas. Full instructions were given, in order that no accidents might occur from the use of this deadly gas.

Arsenate of Lead and Bordeaux Mixture.

Arsenate of lead has proved so valuable an insecticide for the destruction of the gypsy moth, as well as other insects, that several correspondents have inquired if it could be used with Bordeaux mixture. A trial was therefore made on several apple trees on my own grounds, with most excellent results and without any injury to the foliage, though the arsenate of lead was used in the proportion of five pounds to one hundred and fifty gallons of water. The fruit of these trees had been badly affected by the scab for several years, but after a single spraying with the above preparation the fruit in the fall was in excellent condition. Experiments will be performed with these substances another year, before giving a detailed account of the work.

REPORT OF THE CHEMIST.

DEPARTMENT OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.
Assistants: HENRI D. HASKINS, CHARLES I. GOESSMANN, SAMUEL W. WILEY.

Part I. — Report on Official Inspection of Commercial Fertilizers.
Part II. — Report on General Work in the Chemical Laboratory.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS IN 1898.

CHARLES A. GOESSMANN.

The number of licensed manufacturers and dealers in commercial fertilizers and agricultural chemicals during the past year is sixty-one. Thirty-five of these parties have offices for the general distribution of their goods in Massachusetts; the remainder reside in other States, — ten in New York, four in Connecticut, three in Vermont, three in Rhode Island, one in Maine, one in New Jersey, one in Illinois and two in Canada.

The distinct brands of fertilizer, including chemicals, licensed in the State, are two hundred and sixty-four.

Three hundred and seventy-eight samples of fertilizers have thus far been collected in the general market by experienced delegates of the station; of these, three hundred and sixty-three samples were analyzed at the close of November, 1898, representing two hundred and sixty-four distinct brands. The results of these analyses were published for distribution in three bulletins, Nos. 51, 54 and 57, of the Hatch Experiment Station of the Massachusetts Agricultural College, during the months of February, July and November, 1898.

The remaining samples and others coming into our hands before the expiration of the license, May 1, 1899, will be analyzed in due time, and the results published in conformity with our State laws for the regulation of the trade in commercial fertilizers.

The modes of chemical analysis adopted in our examination of fertilizers are, in all essential points, those recommended by the Association of Official Chemists.

For a better understanding and due appreciation of the trade in commercial fertilizers during the past year, the following abstract of our results is here inserted. To arrive at a correct conclusion, it must be borne in mind that only the lowest stated guarantee is legally binding on all sales: —

	1897.	1898.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	3	5
Number with two elements above the highest guarantee,	2	17
Number with one element above the highest guarantee,	60	77
Number with three elements between the lowest and highest guarantee,	69	85
Number with two elements between the lowest and highest guarantee,	63	93
Number with one element between the lowest and highest guarantee,	16	54
Number with two elements below the lowest guarantee,	6	19
Number with one element below the lowest guarantee,	29	90
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee,	3	5
Number with one element above the highest guarantee,	10	24

	1897.	1898.
Number with two elements between lowest and highest guarantee,	13	25
Number with one element between lowest and highest guarantee,	12	17
Number with two elements below the lowest guarantee,	3	2
Number with one element below the lowest guarantee,	6	8
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee,	10	18
Number between lowest and highest guarantee,	13	23
Number below the lowest guarantee,	1	15

A comparison of the above-stated results of our inspection during the years 1897 and 1898 shows no material differences regarding the general character of the fertilizers sold in our market. In a few cases it became our duty to communicate with the manufacturers, and ask for an explanation. Imperfect mixing proved in most of these cases the cause of differences between guarantee and our analysis. As the commercial value of the brand was not materially affected, with only two or three exceptions, the cases were passed over, after a satisfactory explanation from the party interested.

The present condition of the trade in commercial fertilizers offers exceptional advantages to provide efficient manures for the successful raising of farm and garden crops congenial to climate and soil. The fact that the most important essential articles of plant food, as nitrogen, potash and phosphoric acid, are freely offered for sale in our markets in forms suitable to change the manurial refuse of the farm as stable manure and vegetable compost into complete manures for the crops to be raised, deserves the most serious attention of farmers. *To render the stated waste products of the farm in a higher degree efficacious as a manure supply cannot be otherwise considered than as a most promising step in the direction of an economical supply of plant food for the production of farm and garden crops.*

As the manufacturer at best can only prepare his special or so-called complete fertilizers on general lines, not knowing the particular character and condition of the soil which receives them, it becomes the business of the farmer to make his selection with due care. An intelligent selection of fertilizers from among the various brands offered for sale requires, in the main, two kinds of knowledge; namely, that the brand of fertilizer in question actually contains the guaranteed quantities and qualities of essential articles of plant food at a reasonable cost, and that it contains them in such form and proportions as will best meet under existing circumstances the special wants of soil and crop.

As the physical conditions and chemical resources of soils in available plant food frequently differ widely even on the same farm, no definite rule can be given for manuring farm lands, beyond the advice to return to the soil in available form those plant constituents which the crops raised in preceding years have abstracted in exceptionally large proportion, and which will be especially called for by the crops to be raised.

To assist farmers in selecting their fertilizers with reference to the wants of the crops they wish to cultivate, the writer has for years published in his annual reports a compilation of the analyses of farm and garden crops, to serve as a guide to all interested in a rational mode of manuring plants. Copies of these compilations of analyses may be secured by asking for them at the office of the Hatch Experiment Station, at Amherst, Mass.

In making choice from among the so-called complete fertilizers, two points in particular seem to be worth remembering. *First*, select them with reference to the amount, the quality and the kind of essential constituents they are guaranteed to contain, and not merely with reference to the cost per ton; *mere trade names are no guarantee of fitness.* High-priced articles, when offered by reputable manufacturers, have proved in many instances cheaper than low-priced goods. *Second*, buy your supplies of reputable dealers, and insist in all cases on a statement of guaranteed composition.

Valuation of Commercial Fertilizers.

The market value of the higher grades of agricultural chemicals and compound fertilizers depends in the majority of cases on the amount and the particular form of the three essential articles of plant food which they contain, *i.e.*, nitrogen, potash and phosphoric acid. Supply and demand control the temporary market prices not less in the fertilizer trade than in other lines of commercial business.

The approximate value of a fertilizer, simple or compound, is obtained by multiplying the pounds contained in a ton of two thousand pounds by the trade value per pound of each of the three above-stated essential constituents of plant food present. The same course is adopted with reference to the different forms of each, wherever different prices are recognized in the trade. Adding the different values per ton obtained, we find the total value per ton at the principal place of distribution.

As farmers are quite frequently not in the position to secure the desired information regarding the market cost of fertilizers they wish to secure, the official inspectors of commercial fertilizers have aided them for years in ascertaining the current market prices of the following leading or standard raw materials: —

Sulphate of ammonia.	Ammoniate.
Nitrate of soda.	Castor pomace.
Muriate of potash.	Linseed meal.
Sulphate of potash.	Dried blood.
Cotton-seed meal.	Dried ground meat.
Dry ground fish.	Bone and tankage.
Azotin.	Plain superphosphates, etc.

which serve largely in the manufacture of good fertilizers for our market; and have published the results of their inquiries in the form of tables, stating the average trade values per pound, for the six months preceding, of the different kinds and forms of fertilizing materials at the leading places of distribution.

The values stated below are based on the condition of the fertilizer market in centres of distribution in New England during the six months preceding March, 1897 and 1898: —

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1897 and 1898 (Cents per Pound).

	1897.	1898.
Nitrogen in ammonia salts,	13.5	14.0
Nitrogen in nitrates,	14.0	13.0
Organic nitrogen in dry and fine ground fish, meat blood, and in high-grade mixed fertilizers,	14.0	14.0
Organic nitrogen in cotton-seed meal,	12.0	12.0
Organic nitrogen in fine bone and tankage,	13.5	13.5
Organic nitrogen in medium bone and tankage,	11.0	10.0
Phosphoric acid soluble in water,	5.5	4.5
Phosphoric acid soluble in ammonium citrate,	5.0	4.0
Phosphoric acid in fine bone and tankage,	5.0	4.0
Phosphoric acid in cotton-seed meal, castor pomace, wood ashes and fine-ground fish,	5.0	4.0
Phosphoric acid in coarse bone and tankage,	2.5	3.5
Phosphoric acid insoluble (in ammonium citrate) in mixed fertilizers,	2.0	2.0
Potash as sulphate (free from chlorides),	5.0	5.0
Potash as muriate,	4.5	4.25

From these figures it is apparent that some of the best forms of nitrogen and phosphoric acid have suffered, as a rule, a reduction in cost, as compared with preceding years.

For further details I have to refer to preceding annual reports.

Consumers of commercial manurial substances will do well to buy, whenever practicable, on a guarantee of composition of their essential constituents, and to see that the bill of sale recognizes the point of the bargain. Any mistake or misunderstanding in the transaction may be readily adjusted, in that case, between the contending parties.

The responsibility of the dealer ends with furnishing an article corresponding in its composition with the lowest stated quantity of each specified essential constituent.

It is of the first importance, when buying fertilizers for home composition, to consider their cost with reference to what they promise to furnish.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1898, to May 1, 1899), and the Brands licensed by Each.

The Armour Fertilizer Works, Chicago, Ill.: —
- Bone Meal.
- Bone and Blood.
- Ammoniated Bone and Potash.
- All Soluble.
- Bone, Blood and Potash.
- Grain Grower.

Wm. H. Abbott, Holyoke, Mass.: —
- Eagle Brand for Grass and Grain.
- Complete Tobacco Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.

Butchers' Rendering Association, Fall River, Mass.: —
- Bone and Tankage.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.
- Tankage.

H. J. Baker & Bro., New York, N.Y.: —
- Standard Un X Ld Fertilizer.
- Strawberry Manure.
- Potato Manure.
- Complete Cabbage Manure.
- A. A. Ammoniated Superphosphate.
- Complete Manure for General Use.
- Grass and Lawn Dressing.

C. A. Bartlett, Worcester, Mass.: —
- Fine-ground Bone.
- Animal Fertilizer.

Berkshire Mills Co., Bridgeport Conn.: —
- Complete Fertilizer.
- Ammoniated Bone Phosphate.

Hiram Blanchard, Eastport, Me.: —
- Fish, Bone and Potash, ⟨H⟩ B.
- Fish Scrap No. 2, ⟨H⟩ B.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Hill and Drill Phosphate.
- Farm and Garden Phosphate.
- Lawn and Garden Dressing.
- Fish and Potash.
- Potato and Vegetable Manure.
- Potato Phosphate.
- Market Garden Manure.
- Sure Crop Phosphate.
- Gloucester Fish and Potash.
- High-grade Fertilizer.
- Essex Fertilizer.
- Bone and Wood Ash Fertilizer.
- Nitrate of Soda.
- Dried Blood.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulphate of Potash.

William E. Brightman, Tiverton, R. I.: —
- Potato and Root Manure.
- Phosphate.
- Fish and Potash.

Bradley Fertilizer Co., Boston, Mass.: —
- X. L. Superphosphate.
- Potato Manure.
- B. D. Sea Fowl Guano.
- Complete Manures.
- Fish and Potash.
- Ammoniated Bone Phosphate.
- Breck's Lawn and Garden Dressing.
- Sulphate of Potash.
- Corn Phosphate.
- Muriate of Potash.
- Nitrate of Soda.
- Dissolved Bone.
- Fine-ground Bone.

Daniel T. Church, Providence, R. I. (E. Wilcox, general agent): —
- Church's B Special.
- Church's C Standard.
- Church's D Fish and Potash.

Clark's Cove Fertilizer Co., Boston, Mass.: —
- Bay State Fertilizer.
- Bay State Fertilizer G. G. Brand.

Clark's Cove Fertilizer Co. — *Con.*
- Great Planet Manure.
- Potato Fertilizer.
- King Philip Guano.
- Potato Manure.
- Fish and Potash.
- White Oak Pure Bone Meal.

Cleveland Dryer Co., Boston, Mass.: —
- Superphosphate.
- Potato Phosphate.
- Cleveland Fertilizer.

E. Frank Coe Co., New York, N. Y.: —
- High-grade Potato Fertilizer.
- Tobacco and Onion Fertilizer.
- High-grade Ammoniated Bone Superphosphate.
- Gold Brand Excelsior Guano.
- Fish Guano and Potash.
- Bay State Phosphate.
- Vegetable and Vine Fertilizer.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y.: —
- Ammoniated Bone Superphosphate.
- Potato, Hop and Tobacco Phosphate.
- Ammoniated Wheat and Corn Phosphate.
- New Rival Ammoniated Superphosphate.
- Vegetable Bone Superphosphate.
- General Crop Phosphate.
- Universal Grain Grower.
- Special Potato Manure.
- New England Tobacco and Potato Grower.

Cumberland Bone Phosphate Co., Boston, Mass.: —
- Superphosphate.
- Potato Fertilizer.
- Concentrated Phosphate.
- Fertilizer.

L. B. Darling Fertilizer Co., Pawtucket, R. I.: —
- Animal Fertilizer.
- Potato and Root Crop Manure.
- Tobacco Grower.
- Blood, Bone and Potash.
- Special Formula.
- Fine-ground Bone.
- Muriate of Potash.
- Nitrate of Soda.
- Farm Favorite.

John C. Dow & Co., Boston, Mass.: —
- Nitrogenous Superphosphate.
- Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
- Imperial Liquid Plant Food.

W. E. Fyfe & Co., Clinton, Mass.: —
- Wood Ashes.

Great Eastern Fertilizer Co., Rutland, Vt.: —
- Northern Corn Special.
- General Fertilizer.
- Vegetable, Vine and Tobacco Fertilizer.
- Garden Special.
- Grass and Oats Fertilizer.

Thomas Hersom & Co., New Bedford, Mass.: —
- Bone Meal.
- Meat and Bone.

Edmund Hersey, Hingham, Mass.: —
- Ground Bone.

Thomas Kirley, South Hadley Falls, Mass.: —
- Pride of the Valley.

Lister's Agricultural Chemical Works, Newark, N. J.: —
- Lister's Celebrated Onion Fertilizer.
- Lister's Success Fertilizer.
- Lister's Special Potato Fertilizer.
- Lister's Special Tobacco Fertilizer.

Lowell Fertilizer Co., Boston, Mass.: —
- Bone Fertilizer for Corn and Grain.
- Animal Fertilizer.
- Potato Phosphate.
- Bone and Potash.
- Lawn Dressing.
- Tobacco Manure.
- Fruit and Vine Fertilizer.
- Market-garden Fertilizer.
- Ground Bone.

Lowe Bros., & Co., Fitchburg, Mass.: —
- Tankage.

F. R. Lalor, Dunville, Ontario, Can.: —
- Canada Unleached Hard-wood Ashes.

The Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
Bone Manures.
Superphosphates.
Special Crop Manures.
Sulphate of Potash.
Double Manure Salts.
Nitrate of Soda.

E. McGarvey & Co., London, Ontario, Can.: —
Unleached Hard-wood Ashes.

McQuade Bros., West Auburn, Mass.: —
Fine-ground Bone.

Geo. L. Monroe, Oswego, N. Y.: —
Canada Unleached Hard-wood Ashes.

National Fertilizer Co., Bridgeport, Conn.: —
Complete Fertilizers.
Ammoniated Bone.
Market-garden Manure.
Potato Phosphate.
Fish and Potash.
Ground Bone.

Niagara Fertilizer Works, Buffalo, N. Y.: —
Wheat and Corn Producer.
Potato, Tobacco and Hop Fertilizer.
Niagara Triumph.

Packers Union Fertilizer Co., New York, N. Y.: —
Universal Fertilizer.
Wheat, Oats and Clover Fertilizer.
Animal Corn Fertilizer.
Potato Manure.
Gardener's Complete Manure.

Pacific Guano Co., Boston, Mass.: —
Soluble Pacific Guano.
Special Potato Manure.
Nobsque Guano.
High-grade General Fertilizer.
Grass and Grain Fertilizer.
Fish and Potash.
Pacific Guano with 10 per cent. Potash.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
Plymouth Rock Brand.
Star Brand Superphosphate.

Parmenter & Polsey Fertilizer Co. — *Con.*
Special Potato.
Strawberry and Small Fruits.
Ground Bone.
Muriate of Potash.
Sulphate of Potash.
Nitrate of Soda.
P. & P. Potato Fertilizer.

A. W. Perkins & Co., Rutland, Vt.: —
Plantene.

Prentiss, Brooks & Co., Holyoke, Mass.: —
Complete Manures.
Phosphate.
Nitrate of Soda.
Muriate of Potash.
Sulphate of Potash.

Preston Fertilizer Co., Brooklyn, N. Y.: —
Pioneer.
Potato Fertilizer.
Superphosphate, I.

Quinnipiac Co., Boston, Mass.: —
Phosphate.
Potato Manure.
Market-garden Manure.
Fish and Potash.
Grass Fertilizer.
Corn Manure.
Potato Phosphate.
Climax Phosphate.
Pure Ground Bone.
Muriate of Potash.
Sulphate of Potash.
Nitrate of Soda.
Kainit.
Dissolved Bone-black.

Benjamin Randall, East Boston, Mass.: —
Market-garden Fertilizer.
Farm and Field.
Ground Raw Bone.

Read Fertilizer Co., New York, N. Y. (H D Foster, general agent): —
Standard Fertilizer.
High-grade Farmers' Friend.
Practical Potato Special.
Vegetable and Vine.
Fish, Bone and Potash.

N. Roy & Son, South Attleborough, Mass.: —
Complete Animal Fertilizer.

The Rogers & Hubbard Co., Middletown, Conn.: —
Hubbard's Soluble Potato Manure.
Hubbard's Soluble Tobacco Manure.
Hubbard's Fairchild's Formula for Corn and General Crops.
Hubbard's Grass and Grain Fertilizer.
Hubbard's Oats and Top-dressing Fertilizer.
Hubbard's Pure Raw Knuckle Bone Flour.
Hubbard's Strictly Pure Fine Bone.
Hubbard's Fertilizer for all Soils and all Crops.

Russia Cement Co., Gloucester, Mass.:—
X X X Fish and Potash.
High-grade Superphosphate.
Corn, Grain and Grass Manure.
Potato, Root and Vegetable Manure.
Odorless Lawn Dressing.
Potato Fertilizer.
Dry Ground Fish.
Special Manure for Carnations.

Lucien Sanderson, New Haven, Conn.:—
Formula A.
Blood, Bone and Meat.
Dissolved Bone-black.
Nitrate of Soda.
Sulphate of Potash.
Muriate of Potash.
Sanderson's Old Reliable Superphosphate.
Sanderson's Potato Manure.

Edward H. Smith, Northborough, Mass.: —
Ground Bone.

Thomas L. Stetson, Randolph, Mass.: —
Ground Bone.

Standard Fertilizer Co., Boston, Mass.:—
Standard Fertilizer.
Standard Guano.
Complete Manure.
Special for Potatoes.

C. F. Sturtevant, Hartford, Conn.: —
Tobacco and Sulphur Fertilizer.

Henry F. Tucker, Boston, Mass.: —
Original Bay State Bone Superphosphate.
Imperial Bone Superphosphate.
Special Potato Fertilizer.
Bay State Special.

Andrew H. Ward, Boston, Mass.: —
Ward's Chemical Fertilizer.

I. S. Whittemore, Wayland, Mass.: —
Complete Manure.

D. Whithead, Lowell, Mass.: —
Champion Garden Fertilizer.
Bone Meal.

The Wilcox Fertilizer Works, Mystic, Conn.: —
Potato, Onion and Tobacco Manure.
High-grade fish and potash.
Dry Ground Fish Guano.
Fish and Potash 1895 Brand.

Williams and Clark Fertilizer Co., Boston, Mass.: —
Ammoniated Bone Superphosphate.
Potato Phosphate.
High-grade Special.
Fine Wrapper Tobacco Grower.
Royal Bone Phosphate.
Corn Phosphate.
Potato Manure.
Grass Manure.
Fish and Potash.
Prolific Crop Producer.
Onion Manure.
Bone Meal.
Dry Ground Fish.
Sulphate of Potash.
Muriate of Potash.
Nitrate of Soda.
Dissolved Bone-black.

M. E. Wheeler & Co., Rutland, Vt.: —
High-grade Corn Fertilizer.
High-grade Potato Manure.
Superior Truck Fertilizer.
High-grade Fruit Fertilizer.
High-grade Grass and Oats Fertilizer.

A. L. Warren, Northborough, Mass.: —
Fine-ground Bone.

Sanford Winter, Brockton, Mass.: —
Fine-ground Bone.

PART II. — REPORT ON GENERAL WORK IN THE CHEMICAL LABORATORY.

CHARLES A. GOESSMANN.

1. Analyses of Materials sent on for Examination.
2. Notes on Wood Ashes, Condition of Trade, etc.
3. Notes on Fertilizers for Pot Cultivation and Greenhouses.
4. Observations regarding the Action of Acid and Basic Phosphates on the Availibility of the Nitrogen in Blood, Steamed Leather and Leather Scraps.
5. Notes on the Determination of the Available Phosphoric Acid in the Soil.
6. Analyses of Drainage Waters obtained in Connection with Some Field Experiments carried on upon the Grounds of the Station.

1. Analyses of Materials sent on for Examination.

The number of substances tested in this connection amount to several hundred. The results of our examination are already published in detail in Bulletins 51, 54 and 57 of the Hatch Experiment Station of the Massachusetts Agricultural College, in connection with the results of the official inspection of commercial fertilizers collected from original packages by an efficient delegate of the station.

The responsibility of the genuineness of the articles sent on for examination rests in all cases with the parties asking for the analysis. Our publication of the results refers merely to the locality they come from, to avoid misunderstandings. The work carried on in this connection is growing from year to year in importance.

A large proportion of commercial manurial substances consist of by or waste products of various industries. The composition and general character of these materials depend on the current mode of manufacture. The rapid advancement in many branches of industries is at any time liable to affect more or less seriously the commercial as well as the manurial value of their waste products. A frequent examination of that class of materials cannot fail to benefit the vital interests of our farming community. For this reason, arrangements were made, as in previous years, to attend to the examination of substances of interest to farmers, to the full extent of the resources placed at the disposal of the officer in charge of this work.

These investigations are carried on free of charge to farmers of the State, and as far as the financial resources of the laboratory admit. The examination of the materials is, as a rule, carried on in the order they arrive at the station, and the results are considered public property.

The following statement of the names of the different articles sent on and thus far analyzed may suffice here to convey some more definite idea concerning the general character of the work: —

Materials sent on, Dec. 1, 1897, to Dec. 1, 1898.

Air-dried potatoes,	9	Peat,	1
Acid phosphate,	2	Nitrate of soda,	3
Ashes from cremation of garbage,	1	Sulphate of ammonia,	1
Bleachery refuse,	2	Sulphate of potash and magnesia,	1
Broom corn seed,	1	Sulphate of potash,	2
Cotton-seed meal,	2	Sweet clover hay,	3
Compound fertilizers,	21	Sulphate of magnesia,	1
Cremation ashes,	1	Soya bean refuse,	1
Dissolved bone-black,	1	Starch,	2
Fodder material,	1	Sewage,	1
Ground bone,	9	Soil,	12
Ground fish,	1	Silicate of potash,	1
Hop refuse,	1	Tankage,	3
Lime-kiln ashes,	2	Tobacco stems,	1
Liquid fertilizer,	1	Tobacco refuse,	1
Manure,	12	Teopik fibre,	1
Marl,	1	Wood ashes,	79
Muriate of potash,	3	Wool waste,	1
Muck,	5	Whale-bone scrapings,	1
Minerals,	3	Vat deposit,	1
Oxalic acid,	1		

A few of the more important of the above-stated materials, as wood ashes, etc., are discussed more at length in subsequent pages.

2. Notes on Wood Ashes.

Wood ashes for manurial purposes are in our State subject to official inspection, and dealers in that commodity have to secure a license to sell in our State before they can legally advertise their articles for sale. This circumstance makes it obligatory on the dealers to state the amount of potash and of phosphoric acid they guarantee in these materials, and to fasten that statement upon the package or car, etc., which contains them.

Some dealers in wood ashes have adopted of late the practice of stating merely the sum of both, instead of specifying the amount of each of them present. As phosphoric acid and potassium oxide contained in wood ashes are considered, in our section of the country, pound for pound of an equal commercial value, from 4.5 to 5 cents, no particular objection can be raised against a joint statement of both, as far as the mere money value of the samples is concerned; yet, as this mode of stating the guaranteed composition is apt to lead to misconception and abuse, it ought to be discouraged and discontinued.

As the dealer is only obliged to guarantee the amount of potash and of phosphoric acid present in a given quantity of wood ashes, no serious objection can be raised on the part of the buyer on account of moisture, etc., as long as the article contains the specified amount of both potash and phosphoric acid. Wood ashes ought to be bought and sold by weight, and not by measure, for both moisture and the general character of foreign matters are apt to seriously affect the weight of a given measure.

During the past year (1898) 40.1 per cent. of the materials sent on for analysis consisted of wood-ash samples; during the preceding year (1897) they amounted to 40 per cent.

The general character of the wood ashes sold during the stated years may be judged from the following classified statement of our results: —

		No. of Samples. 1897.	1898.
Moisture from 1 to 3 per cent.,		10	9
Moisture from 3 to 6 per cent.,		8	6
Moisture from 6 to 10 per cent.,		13	20
Moisture from 10 to 15 per cent.,		19	22
Moisture from 15 to 20 per cent.,		11	16
Moisture from 20 to 30 per cent.,		10	6
Moisture above 35 per cent.,		1	–
Potassium oxide above 8 per cent.,		3	4
Potassium oxide from 7 to 8 per cent.,		8	6
Potassium oxide from 6 to 7 per cent.,		21	8
Potassium oxide from 5 to 6 per cent.,		28	22
Potassium oxide from 4 to 5 per cent.,		10	25
Potassium oxide from 3 to 4 per cent.,		3	11
Potassium oxide below 3 per cent.,		–	3
Phosphoric acid above 2 per cent.,		4	6
Phosphoric acid from 1 to 2 per cent.,		45	60
Phosphoric acid below 1 per cent.,		24	13
Average per cent. of calcium oxide (lime),		34.29	33.60
Per cent. mineral matter insoluble in diluted hydrochloric acid, from —	below 5,	–	1
	6 to 10,	10	16
	10 to 15,	30	31
	15 to 20,	15	15
	20 to 30,	3	13
	above 30,	1	-

As the majority of dealers in wood ashes guarantee from 4.5 to 6 per cent. of potassium oxide in their articles, it will be seen that a large number of the samples are below even the lowest guarantee; showing, on the whole, that the quality of wood ashes sold in 1898 as a potash source has been inferior, when compared with the preceding year. Whether this circumstance is due to a general decline of the article or to the management of any particular importer or dealer is difficult to decide on our part, as long as farmers do not state the name of the party from whom they have bought, or the cost per ton of the ashes they send on for examination.

It is most desirable to ascertain whether the general character of the wood ashes is gradually declining from natural causes, or whether some parties are handling inferior goods. All interested in the solution of this question will confer a favor on us by sending with their samples of wood ashes the names of the party from whom they bought the article, and state the price per ton asked at the nearest depot for general distribution.

The large percentage of lime, from 30 to 40 per cent., found in genuine wood ashes, imparts a special agricultural value to them as a fertilizer, aside from the amount of potash and phosphoric acid they contain. Wherever an application of lime is desired, wood ashes deserve favorable consideration, on account of the superior mechanical condition of the lime they furnish.

3. Notes on Fertilizers suitable for raising Plants in Pots and Greenhouses.

The interest in raising plants in pots and under glass in greenhouses, by the aid of commercial fertilizers, is gradually increasing, judging from numerous applications for information.

The following analyses represent two samples of fertilizers recommended for that purpose; they were sent on for a general analysis by parties interested in the matter: —

1. Plant Food in Pellet Form, sent on from Newtonville, Mass.

	Per Cent.
Moisture,	3.39
Organic and volatile matter,	41.15
Ash constituents,	58.85
Water soluble material,	82.40
Insoluble residue (in water),	17.60
Total phosphoric acid,	16.59
Soluble phosphoric acid,	14.58
Reverted phosphoric acid,	1.67
Insoluble phosphoric acid,	.34
Potassium oxide, total,	7.96
Potassium oxide, water soluble,	7.63
Sodium oxide,	6.19
Calcium oxide,	4.04
Magnesium oxide,	5.30
Chlorine,	6.05
Sulphuric acid (SO_3),	17.17
Total nitrogen,	7.65
Nitrogen as ammoniates,	7.06
Nitrogen as nitrates,	.50
Nitrogen as organic matter,	.09
Insoluble matter in dilute hydrochloric acid (clay),	14.33

Water solution strongly acid.

2. Liquid Fertilizer sent on from Natick, Mass.

	Per Cent.
Moisture,	90.46
Solid residue,	9.54
Phosphoric acid,	1.24
Potassium oxide,	2.79
Sodium oxide,	1.67
Calcium oxide,	1.82
Magnesium oxide,	.07
Chlorine,	.02
Sulphuric acid (SO_3),	–
Total nitrogen,	1.12
Nitrogen as ammoniates,	.39
Nitrogen as nitrates,	.73
Reaction strongly acid.	

The importance of the interests involved induced the writer some years ago to enter upon a series of experiments, to assist in the development of a more efficient system of manuring several important industrial crops, fruits and garden vegetables. The first results of that investigation are published in the eleventh and twelfth reports of the director of the Massachusetts State Agricultural Experiment Station, to which I have to refer for details. Those of later years are contained in the annual report of the Hatch Experiment Station of the Massachusetts Agricultural College for 1896 and 1897.

In the course of my discussion of the lessons to be derived from the above-stated experiment in field and vegetation house, it was recommended to observe the following rules: —

1. To avoid an accumulation of half-decayed vegetable matter in the soil, and to enrich the latter in the desired direction by means of concentrated chemical manures.

2. To change, wherever practicable, from season to season the position of the various crops, to favor the destruction of parasites and to economize the inherent sources of plant food.

3. To avoid an accumulation of salines in the soil, not called for by the crops, or considered injurious to the chemical or physical properties of the soil.

4. To prevent a marked acidity of the soil, by a periodical application of air-slacked lime, wood ashes, etc.

5. To select the various commercial forms of nitrogen, and potash in particular, with special reference to the kind and the desired character of the crop to be raised.

6. To use as a general fertilizer a mixture of two parts of available potassium oxide, one part of available nitrogen and one part of available phosphoric acid, in such quantities per acre as the conditions of the soil and composition of the crop to be raised called for; allowing, for the composition of one thousand pounds of green garden vegetables, on an average: —

	Pounds.
Nitrogen,	4.01
Phosphoric acid,	1.90
Potassium oxide,	3.90

On account of the frequent cultivation of beans and peas as garden crops, a fertilizer of the following composition suggested itself to me: —

	Parts.
Available nitrogen,	1
Available potash,	2
Available phosphoric acid,	1

More recent observations confirm the advisability of the previously stated rules in a general way; yet they also emphasize the fact that, wherever the quality of the crop controls its economical and commercial value, it seems advisable that care should be taken to secure the exclusion of an accumulation of soluble saline substances not called for by the crop. This circumstance deserves particular attention in cultivation under glass, where the body of the soil is limited, and the removal of such substances by percolation to the lower layers offers but little chance of relief.

In our experiments above described this view of the question of supplying plant food in the greenhouse has aided us in selecting a series of concentrated chemical manures, which for the above reason are now recommended for patronage: —

Name of Substance.	Potassium Oxide (Per Cent.).	Phosphoric Acid (Per Cent.).	Nitrogen (Per Cent.).
High-grade muriate of potash,	50.00	-	-
High-grade sulphate of potash,	50.20	-	-
Potash-magnesia sulphate,	24.32	-	-
Carbonate of potash-magnesia,	18.48	-	-
Phosphate of potash,	32.56	35.70	-
Dissolved bone-black,	-	13.88	-
Odorless phosphate, phosphatic slag,	-	18.42	-
Double superphosphate,	-	47.80	-
Phosphate of ammonia,	-	43.86	10.37
Dried blood,	-	4.02	10.00
Nitrate of soda,	-	-	14.28
Sulphate of ammonia,	-	-	19.59

As the local conditions of the soil and the composition of the individual characteristics of the plants to be raised deserve especial attention, when selecting from the above-stated commercial manurial substances the constituents for the fertilizer mixtures to be used, it cannot be considered judicious to recommend any particular combination as being unfailing and best in all cases. For this reason it has been thought best to state in this connection, as a mere matter of illustration, a few combinations of manurial substances which served us well, as may be noticed from a few preceding annual reports, — State Experiment Station, 1893, pages 241 to 261; and 1894, pages 274 to 285.

The amount of fertilizer recommended per acre, under fair conditions of the soil, contains: —

	Pounds.
Available nitrogen,	60
Available phosphoric acid,	60
Available potash,	120

Some Combinations of High-grade Substances for Use in Garden, Greenhouse and Pots.

1. Nitrate of soda.
   High-grade sulphate of potash.
   Dissolved bone-black.
2. Sulphate of ammonia.
   High-grade sulphate of potash.
   Dissolved bone-black.
3. Dried blood.
   High-grade sulphate of potash.
   Dissolved bone-black.
4. Nitrate of soda.
   Muriate of potash.
   Dissolved bone-black.

Mixtures of muriate of potash and sulphate of ammonia have proved in our experience in many cases objectionable, on account of a mutual decomposition into chloride of ammonia and sulphate of potash.

4. Observations with Dried Blood and Two Kinds of Leather Refuse as the Sources of Nitrogen for growing Rye in Presence of Acid and of Alkaline Phosphates.

In a preceding report an experiment has been briefly described in which dried blood has been compared with leather refuse as a nitrogen source for growing plants, when used in connection with double phosphate and muriate of potash. The differences of the crops raised were more marked with reference to the yield of the straw than to that of the grain. (For details, see annual report of the Massachusetts State Agricultural Experiment Station for 1894, pages 283–285.) It seemed advisable to repeat the experiments, with such modifications as experience suggested, to secure, if possible, *more decisive results*, and to ascertain whether the degree of availability of the nitrogen contained in the dried blood and in the leather refuse would not be more strikingly modified by using *alkaline phosphates* instead of *acid phosphates* as the phosphoric acid source.

The following course was adopted. Winter rye was again selected for the observation. The soil used was taken from the same locality, at eighteen inches below the surface, and freed from coarse materials by repeated screening through a sand screen, as in the first experiment. The fertilizers used were in each case carefully distributed throughout the entire body of the soil. The boxes were the same which had been used in the preceding experiments, containing from seventy-five to eighty pounds of soil, having a depth of eighteen inches.

Six boxes were employed in the experiment; three served for the trial with acid phosphate, — dissolved bone-black; and three with an alkaline phosphate, — phosphatic slag meal. The following mixtures of fertilizers were used (weights are stated in grams; thirty grams equal to one ounce) : —

First Lot, Nos. 1, 3 and 5.

Box 1.

Sulphate of potash,	7.68
Dissolved bone-black,	24.38
Dried blood,	40.22

Box 3.

Sulphate of potash,	7.68
Dissolved bone-black,	24.38
Philadelphia tankage (a steamed leather refuse),	57.16

Box 5.

Sulphate of potash,	7.68
Dissolved bone-black,	24.38
Raw-leather waste,	56.64

Second Lot, Nos. 2, 4 and 6.

Box 2.

Sulphate of potash,	7.68
Phosphatic slag meal,	24.38
Dried blood,	40.22

Box 4.

Sulphate of potash,	7.68
Phosphatic slag meal,	24.38
Philadelphia tankage (a steamed leather refuse),	57.16

Box 6.

Sulphate of potash,	7.68
Phosphatic slag meal,	24.38
Raw-leather waste,	56.64

The Seed. — Winter rye was planted in all boxes Oct. 2, 1894. The young plants came up uniformly in all boxes October 5. They reached a height of from five to six inches before frost set in. After being fully developed, they were reduced in all the boxes to a corresponding number, as in the first experiment.

The watering of the soil was partly by subirrigation and partly by surface application, maintaining as far as practicable the moisture of the soil from 15 to 18 per cent. during the growing season. The experiment was conducted with a view to expose the soil to the unrestricted influence of the local temperature of the various seasons. A layer of snow served as protection to the young growth during severe spells of frost in winter.

The manurial substances used consisted of high-grade sulphate of potash, dissolved bone-black, phosphatic slag meal, dried blood, Philadelphia tankage (a steamed leather), and ground sole leather waste. The amount of nitrogen and potassium oxide applied was the same in each case, while the amount of total phosphoric acid applied in case of the phosphatic slag meal was one-fourth more than in the case of the dissolved bone-black, which is practically all soluble in water.

Composition of the Manurial Substance used, with Reference to Potash, Phosphoric Acid and Nitrogen (Per Cent.).

	Potassium Oxide.	Phosphoric Acid.	Nitrogen.
Sulphate of potash,	50.20	-	-
Dissolved bone-black,	-	14.00	-
Phosphatic slag meal,*	-	18.40	-
Dried blood,	-	4.00	10.00
Philadelphia tankage (steamed leather),	-	-	7.80
Ground leather waste,	-	-	7.02

* Calcium oxide, 48.6 per cent.

They grew at a similar rate during spring until the latter part of April, when those which had received dried blood as nitrogen source (boxes 1 and 2) became more stalky, developing more and broader leaves than the plants in boxes 3, 4, 5 and 6. This difference in their growth became more marked as the season advanced.

The following statement gives the average height of the plants at various stages of observation (inches) : —

	May 1.	May 9.	May 20.	June 1.
Box 1,	8.0	21.5	34.0	50.0
Box 3,	7.0	16.5	24.0	32.0
Box 5,	6.0	14.0	22.5	30.5
Box 2,	9.0	26.0	38.0	56.5
Box 4,	7.0	17.5	25.0	32.5
Box 6,	7.0	17.5	26.0	35.0

The plants in all boxes began blooming about the same time, the first week of June; they were harvested the first week of July. There was no marked difference in regard to time of maturing. The general character of the matured growth will be seen from the subsequent statement of the weights of the average plant in each case (grams) : —

	Box 1.	Box 3.	Box 5.	Box 2.	Box 4.	Box 6.
Moisture,	8-9	8-9	8-9	8-9	8-9	8-9
Total plant,	57.87	26.02	28.80	115.99	30.27	36.21
Kernels,	12.77	5.43	5.80	28.89	6.18	9.75
Chaff and straw,	45.12	20.69	23.00	87.10	24.09	26.46
One hundred kernels,	1.58	1.44	1.48	1.79	1.58	1.62

The plants were in all cases cut two inches above their roots. As it was of interest to know the amount of nitrogen in the kernels of the highest and lowest weights, a nitrogen determination of the kernels obtained in boxes 1 and 3, and 2 and 4 was carried out. The analyses gave the following results : —

No. of Box.	Per Cent. Nitrogen.	Fertilizing Elements Used.
1,	1.84	Dried blood, dissolved bone-black.
3,	1.91	Philadelphia tankage, dissolved bone-black.
2,	2.31	Dried blood, phosphatic slag.
4,	2.19	Philadelphia tankage, phosphatic slag.

Fodder Analyses of Rye Samples (Kernels) as far as Material on Hand sufficed for a Complete Analysis. Samples grown in Boxes 1, 2, 3 and 4 (Per Cent.).

	Box 1.	Box 2.	Box 3.	Box 4.
Moisture,	10.45	9.92	4.87	8.50
Dry matter,	89.55	90.08	95.13	91.50
	100.00	100.00	100.00	100.00

Analysis of Dry Matter.

	Box 1.	Box 2.	Box 3.	Box 4.
Fat,	2.05	2.00	2.12	1.97
Protein,	11.50	14.44	11.94	13.69
Cellulose,	1.55	1.65	1.65	1.62
Ashes,	1.95	1.52	2.20	1.44
Carbohydrates,	82.95	80.39	82.09	81.28
	100.00	100.00	100.00	100.00

Judging from the results obtained in connection with the described experiment the following conclusions suggest themselves : —

Conclusions. — The alkaline phosphate (phosphatic slag meal) has under fairly corresponding conditions increased the availability of the nitrogen contained in steamed leather, in leather scraps and in dried blood in a higher degree than the acid phosphate. The influence is apparent alike in the general character of the entire plant and in the composition of the kernels. The difference in the relative agricultural value of both articles as nitrogen sources remains, however, the same ; for leather in any form, without a previous destruction of the tanning principle, tannin, is worthless for manurial purposes.

5. Contribution to the Determination of the Available Phosphoric Acid in Soils under Cultivation.

The fact that agricultural chemists have thus far failed to point out any mode of soil analysis as reliable, by which the amount of phosphoric acid available to crops can be ascertained, is pretty generally recognized. Attempts are not wanting to solve this important question. Among the well-known investigations in that direction are those of Dr. B. Deyer (1894). Results of later years obtained in this connection upon soils of well-known history at Rothamsted in England are pronounced very encouraging by Dr. Gilbert. The American Association of Official Chemists has during the past year entered upon a systematic investigation regarding the best course to be adopted to determine the available phosphoric acid; in this work the writer has taken some part. A compilation of the contributions to these more recent experiments is to be published soon by the United States Department of Agriculture.

Our local observations at Amherst are briefly described in a few subsequent pages upon a field which had been under careful observation for five years, 1890–95. The following brief abstract of the management of the field work shows the condition of the soil which served for our investigation: —

Field F.

The field selected for this purpose is 300 feet long and 137 feet wide, running on a level from east to west. Previous to 1887 it was used as a meadow, which was well worn out at that time, yielding but a scanty crop of English hay. During the autumn of 1887 the sod was turned under and left in that state over winter. It was decided to prepare the field for special experiments with phosphoric acid by a systematic exhaustion of its inherent resources of plant food. For this reason no manurial matter of any description was applied during the years 1887, 1888 and 1889.

The soil, a fair sandy loam, was carefully prepared every year by ploughing during the fall and in the spring, to improve its mechanical condition to the full extent of existing circumstances. During the same period a crop was raised every year. These crops were selected, as far as practicable, with a view to exhaust the supply of phosphoric acid in particular. Corn, Hungarian grass and leguminous crops (cow-pea, vetch and serradella) followed each other in the order stated.

1890. — The field was subdivided into five plats, running from east to west, each twenty-one feet wide, with a space of eight feet between adjoining plats.

The manurial material applied to each of these five plats contained, in every instance, the same form and the same quantity of potassium oxide and of nitrogen, while the phosphoric acid was furnished in each case in the form of a different commercial phosphoric-acid-containing article, namely, phosphatic slag, Mona guano, Florida phosphate, South Carolina phosphate (floats) and dissolved bone-black. The market cost of each of these articles controlled the quantity applied, for each plat received the same money value in its particular kind of phosphate.

Analyses of Phosphates used.

[I., phosphatic slag; II., Mona guano; III., Florida phosphate; IV., South Carolina phosphate; V., dissolved bone-black.]

	Per Cent.				
	I.	II.	III.	IV.	V.
Moisture,	.47	12.52	2.53	.39	15.96
Ash,	–	75.99	89.52	–	61.46
Calcium oxide,	46.47	37.49	17.89	46.76	–
Magnesium oxide,	5.05	–	–	–	–
Ferric and aluminic oxides,	14.35	–	14.25	5.78	–
Total phosphoric acid,	19.04	21.88	21.72	27.57	15.82
Soluble phosphoric acid,	–	–	–	–	12.65
Reverted phosphoric acid,	–	7.55	–	4.27	2.52
Insoluble phosphoric acid,	–	14.33	–	23.30	.65
Insoluble matter,	4.39	2.45	30.50	9.04	6.26

The following fertilizer mixtures have been applied annually to all the plats, with the exception of Plat 3, which received in 1890 ground apatite and in 1891 no phosphate whatever: —

Plats.	Annual Supply of Manurial Substances.	Pounds.
Plat 1 (south, 6,494 square feet),	Ground phosphatic slag, Nitrate of soda, Potash-magnesia sulphate,	127 43 58
Plat 2 (6,565 square feet),	Ground Mona guano, Nitrate of soda, Potash-magnesia sulphate,	128 43½ 59
Plat 3 (6,636 square feet),	Ground Florida phosphate, Nitrate of soda, Potash-magnesia sulphate,	129 44 59
Plat 4 (6,707 square feet),	South Carolina phosphate, Nitrate of soda, Potash-magnesia sulphate,	131 44½ 60
Plat 5 (6,778 square feet),	Dissolved bone-black, Nitrate of soda, Potash-magnesia sulphate,	78 45 61

The phosphatic slag, Mona guano, South Carolina phosphate and Florida phosphate were applied at the rate of 850 pounds per acre; dissolved bone-black at the rate of 500 pounds per acre. Nitrate of soda was applied at the rate of 250 pounds per acre and potash-magnesia sulphate at the rate of 390 pounds per acre.

Potatoes were raised upon the plats in 1890; in 1891 winter wheat was employed (for details see ninth annual report); in 1892 serradella was the crop experimented with (see tenth annual report); and in 1893 a variety of Dent corn, Pride of the North (see eleventh annual report).

1894. — During the preceding season it was decided to ascertain the after-effect of the phosphoric acid applied during previous years by excluding it from the fertilizer applied. In addition, to secure the full effect of the phosphoric acid stored up, the potassium oxide and nitrogen were increased one-half, as compared with preceding seasons. A grain crop (barley) calling for a liberal amount of phosphoric acid was chosen for the trial. The field was ploughed April 17, the fertilizer being applied broadcast April 20, and harrowed in. Below is given a statement of fertilizer applied: —

Plat 1 (6,494 square feet), ...	64½ pounds of nitrate of soda. 87 pounds of potash-magnesia sulphate.
Plat 2 (6,565 square feet), ...	65¼ pounds of nitrate of soda. 88 pounds of potash-magnesia sulphate.
Plat 3 (6,636 square feet), ...	66 pounds of nitrate of soda. 89 pounds of potash-magnesia sulphate.
Plat 4 (6,707 square feet), ...	66¾ pounds of nitrate of soda. 90 pounds of potash-magnesia sulphate.
Plat 5 (6,778 square feet), ...	67½ pounds of nitrate of soda. 90½ pounds of potash-magnesia sulphate.

Yield of Crop (1894).

Plats.	Grain and Straw (Pounds).	Grain (Pounds).	Straw and Chaff (Pounds).	Percentage of Grain.	Percentage of Straw.
Plat 1, ...	490	169	221	34.49	65.51
Plat 2, ...	405	148	251	34.07	65.93
Plat 3, ...	290	78	212	26.89	73.11
Plat 4, ...	460	144	216	31.30	68.70
Plat 5, ...	390	118	272	30.26	69.74

Summary of Yield of Crop (1890–94).

Plats.	1890. Potatoes.	1891. Wheat.	1892. Serradella.	1893. Corn.	1894. Barley.
Plat 1,	1,600	380	4,070	1,660	490
Plat 2,	1,415	340	3,410	1,381	405
Plat 3,	1,500	215	2,750	1,347	290
Plat 4,	1,830	380	3,110	1,469	460
Plat 5,	2,120	405	2,920	1,322	390

Phosphoric Acid applied to and removed from Field.

[Pounds.]

Plats.	1890.		1891.		1892.		1893.		1894.		Total Amount Added.	Total Amount Removed.	Total Amount Remaining.
	Added.	Removed.	Added.	Removed.	Added.	Removed.	Added.	Removed.	Added.	Removed.			
Plat 1,	24.18	2.56	24.18	1.23	24.18	8.95	24.18	7.20	–*	1.92	96.72	21.86	75.86
Plat 2,	28.01	2.36	28.01	1.19	28.01	7.50	28.01	6.33	–*	1.64	72.04	19.02	53.02
Plat 3,	109.68	2.40	–*	.69	28.01	6.05	28.01	5.95	–*	.76	165.70	15.85	149.85
Plat 4,	36.12	2.93	36.12	1.31	36.12	6.84	36.12	6.68	–*	1.72	144.48	19.84	124.64
Plat 5,	12.34	3.39	12.34	1.22	12.34	6.42	12.34	6.05	–*	1.49	49.36	18.57	30.79

* None.

Conclusions.

From the previous statement of comparative yield we find that the plat receiving dissolved bone-black leads in yield during the first two years, while for the third, fourth and fifth years the plats receiving insoluble phosphates are ahead, phosphatic slag being first, South Carolina floats second and Mona guano third.

Description of Modes of Analysis adopted in our Investigations of Samples of Soil taken from the Above-mentioned Five Plats in September, 1894, in the Manner recommended by the Committee of the American Association of Official Chemists, Prof. Harry Snyder of Minnesota, Chairman.

I. — Total Phosphoric Acid.

Ten grams of soil are digested with 100 c.c. of pure hydrochloric acid, of specific gravity 1.115, for ten consecutive hours in a boiling-water bath, shaking once each hour. The stopper of the flask should carry a condensing tube, to prevent evaporation. The material is filtered, and the residue is washed with distilled water until free of acid. The organic matter in filtrate is oxidized with nitric acid and evaporated to dryness on the water bath, finishing on sand bath to complete dryness. The material when cool is taken up with hot water and a few cubic centimeters of hydrochloric acid, and again evaporated to complete dryness. It is taken up as before, filtered and washed thoroughly with cold water, cooled and made up to 500 c.c.

II. — Directions of the Association of Official Agricultural Chemists for the Determination of Available Phosphoric Acid in Soils, Fifth Normal Hydrochloric Acid being used as the Solvent.

1. Determination of Moisture. — Use the official method described in Bulletin 46, page 48, Division of Chemistry, United States Department of Agriculture. Calculate all results to the water free basis.

2. Determination of Phosphoric Acid Soluble in Fifth Normal Hydrochloric Acid. — (*a*) Preliminary treatment: Digest 20 grams of soil with 200 c.c. of fifth normal hydrochloric acid at 40° C. for five hours. Titrate 20 c.c. of the clear filtrate against a standard caustic soda solution, using phenolphthaline for the indicator. From this data calculate the amount of hydrochloric acid necessary to be added, so that the solution will be fifth normal after allowing for the acid neutralized. (*b*) The determination: Weigh out 50 to 100 grams of soil into an Erlenmeyer flask, and add 10 c.c. of acid, corrected for neutralization as directed under (*a*) for every gram of soil used. The flask is corked with a rubber stopper, which carries a thermometer. The flask is then placed in a water bath previously heated to 40° C., and the contents of the flask are thoroughly shaken every half hour during the digestion. The solution is then filtered through a ribbed filter of two thicknesses of paper, refiltering the first portion, if cloudy. The filter should be large enough to receive the entire contents of the flask. Before filtering the contents, the flask should be well shaken. Four hundred to 600 c.c. of the filtrate (at 20° C.) are evaporated to dryness after adding 1 to 3 c.c. of nitric acid. If there is any appreciable amount of organic matter present, the residue is to be carefully charred. Moisten the residue with hydrochloric acid and add 50 to 100 c.c. of distilled water, and then digest. Filter, neutralize with ammonia, add 5 c.c. of strong nitric acid and 15 grams of nitrate of ammonia in solution. Complete the determination according to one of the official methods given for the determination of phosphoric acid, or use the Goss method as given in Circular No. 4 to accompany Bulletin No. 46.

III. — Determination of the Available Phosphoric Acid in Soils by Means of a One Per Cent. Solution of Citric Acid (Dr. B. Deyer).

Preliminary Treatment. — Twenty grams of soil are digested with 200 c.c. of a one per cent. citric acid solution for five hours, at ordinary temperature (18° to 21° C.). The material is filtered and solution is titrated against a standard alkali solution, to determine the amount of acid neutralized by alkalies in the soil. For the estimation of the "available" potash and phosphoric acid, one per cent. citric acid solution has been employed, digesting 100 grams of air-dried soil with 500 c.c. of the solvent, as directed in the preliminary test, corrected for neutralization, for five hours at room temperature. The filtered solution is evaporated to dryness, charred, and the residue abstracted with dilute hydrochloric acid and water. The filtrate from this operation is treated for the determination of phosphoric acid as directed in one of the official methods.

IV. — Determination of the Available Phosphoric Acid in Soils by Means of a Neutral Solution of Citrate of Ammonia.

Ten grams of the soil are digested for one-half hour, at 65° C., with 500 c.c. of strictly neutral solution of citrate of ammonia, specific gravity 1.09. The flask carries a rubber stopper, and is thoroughly agitated every five minutes. At the expiration of thirty minutes, remove flask from bath and filter as rapidly as possible. Wash thoroughly with water at 65° C. Evaporate the solution to dryness, char, and abstract with dilute nitric acid. Filter and wash thoroughly with water. Burn the residue to a white ash, add it to the solution and bring to complete dryness on sand bath. Take up with hot water and a few cubic centimeters of nitric acid. Digest for one-half hour. Filter and wash thoroughly, and determine phosphoric acid in the solution in the usual way.

Results of Analyses of Soils for Available Phosphoric Acid, by Methods previously described (Soil from Fields of Massachusetts Agricultural College Farm).

No. of Samples.	Moisture.	Total Phosphoric Acid.	Available Phosphoric Acid by $\frac{n}{5}$ Hydrochloric Acid.	Available Phosphoric Acid by 1 Per Cent. Citric Acid.	Available Phosphoric Acid by Neutral Citrate of Ammonia.
1, . . .	.77	.255	.0285	.01325	.0735
2, . . .	.87	.290	.0338	.01650	.0945
3, . . .	.95	.210	.0407	.01420	.0865
4, . . .	1.07	.220	.0330	.01920	.0925
5, . . .	1.02	.180	.0345	.01430	.1070

Analysts: Henri D. Haskins.
Charles I. Goessmann.

Conclusion.

The several modes used by us in determining the amount of available phosphoric acid contained in the soil under examination have given different results. The difference in the amount of available phosphoric acid found by any of the modes of analysis employed does not correspond with the actual yield of the several plats in the field. The results of our investigation are more of a suggestive than decisive character. The work will be continued as far as resources on hand will permit.

6. Analysis of Drainage Waters obtained from Field A of the Hatch Experiment Station.

The field under discussion has been from 1883 to date treated in a systematic way with commercial fertilizers, in the manner briefly described in the following pages. The field consisted of eleven plats, one-tenth of an acre each, with a space of from five to six feet between the adjoining plats. This space was cultivated in connection with the planted plats, yet received no fertilizing material of any description, nor were they seeded down at any time during the experiment. Each plat was provided in the centre with a tile drain running at a depth of from three and a half to four feet through the entire length, which terminated in an open well, to allow the collection of the drainage water for examination whenever desired, to study the character of the soil constituents carried off. The entire field of eleven separate plats were surrounded by a tile drain with an independent outlet, to prevent an access of drainage waters from adjoining fields. A marked gradual decline in the yield of several plats, in spite of a uniform liberal supply of the fertilizer used during the earlier years of the experiment, rendered an examination into the cause or causes of the reduction in the annual yield desirable.

As an examination of the drainage waters coming from the different plats promised to throw some light on the action of the several mixtures of fertilizers used on the soil resources of the field employed in the observation, it was decided to subject them to a careful chemical analysis. The samples used for these analyses were collected in all cases as far as practicable soon after each tile drain began to discharge drainage water. As the temporary flow of the drains in the different plats differed widely in quantity, no attempt was made to ascertain in each case the exact amount discharged in a given time. The examination was instituted for the purpose of ascertaining the general character of the discharge of the drains, and to determine the *relative proportion of various soil constituents they contained.* The results of this investigation are stated farther on, after a brief description of the general management of the field, as well as a detailed statement of the fertilizers used.

Amount of Fertilizing Ingredients used annually per Acre.

Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen,	45 pounds.
	Phosphoric acid,	80 pounds.
	Potassium oxide,	125 pounds.
Plats 4, 7, 9,	Nitrogen,	none.
	Phosphoric acid,	80 pounds.
	Potassium oxide,	125 pounds.

One plat, marked 0, received its main supply of phosphoric acid, potassium oxide and nitrogen in form of barn-yard manure; the latter was carefully analyzed before being applied, to determine the amount required to secure, as far as practicable, the desired corresponding proportion of the three essential fertilizing constituents. The deficiency in potassium oxide and phosphoric acid was supplied by potash-magnesia sulphate and dissolved bone-black. The fertilizer for this plat consisted of 800 pounds of barn-yard manure, 32 pounds of potash-magnesia sulphate and 18 pounds of dissolved bone-black.

The mechanical preparation of the soil, the incorporation of the manurial substances, — the general character of the latter being the same, — the seeding, cultivating and harvesting were carried on year after year in a like manner and as far as practicable on the same day in case of every plat during the same year.

The subsequent tabular statement shows the annual application and special distribution of the manurial substances with reference to each plat since 1889. The fertilizers were in every case applied broadcast as early in the spring as circumstances permitted. They were well harrowed under before the seed was planted in rows by a seed drill.

Plats (One-tenth Acre).	Annual Supply of Manurial Substances.
Plat 0,	800 lbs. of barn-yard manure, 32 lbs. of potash-magnesia sulphate and 18 lbs. of dissolved bone-black.
Plat 1,	29 lbs. sodium nitrate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).

PLATS (One-tenth Acre).	Annual Supply of Manurial Substances.
Plat 2, . .	29 lbs. sodium nitrate (=4 to 5 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 3, . .	43 lbs. dried blood (=5 to 6 lbs. nitrogen), 25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. phosphoric acid).
Plat 4, . .	25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 5, . .	22.5 lbs. ammonium sulphate (=4 to 5 lbs. nitrogen) 48.5 lbs. potash-magnesia sulphate (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 6, . .	22.5 lbs. ammonium sulphate (=4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 7, . .	25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 8, . .	22.5 lbs. ammonium sulphate (=4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 9, . .	25 lbs. muriate of potash (=12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).
Plat 10, . .	43 lbs. dried blood (=5 to 6 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (=12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (=8.5 lbs. available phosphoric acid).

The above-described course of the general management of the experiment has been followed thus far for five consecutive years (1889–93, inclusive).

Kind of Crops Raised.

Corn (maize),	in 1889.
Oats,	in 1890.
Rye,	in 1891.
Soy bean,	in 1892.
Oats,	in 1893.

Amount of Fertilizing Ingredients applied per Acre during 1894.

Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen,	45 pounds.
	Phosphoric acid,	160 pounds.
	Potassium oxide,	250 pounds.
Plats 4, 7, 9,	Nitrogen,	none.
	Phosphoric acid,	160 pounds.
	Potassium oxide,	250 pounds.

Plats (One-tenth Acre).	Manurial Substances Applied.
Plat 0, . .	800 lbs. barn-yard manure, 80½ lbs. potash-magnesia sulphate and 77 lbs. dissolved bone-black.
Plat 1, . .	29 lbs. sodium nitrate (=4 to 5 lbs. nitrogen), 54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 2, . .	29 lbs. nitrate of soda (=4 to 5 lbs. nitrogen), 97 lbs. potash-magnesia sulphate (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 3, . .	43 lbs. dried blood (=5 to 6 lbs. nitrogen), 54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 4, . .	54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 5, . .	22½ lbs. ammonium sulphate (=4 to 5 lbs. nitrogen), 97 lbs. potash-magnesia sulphate (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
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Plat 8, . .	22½ lbs. ammonium sulphate (=4 to 5 lbs. nitrogen), 54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).
Plat 9, . .	54 lbs. muriate of potash (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone black (=16 to 17 lbs. phosphoric acid).
Plat 10, . .	43 lbs. dried blood (=4 to 5 lbs. nitrogen), 97 lbs. sulphate of potash-magnesia (=25 to 26 lbs. potassium oxide), and 114 lbs. dissolved bone-black (=16 to 17 lbs. phosphoric acid).

Analysis of Drainage Water (Per Cent).

100 parts of total solids contain: —

	Plat 0.	Plat 1.	Plat 2.	Plat 3.	Plat 4.	Plat 5.	Plat 6.	Plat 7.	Plat 8.	Plat 9.	Plat 10.
Potassium oxide,	.600	.380	1.210	.637	.700	.125	.544	2.080	.2740	.5100	.410
Sodium oxide,	21.630	23.850	50.180	5.310	16.670	6.290	6.960	20.890	13.6200	25.6400	5.000
Calcium oxide,	14.210	10.660	12.090	18.340	21.870	23.070	20.720	22.800	26.1900	20.7700	7.240
Magnesium oxide,	6.630	5.390	4.160	5.120	5.340	6.980	4.846	4.680	3.8750	3.9600	2.380
Actual ammonia,	.076	.027	.070	.023	.038	.021	.018	.031	.0068	.0100	.025
Albuminoid ammonia,	.525	.043	.108	.185	.077	.302	.338	.068	.0500	.0560	.073
Ammonia as nitrates,	.565	.242	.765	.349	.331	.298	.708	.153	.3920	.0289	.105
Phosphoric acid,	trace	trace	trace	trace	trace	trace	trace	trace	.1210	trace	trace
Sulphuric acid,	20.260	2.010	22.810	7.920	1.470	52.820	18.970	6.090	5.7500	4.4600	28.530
Chlorine,	16.150	26.390	6.040	28.380	38.210	2.420	24.610	35.470	32.0700	36.4100	1.020
Silica,	7.700	3.580	.637	4.950	3.160	3.220	5.576	2.570	2.2260	2.8900	.864

Analysts: HENRI D. HASKINS.
ROBERT H. SMITH.

Drainage Water (Results computed in Percentages).

	Plat 0.	Plat 1.	Plat 2.	Plat 3.	Plat 4.	Plat 5.	Plat 6.	Plat 7.	Plat 8.	Plat 9.	Plat 10.
Total solids,	.0080500	.0265000	.0182000	.0303000	.0256500	.0248000	.0260000	.0265000	.0530000	.0346000	.0787000
Potassium oxide,	.0000480	.0001000	.0002200	.0001930	.0001780	.0000310	.0001415	.0005500	.0001450	.0001770	.0003260
Sodium oxide,	.0017409	.0062205	.0091333	.0016100	.0042728	.0015600	.0018100	.0055366	.0072200	.0088740	.0039344
Calcium oxide,	.0012441	.0028259	.0021997	.0055600	.0056106	.0057200	.0053880	.0059319	.0138820	.0071880	.0057012
Magnesium oxide,	.0005333	.0014272	.0007567	.0015500	.0013693	.0017300	.0012600	.0012396	.0020540	.0013690	.0018738
Free ammonia,	.0000610	.0000072	.0000118	.0000070	.0000098	.0000052	.0000048	.0000078	.0000036	.0000036	.0000197
Albuminoid ammonia,	.0000420	.0000114	.0000198	.0000562	.0000195	.0000750	.0000880	.0000184	.0000267	.0001094	.0000432
Ammonia as nitrates,	.0000460	.0000640	.0001400	.0001060	.0000830	.0000740	.0001840	.0000410	.0002080	.0000100	.0000830
Total ammonia,	.0001490	.0000826	.0001716	.0001692	.0001123	.0001540	.0002770	.0000672	.0002383	.0001230	.0001459
Phosphoric acid,	trace	trace	trace	trace	trace	trace	trace	trace	.0000640	trace	trace
Sulphuric acid,	.0016311	.0005322	.0041511	.0024000	.0003777	.0131000	.0049340	.0016139	.0030500	.0015450	.0224548
Chlorine,	.0013000	.0070000	.0011000	.0086000	.0098000	.0006000	.0064000	.0094000	.0170000	.0126000	.0008000
Silica,	.0006200	.0009500	.0011600	.0015000	.0008100	.0008000	.0014500	.0006800	.0011800	.0010000	.0006800

Without any intention to discuss here in detail the causes of the variations noticed in the composition of the saline residues left when evaporating a definite amount of the drainage water collected from the various plats, it remains of especial interest to call attention to the fact that wherever muriate of potash had been used as a potash source of plant food exceptional quantities of the chlorides of calcium and magnesium proved to be present (plats 1, 3, 4, 6, 7, 8 and 9). The belief that a liberal use of muriate of potash had resulted in wasting in an exceptional degree in particular the lime resources of the soil, and thereby reducing the yield of the crops, has since been confirmed. The annual yield of the crops has been restored to its former satisfactory condition, after a liberal addition of air-slaked lime to the manures used for years upon the field in question.

REPORT OF THE BOTANISTS.

GEORGE E. STONE, RALPH E. SMITH.

Scope of Work.

This division has during the past year made special effort to come into direct contact with a large number of market gardeners and greenhouse growers; and, largely as a result of this more direct contact and the numerous visits made to their establishments, our correspondence has during the past year doubled that of any other year, and has covered a multitude of subjects relating to botany.

We have paid some attention this summer to the asparagus rust, which caused so much damage in this State in 1897. A study of the conditions which caused the rust has been made at various places throughout the State, and spraying experiments have been carried on in co-operation with different asparagus growers.

The results of the study of nematode worms in greenhouses, which has received a great deal of attention by this division for over three years, have been published in Bulletin No. 55, which can be had on application. This bulletin, containing 67 pages and 14 plates, gives a full account of the parasitic species of nematode, its life history and development, together with the results of an extensive series of experiments on the methods of controlling the pest. In these investigations the worthlessness of many supposed remedies has been brought out, and a practical method of treatment developed by which the trouble can be successfully and economically avoided. From a considerable amount of data accumulated during the last three years it appears that the loss experienced by cucumber growers who have been troubled with nematodes in the greenhouse equals 25 to 85 per cent. of the marketable crop; and it is hoped, from the positive results obtained, that little trouble may be experienced hereafter with this pest. There are still, however, some further experiments being made upon nematode-control methods, in co-operation with large greenhouse growers, along lines which promise cheaper and efficient results.

The principal investigations with which this division is concerned at present are largely in connection with market-garden crops such as are cultivated in greenhouses. The division is supplied with greenhouses excellently arranged for experimental purposes, and containing space enough to carry on investigations from which reliable deductions can be drawn. The more important greenhouse crops grown in our greenhouses for experimental purposes are those representing considerable importance in this State, namely, lettuce, cucumbers and tomatoes; and it may be justly said that there is no class of agricultural pursuits which is represented by men of greater intelligence, skill and knowledge.

A brief outline of some of the investigations may not be out of place: —

(*a*) Experiments on the control of the "drop" in lettuce, and a study of the little known habits of the fungus causing the same. A lettuce house, 40 by 12 feet, is devoted to these experiments.

(*b*) Observations on the "top-burn" in lettuce.

(*c*) Experiments on the mechanical conditions of the soil, as affecting the growth of lettuce.

(*d*) Sub-irrigation, as affecting lettuce diseases.

(*e*) Experiments on the pruning of cucumbers, in relation to the maturity and production of fruit; also, observations on the various fungous diseases of the cucumber, and the conditions which favor them.

(*f*) Experiments on the pruning of tomatoes, in relation to the production and maturity of fruit; a study of the fungous diseases of the tomato.

(*g*) Experiments on the growth of violets in sterilized soil and nematode-infested earth, with special reference to the relationship existing between the size, maturity and production of flowers in the plants, and abundance of leaf spots.

(*h*) Experiments with gases and chemical solutions for disinfecting greenhouses and repression of fungi.

(*i*) Further experiments on the relationship existing between electricity and plant growth.

There are a host of fungous diseases common to our out-of-door plants, some of which have received special attention, such, for example, as the asparagus rust, aster disease, etc.; but the practice of spraying fruit trees and garden crops has for many years been largely carried out by the horticultural division, which is well equipped with all of the modern spraying appliances.

A few years ago it was generally believed by the majority of people that botany was incapable of being made of any practical use, and it is doing no injustice to truth to state that it did possess little at that time. To-day, however, this state of affairs has entirely changed, and botany, like chemistry and other allied sciences, has taken its place in the industrial arts, — a fact which is due to the advance of science in general, but more especially to the inherent genius characteristic of the American investigator, which naturally emphasizes the utilitarian aspect of science. The annual loss in the United States to agricultural, horticultural and floricultural products caused by pathogenic fungi and their allies will probably equal $10,000,000. It is, therefore, not only important, but perfectly legitimate, that the principal work of botanists in our numerous experiment stations should consist in studying the life history of these organisms with a view to their repression. In regard to the industrial side of botany, it should not be forgotten that it owes a great deal to the patient investigations of the many scientific workers of the past, who have devoted their attention to matters of purely scientific interest; and our stations would not be where they are to-day were it not for the labors of these men.

In connection with the characteristic utilitarian features of the present American botanists, it may be of some interest to observe the differences existing between European and American methods of combating pests. Some of the most effective spraying solutions were discovered in Europe, but the methods of applying them and the results obtained by their use to our crops far exceed anything ever accomplished there. To one who has paid any attention to the manner of growing plants in Europe and the methods which are pursued in the control of plant diseases, it would seem no exaggeration to state that more is accomplished in this direction in the United States in one year than in Europe in five years.

The past season has been what might be termed a normal one, although, as in every season, some fungi were especially predominant. There are, however, every year types of fungous diseases which affect our shade trees.

Pathogenic Fungi.

The fungous diseases which have been specially common upon our shade trees this last season are as follows: —

Black Spot of the Maple (Rhytisma acerinum, (P), Fr.).

This fungus is characterized by elevated black spots or blotches upon the surface of the leaf, and, while it is not uncommon to a few maples, it has been especially abundant on the silver maple.

Oak Leaf Blight (*Gloeosporium nervisequum*, (*Fckl.*), *Sacc.*).

A fungus apparently identical with that which causes the blight of the sycamore is sometimes found upon the white oak. This produces large dead blotches upon affected leaves, and causes great disfiguration of white oak trees.

Walnut Leaf Blight (*Gloeosporium Juglandis*, (*Lib.*), *Mont.*).

This disease was mentioned in our last report as having been especially abundant during 1897. It has also occurred this year, but to a much less extent.

These diseases are briefly mentioned because complaint has been frequent during the past summer in regard to them, largely, however, from people who possess shade trees which they value. From what we know in regard to the treatment of similar fungi occurring on other plants, it would seem that spraying might hold some of these in check; and the only reply which can be made is, Are the trees valuable enough to receive treatment? Some of these fungi attack large groves, and the expense of spraying would amount to considerable. As a rule, these fungi only make their appearance at intervals, and do not injure the trees to any great extent. In consideration of this fact, it appears questionable to us whether they are worth the trouble; but, should spraying be deemed necessary, it would have to be done early and continued each year.

The disease of the peach known as the "leaf curl" (*Exoascus deformans*, Fckl.) has been unusually abundant during the past season. This disease is well known to most peach growers, causing the leaves to become wrinkled and curled and greatly deformed, finally resulting in their falling to the ground. It is not ordinarily regarded as an especially destructive disease, and does not often cause any appreciable damage to the tree; but, when so abundant as to cause a large proportion of the leaves to fall, it cannot but injure the tree to some extent.

Another disease of the stone fruits, the so-called "plum pockets" (*Exoascus Pruni*, Fckl.), which causes young plants to become swollen and distorted in a peculiar manner, has been received several times this year. Besides the plum (*Prunus domestica*), the wild cherry (*Prunus Virginiana*) is also affected by the same fungus. The disease is not often very abundant, but occasionally causes a considerable diminution of the crop.

For methods of controlling the various diseases of the peach, plum and cherry, consult the spraying bulletin annually issued by the horticultural division of this station.

A Musk-melon Disease.

During the latter part of August our attention was called to a field of musk-melons, in which a destructive disease of the leaves had appeared and seemed to be rapidly increasing. The owner informed us that he had lost his entire crop the year before in the same way. It was evident that the trouble began in the centre of the hills. Here the leaves at the time of our first visit had in many hills wilted and begun to turn yellow and partially died. They were covered with yellow spots, or, in the worst cases, with dead areas of considerable size. At this time the general appearance of the field was good, the only very noticeably affected places being these centres of some of the hills. Still, it could be seen on closer examination that scarcely a leaf in the whole field was entirely healthy. On almost every one there were small yellow spots, more or less abundant, some were slightly wilted, and it was evident enough that the disease was spreading in each hill from the centre outward. The dead areas on the most affected leaves were dry and brittle, marked with slight concentric rings, and a dark, mould-like growth could be seen upon them. Examined with the microscope, this proved to be a fungus, and a species of *Alternaria*. It grew abundantly in the tissue of the leaf as well as upon the surface, where the dark-brown, club-shaped spores were produced. No other fungus or other organism could be found on the affected leaves, and there seemed but little doubt that this was the direct cause of the trouble. Furthermore, Dr. W.

C. Sturgis,* who describes what is evidently the same disease in Connecticut, has succeeded in producing it by inoculating sound leaves with the fungus, thus leaving no doubt that the *Alternaria* is the cause of the trouble. This fungus is a mould-like growth, consisting of a mass of fine filaments which grow upon and in the leaf, consuming its substance and vitality. It reproduces itself by the above-mentioned spores, which are blown by the wind from the surface of the affected leaves to fresh ones, and there germinate and produce the disease. It is not entirely clear why the leaves near the centre of the hill should be the first to show the disease, unless, perhaps, it is because they are the oldest leaves, and thus are growing less vigorously than the outer ones, and less able to resist the attacks of such a fungus. It should not be supposed that the disease spreads outward to the other leaves through the plant itself, as the nature of the fungus shows that this is not the case, but that it spreads entirely by means of the spores which are carried through the air.

As the disease was so far advanced when we first saw it, it was pretty evident that no treatment would be of much avail in checking it. A portion of the field was sprayed with Bordeaux mixture, but the weather continued, as it had been for some time previous, very rainy, and before a second spraying could be made almost every leaf in the field was dead and withered. Some of the melons had reached sufficient size to mature, but nothing like a full crop was obtained. The same disease was met with in one other locality during the season, and no doubt occurred in various parts of the State, though melon-raising is not much practised here. There is no apparent reason why this disease should not be as successfully treated by spraying with Bordeaux mixture as are many similiar ones which are largely prevented by this means. Experiments will be made another season by spraying at the time of blossoming, and several times thereafter during the season. Knowing the nature of

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* Report Connecticut Agricultural Experiment Station, 19 (1895), p. 186, and 20 (1896), p. 267. See also Ohio Bulletin 73, p. 235, and 89, p. 117; Journal Mycology, vii, p. 373.

the disease, it will of course be at once understood that it is very advisable to destroy all affected vines and leaves by burning. It might also be safer not to plant melons on land where the disease had already occurred during the previous season. We do not, however, lay great stress on this, as many farmers have a particular area especially suited to this crop, which they do not like to give up, and the disease is probably disseminated widely enough so that it is about as likely to occur in one place as another.

Rotting of Cabbage.

The rotting of cabbage in the field, caused by a species of bacteria, which has recently been so thoroughly investigated by Russell* and Smith,† appeared this year in a field upon the station grounds, and also occurred to our knowledge in several other places in the State. It is a most destructive disease, causing dead spots to appear upon the outer leaves of the cabbage, and usually resulting in a complete decay of the whole head. Cauliflower is quite susceptible, as also cabbages and turnips. A full description of the disease may be obtained in the above-cited Farmers' Bulletin, which can be obtained upon application to the Secretary of Agriculture, Washington, D. C. No practical remedy is known except a rotation of crops. As the disease occurred here on land which had never been in cabbages before, even this seems rather uncertain.

Further Considerations in Regard to the Drop in Lettuce.

We have already referred to this disease in our last annual report, and it may not be out of place to briefly call attention to the progress which has been made towards the control of this troublesome fungus. The study of the organism which causes the disease has given some suggestive results in regard to its treatment. The ordinary "damping fungus" (*Botrytis*), has been generally regarded as the source of the trouble, and we have so referred to it in our previous report. Further observation has shown, however, that, whatever may

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* Bulletin 65, Wisconsin Experiment Station.

† Farmers' Bulletin 68, United States Department Agriculture.

be the relation between the drop fungus and *Botrytis*, it is certain that the disease is not spread by *Botrytis* spores in the air, but by a mycelium or mould-like growth in the soil itself.

Our control experiments have so far been along three different lines; namely, those in which chemical substances were used on the soil, the application of various gases to the greenhouse, and the effect of different layers of sand and sterilized earth. The results obtained by the use of chemical substances have been entirely negative, and the use of gases does not at the present time give great encouragement. In our last report we called attention to the use of sterilized soil as a possible control method, and during the past winter and also at the present time this method has been in use. Our experiments have shown that the heating method is the only absolute one, although some gain has been made by the use of three-fourths of an inch of sand upon the beds. The sand which was sterilized showed better results than the unsterilized. In both instances, however, cleaner and better plants have been obtained by the use of three-fourths or one-half of an inch placed upon the surface of the soil. Experiments in which three or four inches of the top soil was sterilized gave absolute results in the control of the drop, and those in which two inches of the infected top soil was sterilized have not as yet shown any evidences of the drop. Where one inch of sterilized soil was used and carefully distributed, the loss from the drop has been about four per cent., while in the adjacent beds which were not sterilized the loss was about fifty per cent. These experiments have been carried out in another badly infested house, managed by an experienced lettuce grower, on a much larger scale, with quite similar results.

While this method gives promise of being a practical one, we are not quite certain as yet whether it is the cheapest one which can be utilized, and other control methods are being experimented with. Some growers clean their houses out every year, and put in fresh subsoil mixed with horse manure; but such a method is expensive, probably more so than the heating of an inch or two of the top soil previous to planting the crop. If one is provided with a good steam boiler, as most lettuce growers are, probably two hundred cubic feet of soil could be heated sufficiently in one or two hours' time. This amount of earth will cover twenty-four hundred square feet of soil one inch deep, or a bed twenty-four feet wide by one hundred feet long. Of course this heating will have to be done with every crop, as the stirring of the soil subsequent to planting would redistribute the fungus. As a necessary precaution against the drop, it would also be necessary to have all the soil sterilized in which the prickers are started, and also that which contains the first transplanting. By this means alone much lessening of the drop could be accomplished; but in conjunction with sterilized layers one inch thick in the house, it would in most cases reduce the infection still further. The amount of earth that is employed in the seed bed and also that in which the first transplanting is done is not so large but that it could be entirely sterilized. When this is once accomplished, it would be sufficient for some time to come, provided precautions were taken against outside contamination. The benefits gained from the use of sterilized soil are in themselves, regardless of the drop, sufficient to pay for the process, according to some who have used it, inasmuch as the lettuce plant shows a better color and makes a quicker and larger growth.

The Chrysanthemum Rust.

This comparatively new disease has been not uncommon in the State during the past season; but it is encouraging to note that its attacks seem in most cases where it has occurred to have had but little appreciable effect, and the indications now are that this disease is one which may be fully controlled by proper methods of cultivation and management. We noticed especially a case where a lot of plants were brought in in August to set out in the open bed for fall blooming. Fifteen plants were left over, and remained standing on a greenhouse bench in pots. Later in the season this bench was filled up with other potted plants which had remained out of doors. Though all were of the same lot, the fifteen became badly rusted, while none of the others or those set out in open beds showed any signs of the disease. It seemed pretty evident, therefore, that the high August temperature of the house had a bad effect upon the plants confined in pots, causing them to be more susceptible to the disease. Some of the plants which were still out of doors in a cold frame also became rusted, but these were crowded together so that all the lower leaves had fallen off, and were plainly in poor condition. Of the many plants which were set out in open beds in August or placed on benches with space between them in September, not one showed any noticeable rusting.

It remains to be said that the rusted plants, though badly affected, produced blossoms as good, apparently, both in quality and quantity, as similar healthy plants, and, furthermore, did not spread the disease to other plants, though kept in close proximity to them. Judging, therefore, from this year's experience, it seems probable that the skilful gardener has no great cause for apprehension in this disease.

A New Pansy Disease.

During the past summer our attention was called to a field of pansies at the establishment of a local seed grower, in which the plants were badly affected by a disease of the leaves and blossoms. Upon the affected leaves first appeared small dead spots, each surrounded by a definite black border. These spots soon increased in size, and in the later stages of the disease the affected leaves had an appearance very similar to that of the violet leaf spot (*Cercospora Violæ*, Sacc.). Many plants were killed outright by the disease, and all affected ones were in very poor condition. Besides the spotting of the leaves, many of the blossoms also were affected, the petals being disfigured by dead spots and blotches upon them, while some of the flowers were malformed or only partly developed. The latter was indeed one of the most serious features of the trouble, as the plants were raised for seed, and the yield was greatly reduced by this failure of the blossoms to develop properly.

It was thought at first, from the general resemblance of the leaf spots and close relationship of the two plants, that this might be identical with the violet disease. This, however, did not prove to be the case. Examination showed that the cause of the trouble was a fungus, but one of quite a different nature from *Cercospora*, and belonging to the genus *Colletotrichum*, being apparently a new and undescribed species. This form has therefore been described in the "Botanical Gazette" of March, 1899, under the name *Colletotrichum Violæ — tricoloris*.

This same disease has been seen in a few other localities in the State, and Prof. B. D. Halsted has also very kindly sent us specimens of it from New Jersey, so that the trouble is doubtless widespread. Its occurrence, however, seems to have been comparatively slight, except in the one instance described above. In this case the number of plants was very large, and pansies had been grown upon the same field for several years, which may account for the severe outbreak of the disease.

A portion of this field was sprayed twice with strong Bordeaux mixture; but, as it was already late in the season, and heavy rains prevailed at the time, little success from the treatment was looked for. The owner, however, thought that a beneficial result appeared from the treatment, and from our own observation we can claim at least that later in the season the sprayed portion of the field was certainly in the best condition of any. If this did indeed result from the spraying under such adverse conditions, it seems likely that the disease could be kept well in check by proper treatment.

Physiological Disorders.

Seasonal Peculiarities of Certain Shade Trees.

Some complaints have been made in regard to the falling of leaves on the elm, maple and apple trees. This was especially noticeable on the elm in various sections. We had many specimens sent in for examination, and our attention was called to a number of trees in which certain branches had only half-developed leaves on them. These leaves would linger along a while in this condition, when they would gradually turn yellow and drop to the ground.

Examination made of a great many leaves and branches revealed no fungous or insect pest preying upon them. The condition of the apple trees was similar, although not so prevalent; and in the maple the cast-off leaves were mature ones. The exact cause of this trouble is not obvious, but there can be little doubt that it was a functional disorder. We have observed fine specimens of elm trees, which, after a period of excessive seasons, would suddenly lose all their leaves in midsummer, yet a year or two later would appear as vigorous as ever. Inasmuch as the trees are not materially injured by the falling of a few leaves in midsummer, remedial measures are not necessary.

Over-feeding of Plants.

The over-feeding of plants is not an uncommon occurrence at the present time, when so much concentrated fertilizer is used, and where attention is not given to the proper amounts that should be employed. This trouble not only occurs among florists, etc., but among those who cultivate house plants as well; and the cause of the trouble is usually traceable to the fact that most people are not aware of the strength of the constituents serving as plant food. The normal strength of chemically pure solutions, available for plants, is about one to one thousand or one to two thousand parts, and when these solutions are put on at the rate of one to one hundred or so, ill results must be expected to follow their use.

We now and then have specimens of abnormal plants sent in to us which are merely suffering from some such treatment. A potted specimen of a Johnsonian lily, which had a number of reddish eruptions or blisters upon its leaves, was sent in for examination. These reddish blisters were examined under the microscope, and they showed no evidence of fungi or insects being present. The cells, however, in the vicinity of the blisters showed that they had been stimulated exceedingly, which manifested itself in excessive cell division, giving rise to the blisters; and where this action had taken place excessively the tissues were ruptured, thus producing a ragged, wounded appearance. This trouble could be readily referred to some abnormal features in connection with nutrition, and an inquiry showed that the plants had been heavily fertilized with Chili saltpetre. The same treatment was applied by us to a perfectly healthy Johnsonian lily, with the result that the same activity was shown in the division of the leaf cells, which subsequently gave rise to blisters or ragged eruptions identical with those described.

A number of potted specimens of cyclamens grown by a florist were also brought to our notice last winter, which showed somewhat similiar peculiarities in the leaf. These leaves were blistered, although in quite a different manner from the Johnsonian lily mentioned above. There were no ragged or lacerated eruptions or pustules on the cyclamens, and the manner of blistering was quite different, although it was evidently caused by over-feeding, or at least by injudicious feeding, as it was found that the plants had been heavily treated with nitrate of soda.

A singular case of over-fertilizing or perhaps over-watering was seen in some specimens of carnations sent in to us by a grower. We subsequently visited the greenhouse where they were found, and had an opportunity of seeing these abnormal plants in the benches, beside other plants of the same variety that were not affected. About fifty plants in this house showed this trouble, and it was confined to the most robust specimens of the variety known as the Edith Foster, and in some instances to the Mrs. Fisher. The characteristics of these diseased plants were whitish stems and foliage, which were enlarged to about twice the size of normal ones growing next to them. Repeated examinations of the tissues of the affected plants seem to show that there was nothing the matter with them except what might be expected from improper nutritive conditions, such as might be brought about by too much fertilizer or excessive watering, which caused the plants to be stimulated abnormally in their growth. In the spring the plants were removed from the greenhouse into fresh garden soil, but they failed to recover. The same variety of carnations has already shown similar symptoms this season.

Injudicious use of fertilizers is not an uncommon matter, and more care should be exercised in their application. Most fertilizer companies give explicit directions as to the amounts which should be employed, and the excessive use of them is generally traced to the carelessness of the gardener in applying them. The results of over-feeding generally manifest themselves in some abnormal stimulation to the plant; but these results, even when the same fertilizer is used, do not show themselves in a similar manner on different species of plants. What would give rise to a multiplication of cells and the formation of blisters in the leaf of one plant, would not do it in the leaf of another. In short, stimuli in plants manifest themselves specifically and manifoldly.

The Bronzing of Rose Leaves.

A peculiar bronzing or irregular spotting of rose leaves was brought to our attention last winter by Mr. Alexander Montgomery, Jr., a member of the senior class. This peculiarity in the spotting or bronzing of the leaf is common to grafted varieties of the Tea, Bride and Bridesmaid roses, grown at the extensive Waban conservatories at Natick; and Mr. Montgomery, who was working in the botanical laboratory at that time, made, at my request, some investigations into the cause of the trouble. Both Mr. Montgomery and his father, who is in charge of the Waban conservatories, have had ample opportunity to observe bronzing; and it therefore became a very easy matter to secure valuable data. The only mention which we have noticed in connection with this disease is that given by Professor Halsted of New Jersey, who briefly referred to it in his annual report of 1894.* In this report he gives a figure of the black spot of the rose, and in connection with it is shown what he designates a "discoloration that is most frequently met with on the foliage of the La France, and may be called bronzing." This he states, so far as he knows, is "not due to any fungus, and is likely due to a structural weakness." This reference to the disease by Professor Halsted was not observed until Mr. Montgomery had finished his investiga-

*New Jersey Experiment Station Report, 1894, p. 384.

tions; and, in order to ascertain whether the trouble with which we were concerned was the same which he had briefly alluded to, we forwarded him specimens for examination, which resulted in establishing the identity of the two. There is a certain resemblance between the spots which give rise to bronzing and those which are caused by the black spot; and we found that the impression prevailed among some rose growers that bronzing was simply an immature stage of the black spot. To any one thoroughly familiar with the characteristics of both diseases, the differences between them would be evident, and they would not be likely to confound one with the other.

The investigations of Mr. Montgomery showed that the abnormal condition of the rose leaves subject to bronzing was not in any way connected with fungi, but is of a physiological nature, or structural weakness, as Professor Halsted had correctly surmised. The first symptoms are manifested in a mottled, bronzing coloration of the leaf. These spots subsequently become more prominent, ranging from one-sixteenth of an inch to one inch in size; the infected portions of the leaf frequently turn yellow, and eventually the leaflets and leaf stalk drop to the ground. Sometimes, however, a whole leaflet becomes bronzed, and the yellowish color is not observed. Numerous microscopic cross-sections made of the bronzed leaf spots showed that the epidermal and adjacent cells were in an abnormal condition. The living contents of the cells were disintegrated, the protoplasm and cell walls had turned a reddish-brown color, and numerous very minute bodies about the size of micrococci filled the affected cells. These minute bodies proved upon examination to be crystals of calcium oxalate. The excessive deposits of calcium oxalate indicate that the leaf cells, being unable to obtain sufficient nourishment, were not able to assimilate the calcium salts, and consequently it is deposited in the cells in the form of calcium oxalate. It may be said that all of this phenomenon is nothing extraordinary, but merely concomitant with the death of the leaf, and can be observed in other species of plants. Mr. Montgomery states that the bronzed leaves are more susceptible to disease, and he has observed the occurrence of rust upon them, while healthy leaves would be entirely free.

A further examination of the affected plants at the Waban conservatories, made by Mr. Montgomery and myself, showed that all leaves even of plants subject to it were not affected, but that it was confined in every instance to two places: first, where a stem is cut and a new branch starts, the leaf at the base of the branch begins to bronze; second, when an eye or axillary bud is rubbed off, the leaf generally becomes bronzed.

There is a difference in susceptibility between young plants and old ones. Roses planted in the middle of June show bronzing the first of August, but it is scarcely noticed after the first year's growth. Bronzing appears to occur more largely upon plants which show rapid growth than on those which have grown more slowly; for this reason apparently the root plants or ungrafted ones at the Waban conservatories which are not so vigorous as the grafted ones are not susceptible to it. Bronzing sometimes occurs upon small, weak stock.

It should be stated, however, that, since bronzing occurs on leaves at the axils of the shoots which bear the flowers, no real harm is done to the marketable foliage, as the cutting of the flower stalk is always above the position of the leaves which are bronzed. The most intelligent and successful rose growers always take the most care and pride in their plants, and they are suspicious of any abnormal feature which in any way mars the beauty of them; and this is, so far as we have observed, the only inconvenience which this trouble of bronzing gives rise to.

It is quite evident that we have in the bronzing of rose leaves a physiological phenomenon which is not uncommon to other plants. We have observed a similar falling of the axillary leaves in other species of plants. In the rose it is probably a correlative phenomenon, which is brought about, or at least augmented, by years of cultivation and development along certain lines. Any form of mutilation, whether it be a cut or a mere scratch, acts as a stimulus to a plant; but the manner of reaction of the plant may not always be the same either in kind or degree. As a rule, the cutting of primary organs, such as a shoot, will give rise, among other things, to increased activities in the secondary organs, such as a side shoot or side root; and conversely the cutting of a secondary organ or branch will stimulate the primary organ or main shoot. Then, again, the effects of stimuli caused by cutting are more marked near the source of injury, and less marked the further away an organ is from it. For example, the cutting of the main axis near an eye or bud would give rise to increased activities in the axillary bud, which would manifest itself in the development of a new shoot. The nearer the cut to the eye or bud, the more marked will be the stimulation, or resultant activities, and the more completely will it assume the characteristics of the primary shoot. The better condition the plants are in, and the more suitable and available plant food with which they are supplied, the more rapid will be the growth of the shoot, and the more marked will be the correlative effects. Such, in fact, are some of the laws governing correlation in plants.

In the case of the bronzing and subsequent death of the axillary rose leaves, the stimulative effect of cutting causes a marked growth of the shoot, and the nutritive substances are thereby utilized by this organ to such an extent that some other portion of the plant is made to suffer. In this instance it is the axillary leaf which finally becomes bronzed, turns more or less yellow and dies. In other words, bronzing is nothing more or less than a physiological disorder, and falls under the domain of plant irritability.

Cucumber Wilt.

The growing of cucumbers under glass is carried on extensively in some places in this State, and a disease known as the wilt has been reported to the station a number of different times. Complaints in regard to this disease have always come from certain localities where it has, as a rule, been quite universal among the different growers. The symptoms of the disease are a wilting of the plant, or, more strictly speaking, of the foliage, whenever it is subjected to the intense rays of the sun.

We visited several cucumber houses this last spring in which the plants were subject to wilt, and observed a number of houses which contained badly affected plants. In those houses running north and south, the vines in the morning on the east side, which are subject to the sun's rays, would be entirely wilted; while those on the west side, and away from the sun's rays, were not in the least affected. In the afternoon, when the sun had reached the west side of the house, the vines would then become badly wilted, and those on the east side, when no longer exposed to the direct rays of the sun, would commence slowly to recover. The cause of the wilt in every instance was not difficult to understand; but, as a necessary precaution against drawing deductions too hastily, we examined every portion of a number of plants very carefully, to convince ourselves that there was no other cause than that which we had in mind. It is well known that there is a bacterial disease of cucumbers that gives rise to a wilting of the leaves, but careful examination of the tissues shows nothing in the nature of bacteria to be present.

At about the same time we visited several other cucumber growers in other sections of the State, and had an opportunity of examining many vines in about the same stage of development. In some instances the identical varieties of cucumbers were grown, but in the majority of cases another variety was used, namely, the White Spine, and in all cases the methods of cultivation were radically different, and the wilting of the vines was something unknown to them. Long before we visited the region of wilt a number of letters of inquiry had shown us that the disease in question was local, and the majority of growers had never had trouble with it.

The cause is not due to any organism, whether insect or fungous, but to extremely abnormal conditions of the plants, brought about by irrational methods of cultivation that give rise to defective transpiration, or, in other words, to the giving off of water from the leaves. The activity of transpiration is affected by various causes. It is well known that the stomata or breathing pores of the leaf are open during sunshine and closed during darkness, and that the greatest activity in transpiration takes place during sunshine. This fact is frequently demonstrated by young cucumber plants in tolerably good conditions of health, which not infrequently show some indications of wilt in sunshine, though not enough to cause any amount of harm. This is especially so when they are forced too rapidly, and when the texture of the leaf is not sufficiently developed. The temperature of the air affects transpiration. A plant in an atmosphere saturated with moisture will not exhale any watery vapor, provided that the temperature of the plant is not higher than that of the air; but when the temperature of the air is high, and the proportion of moisture small, transpiration is promoted. Transpiration is further affected by the temperature of the soil in which the roots are embedded. When the roots are warmed, transpiration becomes more active, and consequently there exists more root absorptive activity. The nature of liquids which the roots absorb and the kind of soil in which they grow also affect transpiration. Plants transpire more when grown in sandy soil than when grown in clay soil; also when grown in acid soil than when grown in alkaline soil. One per cent. solutions of potassium nitrate and other salts diminish transpiration, and we have been able to produce severe cases of the wilt by watering pots of cucumber plants with a one per cent. solution of potassium nitrate.

The wilt, however, in the houses mentioned before was not due to temperature or constituents of the soil, but was brought about, as we have already inferred, by irrational methods of treatment of the plants, and depends upon other causes. In all probability, the cause of the wilt may be attributed partially to the characteristic peculiarities of the varieties of cucumbers grown, as most of the varieties are Telegraph or Giant Pera. In many cases hybrid forms are obtained by crossing these with the White Spine. These varieties present a different appearance from the White Spine; their stem and leaves appear to be small, and the plants do not appear normally as green and rugged as the White Spine.

The methods of growing cucumbers where the wilt occurs are radically wrong in many ways. The houses are imperfectly supplied with ventilation, consequently little use can be made of this necessary feature. Then, again, they are supplied either wholly or partially with two layers of glass, which are set about two inches apart, thus leaving an air space in between for the purpose of keeping out the cold, but which in reality becomes filled up with dirt, and is an excellent aid in shutting out the light. Plants started in such a house in winter continually suffer from lack of light, — a feature which we have often observed in the greenhouses in this State. Their leaves become pale, and they are attached to the stalk by means of elongated petioles, and present all the phenomena of partial etiolation, or, in other words, they resemble plants grown in the dark. If we add to such plants an enormously high temperature, without any proper ventilation to make them stocky and rugged, then we have a crop that is so tender and abnormally matured that it is incapable of standing strong sunlight. If such a crop is carried over until spring, and subjected to the intense rays of the sun occurring in that season of the year, the tender, etiolated, sickly colored leaves commence to wilt even with the house closed and a considerable degree of moisture.

We observed as many as a dozen houses last spring affected in this way, and not in a single one did we see more than a dozen or so of what might be termed fairly good-colored and healthy plants. Whenever we observed a plant which possessed any color or texture in its leaves, we found plants which showed no indication of the wilt. We examined at the same time in another locality a crop of a similar variety of cucumbers grown in a house provided with a single layer of glass, which had also received sufficient ventilation, and the plants were in an exceedingly vigorous condition.

These facts show what it is always necessary to bear in mind, that some varieties of plants can be grown by different growers with entirely different results, and that it is essential to pay the greatest attention to conditions which are normal to the plants.

While the cause of the cucumber wilt is due, as we have already pointed out, to irrational methods of greenhouse management, the specific cause can be traced directly to the lack of texture in the plants, brought about by too high a temperature and lack of light in the beginning, which does not enable them to stand up under the powerful rays of the spring sun, as the amount of water thrown off from their tender leaves is more than can be supplied by their roots. This irrational method seems to have its origin in a desire to save coal, and starve the plant by utilizing double layers of glass, and to indulge in too much forcing; or, in other words, to get more out of the plant in a certain length of time than its inherent capacity warrants. In these methods of culture, affecting, as they do, a single locality, we see nothing but practice based upon a disregard of the normal functions of the plant, and mistakes due to local conception of greenhouse management. The remedy in such a case is obvious, and consists in giving the plants during their young stage of growth plenty of light and air, and not allowing them to grow too rapidly. Cucumber plants grown in this manner will possess color and texture, and they will be capable of standing the spring rays of the sun without wilting.

Some Difficulties which City Shade Trees have to contend with.

For some years back our larger cities have had park commissions, whose duty consists, among other things, in seeing to the setting out and caring for shade trees. Many of these cities, having seen the necessity of a more general oversight in regard to the care of trees, have gone a step further, and have secured the services of a trained forester, whose business it is to pay special attention to their welfare.

This department frequently has specimens of diseased leaves and branches, especially of trees, sent to it for the purpose of determining what is the matter with them. Sometimes these specimens are from trees in which a single branch has lost its leaves in mid-summer, or they may be specimens from a tree which has died suddenly. An examination of the specimens frequently shows that there is no reason for believing that their abnormal condition is caused by either insect or fungi, although at times there may be observed a few aphids on them, which it is generally supposed are the cause of the trouble. The causes of these troubles, however, are in many instances to be traced to conditions which are peculiar to our times. In this age of electric lights, trolley cars, sewers, pavements, gas, and transmission of steam for heating purposes, it must be confessed that the practice of setting out shade trees along the borders of streets in our cities becomes rather discouraging. The price of enjoying these modern appliances of scientific thought means more than the mere cost of digging up our city streets and lopping off the limbs of trees every few months; in many instances it means the death of many shade trees, and it may eventually lead to the question whether it is worth while to bother at all with trees for our city streets. The sickly, disfigured, mutilated specimens of trees which are now and then seen in our busy city streets have very little to recommend them, and in many cases thoroughfares would become improved without them.

Some of the agencies which more especially affect our trees are electricity, gas and steam. These may affect the tree directly, by escaping and coming in contact with some portion of it, or indirectly as by the lopping of limbs for wires or the digging of trenches for the pipes, which very frequently results in destroying portions of the root system. There are other agencies, however, which are associated with the death of the tree. One of these is the borer that is very troublesome to the rock maple. Trees affected with these can be readily detected by an examination of the bark of the tree for round holes about one-quarter of an inch in diameter, and in autumn the affected limbs can be readily detected by a premature coloration, or hectic flush, as it were, of the leaves. Then, again, there is the work of horses' teeth, which, according to Mr. James Draper, who has had many years' experience as a park commissioner at Worcester, inflicts more damage than any other single thing to city trees. Many of the specimens of diseased shade trees which are sent in to us year after year can be referred to one of the above agencies as a cause of the trouble.

The death of many trees can be referred to illuminating gas. If a leak occurs in the pipe, the gas escapes very readily into the soil, especially if it is porous, and when it comes in contact with the roots they are asphyxiated, and the result to the tree manifests itself very quickly. The symptoms of gas poisoning are most generally a sudden falling of the leaves, a deadened appearance of the bark, due to the collapse of the cambium or living layer, brought about by the asphyxiation of the roots, which results in the rapid death of the tree. In mild instances of poisoning the effect shows only upon one side of the tree, but in general the tree seldom escapes death. We have observed many single trees killed by gas on the private grounds of city residences, without the owner ever surmising what the trouble was; and this last summer we had an opportunity to examine whole rows of native trees which had died by gas asphyxiation. Some of the trees which we observed were at a distance of fifty feet from the nearest gas main, while others succumbed when not nearer than one hundred feet to the leak in the pipes. While it is advantageous to all gas companies to stop these leaks as soon as they are found, it becomes practically impossible to do so in every instance, and the death of trees from this source must constantly be expected. As a matter of fact, the death of some fine shade tree is not infrequently the first indication the gas company has of a leak in its main.

Abnormal respiratory conditions, which usually result in either a sudden or lingering death to trees, occur where they have become submerged in water, or where they have been covered with a foot or more of soil. We have noticed trees growing beside sloping roadsides which had become filled in with earth only on one side of the tree, resulting in that side of the tree becoming dead, while the other side would linger along in an unhealthy condition for years.

Less often does the death of trees result from steam, as the transmission of this is not so common. Occasionally, however, where steam pipes are laid near trees, they are sometimes injured.

The various forms of concrete and pavements and the large surface of the ground covered by them about the city streets are a menace to the health of trees, and the sickly conditions which they present are often due to these. Some of our more modern city streets obviate this matter by leaving a wide space of turf between the sidewalk and road, for the purpose of planting trees. This gives the roots a chance to develop normally, inasmuch as the respiratory functions are not interfered with, as is the case when they are covered with pavements. Many of the streets in Springfield are especially commendable in this direction.

Not a little of the disfiguration of trees is directly due to the linemen in lopping limbs, and more especially to the direct effect of electric currents. We have observed no instance where electricity has killed a tree outright, but there are many cases where the limbs have been killed by burning. This effect is not only caused by the alternating current of the electric lights, but by the direct current of the trolley system; the latter current being probably more injurious, provided the same amount of amperes and voltage is employed. The damage done by grounded wires takes place when trees are moist, as at that time the resistance is reduced, and the current becomes increased and has a better opportunity to become dispersed. We have known of instances where trees and the grass for some distance about them have been charged with the escaping current. The damage to the trees, however, is due to the heating effect of electricity. The wire becomes grounded on a limb, and when moist the current escapes. At first comparatively little current passes through the limb, as the resistance is high; but, as the heat increases the resistance decreases, with the result that a large amount of current passes through, which gives rise to still more heat, and subsequently develops into a blaze. The action of electricity, as we have already stated, is local in its effects. The injury, while sufficient to kill every portion above the limb or trunk, does not, so far as our observation goes, destroy the tissues very far above the point of grounding. There are reasons for believing, however, that the effects of the direct current are more severe than those of the alternating current. In the case of the alternating current the anode and cathode alternate very quickly, while in the direct current no alternation takes place, and this results in an electrolysis of the cells, which in turn produces disintegration and quick death to the protoplasm. In short, we may say that all of the injury to trees by electricity is brought about by heating, and by electrolysis and disintegration of the cell contents. Some observations made by Professor Hartig of Munich upon the effects of lightning on trees are interesting in connection with the subject of electricity. He observed that when a tree is struck by lightning the current usually travels along the cambium zone or living layer of the tree, just under the bark, inasmuch as at this point the current finds the least resistance. Sometimes the burning effect is more marked just inside and outside of the cambium layer, where the resistance is slightly greater, — a feature which is shown by the dead areas in the trees many years after. There are many trees struck by lightning which show scarcely any injury, and others will show only a small dead area which coincides with the path of the current. Professor Hartig has made many observations upon trees struck by lightning, and his practised eye is able to detect trees that have been so affected which to the ordinary observer would appear perfectly sound.

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